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Weathering the Storm: Climate Change, Vulnerability, and Adaptation in Bangladesh

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WEATHERING THE STORM:

CLIMATE CHANGE, VULNERABILITY, AND ADAPTATION IN BANGLADESH

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ABSTRACT

The world is guaranteed a certain level of climate change due to the emissions already released into the atmosphere. Therefore, adaptation to climate change is necessary. Increases in diarrheal disease and malnutrition due to climate change are analyzed for Bangladesh. Relative risks determined by the World Health Organization, estimates obtained from agricultural models, and migration estimates are utilized to determine the costs associated with each of these diseases, as well as reductions in rice production and increases in urban migration. It is found that climate change will create additional costs for treating each of these diseases that equal .05% of Gross Domestic Product (GDP), losses to rice production equal to 1.5705% of GDP, and increases in urban migration of 4.2%. Utilizing a vulnerability framework, adaptation policies are recommended that reduce societal vulnerability to these impacts.

Contents

Chapter 1: Introduction

"Economic vulnerability due to reduction of controls on the movement of finance and goods has introduced a new era of economic volatility. Low, unstable prices destroy earnings and the ability of poor, commodity-dependent countries—already constrained by the burden of debt and structural adjustment policies—to invest in development. Financial volatility wrecks the livelihoods of millions. But of all the new threats, it is the many dimensions of global warming that are least analyzed for their impacts on efforts to improve well being[1]."

Vulnerability is an intuitively simple concept, and yet inherently difficult to define for policy making purposes. It can be so all encompassing that it proves useless or so narrowly defined as to miss many of the most relevant issues. Striking a balance between these two extremes is of utmost importance. Global vulnerability increasingly reflects the deep social and economic divisions within and between societies differentiating those who have, from those who don't. In many nations within the developing world a small percentage of the population benefits from the majority of the wealth created. Outside of this sliver of population, the vast majority of the world's poor carve out an existence in an increasingly hostile environment that lacks even the most basic public goods such as health care or education.

Social and economic vulnerability is currently being driven by a set of global trends that further exacerbates the problems of the poor. Macroeconomic changes have

[1] A.Simms and J. Mcgrath et al., *Up in Smoke?,* IIED, (2004), 5.

created both rural and urban instability that has resulted in rising levels of inequality and poverty in the developing world. This trend has resulted in rapid urbanization as the rural poor seek economic opportunity and flee unsustainable livelihoods brought about by economic and environmental changes. In addition, rapid unplanned urbanization has increased inequality and overall poverty as migrants are forced to live on the fringes of undeveloped societies that offer little opportunity for the generation of livelihoods or income. The result is urban squalor and destitution of monumental proportions. Many within the international community have sought to rectify this assault on human dignity. Perhaps the most well known codification of their efforts can be found in the Millennium Development Goals (MDGs) which specifically address the plight of the poor and destitute in developing countries around the world. While there has been much laudable success at achieving the eight goals and their accompanying targets, much work has yet to be done if lives are to be genuinely improved.

There is, however, a dark cloud looming on the horizon that threatens to not only halt, but perhaps irrevocably reverse, the progress made towards these noble goals. That threat is global climate change. Not only is this threat very real, its effects are already being felt around the world. In fact, communities from such diverse locales as Shishmaref Alaska, to the Cartaret Islands of Papua New Guinea, have already been forced to flee the encroaching effects of rising sea levels, high winds and storm surges[2]. These "climate canaries" have sent a signal that the developing world can not afford to ignore. Unfortunately, despite the best efforts of the global community in mitigating greenhouse gas emissions, we are locked into a certain amount of climatic change due to the time lag

[2] Oli Brown, *Migration and Climate Change,* IOM, (2008), 25-27.

between the emissions that have been released to date, and natural sequestration[3]. This simple fact makes climate change adaptation unavoidable.

In order to effectively adapt to the coming changes, nations must be able to properly assess vulnerability in a local context. The four factors proposed by the vulnerability framework provide the developing world with a tool for doing so by enabling them to identify the multiple pathways through which climate change will interact with human activity, settlements, and health. I argue that this framework enables the creation of adaptation policies that emphasize no-regrets solutions targeted at the existing vulnerability of a given population to four factors: macroeconomic context, socio-economic context, institutional context, and local environmental context.

With the aid of this framework, the potential vulnerability of children's health in Bangladesh will be assessed as there is now strong evidence linking climatic changes to human health. While climate change presents a daunting array of risks to human health, research has shown that these changes will directly affect diarrheal disease as temperature and precipitation changes lead to increased conditions that breed vector and waterborne diseases that prey upon the young. Diarrheal disease, a leading cause of under-five (under-five) mortality in nearly all low-income countries, has received considerable attention as it kills over 1.8 million people every year, of which 90% are children under-five in developing countries[4]. These numbers will likely spike as increased flooding and storm surge threaten what little sanitation infrastructure exists in coastal and riverine slum settlements.

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[3] G. Prins & S. Rayner, *The Wrong Trousers, Radically Rethinking Climate Policy* (James Martin Institute/Mackinder Centre, 2007), 36-37.

[4] Water Sanitation,and Hygiene Fact Sheet, (*WHO* 2004), 1.

Adaptation policies aimed at decreasing vulnerability to diarrheal disease will be assessed for a level of climatic change similar to the B1 scenario of the recent fourth assessment report by the Inter Governmental Panel on Climate Change (IPCC). In this scenario global emissions of carbon dioxide peak between 550 and 600 parts per million. These emissions cause global temperatures to rise by 2 degrees Celsius, global sea levels rise by around .3 meters, and results in the costs of adapting to the increased diarrheal disease burden ranging from $3.333-10.689 million[5].

Utilizing the vulnerability framework, it is determined that adaptation policies must move beyond traditional public health interventions to include a range of policy interventions that address the scale of the problem. The expanded array of policy options that must be utilized to avoid the deleterious effects of climate change include diversifying the economy away from single sector dependence, as well as many of the constrictive policy measures that Structural Adjustment Programs (SAPs) have forced developing countries to accept. These economic adjustments, combined with policies aimed at lowering inequalities and providing livelihood generation will help to address many of the cross-cutting issues of urbanization, poverty and migration. In an institutional context, the strengthening of both national and local levels of government and civil society will increase their ability to respond to extreme weather events, and expand people's access to power and representation. These broader policy options will complement the traditional public health approach provided by state and civil society institutions of hygiene education, as well as the creation and "climate proofing" of water

[5] K. Ebi, "Adaptation costs for climate change-related cases of diarrhoeal disease, malnutrition, and malaria in 2030." *Globalization and Health* 4, no 9 (2008): 1.

and sanitation infrastructure. Finally, the issues surrounding local environments are addressed through the development of adaptation forces that provide environmental improvement, economic opportunity, and disaster preparedness. These forces will be integrally linked to institutional structures that devolve resources and authority to local levels. Ultimately these policies provide Bangladesh with the ability to weather the coming storm.

Chapter 2: Adaptation

"Adaptation is becoming a euphemism for social injustice on a global scale. While the citizens of the rich world are protected from harm, the poor, the vulnerable and the hungry are exposed to the harsh reality of climate change in their everyday lives… We are drifting into a world of 'adaptation apartheid'. Allowing that drift to continue would be short-sighted. Of course, rich countries can use their vast financial and technological resources to protect themselves against climate change, at least in the short-term—that is one of the privileges of wealth. But as climate change destroys livelihoods, displaces people and undermines entire social and economic systems, no country—however rich or powerful—will be immune to the consequences. In the long-run, the problems of the poor will arrive at the doorstep of the wealthy, as the climate crisis gives way to despair, anger and collective security threats. None of this has to happen. In the end the only solution to climate change is urgent mitigation. But we can—and must—work together to ensure that the climate change happening now does not throw human development into reverse gear. That is why I call on the leaders of the rich world to bring adaptation to climate change to the heart of the international poverty agenda—and to do it now, before it is too late."—Desmond Tutu[6]

[6] K. Watkins et al., "Human Development Report 2007." *United Nations Development Program,* (2007), 166.

In order to address the vulnerability induced by climate change adaptation is critical. In their critique of the large-scale failing of current global climate policy, Prins and Rayner specifically call for increased spending on adaptation measures to form an integral piece of the post-Kyoto governance puzzle as "even the most stringent mitigation efforts cannot avoid further impacts of climate change in the next few decades"[7]. While the IPCC and the United Nations Framework Convention on Climate Change (UNFCCC) recognize both mitigation and adaptation as appropriate policy responses to climate change, mitigation has been the overwhelming recipient of funding and attention up to this point. This is due to the belief, held by many, allowing for adaptive measures will serve to delay or obstruct attempts at mitigation[8]. The dilemma is that the beneficial effects from mitigation measures will take many decades to incur[9]. While the world awaits these effects, millions will become increasingly vulnerable to a myriad of effects. A callous and irresponsible refutation of the immediate need for adaptation policy disregards the fate of these millions and places all levels of society in danger.

In many ways, adaptation measures are not radical departures from traditionally advocated policy proposals. As the case for water and sanitation infrastructure in relation to diarrheal disease and climate change will clearly demonstrate, the proposals embodied in the MDGs are now nearly irrefutable. Adaptation measures will in many cases simply involve ramping up efforts to achieve previously defined goals that have not yet been attained. However, it is possible to mistake the forest for the trees so to speak, as climate

[7] R.J.T. Klein, and S. Huq, et al., 2007: Inter-relationships between adaptation and mitigation. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK: 747.
[8] Prins & Rayner, 35-37.
[9] R. Pielke Jr. and G. Prins, "Lifting the taboo on adaptation." *Nature* 445, no 8 (2007): 1-3.

change will have pervasive societal impacts that will also indirectly affect diarrheal disease. Therefore adaptation policies aimed at limiting societal vulnerability to diarrheal disease will likely include aspects that fall far outside traditionally advocated policies.

The importance of societal changes in the form of adaptation policies is best evidenced by the drastic reduction in the costs of climate change they can bring about. One recent global study estimates that $1 invested in pre-disaster risk management activities in developing countries can prevent US$7 in losses[10]. For example, in China, $3 billion was spent on flood defenses in the four decades prior to 2000, which is estimated to have avoided $12 billion in losses[11]. These numbers are all the more important for developing countries due to the lack of financial resources they will be able to muster, as the global costs of increased climate variability will be large and most likely distributed very unevenly[12]. The ability to adapt is thus emerging as a potential driver of wider disparities in wealth, security and opportunities for human development and hence vulnerability[13].

Despite the strong economic arguments for adaptation, economic determinism is a pitfall that must be avoided in adaptation efforts. The human and social capital that many countries have utilized to create impressive disaster response efforts have occurred largely in the absence of significant levels of economic resources. Some scholars argue that strategies like rapid industrialization and GDP growth allow nations to better economically manage the transition to a post-climate change world; such strategies,

[10] Watkins et al., 176.
[11] Watkins et al., 176.
[12] Ian Burton, "Do We Have the Adaptive Capacity to Develop and Use the Adaptive Capacity to Adapt?" In *Climate Change, Adaptive Capacity and Development,* edited by Joel B Smith, Richard JT Klein and Saleemul Huq, London England: Imperial College Press, (1999): 138.
[13] Watkins et al., 168-198.

however, build the proverbial castle on a foundation of sand. These mal-adaptations fail to address the broader picture of vulnerability to which societies must adapt as higher levels of GDP and economic activity that are not spread evenly throughout society will not reduce the vulnerability of the poor or marginalized in society. Therefore, it is absolutely imperative that the many diverse linkages that drive vulnerability to climate change and diarrheal disease be addressed in order to arrive at cross-cutting strategies which attempt to simultaneously address the many separate, yet integral issues. While mankind waits for the world to accept this fundamental truth, the developing world must act now, or risk watching many of its hard-earned improvements in human development be swept away by climate change.

Vulnerability: Exposure, Sensitivity, and Adaptive Capacity

To begin, vulnerability can be disaggregated into its three relevant components of exposure, sensitivity, and resilience. This allows it to be "enabled" so to speak, giving policymakers the ability to draft policies targeted at its specific components. Exposure refers to the degree to which a system comes into contact with stress, sensitivity refers to the degree to which a system is affected by exposure to stress, and resilience refers to the ability of the system to recover from the damage associated with the stress[14]. In relation to climate change, the definition is slightly altered as vulnerability is seen as "a function of the character, magnitude, and rate of climate variation to which a system is exposed,

[14] P. McLaughlin and T. Dietz "Structure, agency and environment: Toward an integrated perspective on vulnerability." *Global Environmental Change* 18, no 1 (2008): 100.

its sensitivity, and its adaptive capacity."[15] The primary difference in these definitions is the use of the term adaptive capacity which is defined as "the ability of a system to evolve in order to accommodate environmental hazards or policy change and to expand the range of variability with which it can cope."[16] Ultimately, the disaggregation of vulnerability into these three components allows for the formation of targeted polices aimed at reducing either exposure or sensitivity, or increasing adaptive capacity.

Adaptation policy options deal with modifying or altering these various components in order to reduce vulnerability[17]. To shape these policies as precisely and accurately as possible it is necessary to identify which component of vulnerability specific policies are meant to act upon. For example, are policies aimed at increasing adaptive capacity by strengthening the institutional context of a country, or are they aimed at reducing exposure to adverse environmental impacts by creating or strengthening infrastructure? In many ways this question points to the complexity of adaptation as the institutional context of a country is integrally linked to its macroeconomic context and vice versa. Therefore many policies may address aspects of each individual context despite the fact that they are aimed at either reducing exposure or increasing adaptive capacity.

[15] Neil Adger, "Vulnerability." *Global Environmental Change* 16, no. 3 (2006): 273.
[16] Adger, 270.
[17] Bary Smit and I. Burton, et al. "An anatomy of adaptation to climate change and variability." *Climatic Change* 45, no 1 (2000): 202.

Adaptation: Who, What, How?

The most important questions pertaining to adaptation are *who* adapts, to *what* do they adapt, and *how* does this adaptation occur?[18] There are two main forms of adaptation: autonomous and planned. In contrast to planned adaptation, autonomous adaptation takes place on an ad-hoc basis in the absence of planning[19]. Planned adaptations are preferable to autonomous planning for a number of reasons, as autonomous adaptations tend to be reactive and costly[20]. Planned adaptations utilize the questions of who, what and how to enable adaptations that are conscious policy options, multi-sectoral in nature, and aimed at altering either exposure levels, sensitivity, or adaptive capacity in a society[21].

Who adapts, depends greatly on the scale of adaptation, be it local, national, or international. In terms of the vulnerability framework and adaptation policy in this paper, policymakers at the national level are those who are adapting. National policymakers are chosen due to the fact that macro-level advances in adaptive capacity are likely to have a broader impact on reducing vulnerability than micro-level adaptations. However, they must enable adaptations at both local and international levels as the many linkages between vulnerability and climate change will be shown to require action at all three of these levels. The importance of national level adaptation planning is vital in facilitating the ability to cope at a local level. In the absence of national level adaptations the

[18] Smit et al., 200.
[19] Bary Smit, and Olga Pilifosova, "From Adaptation to Adaptive Capacity and Vulnerability Reduction" In *Climate Change, Adaptive Capacity and Development,* edited by Joel B Smith, Richard JT Klein and Saleemul Huq, London England: Imperial College Press, (2003): 9-10
[20] Smit & Pilifosova, 9-10.
[21] S. Borron, *Building Resilience for an Unpredictable Future: How Organic Agriculture Can Help Farmers Adapt to Climate Change*. United Nations Food and Agricultural Organization (2006): 6.

resilience at the local level is greatly reduced as it is rarely independent of the adaptive capacity of the state[22].

The importance of enabling local levels of adaptation cannot be overstated. The devolution of decision making and resources to the local level will enable decisions to be made closest to their application which serves to enhance their overall effectiveness[23]. This must be accompanied by national planning efforts and capacity building at local levels in order to avoid the exacerbation of local inequalities. Indeed, without proper access for vulnerable communities, the benefits of these adaptations will not be realized at either level[24]. The success of adaptation efforts does not solely depend on creating adaptive capacity, but on where it is created, who controls it, and who has access to its benefits[25]. *Who* not only becomes those that are shaping the policy at the national level, but those that are benefitting from it at a local level.

The question of *what* a set of national policymakers are adapting to refers to the specific climate impact, as well as to the component of vulnerability related to that impact. For example, a cyclone could be the specific impact a society is adapting to, while the specific efforts could be aimed at either reducing exposure to the impacts of the cyclone, reducing sensitivity to the impacts of the cyclone, or increasing adaptive capacity to respond to the impacts of the cyclone. The two biggest questions then are how policymakers determine which are the most important exposures and which component

[22] Smit & Pilifosova, 23-24.
[23] H. Mcgray, "Weathering the Storm: Options for Framing Adaptation and Development." *World Resources Institute,* (2007), 28.
[24] Klein et al., 766-769.
[25] Watkins et al., 173.

of vulnerability is best to act upon. This provides multiple dilemmas for policymakers regarding the prioritizing of adaptations.

Determining which exposures are of the highest priority requires the identification of the multiple pathways through which a particular exposure may harm society. This helps to reduce myopic adaptation policies that neglect the broader impacts singular climate events or processes can have. In practice, this means that development activities are likely the best adaptation responses, as they respond to broader issues of vulnerability that climate change stimuli are likely to affect[26]. In the case of cyclones, the impacts are more confined to specific locales, while temperature rises can have pervasive effects on diverse regions and levels of society through, for example, reductions in agricultural production. It is not entirely feasible to shape a policy that adapts to temperature rise as it manifests itself in a variety of ways at multiple levels of society. In contrast, adaptations to specific events are much more manageable. However, the indirect impacts of climate change are likely to be of a higher magnitude which creates the need to identify a means of effective adaptation.

Once exposures that cause the largest levels of harm to a society are identified, the problem of determining the most appropriate component of vulnerability to target still remains. A solution to this problem lies in the concept of "no-regrets" adaptations. A recent approach to adaptation has been to identify sensitivities in a system or community to climate change and then manage these sensitivities in terms of adaptation[27]. This

[26] B. Apuuli, and J. Wright, et al. "Reconciling national and global priorities in adaptation to climate change: with an illustration from Uganda." *Environmental Monitoring and Assessment* 61, no 1 (2000): 155-159.
[27] Smit & Pilifosova, 9-11.

approach to the question of *what* is far superior as it gives policymakers the ability to create no-regrets adaptations to climate change that can be justified within a development framework regardless of whether climate change occurs or not[28]. This means that even if many of the uncertainties surrounding specific impacts related to climate change are too large to justify climate specific responses, a "no-regrets" adaptation response that addresses existing societal sensitivities can still be advocated. The result is that even in the absence of climate change impacts, society benefits from these adaptation efforts, and time and effort is not lost debating the specifics levels of climate change exposures that are inherently uncertain.

How adaptations are carried out in order to reduce societal sensitivities can now be addressed. Reducing sensitivity by policymakers at a national level in response to pervasive climate exposures has only recently begun. At a national policy level The United Nations Framework Convention on Climate Change (UNFCCC) has helped to spur action on adaptation by creating the Nairobi Work Program (NWP)[29]. While the limitations of the United Nations are well known, the potential contribution that the NWP and UNFCCC can have for international adaptation efforts may still be significant. The programs may play an effective role as a catalyzing agent in creating momentum for adaptation activities and funding allowing information and resources to be marshaled, while encouraging locally appropriate solutions.

This has begun to occur as the UNFCCC has allocated funding for developing countries to create National Adaptation Programs of Action (NAPAs) under the Global

[28] Apuuli et al., 155-159.
[29] *United Nations Framework Convention on Climate Change*, http://www.unfccc.int.

Environmental Facilities Least Developed Country Fund (GEF-LDCF). NAPAs identify the urgent and immediate adaptation needs of a country for which "further delay could increase vulnerability or lead to increased costs at a later stage"[30]. Over 40 of the least developed countries have received funding under the convention to prepare their NAPAs, which draw on existing information and community-level input to prioritize adaptation plans[31]. Unfortunately, the program suffers from severe budget constraints as a paltry $32 million has thus far been allocated, of which $12 million has been spent on the NAPA process[32].

Despite funding shortfalls, NAPAs are able to provide a country with a much needed assessment of the specific exposures that will be faced by different regions of the country, sectors of the economy, as well as social and ethnic groups. It also provides a clear signal to the international community about the importance of adaptation for developing countries that could catalyze increased funding in the form of ODA or other international resources. Finally, despite significant resource constraints on the NAPA process and adaptation in general, institutional and infrastructural capacity for adaptation efforts aimed at disaster risk management have been created, and in many cases, without high levels of national wealth[33]. However, the impetus for action, as well as funding for that action is thus far extremely limited.

The most crucial shortcoming in need of remedy is the lack of integration of NAPAs into decision making at all levels of government. The case of poverty reduction

[30] www.unfccc.int.
[31] www.unfccc.int.
[32] Verheyen, Roda. "Adaptation Funding: Legal and Institutional Issues." In *Climate Change, Adaptive Capacity and Development,* edited by Joel B Smith, Richard JT Klein and Saleemul Huq, London England: Imperial College Press, (2003): 165.
33 Watkins et al., 196-198.

strategies is a glaring example. The Poverty Reduction Strategy Papers (PRSPs), prepared for the World Bank, are development plans that were a precondition for access to debt relief while serving as a framework for better coordination between development partners[34]. Ideally, the NAPA and PRSP approaches should have led to "common project proposals and increased resources allocated to converging priorities"[35]. In practice, however, a fundamental disunity in the efforts and implementations of the two approaches exists as evidenced by a widespread failure of efforts to mainstream adaptation into PRSPs[36]. The UNFCCC has cited a lack of cooperation among ministries as a major barrier to progress on adaptation which is conclusively demonstrated by the case of NAPAs and PRSPs[37]. In order to bring about real progress on reduction in societal sensitivity to climate change, key governmental departments in various sectors must be involved in the planning and development of adaptation strategies[38].

As with most public policy decisions, the success of any individual adaptation or policy will hinge on the extent to which the strategy recognizes "the systemic nature of climate impacts" and thus the need for participation by many sectors to reduce sensitivity[39]. It is therefore of vital importance to safeguard adaptations by avoiding vertical myopia in project and policy planning. The vulnerability framework proposed in this paper effectively demonstrates why vertical programs are doomed to failure as

34 Mcgray et al., 34-36.
35 Mcgray et al., 34-36.
36 Mcgray et al., 34-36.
37 "Climate Change: Impacts, Vulnerabilities, and Adaptation in Developing Countries." *United Nations Framework Convention on Climate Change,* (2007), 44.
38 Climate Change: Impacts, Vulnerabilities, and Adaptation in Developing Countries, 44.
39 Haines, A., and R. Kovats, et al. "Climate change and human health: impacts, vulnerability, and mitigation." *Lancet* 367, (2006): 2107.

climate change impacts are likely to affect multiple levels and sectors of society simultaneously.

Another pitfall of which policymakers must be wary, is mal-adaptation, or the need to adapt to adaptations. The green revolution is a prime example of the possibility of such mal-adaptations actually increasing societal sensitivity. While the green revolution undoubtedly increased agricultural yields due to a variety of innovations, it has been seriously criticized for exacerbating inequalities between small and large landowners, and creating a larger gap between the rich and the poor. It has also been criticized for requiring large amounts of unsustainable inputs of energy, chemical fertilizers and water[40]. This is not to say that the green revolution was not successful, it merely highlights the need for a thoughtful critique of any adaptation policy in order to avoid as many of the negative side effects policies can have.

40 Kates, R. "Cautionary tales: adaptation and the global poor." *Climatic Change* 45, no 1 (2000): 11-12.

Chapter 3: Climate Change Vulnerability Framework

Vulnerability induced by climate change lies in the complex interactions between non-climatic sources of change and stress, including physical infrastructure, and human social and political systems[41]. The key to adaptation is properly assessing these interactions and identifying the key mediating factors in order to reduce the vulnerability of industry, settlements, and society[42]. In many ways, vulnerability to climate change exposes existing vulnerabilities within a society. Assessments of these vulnerabilities to climate events stem largely from the natural hazards field that seeks to identify the reasons that certain segments of the population suffer disproportionate effects of climate events. In addition, there is a large body of work on the vulnerabilities that determine negative health outcomes. Some of the most significant factors identified by this body of literature are population density, level of economic development, food availability, income level and distribution, local environmental conditions, pre-existing health status and the quality and availability of public health care[43]. These factors have been integrated with the results of the most recent set of reports released by the IPCC, which identified a

[41] T.J. Wilbanks, and P. Romero Lankao, et al., 2007: Industry, settlement and society. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK: 359.
[42] Wilbanks et al., 359.
[43] A. McMichael and Campbell-Lendrum, D. et al. "Climate Change and Human Health: Risks and Responses." *World Health Organization*, (2003), 220-262.

set of factors that rendered industries, settlements and societies most vulnerable to climate change. These included local environmental factors such as coastal and river flood plain location and extreme weather activity, economic factors such as a dependence on climate-sensitive resources, and the existence of rapid urbanization[44]. It is from these three bodies of literature that a broader picture of vulnerability has been derived.

The resulting vulnerability framework paints a development picture full of staggering setbacks. These obstructions will arise as higher temperatures, rising sea levels, and increased extreme weather activity prey upon the weaknesses of societies as a whole, as well as upon particular, vulnerable groups within societies. While the planet is ensured a certain level of warming due to emissions that have already been released, numerous scientists have begun to identify feedback loops, whereby the impacts of warming intensify the process of warming itself. For example, the melting of arctic sea ice is increasing warming effects due to increased exposure of dark ocean waters. These dark waters absorb more sun light than white snow pack and hence more of its energy and heat. Few of the General Circulation Models (GCMs) accurately capture these feedback loops as many recent papers highlight that the impacts predicted for as far as 2100 have now been reforecast for 2030, an arctic summer free of ice being one of them[45]. It is in this context that the conservative nature of the climate change scenario utilized in this paper must be weighed.

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[44] Wilbanks et al., 59-61.

[45] "Feedback Loops in Global Climate Change Point to a Very Hot 21st Century", *Science Daily,* http://www.sciencedaily.com.

Local Environmental Context

A country's natural resources and local environmental conditions can determine many aspects of society including economic development, human health, and even political cooperation and integration. This component of the framework is largely exogenous to policy making as it is simply impossible to remove entire mountain ranges or raise hundreds of miles of low-lying coastal areas. Therefore, the framework begins with geographic, topographic, environmental degradation and local weather conditions as a background from which countries can either reduce, or add to, climate change vulnerability. These components are all integrally linked to climate change as many impacts are simply alterations to existing weather patterns and environments. This means that countries will not likely suffer from previously unknown environmental stresses due to climate change alone. The increased vulnerability of a nation to climatic changes is therefore linked to existing levels of adaptation to climate events. Furthermore, economic development and land use patterns cause environmental degradation that exposes them to the negative effects of natural hazards.

One of the first and foremost determinants of vulnerability is geography. Existing geographic vulnerability can take several forms. In terms of economic vulnerability it has been readily observed that countries that lack ocean access in the form of a trading port are often much less developed than their neighbors who do enjoy such access. Examples of poor landlocked countries from all regions of the world abound, including Bolivia, Tajikistan, Afghanistan, Niger, Chad, Nepal etc. While this geographic determinism is overly simplistic (Switzerland is one of the richest countries in the world), it is

undoubtedly true that to an extent it can hamper economic activity reducing a governments access to trade, taxation, and revenue generation.

In relation to climate change however, countries that have large proportions of their populations in coastal zones, especially low elevation coastal zones (defined as the contiguous area along the coast less than ten meters above sea level), are at significant risk of natural hazards due to extreme weather activity. This negates some of the benefits of access to trade and economic opportunity that coastal locations provide. This exposure is all the more severe for coastal economies that are linked to natural resources that are themselves vulnerable to natural hazards. For example, coastal locations dependent on tourism or agricultural development for revenue can face significant threats. This vulnerability, however, varies widely by region, as many coastal regions face very little extreme weather activity, while others such as the Caribbean and Southeast Asia incur significant annual damage.

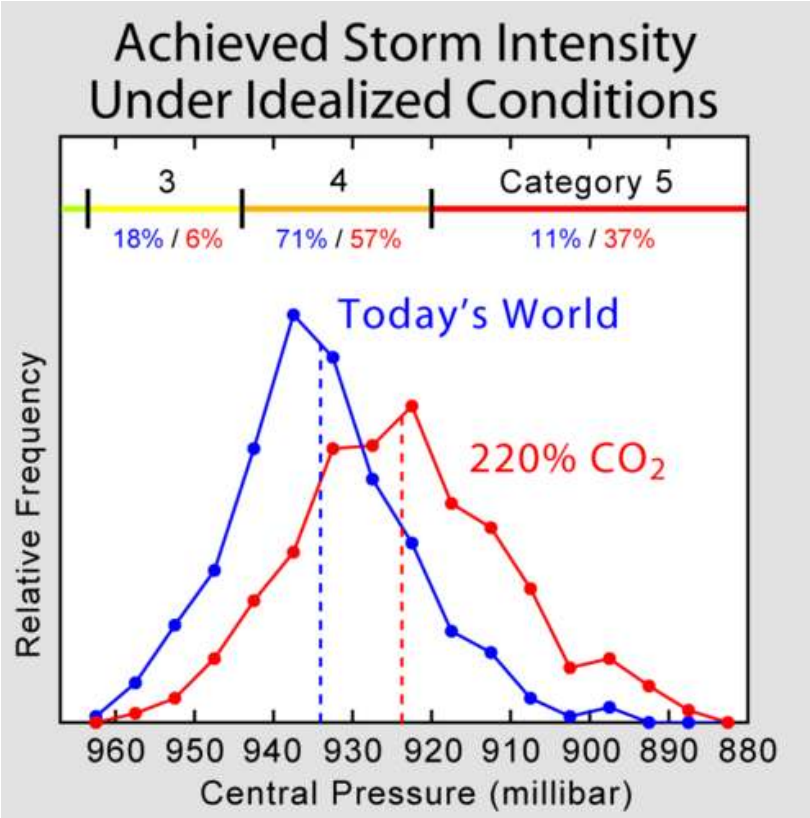
Coastal locations also create vulnerability to sea level rise. According to the fourth assessment report released by the IPCC, global mean temperatures are expected to increase anywhere from 2-6 degrees Celsius, resulting in a .18 to .59 meter sea level rise[46]. These predictions have come from observations spanning the forty-year period 1963-2003 when sea levels rose at an average rate of 1.8mm a year[47]. That rate increased from 1993-2003 to about 3.1 mm/year, suggesting feedback loops that were approaching

[46] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA: 5.

[47] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis,* 5.

alarming levels[48]. At merely a 2 degree change in average temperatures, the IPCC predicts that global sea levels will rise by .18-.48 meters[49]. This is particularly important for the 13%[50] of the worlds' population now living in the low elevation coastal zone.

Figure 3.1



Source: Global Warming Art, 2007

[48] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis,* 7.
[49] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis,* 7.
[50] McGranahan, G., and D. Balk, et al. "The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones." *Environment and Urbanization* 19, no 1 (2007): 17.

These populations will likely be increasingly exposed to inundation caused not only by rising sea levels but larger storm surges. This is highly problematic as observations show that over the past 50 years tropical storms have been lasting 60% longer and spinning winds 50% more powerful[51]. These increased wind speeds will likely lead to larger levels of storm surge and thus higher levels of damage if coastal vulnerability is not properly addressed[52].

Geographic location is also important to the extent that a country's natural resources can be manipulated by its neighbors. This vulnerability is most evident in water supplies, as international river basins account for the majority of river basins, covering some 45.3% of the earth's land surface and affecting around 40% of the world's population[53]. These basins can pose difficult tasks for nations attempting to utilize scarce water resources. Due to the transboundary nature of managing these basins, few mechanisms for dispute resolution are available for countries, and the international law that does exist is at times contradictory. Fortunately, riparian nations have cooperated far more often than not since 1948[54]. However, significant vulnerabilities still exist for many countries that face regional power inequities.

Compounding the problems associated with the lack of strong legal institutions and mechanisms to resolve disputes are rapidly expanding human populations that have increased water scarcity and induced deteriorating water quality in many areas of the world. Numerous countries around the world are classified as water-stressed, largely

[51] Bill McKibben, "Year one: Climate chaos has arrived." *Sierra* (2006): 32.
[52] A. Ali, "Vulnerability of Bangladesh to climate change and sea level rise through tropical cyclones and storm surges." *Water, Air, & Soil Pollution* 92, no 1 (1996): 172.
[53] Wolf, A. "Water and human security." Aviso 3 (1999): 29.
[54] Wolf, 1999, 32.

resulting from unsustainable water uses and rapidly expanding populations[55]. Many of these areas intensify water issues by exceeding the land's natural carrying capacity for human populations by relying heavily on underground aquifers to supply their water needs. The resulting chronic water shortages affect human and ecosystem health, as well as economic development making water supply issues critically important.

Tensions surrounding water supply issues will be further complicated by climate change as it alters local weather conditions that determine precipitation. Increased temperatures are already leading to greater seasonal differences in water availability paradoxically resulting in both increased drought and flooding occurrence. The IPCC predicts that climate change will cause dry regions to experience a decrease in water availability due to river runoff of 10-30% by 2050[56]. This will dramatically increase vulnerability, as even relatively small changes to water systems in the form of temperature and rainfall are usually amplified by a factor as high as six in seasonal water flows[57].

The added stress to water systems, especially in arid regions, will combine with development pressures to diminish a population's access to adequate amounts of quantity and quality of water[58]. This could be particularly harmful for domestic urban users that traditionally receive a fraction of the allotment that more "economically productive"

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[55] Wolf, A. "Water Wars" and Water Reality: Conflict and Cooperation Along International Waterways." *Environmental Change, Adaptation, and Security* (1999): 252-255.
56 IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK: 11.
57 M. Muller, "Adapting to climate change: water management for urban resilience." *Environment and Urbanization* 19, no 1 (2007): 102.
58 M. Babel, and S. Wahid. *Fresh Water Under Threat South Asia.* Bangkok: United Nations Environmental Program, (2008), 12.

users such as agriculture or industry do. However, it will likely also hamper agricultural productivity, as agriculture and industry make up the overwhelming bulk of the demands placed on the water supply[59]. With decreasing water supplies due to climate change and increasing demands due to rapid growth rates, as well as agricultural and industrial activity, the developing world, is facing an acute crisis of water scarcity[60].

In contrast to the issues surrounding drought, flooding events that are expected to increase with climatic changes are more readily affected by topographic factors. Topography, or "the lay of the land", consists of plains, rolling hills, or mountains, along with the type and extent of vegetative cover that occurs within a country. Vegetative cover is important as it provides a variety of benefits to human settlements, including dampening the effects of extreme weather activity. For example, in coastal locations mangrove forests have been proven to provide a natural defense to cyclones, as the 2004 Asian tsunami clearly demonstrated. The existence of shrubs and trees on hillsides also provides an anchor for soil that avoids mudslides during heavy rainfall events. This also serves to dampen the effects of flooding on downstream settlements as it obstructs the flow of water. Finally, vegetation is a source of raw materials for construction as well as trade[61].

Societies that lack the important benefits of vegetative cover, or have reduced these benefits through landscape denuding or deforestation, place themselves at considerable risk of flooding events. In burgeoning coastal populations, this has occurred as increased economic activity has placed high levels of demand on natural resources that

59 Sandra Postel, *Last Oasis* (New York: World Watch Institute 1996), 99-146.
60 Postel, 99-146
[61] Wilbanks et al., 369

rapidly degrades natural environments. The loss of coastal wetlands and mangroves is a direct result of this activity[62]. For example, many wetland areas have been drained for development purposes or to reduce the prevalence of malaria which has removed natural buffers to tidal floods[63]. As populations increasingly move towards coastal locations, land use changes and development of various kinds further threaten natural ecosystems that serve as buffers between the ravages of the sea and human settlements[64]. Unfortunately, these land use changes are not likely to abate, as projections are that 30% of global coastal wetlands will be lost within the coming century[65].

Urban areas are particularly vulnerable as natural vegetation has been replaced by large tracts of paved land that decrease the land's ability to absorb water, leading to prolonged, heavy flooding[66]. The vulnerability of urban areas to flooding was vividly illustrated by the Maharashtra floods in India, including the highly publicized Mumbai flooding. These floods were caused by a record 944 mm of rain leading to a loss of over 1,000 lives and more than $250 million (USD)[67]. This extreme weather event, combined with inadequate drainage facilities and a 40% reduction in coastal mangroves to grind the normally bustling city to a halt[68]. The vulnerability experienced by urban areas will be

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[62] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability,* 9
[63] McGranahan, 19.
[64] Watkins et al., 26-27.
[65] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability,* 16.
[66] Muller, 102-104.
[67] Cruz, R.V., H. Harasawa, M. Lal, S. Wu, Y. Anokhin, B. Punsalmaa, Y. Honda, M. Jafari, C. Li and N. Huu Ninh, 2007: Asia. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 476.
[68] M. Q. Mirza, and Q. K. Ahmad, "Climate Change and Water Resources in South Asia." (Leiden: Balkema Publishers, 2005), 171-177.

greatly affected by climate change, as increases in precipitation in wet months collide with losses in vegetative cover to increase flooding events. Estimates place the increase in rainfall and runoff between 10-40%, leading to significant vulnerability for urban environments[69].

Reductions in vegetative cover are only one example of environmental degradation that can create vulnerability. While environmental degradation can take multiple forms, in this context, it is defined as a reduction in the services created by the environment caused by human activity. Other examples include salinization and desertification due to intensive farming techniques, deforestation due to industrial and agricultural development, and chemical pollution arising from industrial development. Losses in forest cover are particularly important for the anchor effect that vegetation has on soil. The loss of this anchor effect due to deforestation places communities at an increased risk of soil erosion during rain events[70]. Increased flooding also occurs as water is less obstructed during rainfall events which can also induce mudslides[71]. In terms of human health, deforestation can also introduce new diseases into peri-urban environments by creating habitats where disease vectors, such as mosquitoes, can thrive thereby introducing potentially deadly diseases like malaria or dengue[72]. Ultimately, environmental degradation can seriously reduce environmental resilience which,

[69] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability,* 11.
[70] Wilbanks et al., 369.
[71] Wilbanks et al., 369.
[72] McMichael, 150-152.

combined with climate change, land use changes, pollution, and the overexploitation of resources, is likely to exceed the resiliency of ecosystems within this century[73].

It is important to note that environmental degradation is integrally linked to other components of the framework, including economic development and agricultural commodity or natural resources dependence for developing countries. In many cases the overexploitation of land and natural resources that create short-term profits often result in long term environmental degradation that can have lasting effects on natural environments. It also affects the socio-economic context by reducing rural incomes and creating conditions for increased migration to urban centers.

Ultimately, damage to society will be both direct and indirect, occurring where climate hazards and societal vulnerability converge[74]. However, the devastating societal impacts of these hazards are not a foregone conclusion. For example, Cuba has constructed infrastructure, utilizing relatively little capital, in one of the world's most extreme tropical cyclone zones. It has successfully used this system to save lives and limit damage to property without a developed economy by implementing an effective early warning system, along with a highly developed civil defense infrastructure based on community mobilization[75]. This example clearly demonstrates the need to assess these impacts in relation to macroeconomic, socio-economic, and institutional factors in order to accurately assess, and respond to, vulnerability.

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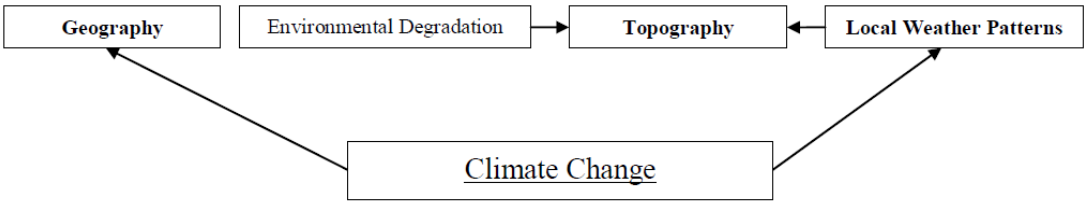
[73] Neil Adger and M.M.Q. Mirza et al., 2007: Assessment of adaptation practices, options, constraints and capacity. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 733-735.

[74] J. Fricas,and T. Martz, "The impact of climate change on water, sanitation, and diarrheal diseases in Latin America and the Caribbean." *Population Reference Bureau.* http://www.prb.org.

[75] Watkins et al., 183.

Figure 3.2



Underlying Drivers of Vulnerability in Bold

Macroeconomic Context

Development theorists for decades have stressed economic development, industrialization and urbanization as pathways to prosperity and security[76]. Ironically these policy prescriptions could be what are driving much of the vulnerability in the developing world today. Following the debt crisis of the 1970s and 80s, many developing countries were forced to turn to international institutions such as the International Monetary Fund (IMF) for financial assistance. This "assistance" came in the form of Structural Adjustment Programs (SAPs) that imposed draconian measures for balancing budgets and achieving macroeconomic stability. In many cases countries were forced to rely on a narrow set of export commodities in order to pay debt obligations on these loans. In addition to SAPs, countries were advised by international institutions and donors to develop a limited set of exports to secure foreign exchange for such vital purchases as technology and industrial equipment to fuel the process of industrialization. For many countries the only option was to exploit their natural environments for

[76] M. Todaro and S. Smith, *Economic Development* (Essex: Pearson Education Limited, 2009), 209-273.

resources or agricultural commodities. The net result was an over-reliance on natural resources for national income and economic development[77].

The development of single sector economic dependence places countries in a precarious position in an increasingly volatile global economy. This is evidenced by the large price swings commodities such as coffee and cocoa endure. Unfortunately, this problem is not unique to commodity production. Fishing and tourism are other sources of developing country income that are particularly vulnerable to both economic whims. Agriculture, fishing, and tourism are also heavily dependent on climatic conditions. Any significant changes in local weather activity including increases in flooding or drought brought about by changes in precipitation, can dramatically affect the economies of developing nations[78].

In addition to single sector economic dependence, coastal population shifts place nations and communities at considerable risk of natural and man-made hazards as described in the local environmental context. These shifts were driven in part by colonialism and the expansion of international trade, resulting in the development of large coastal cities. Nowhere is this more evident than in the developing world where, on average, 14% of populations reside in low elevation coastal zones, in comparison with 10% of OECD countries[79]. This is even more marked in urban populations, with the

[77] H.-J. Chang, and I. Grabel, *Reclaiming Development* (London: Zed Books Limited, 2004), 7-53.
[78] Cutter, S., B. Boruff, et al. "Social Vulnerability to Environmental Hazards." *Social Science Quarterly* 84, no 2 (2003): 245-255.
[79] McGranahan, 17.

developing world having 21% of its population in this area, compared to only 11% of OECD countries[80].

The net effect of these recent trends in economic development has been to reduce macroeconomic stability in the developing world. This has affected the health and well-being of these populations in a variety of ways. In the case of SAPs, many of the lending restrictions made by the IMF were aimed at balancing budgets to produce stable macroeconomic environments. This IMF policy resulted in reductions in social spending programs for education and healthcare, shrinking the small social safety net these poor countries could afford. Citizens in these countries are now forced to spend scarce personal income on these services. In countries where a majority of the population struggles to earn enough income to feed themselves, the purchase of health services or education, are luxuries few can afford. This has been compounded by single sector economic dependence, as high price volatility of primary commodities reduced wages and income that were needed to cover these expenses, previously provided to the population by the government. The resulting vulnerability of the population as a whole has thus largely resulted from macroeconomic changes.

Climate change is likely to wreak havoc on unstable economies that are overly reliant on natural resources and agricultural production. Evidence has steadily accumulated that increasing temperatures, changes in precipitation, and alterations to growing seasons are already occurring. It has been estimated that for a 2 degree warming scenario, climate change could cause reductions in GDP of up to 3% in the developing

[80] McGranahan, 26.

world[81]. These impacts will cause reductions in economic gains for nations as a whole while greatly endangering poor households that depend on these climate sensitive sectors for their livelihoods. The resulting instability will add yet another layer of stress upon unstable macroeconomic environments in developing countries.

Agriculture commodity production is perhaps the most vulnerable form of single sector economic dependence in relation to climate change. Temperature increases of 1-3 degrees are expected to cause earlier and heavier spring discharge of water stored in the form of ice and snow. This alters the availability of water necessary for particular stages in the growing cycle. In addition, precipitation changes occurring at this level of warming alter the seasonal distribution of rainfall, creating similar effects on agricultural production. Ultimately, any change in global mean temperature above three degrees is likely to negatively affect agricultural yields in all regions of the world as drought affected areas increase in extent, while heavy precipitation events increase the incidence of flooding and significantly alter crop production[82].

The resulting macroeconomic downturn will severely impact economic activity resulting in lower levels of foreign exchange, and tax revenue. In addition to the resulting macroeconomic instability, famines can arise due to economic factors that take the place of supply shortages thereby forcing "artificial famines" as supply reductions lead to price increases[83]. This can happen as declining yields force countries to divert crop production destined for domestic consumption to foreign sale in order to secure foreign exchange

[81] Nicholas Stern et al, *Stern Review on the economics of climate change: Summary for Policymakers* (London: HM treasury, 2006), 9.
[82] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, 16.
[83] Adger, 270-271.

needed for debt repayments or other activities. The potential harm climate change could cause will interact with increasing demands for food, food price volatility associated with macroeconomic instability, and the reduction of state-sponsored agricultural extension services that all helped fuel the recent food crisis from 2006-2008[84].

As a result of the implications of macroeconomic instability, developing country vulnerability is thought to be more or less dictated by a lack of economic development. In this view, high levels of economic development provide resources for the management or reduction of vulnerability, while low levels of development greatly hinder it. However, it is important to note that increased economic activity does not necessarily reduce vulnerability. Economic determinism fails to recognize the vast reservoir of adaptations that human societies have built up over centuries of habitation in many extremely vulnerable areas of the world, many of which are greatly aided by human, social, and natural capital rather than fiscal resources[85].

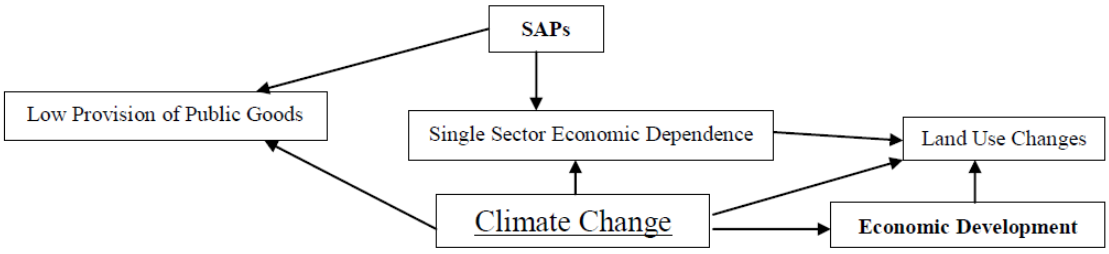
Even so, governments will likely seek to insulate important or vulnerable economic sectors. In general, the least impacted sectors are likely to be industrial, while the most heavily impacted are agricultural, a situation that overwhelmingly affects the developing world. Inevitably, the weight of the impacts on the most greatly affected communities within a nation will be lost in national statistics that average out economic costs in relation to national GDP. In the absence of disaggregation of economic effects on local communities and individual sectors, a nation's vulnerability will increase as

[84] "Tackling the Global Food Crisis." *United Nations Conference on Trade and Development*, 2008, http://www.unctad.org, 2-3.
[85] Adger, 273-276.

generalized responses do not address specific sectoral or local economic contexts and squander scarce resources[86].

Ultimately climate change exposes the fragile nature of these economies. These changes will likely cause harmful reductions in state revenues as natural resources and agricultural commodity production is reduced. These reductions will lead to further decreases in state spending on social programs, a situation which has already led to severe repercussions for society, particularly for the poor. It will also reduce demand for labor and job opportunities as the macroeconomic situation deteriorates.

Figure 3.3



Underlying Drivers of Vulnerability in Bold

[86] Wilbanks et al., 378-385

Socio-economic Context

In addition to reductions in social spending, the population in need of these programs has grown dramatically in recent years as dramatic population growth has masked achievements in poverty reduction. Over the past century, unprecedented population growth marked by increasing urbanization has been witnessed across all regions of the world. The United Nations Population Division (UNPD) projects that this trend is unlikely to abate as the world is expected to experience a population increase of 2.5 billion people by the year 2050 which is equivalent to the entire *world population* of 1950[87]. Not only will the developing world absorb the majority of these new inhabitants, increasing its population from 5.4 to 7.9 billion people by 2050, the UNPD projects that the total number of urban dwellers worldwide will account for 6.4 billion of the total world population of 9.2 billion.[88]. These numbers are staggering and form the oft-cited hockey stick graph of human population explosion utilized by a variety of academics, activists, and politicians to visually demonstrate the dynamic nature of human expansion.

The complete inversion of the rural/urban population composition of 1950, accompanied by the squalor of slum settlements, provides unprecedented impetus for a significant shift in development planning and policy. While increases in population size are largely due to the success of public health interventions, the socio-economic conditions of this population are overwhelmingly determined by urbanization that is integrally linked with economic development and the creation of vast differences in

[87] "World Population Prospects the 2006 Revision." *United Nations*, 2007, http://www.un.org/esa, 1-9.
[88] *United Nations,* http://www.un.org/en.

wealth between rural and urban areas. Between 1970 and 2000, the income gap between the richest and the poorest 20% of the world population shifted from a factor of 32 to 78[89]. This was most pronounced in urban areas of the developing world where an estimated 70% of urban populations now live in slum-like conditions[90]. Incredibly, within the next 30 years the number of slum dwellers is likely to increase to about 2 billion[91], the majority of whom are expected to reside in small (under 500,000) and medium-sized cities (1-5 million)[92].

To put these statistics into context, a staggering 99.4% of urban dwellers in Ethiopia and Chad reside in slums[93]. The poorest urban populations are most likely found in Maputo and Kinshasa where two-thirds of the population "earn less than the cost of their minimum required daily nutrition"[94]. The term 'inequality' hardly defines the stark contrast between slum settlements and penthouse high rises that have become staples of urban cityscapes, as the world economy increasingly becomes integrated along laissez-faire, neo-liberal guidelines. These conditions overwhelmingly impact specific demographic groups, namely women, children and the elderly. For example, of the 140,000 deaths caused by cyclones in Bangladesh, mortality rates for children under 10 years of age were six times that of adult men[95]. Ultimately, slum environments provide

[89] Watkins et al., 25.
[90] Diarmid Campbell-Lendrum and C. Corvalan. "Climate Change and Developing-Country Cities: Implications for Environmental Health and Equity." *Journal of Urban Health* 84 no 1 (2007): 111.
[91] Watkins et al., 101.
[92] Wilbanks et al., 363.
[93] M. Davis, *Planet of Slums: Urban Involution and the Informal Proletariat*, (New Left Review 26, 2004): 13-14.
[94] Davis, M, 13-14.
[95] Campbell-Lendrum et al, 19.

drastically inadequate protection for the health and livelihoods of these vulnerable segments of society.

Slum settlements create vulnerability for a number of reasons. First, they are often located in extremely vulnerable areas, such as riverine or coastal floodplains often lacking many of the most basic public goods like piped water and sanitation infrastructure. In addition, education and employment are extremely difficult to obtain in slum areas reinforcing a cycle of poverty and exacerbating inequalities. These problems are compounded by high population densities, informal housing arrangements, and high concentrations of solid and liquid wastes[96]. The conditions created by high concentrations of solid and liquid wastes and the ineffective or absent efforts at removing this waste breed infectious diseases that are easily spread by the high population densities of slum areas. Many of these problems are linked to rapid unplanned urbanization where even basic urban planning zoning laws either don't exist or are not enforced. The resulting poor health is fed by, and feeds, poverty.

Despite these conditions, migrants continue to stream into urban environments for a variety of reasons. Urban migration is often a last resort for poor families around the world, and involves a somewhat voluntary choice in movement, including when, where and how migration occurs [97]. However, as sustainable economic opportunity in rural areas decreases, and national policies increasingly allocate resources to urban areas,

[96] T. Tanner and T. Mitchell, et al., *Urban Governance for Adaptation: Assessing Climate Change Resilience in Ten Asian Citie*s, (UK: Institute of Development Studies, 2007), 5-7.
[97] D. Bates, "Environmental Refugees? Classifying Human Migrations Caused by Environmental Change." *Population and Environment* 23, no 5 (2002): 467-468.

many rural populations turn to migration as a livelihood diversification strategy[98]. The problem is further intensified by rural urban wage differentials that provide an impetus to seek opportunity in urban areas[99].

Compounding these problems is the fact that in many areas of the developing world, rural elites have consolidated ownership of fertile land, forcing subsistence farmers onto increasingly marginal land. This causes a variety of environmental problems, including soil degradation and desertification, as farmers are forced into unsustainable farming practices in order to survive. Eventually, these practices force people from unproductive land to search for scarce opportunities available in urban environments. These migrants are known as environmental refugees. While the forces driving environmental migration can arise from gradual deterioration of local environments, they can also be caused by the onset of sudden environmental disasters. Oftentimes victims of highly publicized disasters receive large amounts of foreign aid to mitigate the impacts of displacement while millions of others uprooted by gradual environmental change, considered migrants, receive comparatively little support. This situation aggravates the problems of the urban poor and leads to ever burgeoning slum settlements[100].

Climate change will greatly affect many of these vulnerabilities. The dire situation faced by slum settlements will be exacerbated as the environmental risks urban communities face as described in the local environmental context increase. It will also

[98] Randall Kuhn et al., *The Logic of Letting Go: Family and Individual Migration from Rural Bangladesh* (Defense Technical Information Center, 2002), 6-8.
[99]Todaro, 209-273.
[100] Bates, 468-475.

lead to increases in urbanization that will further compound these problems by reducing negatively impacting already highly unstable rural livelihoods. It will likely increase urbanization as a variety of gradual environmental changes such as desertification, sea level rise, and acidification of oceans, will all likely drive rural to urban migration as well as further consolidations of urban areas that are less heavily impacted. These gradual changes, exemplified by an upsurge in average temperature, are accompanied by fluctuations in weather extremes, such as drought and hurricanes, that will combine to significantly affect population mobility patterns in the years to come[101].

These two sets of environmental drivers can be conceptualized as climate processes in the case of long-term changes and climate events in the case of singular, extreme weather events[102]. The linkage between climate events and displacement or migration, is relatively apparent, while migration induced by climate processes can at times be masked by other "pull" factors such as the lure of economic gain. However, climate processes will likely lead to long-term migration flows regardless of "pull" factors[103].

Africa provides a telling case of how climate processes are driving rural to urban migration. Over the last 50 years, Sub-Saharan Africa has averaged a growth rate of urbanization 10 times that of OECD countries[104]. This urbanization has often been linked to the pull effect of economic opportunity and increased living standards on the rural poor. While a number of factors are driving this exorbitant rate of urbanization, a recent

[101] C. Tacoli, "Migration and Adaptation to Climate Change." (*International Institute for Environment and Development*, 2007) 1-2.
[102] Brown, 17.
[103] Tacoli, 1-2.
[104] S. Barrios and L. Bertinelli, et al., "Climatic change and rural–urban migration: The case of sub-Saharan Africa." *Journal of Urban Economics* 61, no 3 (2006): 358-359.

study found that increasingly erratic and declining rainfall patterns have led to a push, rather than pull, effect in rural/urban migration, which both Western and Sub-Saharan Africa are particularly prone to due to their local environmental conditions[105].

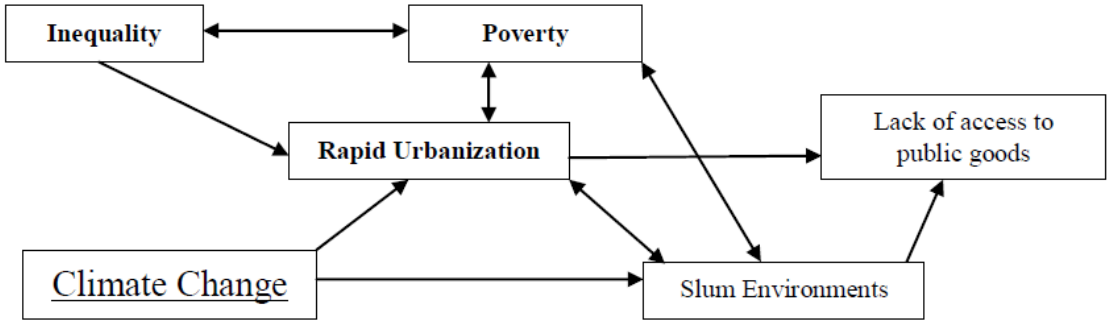
Even in the absence of an artificial famine, declining rainfall will reduce yields and likely push subsistence farmers into degrading land practices as they eke out what little productivity is left in their land. Declining yields could induce large scale rural landholders to seek further land consolidations to ensure adequate crop yields and income. They may achieve these consolidations by purchasing the land of subsistence farmers or via political or legal means. This poses threats to long-term development prospects in rural areas, as the increasingly severe effects of climate change lead to a radical transformation of traditional livelihoods, including long-term and permanent migration to urban centers[106]. These new streams of urban migrants will likely follow existing patterns of rural to urban migration, ultimately magnifying the negative effects of urban living through higher population densities, larger and more frequent slum settlements, and increases in poverty and inequality[107].

Further increases in rural to urban migration will lead to pronounced vulnerability for industries, settlements and societies, where rapid urbanization is already occurring that will overwhelmingly affect the urban poor and those living in slum settlements. Large, unplanned slum settlements located in areas already prone to flooding, storm surge, and other natural hazards will be the most vulnerable as climate change increases the incidence of these events. The risky locations of many of these settlements, namely

[105] Barrios et al., 358-359.
[106] Tacoli, 1-2.
[107] Brown, 16-21.

those in coastal locations, will expose societies to sea level rise and the many facets of a faster hydrological cycle through increased flooding that will wreak havoc on urban societies[108].

Figure 3.4



Underlying Drivers of Vulnerability in Bold

Institutional Context

The squalid conditions slum dwellers find themselves in are often mediated by the effective, or ineffective, actions of municipal and state governments, and civil society actors. These two sets of actors create the institutional context of a country and generally limit or increase the vulnerability created by the local environment, macroeconomic, and socioeconomic contexts. The harsh reality is that many governments in the developing world currently fail to adequately respond to existing vulnerability. Adding the additional stress of climate change will undoubtedly aggravate this situation. As with all of the

[108]Wilbanks et al., 373.

factors that make up vulnerability in relation to climate change, the significance of the institutional context lies in its interactions with various other stresses including negative impacts on economic and social structures[109].

The intersection of institutional capacity and climate change impacts displays the adaptive capacity a country wields[110]. The adaptive capacity of a nation relies on its institutional resilience, stability, robustness, and flexibility in the face of climatic stimuli[111]. These factors are apparent in the sharp contrast between adaptive capacity in response to hurricane activity in Honduras and the United States. While both are exposed to similar climate stresses, Hurricane Mitch accounted for damages equal to 75% of Honduran GDP in 1998, while Hurricane Andrew accounted for losses less than 1% of American GDP in 1992[112]. These two reactions to natural hazards demonstrate the vital importance of institutional context in determining vulnerability. Ultimately, the characteristics of climate resilient institutions include revenue generation, decentralization, institutional flexibility, and participation, as they are all vitally important for determining institutional vulnerability to climate change[113].

One of the most direct impacts governments can have on reducing vulnerability is through the provision of basic public goods such as water, sanitation, drainage, health

[109] Wilbanks, et al., 359-361.
[110] Adger, 273-276.
[111] Neil Adger, *Social Aspects of Adaptive Capacity,* In *Climate Change, Adaptive Capacity and Development,* edited by Joel B Smith, Richard JT Klein and Saleemul Huq (London England: Imperial College Press, 2003), 32-35.
[112] John Handmer, *Adaptive Capacity: What does it mean in the context of natural hazards?,* In *Climate Change, Adaptive Capacity and Development,* edited by Joel B Smith, Richard JT Klein and Saleemul Huq, (London England: Imperial College Press, 2003), 54.
[113] Tanner et al., 5-9.

services, education and improved housing that tax generation allows[114]. In low and middle-income countries, the provision of these services is often constrained by the government's ability to levy and collect taxes on domestic economic activity and international trade. The importance of government revenue is therefore linked to the macroeconomic context and climate change impacts that reduce GDP. In addition to reductions in revenue from crop and other natural resource failures, government revenues may also decrease as they respond to an increased number of climate events. This will prove immensely costly as adequate funding is lacking in many developing countries for management of current climate events and variability[115].

The added costs brought about by the increasing number and severity of climatic events will undoubtedly stretch vulnerable nations to their limits. This is unfortunately colliding with an international trend to reduce official development assistance (ODA) and push for a heavier reliance on trade, private investment and the mobilization of domestic funds[116]. This trend mirrors many of the neo-liberal developments of the past thirty years and will prove to further increase vulnerability. The combination of reductions in funding, along with improper spending, will tax what little resources local governments have revealing institutional vulnerabilities as governments are unable to raise additional funds from the local tax base, or unable to secure resources from the national government due to centralization of power and resources[117].

[114] Tanner et al., 5-9.
[115] Verheyen, 164.
[116] Verheyen, 164-166.
[117] Verheyen, 164-166.

This situation is worsened by a lack of human capital in the form of educated and competent civil servants. The provision of human capital is difficult for many developing countries as one of the public goods that is lacking is education. Those who can afford what limited access to education does exist often either voluntarily, or for a lack of options, seek opportunities in the developed world. This phenomenon of "brain drain" exacerbates the problem of a lack of qualified and educated people available for governmental posts.

The lack of competent and effective civil servants can drastically affect the flexibility of governmental institutions which is vital to responding to emerging health threats as well as to natural disasters brought about by changing economic, social, and natural environments. This problem is worsened by the fact that in many areas of the developing world governmental corruption is a serious problem, as those who do manage to secure government posts often profit from existing arrangements, or lack the proper incentive to make serious changes to existing power structures. This is evidenced by the power many central governments enjoy often at the expense of lower levels of government[118]. This results in centralization of power and resources that further institutionalizes political rigidity in responding to social, economic, and environmental stresses. This has had tragic consequences for the AIDS epidemic, as the failure to adequately respond to the epidemic by many sub-Saharan governments clearly demonstrates[119].

[118] McGranahan, 35.
[119] H. Schneider,"On the fault-line: the politics of AIDS policy in contemporary South Africa," *African Studies* 61 no 1 (2002): 145-167.

In the absence of effective institutions, governments face institutional rigidity that can interact with climate change impacts to form mal-adaptations based on past experience or ideology[120]. These mal-adaptations may prove particularly harmful for developing countries that have followed the strictures of SAPs. A telling example is the wisdom of economies of scale in resource planning. For example, the construction of dams has been trumpeted for decades, despite the very significant social and environmental impacts that these projects can have on populations and environments. It is still very unclear as to the net benefit these projects have when all externalities are included in project costs. However, solutions like these are being put forward as both mitigative and adaptive responses for their supposed ability to reduce greenhouse gas emissions while managing dwindling water supplies and increased flooding. Dams not only increase greenhouse gas emissions through the decomposition of trapped organic matter, but heighten the vulnerability of displaced communities[121]. The example of dams is a microcosm of mal-adaptations that institutional rigidity can cause.

In addition to institutional rigidity, centralization of power and resources can greatly increase vulnerability to natural hazards and, therefore, climate change. Decentralization has emerged as a response to the problems associated with national level planning and mal-adaptations that lacked local context. It has accompanied many of the SAPs in an effort to build local levels of government that are capable of addressing their own needs in order to sever their ties to strong centralized state institutions. Despite what may seem a good prescription for empowering local communities, decentralization has

[120] Adger, 2003, 65-67.
[121] D. Biello, "The Dam Building Boom: Right Path to Clean Energy." *Yale Environment 360,* 2009, http://e360.yale.edu.

oftentimes exacerbated inequalities and strengthened the power of local elites[122]. This has resulted in part from insufficient time and resources being devoted to the task of improving accountability mechanisms and capacity at local levels[123]. In addition to the lack of time and effort spent at fleshing out what could be a strong mechanism for empowering local communities, adaptation and responses to natural hazards and climatic changes, also tend to reinforce resource and entitlement inequalities as well as social hierarchies[124]. Ultimately the failure of decentralization schemes creates national level planning that neglects local social, cultural, and environmental realities and increases vulnerability[125].

Where governments have failed due to a lack of competent personnel or institutional rigidity, or centralization of power and resources, civil society has attempted to intervene and provide basic public goods as well as a voice for the marginalized and oppressed. A recent push by civil society actors towards participatory development has been directed at empowering people by providing them access and representation to political power structures. Political empowerment and representation are tremendously important to those who are marginalized in the developing world as many of the things they are denied relegate them to a lifetime of poverty and vulnerability. This is particularly true for women who are shut out of what little opportunities are available due to patriarchal social and political structures. While participatory approaches have been

[122] Rebecca Marsland, "Community Participation the Tanzanian Way: Conceptual Contiguity or Power Struggle?" *Oxford Development Studies* 34, no 1 (2006): 65-79.
[123] Tanner et al., 5-9.
[124] Marsland, 65-79.
[125] Handmer, 65-68.

heavily criticized, they have experienced success in affecting change at multiple levels of government[126].

While NGOs have attempted to empower local groups in order to improve democratic participation, the emergence of public private partnerships (PPPs) has negated some of their gains and increased vulnerability. PPPs have been heavily criticized for being undemocratic and marginalizing vulnerable groups[127]. They have also failed to address the important issues of participation, inclusion, accountability and transparency in order to build climate resilient institutional capacity. Ultimately, both decentralization and PPPs are likely to be solutions that governments turn to as they have been utilized in the past. This is not to say that these solutions could not aid in adaptation; however, without revisions to their past implementations, they are likely to heighten vulnerability. In institutionally rigid nations the likelihood of these solutions receiving serious critical attention in order to maximize their effectiveness is very low.

In the end, ineffective institutions can dramatically worsen the impacts of climate change. One of the most pressing problems is the diversion of scarce resources either to mal-adaptations, or to adaptations that do not address urgent priorities or underlying causes of vulnerability[128]. This is often the case in states that are driven by an ideology that fails to critically analyze past solutions to new problems[129].

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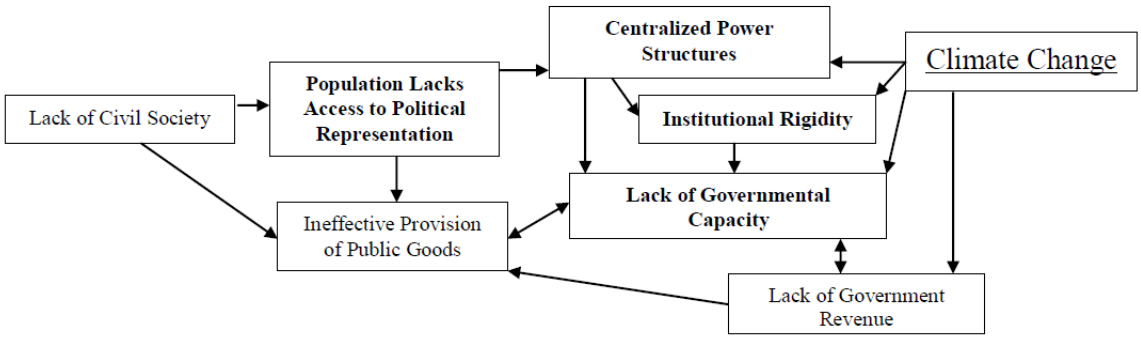
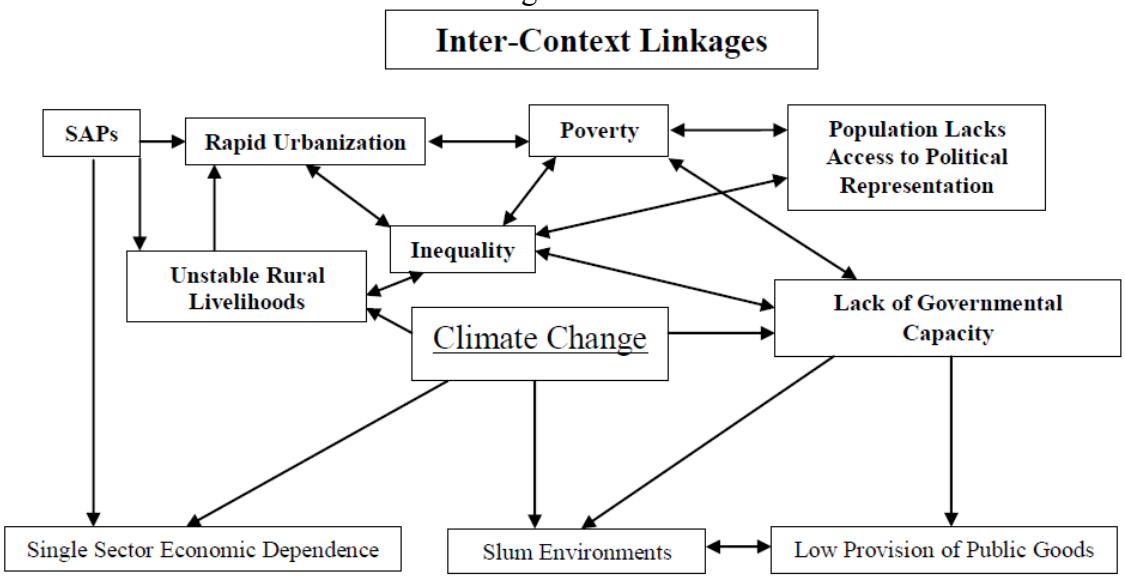
[126] S. Hickey and G. Mohan, "Relocating participation within a radical politics of development." *Development and Change* 36, no 2 (2005): 240-260.
[127] Tanner et al., 5-9.
[128] Adger, 65-67.
[129] Handmer, 65-68.

Figure 3.5



Underlying Drivers of Vulnerability in Bold

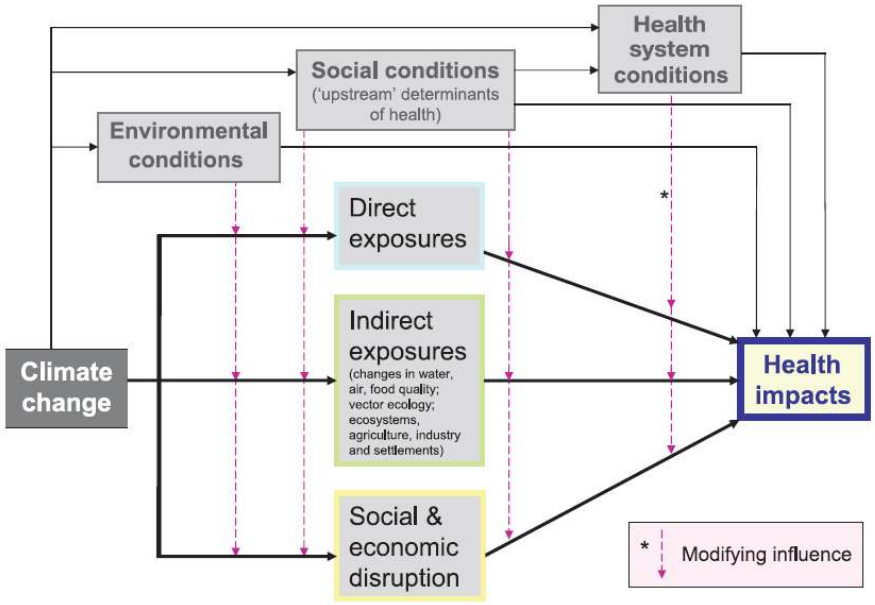
Figure 3.6



Underlying Drivers of Vulnerability in Bold

Chapter 4: Climate Change Vulnerability and Human Health

Figure 4.1



Source: IPCC, 2007

Climate change is, and will continue to, affect human health through multiple direct and indirect pathways that intersect with the existing vulnerabilities laid out in the preceding framework[130]. Examples of direct impacts include increased extreme weather events such as heat waves and flooding, while indirect impacts include changes in habitat conditions for vector and waterborne diseases (malaria & dengue), as well as long

[130] McMichael et al., 1-15.

malnutrition due to reductions in crop yields[131]. In the long run, the less direct pathways through which climate change affects human health may prove to be of a greater magnitude, as they interact with existing vulnerabilities, human activity and environments[132]. The problematic nature of indirect pathways is shown in Table 1 as malnutrition far outstrips other selected health impacts of climate change.

Table 4.1: Estimates for the impact of climate change in 2000 in thousands of DALYs

	Malnutrition	Diarrhoea	Malaria	Floods	Total	Total DALYs/ million population
African region	616	414	860	4	**1894**	**3071.5**
Eastern Mediterranean region	313	291	112	52	**768**	**1586.5**
Latin American and Caribbean region	0	17	3	72	**92**	**188.5**
South-East Asian region	1918	640	0	14	**2572**	**1703.5**
Western Pacific region[a]	0	89	43	37	**169**	**111.4**
Developed countries[b]	0	0	0	8	**8**	**8.9**
World	2847	1460	1018	192	**5517**	**920.3**

[a] without developed countries.
[b] and Cuba.

Source: WHO, 2003

In order to adequately adapt, a nuanced understanding of the causes and effects of climate change vulnerability including existing vulnerabilities of the poor, need to be taken into account[133]. The vulnerability of the poor is particularly important in the case of infectious disease and malnutrition that feed off of these vulnerabilities, as well as each other, to exact heavy tolls on the health of poor populations. Diarrheal disease, in particular, is a leading cause of death in children under-five, and is expected to increase

[131] A. Haines and R. Kovats, et al., "Climate change and human health: impacts, vulnerability, and mitigation." *Lancet* 367, (2006): 2101-2107.
[132] McMichael et al., 11.
[133] Wilbanks et al., 378-383.

as global temperatures rise. While many other diseases produce significant burdens, the following analysis will demonstrate the significant challenges posed by climate change in relation to diarrheal disease and its linkage to malnutrition.

Diarrheal Disease and Malnutrition Background

Fecal contamination of human environments is the most important environmental health issue in the world, responsible for the death of approximately 3 million children per year[134]. Diarrheal disease, which results from this contamination, is a symptom of infection caused by a host of bacterial, viral and parasitic organisms, most of which can be spread by contaminated water. It spreads from person to person, or to food, through individuals who do not properly wash their hands after contact with fecal matter.[135]. Some of the main causes of diarrheal disease include a shortage of water and unclean conditions that spread germs, cause diarrhea, and exacerbate poor nutrition[136].

The resulting disease burden attributable to diarrhea is 1.81 million deaths or 6.9% of all deaths worldwide, making it the 3rd leading cause of death for low income countries[137]. From one month to five years of age, diarrhea is the second leading cause of death worldwide, accounting for 18% of all mortality[138]. Most children that die from diarrhea do so as a result of dehydration[139]. Dehydration results from large losses of

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[134] A. Hussain and S. Ali, et al., "Determinants of mortality among children in the urban slums of Dhaka city, Bangladesh." *Tropical Medicine & International Health* 4, no 11 (1999): 6.
[135] Cairncross, S. and V. Valdamanis. "Water Sanitation & Hygiene: Simple, Effective Solutions Save Lives." *Disease Control Priorities Project*. 2007. www.dcp2.org.
[136] D. Werner, and C. Thuman, et al., *Where there is no doctor: a village health care handbook for Africa* (London: Macmillan, 1993), 153-161.
[137] Water Sanitation and Hygiene Fact Sheet, WHO 2004, 1-2
[138] Bryce, J., and C. Boschi-Pinto, et al. "WHO estimates the causes of death in children." *The Lancet* 365, (2005): 1150.
[139] Werner et al., 153-161.

liquid that develops more quickly in and is most dangerous to small children[140]. While dehydration can easily be cured in most developed countries, simple and relatively cheap treatments such as oral rehydration therapy are lacking in many resource poor settings. The result is millions of needless deaths that can easily be prevented with simple, cost effective methods.

To make matters worse, malnutrition synergistically interacts with diarrheal disease to further aggravate morbidity and mortality. It contributes to more than one third of all child deaths, as 20 million children under the age of five are severely malnourished[141]. Malnourishment leaves them more susceptible to both illness and death, resulting in the deaths of nearly 10 million children under the age of five each year[142]. It is also linked to diarrhea as it is more common and dangerous in malnourished individuals[143]. Repeated or persistent diarrhea also takes a heavy toll on an individual's nutrition as the individual has a tougher time absorbing and utilizing micronutrients[144]. Malnutrition, therefore, simultaneously heightens susceptibility to infectious diarrhea, resulting in a "vicious cycle" that is perpetuated amongst children in developing countries[145]. In the presence of grinding poverty around two-thirds of these deaths, that could be prevented through low-cost interventions such as oral rehydration therapy, access to adequate water supplies and proper nutrition, continue to occur[146].

[140] Werner et al., 153-161.
[141] *World Health Organization,* www.who.int.
[142] www.who.int.
[143] Werner et al., 153-161.
[144] Werner et al., 153-161.
[145] Werner et al., 153-161.
[146] www.who.int.

Unfortunately, as with diarrheal disease, nearly all the burden of disease associated with malnutrition is borne by the under-five age group in developing countries[147].

This intolerable burden is in danger of increasing. In relation to climate change the vulnerability associated with diarrheal disease may be aggravated by several impacts that follow both direct and indirect pathways. These pathways interact with human social, political, and economic systems increasing vulnerability for populations around the world. The following analysis assesses the increased threats to human health and wellbeing this disease poses due to climate change. Ultimately, this analysis will help yield policies that adequately address the issues that undergird vulnerability to diarrheal disease and climate change.

Local Environmental Context

Environmental factors heavily impact the incidence and prevalence of diarrheal disease which is why it is particularly vulnerable to climatic change. They contribute to around 94% of the 4 billion cases of diarrhea that are estimated to occur every year[148]. Many of the conditions that produce higher than average rates of diarrheal disease are seasonal in nature and peak in warmer months[149]. Research shows that organisms, many of which are endemic to developing regions, are highly sensitive to variations in both temperature and precipitation[150]. Studies have shown that for every one degree change

[147] Campbell-Lendrum et al., 2.
[148] Fricas & Martz, 1-5.
[149] Fricas & Martz, 1-5.
[150] McMichael et al., 18-39.

Celsius in air temperature, the incidence of diarrhea can rise by as much as 8%[151]. It is important to note that the effects of increasing temperatures were more marked in winter months that were typically cool, leading to as high as 12% increases in diarrheal disease for every one degree change[152]. These climatic linkages portend the possibility of dramatic seasonal rises in diarrhea as winters become milder and average temperatures continue to increase.

Increased water temperatures also provide ideal conditions for cholera epidemics which cause significant morbidity and mortality in developing countries[153]. In terms of geographical location, the vulnerability of coastal populations in the developing world that are exposed to zooplankton which is a reservoir of the cholera-causing organism, Vibrio cholera is increased. Zooplankton feeds upon phytoplankton, which tends to increase as ocean temperatures rise[154]. This indirect pathway nonetheless causes cholera epidemics that continually ravage the developing world.

Additionally, metabolic rates for other organisms that cause diarrheal disease are linked to average temperatures, meaning as temperatures rise, growth rates of many organisms will likely also rise[155]. Higher temperatures also increase exposure to bacterial and parasitic diarrhea, and lengthen survival of bacteria such as E. coli in contaminated food[156]. Higher temperatures that contaminate food supplies will likely interact with reductions in water supplies due to climatic change that lead to reductions in hygienic

[151]W. Checkley, and L. Epstein, et al., "Effects of EI Niño and ambient temperature on hospital admissions for diarrhoeal diseases in Peruvian children," *The Lancet* 355, no 9202 (2000): 442.
[152] Checkley et al., 445-448.
153 Fricas & Martz, 1-5.
154 McMichael et al., 49.
155 McMichael et al., 107.
156 Checkley et al., 445-448.

food practices[157]. This will further augment the prevalence of the organisms that cause diarrhea in many areas of the world.

Reductions in water supplies are also linked to the seasonality of diarrheal disease, as its prevalence is linked to precipitation. Seasonal alterations in water supplies caused by climate change will be heightened in urban areas that are prone to both flooding and drought. This will greatly compromise hand washing in domestic users that already receive the smallest allocation of water resources[158] and therefore increase diarrheal rates in dry seasons[159]. In addition to reductions in supply, flooding caused by either sea level rise or heavy rainfall events can lead to contaminated water supplies as sewage networks overflow and cause fecal contamination[160]. Some of the major causes of diarrhea linked to contaminated water supplies - Cholera, Cryptosporidium, E.coli, Giardia, and Shigella - have been associated with heavy rainfall events in many countries[161].

It is important to remember that, though these local environmental factors may exogenously drive vulnerability to diarrheal disease by creating conditions for these organisms to thrive, as with all climate change impacts, these factors are still heavily mediated by macroeconomic, socio-economic, and institutional factors. As the vulnerability framework described, the availability of water has been reduced by development of various kinds inducing high levels of water scarcity in many areas. This activity ultimately affects human health, as adequate amounts of water are needed for

157 Campbell-Lendrum et al., 12-14.
158 Postel, 99-146.
159 Campbell-Lendrum et al., 12-14.
160 R. Singh and S. Hales, et al., "The influence of climate variation and change on diarrheal disease in the Pacific Islands," *Environmental Health Perspectives* 109, no 2 (2001): 156-158.
161 McMichael et al., 111.

drinking, cooking, and hygiene. In relation to diarrheal disease, water supplies are of paramount importance[162].

Table 4.2: Relative Risk of Climate Change-attributable Diarrheal Disease in 2030

Region	Relative risks	
	Unmitigated emissions	S550
African region	(0.99–1.16)	(0.99–1.11)
Eastern Mediterranean region	(0.98–1.16)	(0.98–1.11)
Latin American and Caribbean region	(0.92–1.08)	(0.95–1.05)
South-East Asian region	(0.99–1.17)	(0.99–1.12)
Western Pacific region[a]	(0.92–1.09)	(0.95–1.06)
Developed countries[b]	(0.94–1.06)	(0.93–1.08)

[a] without developed countries.
[b] and Cuba.

Source: WHO, 2003

Macroeconomic Context

In macroeconomic terms, vulnerability to diarrheal disease follows a more complex pathway than local environmental factors, such as temperature and precipitation changes. However, the implications for macroeconomic instability are no less severe. Climate change is likely to impact diarrheal disease through its linkages to single sector economic dependence, reduced agricultural yields and hence malnutrition. The causal linkages in this chain are far from concrete, as many intervening factors can positively or

162 Campbell-Lendrum et al., 12-14.

negatively affect the outcome of malnutrition. Regardless of these uncertainties, malnutrition will increase with reductions in agricultural production[163].

According to the Stern report, declining crop yields could leave hundreds of millions. Increases in malnutrition, which accounts for an estimated 15% of total DALYs[164], creates the potential for drastic increases in vulnerability to diarrheal disease. However, the reduction in yields likely to occur due to temperature rise, combined with recent macroeconomic developments described in the initial framework, will likely exaggerate the effects of artificial famines, thus increasing overall levels of malnutrition. This situation will affect subsistence farmers in rural areas as well as the urban poor who will be unable to afford food at increased prices.

As malnutrition increases due to reductions in agricultural yields, these same reductions may reduce macroeconomic stability as well as a country's ability to provide public health services to the millions more that face increases in malnutrition and diarrheal disease. For a 2 degree warming scenario estimates for the increased costs associated with diarrheal disease and malnutrition range anywhere from $3.333-10.689 million[165]. The associated decline in global economic output for a 2 degree change has already been stated as 0-3%[166]. In terms of macroeconomic stability, reductions in export revenue due to reductions in crop yields will help feed a cycle of diminishing health quality in many developing countries.

[163] McMichael et al., 145.
[164] McMichael et al., 145.
[165] Ebi, 3-6.
[166] Stern Review: Summary for Policyakers, 2006, 9.

In addition to macroeconomic instability, the potentially negative effects on income for the urban poor in nations that are heavily reliant on single economic sectors reliant on climatic factors will be aggravated by reductions in aggregate demand for labor, due to the resulting macroeconomic downturn. Reductions in economic opportunity will lead to lowered household incomes and a further inability to purchase health care or adequate amounts of food, resulting in significant levels of food poverty and malnutrition that will aggravate vulnerability to diarrheal disease[167]. As governments have already been forced to reduce spending on these vitally important programs due to SAP budget constraints, further reductions in household income will be extremely harmful.

Table 4.3: Relative Risk of Climate Change-attributable Malnutrition in 2030

Region	Relative risks	
	Unmitigated emissions	S550
African region	(1.00–1.05)	(1.00–1.00)
Eastern Mediterranean region	(1.00–1.12)	(1.00–1.06)
Latin American and Caribbean region	(1.00–1.00)	(1.00–1.10)
South-East Asian region	(1.00–1.27)	(1.00–1.22)
Western Pacific region[a]	(1.00–1.00)	(1.00–1.02)
Developed countries[b]	(1.00–1.00)	(1.00–1.00)

[a] without developed countries.
[b] and Cuba.

Source: WHO, 2003

[167] McMichael et al., 145.

Socio-economic Context

The stress macroeconomic instability will place on national, as well as on household level income, will overwhelmingly affect the poor. Research shows that in the developing world, poor populations already shoulder the majority of the burden of infectious disease; the same is true for diarrheal disease[168]. To put the disease burden in perspective, it is not present in the top ten killers of either middle or high income populations and yet still constitutes 3.7% of global deaths[169]. Without causing significant mortality in middle or high income countries diarrhea is still the 5th most lethal killer worldwide[170]. The vulnerability due to poverty alone is staggering and is a significant driver of vulnerability in the socio-economic context.

Poverty can lead to a myriad of problems that exacerbate vulnerability to diarrheal disease and climate change in urban settings. These problems largely stem from conditions that create an environment that breeds infectious disease. Poverty feeds this environment by increasing migration, lowering nutrition levels, increasing population densities, and reducing a population's access to water and sanitation infrastructure[171]. In addition to a lack of basic public goods, slum are often located in areas prone to flooding events that increase levels of diarrheal disease, and are expected to increase with climate change.

In many countries becoming sick can be a death sentence as monetary resources are simply not available for medical care. This situation is far worse in highly unequal

[168] P. Heuveline and M. Guillot, et al., "The uneven tides of the health transition," *Social Science & Medicine* 55, (2002): 318-320.
[169] www.who.int.
[170] www.who.int.
[171] McMichael et al., 48.

societies as the poor are already vulnerable to climatic factors that influence diarrheal disease due to the lack of public resources they receive. This results in exactly the conditions that benefit the spread of diarrheal disease, namely a lack of water and sanitation infrastructure as well as a lack of general education concerning hygiene. This is particularly important for diarrheal disease as around 88% of diarrheal disease is attributed to unsafe water supply, inadequate sanitation and hygiene[172].

It has been demonstrated that increasing inequality within a population heightens collective vulnerability, and is associated with a reduction in the provision of public goods[173]. This is due to fact that wealthy segments of society rarely make decisions that benefit society as a whole[174]. Ironically, the vulnerability of the poor to infectious disease may jeopardize the well-being of more economically advantaged members of society through spillover effects and the opportunity cost of public services committed to dealing with problems related to the disadvantage[175]. Regardless of this fact, it has been shown that the privileged in society have rarely acknowledged these potential spillover effects, let alone enacted policies to improve the health of the poor even out of self motivation, which has left the poor far more vulnerable to diarrheal disease.

Inequality also lays the groundwork for climate induced migration by creating unstable rural livelihoods. Rural to urban migration will likely lead to an increased prevalence of diarrheal disease as high population densities aggravate the fact that human

[172] Water Sanitation and Hygiene Fact Sheet, 1-2.
[173] P. Kelly and Neil Adger, "Theory and Practice in Assessing Vulnerability to Climate Change And Facilitating Adaptation," *Climatic Change* 47, no 4 (2000): 330.
[174] Todaro, 209-273.
[175] McMichael et al., 14.

migrations have been a main driver of epidemics throughout history[176]. In addition to increasing disease prevalence, these migrants will likely further reduce marginal employment opportunities as the labor pool grows in the absence of changes in demand. This will increase large scale inequalities in income distribution, ultimately reducing the ability of the poor to pay for their own wellbeing.

Ultimately, this situation disproportionately affects specific demographic groups, namely children. Currently, a child born in the developing world is 13 times as likely to die within the first five years of life compared to a child in the industrialized world[177]. Climate change will dramatically aggravate this situation as most current research points to the fact that the additional burden of disease associated with climate change will be borne by children in developing countries[178].

Institutional Context

In an ideal world, government and civil society institutions would act to reduce this vulnerability; however, high levels of inequality and a lack of human capital have been shown to actually drive it. In reference to diarrheal disease and climate change, public goods have been shown to be essential for decreasing vulnerability. As Dr Lee Jong-Wook former director general of the WHO put it, "Water and Sanitation is one of the primary drivers of public health. I often refer to it as 'Health 101', which means that once we can secure access to clean water and to adequate sanitation facilities for all

[176] R. Colwell, "Global climate and infectious disease: the cholera paradigm," *Science* 274, (1996): 2025–31.2028.
[177] Campbell-Lendrum et al., 16-18.
[178] Haines A., et al., 2107

people, irrespective of the difference in their living conditions, a huge battle against all kinds of diseases will be won."[179]

In fact an improved water supply reduces morbidity by anywhere from 6%-25%, while improved sanitation reduces it by as much as 32%[180]. In addition to these infrastructural factors, hygiene and disease education is also vital to prevent transmission and infection. Hygiene interventions, including hygiene education and promotion of hand washing can lead to a 45% reduction in incidence rates[181]. Combined with proper nutrition, these factors could prevent the majority of diarrheal disease[182]. Unfortunately, many in the developed world lack these basic measures thereby greatly increasing their vulnerability to diarrheal disease.

Despite the ability of these public goods to greatly reduce morbidity and mortality, as of 2002 17 % of the global population, or 1.1 billion people, lacked access to improved water sources[183]. Of the 1.1 billion without improved water sources, nearly two thirds lived in Asia[184]. In addition, 42% or 2.6 billion people, lacked access to improved sanitation[185]. The result is that in some of the most heavily affected areas, namely Southeast Asia (8.5%) and Africa (7.7%), diarrheal disease is responsible for a considerable percentage of overall mortality[186]. In urban settings, fecal contamination in sewage, septic tanks and latrines is a particular problem for the poor[187]. In the absence of

[179] Water Sanitation and Hygiene Fact Sheet, 1-2.
[180] Water Sanitation and Hygiene Fact Sheet, 1-2.
[181] Water Sanitation and Hygiene Fact Sheet, 1-2.
[182] Werner et al., 153-161.
[183] Water Sanitation and Hygiene Fact Sheet, 1-2.
[184] Water Sanitation and Hygiene Fact Sheet, 1-2.
[185] Water Sanitation and Hygiene Fact Sheet, 1-2.
[186] Water Sanitation and Hygiene Fact Sheet, 1-2.
[187] Cairncross & Valdamanis, 1-4.

proper sanitation and water treatment facilities, the use of personal hygiene measures is vital for disease prevention[188]. However, these same populations also lack education and health services, further rendering them vulnerable to diarrheal disease.

Climate change will increase this vulnerability by damaging the physical infrastructure of the water delivery and sanitation systems that do exist in the developing world. This will occur through the erosion of pipelines as a result of heavy rainfall and flooding events[189]. Sewer outfalls, which usually empty into rivers or the sea, as well as sewage treatment works, are also at risk of damage during floods[190]. The effects on sewage systems is of vital importance as they are the main determinant of the contamination of urban flood water with fecal material, which presents a substantial threat of enteric disease[191]. This will tax the resources of institutions already struggling to provide these vital services to their populations, as they are forced to pay for repairs and the "climate proofing" of existing infrastructure.

Despite the billions who lack access to these essential services, in all regions of the world, except notably sub-Saharan Africa, most countries have made significant strides towards meeting their MDG of reducing under-five child mortality. However, efforts towards increasing access to water and sanitation have been slow, which is of particular concern in relation to climate change. Much of the failure to rapidly extend these services to all citizens stems from institutional rigidity and a lack of resources. As the effects on sanitation networks show, increased funding requirements will be

[188] Cairncross & Valdamanis, 1-4.
[189] Campbell-Lendrum et al., 6-14.
[190] Hussain et al., 5.
[191] Corvalan, C., "Climate change and human health: risks and responses," (*World Health Organization,* 2003) 14.

mandatory for climate proofing existing infrastructure as well as creating new water and sanitation infrastructure to avoid increased deaths due to diarrheal disease. At present rates it is highly doubtful that many of the poorer nations in the world will be able to secure funding to do so. Coupled with the pervasive macroeconomic effects in reduction of export earnings, existing funding sources are likely to greatly diminish.

Unfortunately, NGOs are unlikely to step in and provide these services as water and sanitation infrastructure can be very expensive. Many NGOs do provide water purification methods, dig wells, and provide latrines of various forms; however, much of this activity is in a piecemeal fashion that does not currently take into account the many effects associated with climate change that are likely to occur. For example, NGOs in many countries are primarily located in rural areas despite the global trends towards urbanization. While some of this activity is meant to strengthen rural livelihoods and stem the tide of urban migrants, much of it simply reflects the whims of distant donors who are not attuned to many of the serious causes and consequences of vulnerability in the developing world. The lack of planning and coherence is not the fault of civil society, as it is simply a collection of actors that lack a single unifying body. What this signals is the vital importance of governments in the institutional context for achieving vulnerability reduction at the needed scale. Ultimately, governments will need to be able to perform a variety of functions in addition to increasing monetary resources. These include increasing human capital, national stability, and institutional flexibility.

A final note for the institutional context is that many of the successes in control of infectious diseases, such as smallpox and polio, have been due to global commitment[192]. The likely reduction in national resources and increased burden due to climate change will create a certain level of dependency for many developing nations on resources coming from neighboring countries or the international community. Again, institutional flexibility and human capital will prove vital in order to secure outside aid through treaty negotiations or other means as the scope of these problems will be much larger than the domestic resources of individual nations.

[192] McMichael et al., 122.

Chapter 5: Bangladesh

The case study chosen for this paper is Bangladesh as it has been one of the first countries to initiate the NAPA process and move forward with adaptation at a national level. It also suffers from a high incidence of diarrheal disease in the under-five population, which results from a variety of factors related to the vulnerability framework. The country's vulnerability is driven by a confluence of climatic impacts related to the local environmental context including seasonal distribution of water supplies, flooding, sea level rise and extreme weather activity. However, its vulnerability is increased by macroeconomic, socio-economic, and institutional factors that magnify the vulnerabilities created by its local environment.

The climate change scenario utilized for this paper corresponds to the lower bound of the IPCC scenarios where carbon dioxide emissions are stabilized between 550-600ppm, with global temperature increases of 2 degrees Celsius and sea level rise of .3 meters[193]. Migration for this scenario has also been estimated at between 5-10% along existing routes[194]. This scenario roughly corresponds to the most optimistic IPCC scenario, B1. It follows a story line that allows for a rapid change towards a service and information economy that reduces material intensity and introduces clean and efficient technologies on a large scale. These innovations allow for sweeping changes that are

[193] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis,* 7.
[194] Brown, 28.

highly unlikely in light of the limited progress made in both international treaty negotiations, and the decrease in either material intensity or emissions in the global economy[195]. Despite its highly improbable nature, this scenario was chosen because it serves to highlight that even at the very low end of climate change impacts, traditional public health sector responses are inadequate as an adaptation response to climate change. Therefore holistic adaptation policies that recognize and assess these impacts according to the vulnerability framework are needed in order to adequately respond to heightened levels of vulnerability.

Diarrheal Disease Burden and Malnutrition Complications for Under-five Mortality

Bangladesh faces many difficult challenges in achieving positive developmental outcomes, which will be clearly laid out in the following sections. In spite of the many challenges the country faces, it has made laudable progress in reducing under-five mortality (a 54%[196] reduction as of 2005), which has placed it well on the way towards achieving its MDG reduction of 66%[197]. Unfortunately, the country still suffers from an under-five mortality rate of 77 per 1,000 live births, placing it above the South Asian regional mortality rate of 66[198]. Diarrheal disease accounts for nearly 20% of this mortality in Bangladesh, ranking second only to neonatal causes[199]. In comparison to

[195] Prins & Rayner, 1-7.
[196] "Millennium Development Goals Report." *United Nations*, 2008, www.un.org. 42-45.
[197] *United Nations Millenium Development Goals,* http://www.un.org/millenniumgoals.
[198] Millennium Development Goals Report, 42-45.
[199] "Bangladesh mortality profile" *World Health Organization*, www.who.int, 2009.

other South Asian countries, it has the fifth highest percentage of under-five mortality due to diarrheal disease, though it is only 1.9% greater than the regional high[200].

In addition to this large burden, complications posed by malnutrition are immense. Malnutrition is a societal problem that afflicts over 40% of the population, who consume less than the absolute minimum caloric intake per day[201]. It accounts for over half of under-five mortality and significantly increases morbidity and mortality due to diarrheal disease. As of 2005, Bangladesh had reduced the percentage of underweight children to 51% from a baseline of 67%, as well as the percentage of severely underweight children to 13% from 25%[202]. Despite this success, the proportion of underweight children is still 16% higher than the majority of Asian nations at similar levels of economic development[203]. Child malnutrition is pervasive and particularly pronounced amongst the poor; more than 60% of children suffering from stunting belong to the poorest levels of society[204]. The existing burden of diarrheal disease and the complications posed by widespread malnutrition are already being affected by climate change as the global disease burden of climate-change attributable diarrheal disease and malnutrition are the largest in Bangladesh[205]. The situation the country faces undoubtedly warrants a focus on adaptation policies in order to avoid serious setbacks in the progress it has made.

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[200] "WHOSYS", *World Health Organization,* www.who.int/whosys, 2008.
[201] "Bangladesh: State of the Environment Report," *(United Nations Environmental Program*, 2001) 20.
[202] Bangladesh State of the Environment, 20.
[203] Bangladesh State of the Environment, 20.
[204] Bangladesh State of the Environment, 20.
[205] "Climate Change and Bangladesh," (*Climate Change Cell, Department of Environment, Government of the People's Republic of Bangladesh*, 2007), 10.

South Asia Regional Context

It is useful to begin by briefly describing the regional setting in which Bangladesh finds itself in relation to the vulnerability drivers and climate change. As the linkages between the vulnerability framework, climate change, and diarrheal disease have been elucidated, this section will describe the most prominently related trends that are occurring in South Asia. The most relevant regional aspects that are driving existing vulnerability are population growth, urbanization, land use changes, and reductions in fresh water supply. The linkages between these existing vulnerabilities and the exposure to climate change impacts have been shown to increase vulnerability to diarrheal disease which is likely to be a significant challenge for the region.

As of 2002, the total reported population in Asia was 3.9 billion[206]. A year prior, the Asia/Pacific region reported the largest percentage, 24.7%, of the world's urban population[207]. While many attribute increased populations to the astronomical growth rates of large urban centers in China, much of the soaring rates of urbanization can be attributed to other countries in the South Asia region including Nepal, Bangladesh, Bhutan and Pakistan, all of which displayed urban growth rates higher than China's between 1970 and 1995[208].

The region is one of the most densely populated in the world, with much of the population density found in urban areas. The current rural to urban population ratio is 3:1[209]. This population density is striking considering that more than 1/5th of the world's

[206] Cruz et al., 472.
[207] *United Nations Habitat,* http://www.unhabitat.org.
[208] *United Nations Food and Agricultural Organization,* http://www.fao.org.
[209] Mirza et al., 1-8.

inhabitants are crammed into only 3.3% of the earth's land[210]. The enormous levels of population growth and urbanization are demonstrated by the fact that the South Asian sub-region contains seven of the world's 10 most populous countries - China, India, Pakistan, and Bangladesh - as well as 5 of the world's 20 megacities[211]. Despite the burden that these large populations place upon both natural and fiscal resources, population growth in Asia will continue to rapidly grow in coming decades. The majority of the region's population growth is forecasted to come from South Asia where 570 million people will be added in India, 200 million in Pakistan and 130 million in Bangladesh over the next 50 years[212].

While urbanization has grown in tandem with rising populations, rural to urban migration has helped to fuel much of this rapid growth due to a variety of push, as well as pull, factors. Currently, 64% of urban growth is created by migration[213]. These population movements are linked to pressure on natural resources and the environment arising from agricultural and industrial development that weaken the opportunity for sustainable rural livelihoods[214]. Much of this development pressure comes from burgeoning urban populations that stimulate demands for goods and services[215]. This situation has created a self-reinforcing cycle, as demand for goods and resources from urban centers drives pressures on natural resources that undermine rural livelihoods, thus inducing migration that further grows urban populations and stimulates demand.

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[210] A. Jaitly, "South Asian Perspectives on Climate Change and Water Policy," In *Troubled Waters Climate Change, Hydropolitics and Transboundary Resources*, edited by David Michel, and Amit Pandya, (Washington DC: Henry L. Stimson Center, 2009), 17.
[211] Mirza et al., 1-8.
[212] Cruz et al., 472.
[213] Cruz et al., 472.
[214] Mirza et al., 2-8.
[215] Cruz et al., 473.

This vulnerability is complicated by a regional trend towards reductions in fresh water supply that is needed to combat the spread of diarrheal disease. Existing levels of demand placed upon water resources have decreased water availability per capita by almost 70% since 1950, placing the region in serious danger of physical or economic scarcity of this precious resource by 2025[216]. India, Pakistan, Nepal and Bangladesh have all experienced water shortages that are linked to rapid urbanization, population growth and inefficient water use[217]. The resulting precipitous decline in freshwater resources is shown by the fact that per capita water availability in South Asia has fallen from 21,000 cubic meters in 1960, to 8,000 in 2005[218]. Water stress is defined as less than 1,700 annual cubic meters of fresh water per capita, while water scarcity is experienced below 1,000 cubic meters[219]. The reductions experienced throughout the region place them on a treacherous path towards these levels. In fact, a decrease in freshwater availability throughout Asia, along with population growth and rising standards of living, will significantly affect the livelihoods of up to 1.2 billion people who will be exposed to water stress in coming years[220].

The combination of domestic, industrial, and agricultural demand due to population growth, urbanization and economic development are the driving forces behind increasing levels of water stress in South Asia. Agriculture is the largest culprit as it places the highest level of demand on water resources and is the single largest contributor

[216] Jaitly, 22.
[217] Cruz et al., 471.
[218] Jaitly, 20-21.
[219] Jaitly, 22.
[220] Cruz et al., 472.

to South Asian economies[221]. Weak governmental institutions responsible for regulating water supplies have provided industrial and agricultural users free range to exploit water resources as they see fit. The most important regional impacts related to climate change and freshwater availability, are therefore inextricably linked to the forces of land use intensification for agriculture, industrialization and urbanization[222]. The linkages between these various forces tend to feed each other and further increase vulnerability. For example, increasing demand for food and soaring levels of economic development will reduce the amount of adequate arable land for agriculture needed to sustain rural livelihoods as well as feed ever expanding urban populations[223].

Additional stresses to water supplies created by climate change will arise as a result of seasonal changes in rainfall and glacier melt. Rainfall is already seasonal in nature, as it is primarily driven by the Southwest summer, and Northeast winter, monsoons[224]. Climate change has been shown to increasingly allocate water towards the wetter months, rendering the drier months even more drought prone. Water availability is already drastically reduced during the dry season which accounts for only 10-30% of rainfall[225]. In addition, nearly 80% of the dry season flow of the Indus, Ganges and Brahmaputra Rivers, which comes from Himalayan glaciers located on the Tibetan Plateau, has receded in recent decades[226]. Alterations in dry season water supply as rainfall and glacier melt decreases, combined with surges in water demand resulting from

[221] Mirza et al., 2-8.
[222] Cruz et al., 471.
[223] Cruz et al., 471.
[224] Mirza et al., 77-99.
[225] Mirza et al., 77-99.
[226] R. Watson, and M. Zinyowera, et al., "The Regional Impacts of Climate Change: An Assessment of Vulnerability," (*Intergovernmental Panel on Climate Change,* 1997) 14.

development activity, will have the greatest impact on the agricultural sector as it is the most sensitive sector, to climate change induced-impacts in the region[227].

Reductions in water supplies due to climate change will likely lower water availability in urban areas as agricultural users divert more and more of a dwindling resource. The result will be a diversion of scarce resources away from domestic purposes in favor of more economically productive uses such as agriculture. The situation is worsened by public utilities unable to deliver water services or collect payment for them in urban areas, resulting in low levels of investment in infrastructure and maintenance[228]. As the conditions that favor the spread and generation of diarrheal causing organisms increase due to climate change, reductions in water supplies will prove particularly harmful for communities that lack access to sanitation networks. This situation will likely have significant impacts on diarrheal disease, which taken in tandem with increases in malnutrition rates due to reductions in agricultural yield, will greatly increase the spread of diarrheal disease. The result is a dangerous combination for a region already suffering high rates of diarrheal disease, malnutrition and under-five mortality.

At the other end of the spectrum, the seasonal allocation of water during the rainy or wet months is likely to significantly increase; the region is already prone to large scale flooding that has risen greatly in recent years. Bangladesh, Nepal and the north-east states of India all experienced extreme rainfall events during 2002, 2003 and 2004 that resulted in unprecedented levels of flooding[229].

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[227] Cruz et al., 471.
[228] Jaitly, 18.
[229] Cruz et al., 476.

The effects of a skewed seasonal distribution of water are even worse for coastal communities. It will prove particularly damaging to heavily populated delta and mega delta regions in South, East, and South-East Asia that are at the greatest risk of sea and river flooding[230]. It will increase the flood risk from anywhere from 13 to 94 million people, with almost 60% of this increase spanning the coast from Pakistan to Burma[231].

One of the most significant repercussions in terms of salinization of water supplies caused by rising sea levels is back water effect (BWE). BWE refers to "the retardation of a river outflow by a rise in the level of water at the mouth of the river"[232]. This can cause a flow reversal as water moves back upstream from the mouth of a river emptying into the sea[233]. Saltwater from the Bay of Bengal is reported to have penetrated 100 km or more inland along tributary channels during the dry season[234]. This effect combined with declining river runoff will seriously affect fresh water supplies and hence diarrheal rates[235].

Unfortunately, these vulnerabilities intersect with patterns of human settlement that are drastically reducing mangrove forests in the region. The loss of these coastal ecosystems and the host of benefits they have for local communities will place around one million people along the coasts of South and South-East Asia at a heightened risk of flooding[236]. In addition to flooding risk, extreme weather events are endemic to South

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[230] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability,* 12.
[231] Cruz et al., 484.
[232] A. Ali, "Climate change impacts and adaptation assessment in Bangladesh," *Climate Research* 12, (1999): 114.
[233] Ali, 1999, 112.
[234] Cruz et al., 477.
[235] Cruz et al., 487.
[236] Cruz et al., 484.

Asia and are predicted to magnify in intensity in coming years. This is evidenced by cyclone activity originating from the Bay of Bengal and Arabian Sea, which is occurring less frequently but with higher intensity since 1970[237].

While all of these pathways will lead to increases in morbidity and mortality, the convergence of reductions in water supplies, increases in temperature and flooding, as well as extreme weather events that threaten sewage infrastructure create very strong risks of increasing burdens of diarrheal disease. In the case of sewage infrastructure, the potential risk posed by rising sea levels is aggravated by coastal development and reductions in wetlands that exacerbate a process of erosion that is endangering coastal water and sanitation infrastructure as shorelines retreat. This is compounded by the fact that climatic changes leading to conditions and habitats that are favorable to both vector and waterborne diseases have been highlighted as important problems for the region as the case of coastal water temperature leading to increases in the abundance and toxicity of cholera clearly demonstrates. This will lead to increases in vulnerability as the current global burden of climate-change attributable diarrhea and malnutrition are already the largest in the South and Southeast Asian countries of Bangladesh, Bhutan, India, Maldives, Myanmar and Nepal in 2000[238].

[237] Ali, 1999, 112.
[238] Ali, 1999, 112.

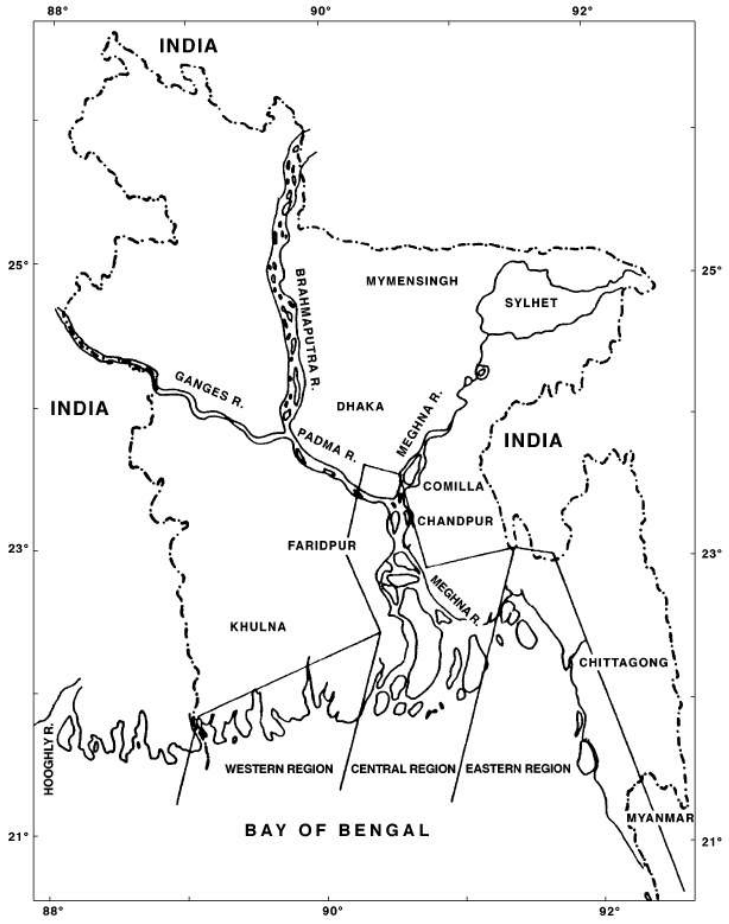
Bangladesh Local Environmental Context

While social, political, and economic factors all drive vulnerability to climate change, when analyzing Bangladesh it is difficult to ignore the paramount role the local environmental context plays in exogenously creating this vulnerability. Geographic, topographic, and local weather conditions all drive the unusually high vulnerability the country exhibits to both climate events and processes. This vulnerability is derived from the awe-inspiring wrath of nature's often violent fury, occurring at the nexus of two dynamic environments: a giant delta that contains the world's largest coastal mangrove forest, the Sundarbans; and the mighty Himalayan plateau. The result is a paradox of a simultaneously life-sustaining, and life-threatening, monsoon cycle that wreaks havoc on what is, for all intents and purposes, a densely populated floodplain ravaged by high cyclonic activity.

Despite more than half the country being located north of the Tropics, the climate is characterized by high temperatures and excessive humidity, creating a tropical climate throughout the year. The environment to the north of the country provides life sustaining water derived from seasonal glacial melt from the Himalayan plateau as well as the annual monsoons. This water is transported to the country via three major rivers: the Ganges, the Brahmaputra, and the Meghna (GBM). The majority of the flow of these tremendous rivers originates in foreign countries and finds an outlet to the sea in the Bay of Bengal. Much of the land along the riverbanks, including vast flood plains, is made up

of highly fertile alluvial soil, which is undergoing a constant process of erosion and accretion as the rivers ebb and flow with the seasons[239].

Figure 5.2



Source: Ali, 1999

[239] Bangladesh State of the Environment Report, 9.

The powerful swings of the monsoonal pendulum move the country from abundant rainfall and flooding, to water-scarce conditions and drought. Despite having an annual per capita endowment of fresh water amongst the top in the world, severe droughts have hit the country 11 times over the past half century, affecting nearly 50% of the country[240]. The regular occurrence of drought is often due to the failure of the seasonal monsoons, which is aggravated by wide seasonal variations in water runoff ratios between the dry and wet seasons as high as 1:6[241]. The situation is further exacerbated by the overuse of groundwater supplies that have increased as a percentage of land from nearly zero in 1960, to 70% as of 1999[242]. While this irrigation has been a large driver in achieving food security, the over-extraction of underground aquifers has dramatically decreased both the quantity and quality of fresh water supplies.

At the other end of pendulum, flooding annually affects about 20% of land; in extreme cases, like in 1987, 1988, and 1998, this figure is as high as 70%[243]. There are four distinct types of flooding that affect Bangladesh: flash floods, rain induced floods, monsoonal floods and coastal floods[244]. These flood events are aided by the topography of the country that is primarily a floodplain (80%), with altitudes ranging no more than 13 meters above sea level[245]. In fact 10% of the country is hardly one meter above sea

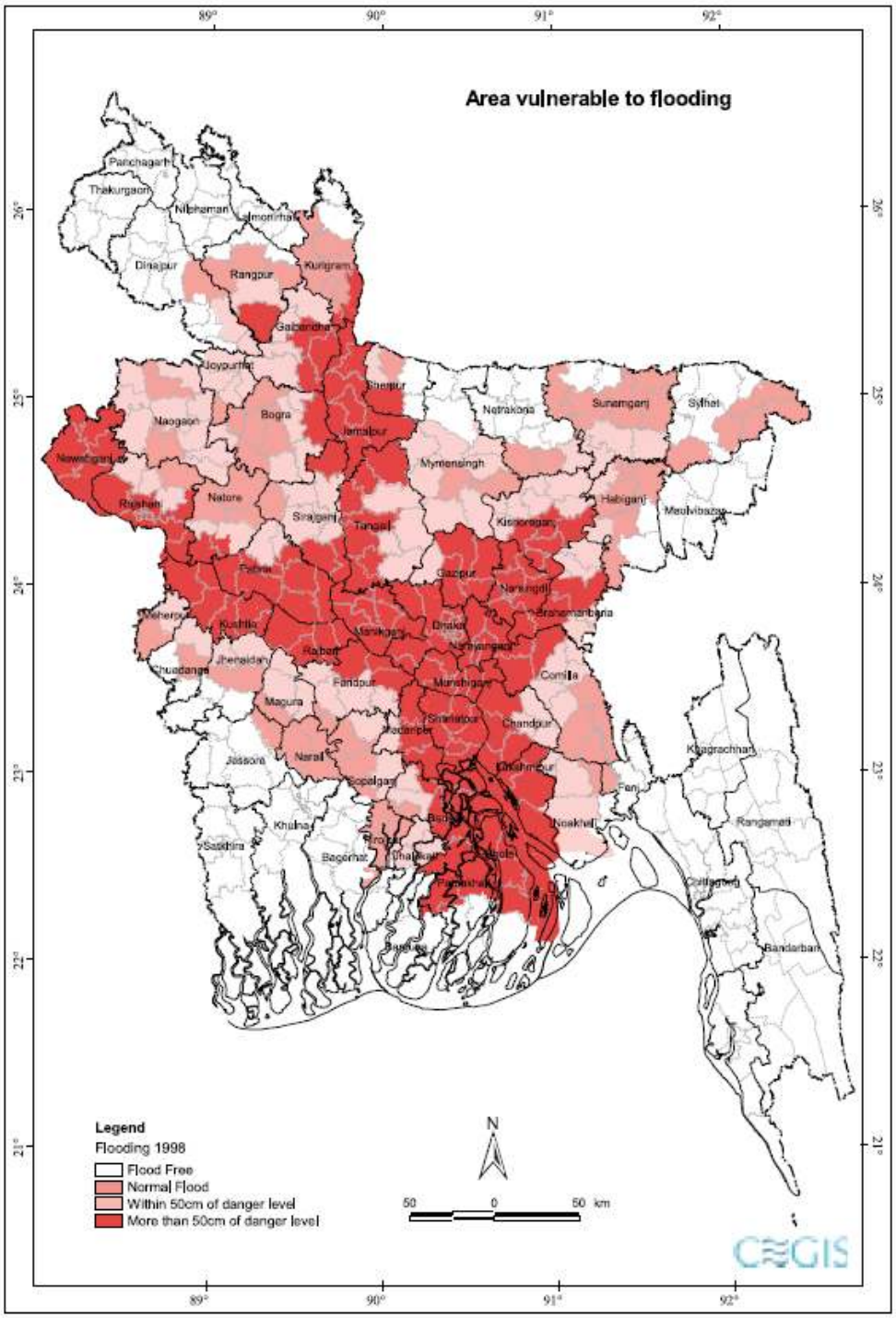
[240] Mirza et al., 231-252.
[241] Mirza et al., 231-252.
[242] Jaitly, 22.
[243] Mirza, 129.
[244] "National Adaptation Program of Action," (*Ministry of Environment and Forests Bangladesh*, 2005) http://unfccc.int. 1-3.
[245] Mirza et al., 231-252.

level while another one third continually faces tidal incursions[246]. As a result of these conditions the effects of all four forms of flood events are dramatically increased.

Of all flood events, monsoon floods that occur in the flood plains of the major rivers between June and September cause the most damage[247]. The floods of 1987, 1988 and 1998 were all monsoonal and due mainly to runoff from cross-border basin areas of the GBM system[248]. To give an idea of how devastating these floods were, the 1988 floods inundated 61% of the country, causing an estimated 2,000-6,500 deaths, $1.2 billion in damages and leaving more than 45 million homeless, while the 1998 floods caused an estimated 1,100 deaths, $2.8 billion in damage and left 30 million people homeless[249]. This destruction is a combination of a variety of factors, including snow and glacier melt, El-Nino induced conditions, a loss of drainage capacity due to the siltation of principal distributaries, backwater effect (BWE), unplanned urbanization, deforestation, and the synchronization of flood peaks of the major rivers[250].

[246] Ali, 1999, 113.
[247] Bangladesh NAPA, Ministry of Environment and Forests, 1-3.
[248] Mirza et al., 231-252.
[249] Bangladesh NAPA, Ministry of Environment and Forests, 6.
[250] Mirza et al., 231-252.

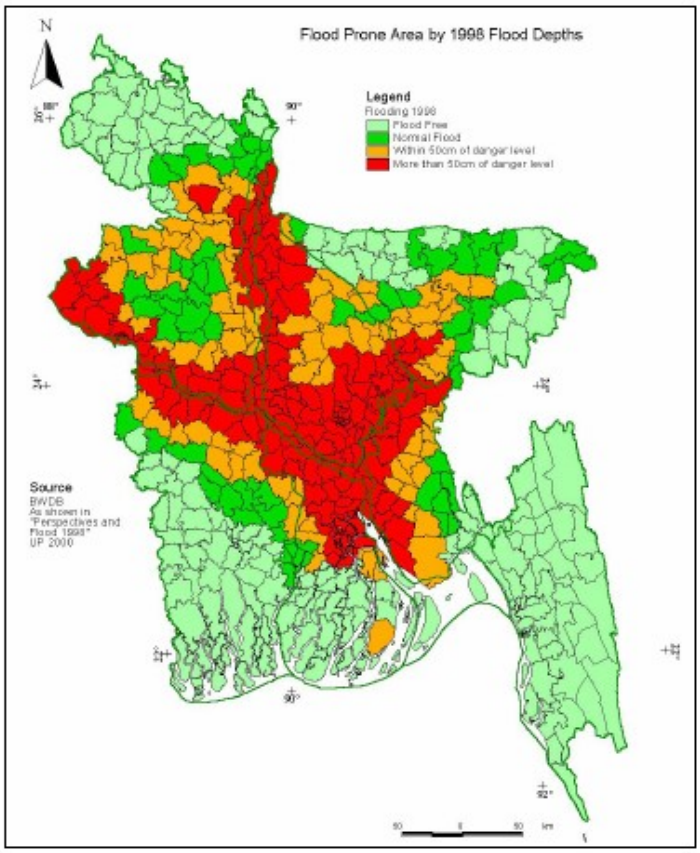
Figure 5.3



Source: CEGIS, Dhaka

Figure 5.4

Figure 3. Flood Prone Area by 1998 Flood Depth



Source: WARPO

While many of these factors are linked to environmental degradation, deforestation is the most apparent. It has resulted in a 50% reduction in forest cover during the last 20 years, adding to the environmental stress of flood events as topsoil is lost and land is eroded. Bangladesh has a classified natural forest area of about 10%, however only 6-8% of this is vegetative cover capable of mitigating flood events. Despite the efforts of afforestation programs, progress in reducing vulnerability has been

limited[251]. The major causes of deforestation are industrialization, rapid urbanization, and high population pressure on existing forestland, both for settlement and agriculture[252].

Another contributing factor to the damage caused by floods is BWE. BWE is created by the congruence of freshwater carried by the GBM river system, and the intrusion of seawater from the coast. The effect causes saline seawater to enter the mainland through the rivers, adversely affecting agriculture, sweet-water shrimp cultivation, and the availability of potable water for domestic use. BWE causes floodwater inside the country to accumulate, causing severe inundation and further aggravation of existing flood situations[253]. The effect is particularly pronounced in the Meghna River estuary, which accounts for 90% of the water that discharges into the Bay of Bengal[254]. It is important to note that BWE also affects drought situations during the dry season, when salinity penetrates further and deeper into the mainland, reducing freshwater supplies.

While the existing patterns of flooding and drought associated with the monsoonal cycle cause colossal damage to Bangladeshi society, alterations to this cycle that have been reported frequently in recent decades portend dire consequences. According to the Bangladesh Water Development Board, the severity of floods have become more frequent during the past 50 years, with at least 7 big floods affecting about 35-70% of the land area[255]. In addition, three out of five very high intensity floods of the

[251] Bangladesh State of the Environment Report, 17-18.
[252] Bangladesh State of the Environment Report, 17-18.
[253] Ali, 1999, 112.
[254] Ali, 1999, 112.
[255] S. Hossain, "Flood Forecasting and Warning Center Annual Report," (*Bangladesh Water Development Board*, 2007), 3.

past century have occurred during the past three decades[256]. As recently as 2004 and 2007 flooding occurred that was comparable, in terms of flow, to the 1998 and 1988 mega floods. The central and northeastern areas of the country are extremely vulnerable to these events and suffer greatly during the peak discharge of the Brahmaputra and Meghna rivers[257]. The vulnerability of these populations will be increasingly exacerbated as floodplain populations continue to increase[258].

While much of the rise in damage associated with flooding events is due to improvement increases in human settlement in flood-prone areas,[259] climatic change is undoubtedly playing a significant role. In Bangladesh, average temperature has registered an increasing trend of about 1°C in May and 0.5°C in November during the 14 year period from 1985 to 1998[260]. In addition to rising temperatures, the annual mean rainfall has increased with decadal rain anomalies above long term averages since the 1960s resulting in serious and recurring flooding events in 2002, 2003, and 2004. Glacial melt occurs at the same time as the summer monsoon, meaning that the intensification of seasonal monsoon rain events will cause large scale flooding placing the country at a heightened risk of flood disasters similar to those experienced in 1987, 1988, and 1998[261].

Climatic changes in Bangladesh will likely reflect the increasing intensity of existing environmental conditions that lead to severe weather events and seasonal water

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[256] Mirza et al., 231-252.
[257] Mirza et al., 231-252.
[258] Mirza et al., 231-252.
[259] Monirul Qader Mirza, and M., R. Warrick, et al., "Are floods getting worse in the Ganges, Brahmaputra and Meghna basins?" *Global Environmental Change B: Environmental Hazards* 3, no 2 (2001): 128.
[260] Climate Change and Bangladesh, 6.
[261] Huq, S. and Asaduzzaman, M. "Overview." In *Vulnerability and Adaptation to Climate Change for Bangladesh* edited by S. Huq, Z. Karim, M. Asaduzzaman and F. Mahtab, (Dordrecht Netherlands: Kluwer Academic Publishers, 1999), 1-10.

inequities. The major challenges the country will face in relation to diarrheal disease and malnutrition include: a scarcity of fresh water due to less rain and higher evapo-transpiration in the dry season as well as increasing salinization of surface water, flooding due to drainage congestion, heavy monsoon precipitation and rising sea levels, and prolonged and widespread drought[262]. These challenges will be dictated by the seasonal monsoon pattern. During the monsoon (wet) season, increased rainfall will lead to worsened drainage congestion, water logging and ultimately widespread flooding[263]. This will primarily be due to differences in timing of water flow. Increasingly, the country will see more of its annual flow during the wet season as glaciers melt faster. On the other hand, the dry season will experience a drastic reduction in trans-boundary surface water inflows[264].

A significant mediating factor in this seasonal water availability is the fact that neighboring countries control 92% of Bangladeshis' surface water arriving through the GBM system[265]. As Bangladesh is heavily reliant on surface water runoff from the Himalayan plateau, the country is vulnerable to water diversions by upstream neighbors. One of the most important of these is the Farakka Barrage, which has had a particularly devastating effect on South-Western Bangladesh as India has unilaterally diverted the river since 1975 to ensure water supplies for energy production and agriculture. These diversions affect around 35 million people who depend upon the Ganges river basin for

[262] Mirza et al., 2005, 231-252.
[263] Mirza et al., 2005, 231-252.
[264] Mirza et al., 2005, 231-252.
[265] Bangladesh NAPA, Ministry of Environment and Forests, 1-3.

their water needs[266]. In the Barguna district alone, as a result of disruptions to agricultural and industrial production, as well as domestic water supplies, 50% are now landless[267].

The resulting increases in water and soil salinity, due to reduced dry season flows caused by excessive upstream withdrawals in India, will likely intensify as river flows change due to melting glaciers and variations in precipitation[268]. This increased stress is added to a situation that has already forced the migration of thousands of rural farmers, many of them to India. Despite the creation of a Joint Rivers Commission and Ganges Water Agreement in the 1970s the situation between the countries is still extremely tense. Climate change is likely to aggravate this situation immensely as Bangladesh and India have been identified as countries where increased stresses on water supplies create a high risk of violent conflict[269].

In addition to the wide array of problems surrounding its water supplies, Bangladesh is extremely susceptible to tropical cyclones originating in the Bay of Bengal. The destruction these storms cause is highlighted by the fact that although only 1% of global cyclones strike Bangladesh annually, yet they experience fatalities that account for 53% of the world total[270]. Much of the death and destruction is caused by storm surges that can reach as high as 10 meters[271].

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[266] A. Swain, "Displacing the Conflict: Environmental Destruction in Bangladesh and Ethnic Conflict in India," *Journal of Peace Research* 33, no 2 (1996): 197.
[267] Swain, 193.
[268] Jaitly, 22.
[269] Jaitly, 18-19.
[270] Ali, 1996, 172-179.
[271] Ali, 1996, 172-179.

Unfortunately, the cyclones originating from the Bay of Bengal have shown increasing intensity since 1970 despite a decrease in frequency[272]. In addition, it is estimated that the increased likelihood of cyclones making landfall will be 32% with increased storm surge heights of 21%[273]. As these cyclonic impacts increase, coastal communities will increasingly come into contact with the overwhelmingly destructive forces originating in the Bay of Bengal and the adjoining North Indian Ocean and face increased impetus for migration[274]. In addition to the implications for migration caused by increased cyclonic activity, more intense storm surges may inundate low-lying coastal deltas and cause reductions in freshwater stores due to saline contamination[275].

In spite of its overwhelming vulnerability to cyclonic activity, the country has been blessed with the natural protection of the Sundarbans, the world's largest mangrove forest. This forest provides vital protection from tropical cyclones and storm surges. Unfortunately, Bangladesh has been tearing down this protective wall rapidly in recent years, highlighted by the losses experienced in the Sal forest of 83%[276]. This drastic reduction in mangrove forest is largely attributed to the creation of human settlements and economic activity that now places coastal communities in even more severe danger as climate change increases the wind speed and storm surge of cyclones that make landfall[277].

Owing to the fact that the vast majority of the country barely rises above sea level, the effects of cyclonic activity will coincide with sea level rise to cause high levels of

[272] Climate Change and Bangladesh, 9.
[273] Ali, 1996, 172-179.
[274] Ali, 1996, 171.
[275] Jaitly, 20-21.
[276] Bangladesh State of the Environment, 17-18.
[277] Mirza et al., 2005, 231-252.

damage. For a 2 degree temperature change, sea level rise in Bangladesh has been estimated at .3 meters[278]. This rise will lead to saltwater intrusion in coastal aquifers that will decrease water supplies for both agricultural and domestic purposes. In addition to the destruction of crops, inundation of cities, and direct effects on morbidity and mortality, these impacts will hasten the existing destruction of sources of natural protection, such as mangrove forests as saltwater intrusion destroys fresh water access for these forests[279]. The resulting vulnerability of coastal areas will be acute due to the combined effects of climate change, loss of protective mangroves, and upstream water diversion by neighboring countries[280].

Ultimately, the climatic impacts that lead directly or indirectly to flooding and drought will influence diarrheal disease outbreaks as they interact with higher surface temperatures[281]. Cholera epidemics are an example of the confluence of these climatic linkages that are endemic to Bangladesh and demonstrate a distinct seasonal fluctuation that is mostly attributable to environmental factors[282]. They begin in the char islands at the end of the monsoon season and are linked to zooplankton blooms that provide excellent habitats for their survival[283]. The seasonality of Cholera as well as other diarrhea causing organisms will be greatly affected by temperature increases that have already been higher in colder months when temperature increases most greatly affect diarrheal disease. Cholera along with a variety of diarrheal diseases caused by Giardia,

[278] Ali, 1999, 113.
[279] Cruz et al., 488.
[280] Bangladesh NAPA, Ministry of Environment and Forests, 8-18.
[281] Cruz et al., 487.
[282] R. Sack and A. Siddique, et al., "A 4-year study of the epidemiology of Vibrio cholerae in four rural areas of Bangladesh," *The Journal of Infectious Diseases* 187, no 1 (2002): 96-97.
[283] Cruz et al., 487.

Salmonella and Cryptosporidium will contaminate drinking water in these coastal locations as the conditions in which they thrive increase[284]. Climate change will also add to the environmental health risk associated with diarrheal disease that is already increasing rapidly as a result of industrial growth and urbanization[285]. However, it is impossible to disaggregate the increases in morbidity and mortality due to climatic factors from inextricable linkages to socio-economic factors of poverty, hygiene behavior, and a lack of access to water and sanitation infrastructure[286].

Environmental factors that are directly linked to diarrheal disease are obviously of tremendous concern to adaptation policymakers in reducing under-five mortality. However, many of the vulnerabilities to climate change are indirect in their relation to diarrheal disease and malnutrition. These indirect risks can cause societal upheavals or shocks that can decrease both macroeconomic and institutional stability. These risks are arguably just as important as they will decrease the country's ability to react and adapt to increasing levels of diarrheal disease and malnutrition that climate change creates.

Bangladesh Macroeconomic Context

While the country is subject to high levels of vulnerability due to its environment, one of the factors that helps to mediate this vulnerability for developed countries - high levels of diversified economic development that are relatively equally distributed throughout society - is all but absent in Bangladesh. The result is a desperately poor

[284] Cruz et al., 487.
[285] P. Patel et al., "Bangladesh Country Environmental Analysis," (*World Bank*, 2006), 1-5.
[286] Cruz et al., 484.

country whose wealth is unequally distributed. In macroeconomic terms, much of this vulnerability is due to the fact that it is a predominantly rural economy that is relatively undiversified[287]. This has led to a heavy reliance on an agricultural system that is at the mercy of nature and increasingly high levels of climatic change.

In spite of its reliance on agriculture, the country has not followed the path of many developing countries in becoming reliant on the export of agricultural commodities. For better or worse the country has turned towards manufacturing - a particularly notable amount of activity is devoted to the ready made garment industry - to take advantage of its low cost of labor and spur economic development. As a result, 46% of the $67.69 billion in current GDP is created from manufacturing[288]. Much of this activity takes place in the services sector, accountable for the bulk of economic output at 53% of GDP[289]. This production has helped the country to reduce its direct reliance on agriculture to 19%[290].

The shift away from agricultural production as a primary component of GDP has, however, followed international economic trends stemming from neo-liberal policies. From 1971-1976 the country heavily regulated and nationalized many productive industries; along with much of the developing world this was followed by an era of reduced state control and trade liberalization[291]. Starting in the early 1990s the country substantially reduced its tariffs and allowed for conversion of its current account. Much of this trade reform is linked to the readymade garment industry that accounts for 75% of

[287] Bangladesh State of the Environment, 10-11.
[288] *World Bank,* www.worldbank.org.
[289] www.worldbank.org.
[290] www.worldbank.org.
[291] S. Ahmed and Z. Sattar, *Trade Liberalization, Growth, and Poverty Reduction The Case of Bangladesh,* (2004, World Bank), 11.

merchandising exports, and is linked to broader attempts to achieve economic development via integration into the international trading system[292]. This has not, however, helped to diversify the country's geographic distribution of economic activity as more than 80% of the garment industries are located in Dhaka[293]. The high concentration of readymade garment exports in relation to the country's economy as a whole, renders it extremely vulnerable to external shocks[294].

Such shocks would have significant repercussions for the country's macroeconomic stability. Despite a steadily declining external debt servicing ratio (debt service as a % of export earnings) that fell from 15.8% in 1992 to 6.5% in 2003, the country's external debt actually rose from $13.3 billion to $17 billion[295]. Therefore the declining debt service ratio was actually attributable to increased exports and economic growth, rather than decreased external debts. This increased level of debt could prove to be a significant problem as reductions of 0-3% of GDP will make it extremely difficult for the country to continue to service this debt through the sale of exports. A potential negative feedback loop is also the reductions in state revenue that would further hamper economic development. In fact a survey of 1,000 firms in Dhaka and Chittagong found that the factor that most significantly constrained their operations behind corruption was the country's lack of infrastructure[296]. In order to avoid further complications of this tenuous situation the capital account convertibility restrictions the country has maintained are extremely important. Without such restrictions, attacks on the currency can weaken it

[292] www.worldbank.org
[293] "Dhaka, Bangladesh Disaster Risk Management Profile," *3CD City Profile Series*, www.emi.pdc.org. 11.
[294] P. Patel et al. "Bangladesh Growth and Export Competitiveness," (*World Bank*, 2005), 28-31.
[295] Bangladesh Growth and Export Competitiveness, 21-28.
[296] Bangladesh Growth and Export Competitiveness, 21-28.

in relation to foreign currencies in which its debt is held. Such attacks pose the potential for future balance of payments crises and currency devaluations that was a large contributor to the financial crisis that swept Southeast Asia in the late 1990's[297]. Relinquishing this measure of control can have important repercussions for macroeconomic stability, forcing reductions in state spending on public goods.

Capital account convertibility restrictions are one of several integral components of economic development policies that are vitally important for developing countries in order to retain macroeconomic stability. Export and import tariffs are also important as they provide developing countries with revenue generation and industry protection[298]. Bangladesh has retained an escalating tariff structure that protects domestic producers in many industries and provides desperately needed national revenue[299]. These measures provide the country with a modicum of stability that currently developed countries have utilized to achieve their own economic development in the modern era. In fact, developed countries have largely ignored laissez-faire policy strictures and retained control over their macroeconomic environment. They have done so in order to protect domestic industries and limit exposure to unstable international economic environments and the power inequities involved in developed/undeveloped country trade relations[300].

In spite of retaining these important economic controls, the economy is still vulnerable due to high levels of single sector economic dependence. This is due to the fact that both manufacturing and services are still very much reliant on stable levels of

[297] Chang & Grabel, 7-53.
[298] Chang & Grabel, 7-53.
[299] Bangladesh Growth and Export Competitiveness, 21-28.
[300] Chang & Grabel, 7-53.

agricultural production either for processing of agricultural products, or for servicing both key sectors of the economy[301]. In fact, despite the majority of GDP being generated by the service sector, nearly 2/3 of Bangladeshis are employed in agriculture with rice being the single most important product[302]. In the early 1990s the country achieved self-sufficiency in cereal production mainly due to rice, the main staple of the Bangladeshi diet[303]. However, increases in total yields were due largely to the mechanization of agriculture, with an emphasis on particular varieties of high-yield crops that resulted in the loss of many traditional varieties of rice. In addition, the practice of monocropping has caused the deterioration of soil fertility and an overall decline in productivity, despite the rise in total production due to the increasing levels of agricultural activity[304]. This renders the sustainability of current levels of total cereal production questionable, as they are heavily reliant on rice production alone.

To demonstrate this vulnerability, take the findings of the Bangladesh Agricultural Research Council who found that rice production could face a 10-33% reduction at only a 2 degree Celsius temperature change[305]. The council took into account both the fertilization effects of higher levels of carbon in the atmosphere, as well as a likely 60% moisture stress (drought)[306]. Taking the average crop reduction of this

[301] Bangladesh State of the Environment Report, 10-11.
[302] Dhaka Disaster Risk Management Profile, 3.
[303] Bangladesh State of the Environment Report, 10-11.
[304] Bangladesh State of the Environment Report, 10-11.
[305] Zaharul Karim, Ghulam Hussain, and Ahsan Uddin Ahmed, "Climate Change Vulnerability of Agriculture," In *Vulnerability and Adaptation to Climate Change for Bangladesh* edited by S. Huq, Z. Karim, M. Asaduzzaman and F. Mahtab, (Dordrecht Netherlands: Kluwer Academic Publishers, 1999) 47-51.
[306] Karim et al., 47-51.

estimate of 21%, and applying it to the 2005 production level of 24,569,000[307] tons, the country would stand to lose $737,807,070 (5,159,490 x average price of $143/ton[308]=$737,807,070) or 1% of its GDP resulting from reductions in rice production alone.

Unfortunately, these calculations do not take into account the effects of increased flooding that are also likely to occur due to climate change. During an average year, 20-25% of the country will be inundated by river spills and drainage congestions[309]; for example extreme flooding in 1988 left 61% of the country inundated, caused US$ 1.2 billion in damage, and left more than 45 million homeless[310]. The total monetary loss caused by the 1998 flood amounted to 3% of the country's GDP[311] and the inundation for an average year leads to the destruction of 500,000 tons of crops each year[312]. Given a 2 degree temperature change, the peak discharge of the Ganges, Brahmaputra, and Megna Rivers will increase by 8.5%, -.5%, and 4.5%, respectively, leading to inundation causing 1.707 million tons of crops to be damaged[313]. To put these changes in perspective, the country would now be averaging crop losses above those incurred by the flooding of 1987, which saw 1.32 million tons of crops damaged. Given that 94%[314] of the country's

[307] *Bangladesh Ministry of Agriculture,* http://www.moa.gov.bd.
[308] "FAOSTAT," *United Nations Food and Agricultural Organization,* www.unfaostat.fao.org 2009.
[309] Bangladesh NAPA, Ministry of Environment and Forests, 6.
[310] Bangladesh NAPA, Ministry of Environment and Forests, 6.
[311] Monirul Qader Mirza, "Global warming and changes in the probability of occurrence of floods in Bangladesh and implications," *Global Environmental Change* 12, no 2 (2002): 125.
[312] Karim et al., 40-43.
[313] Karim et al., 47-51.
[314] Karim et al., 40-43.

crop production is rice, which fetches an average price per ton of $143[315], the additional cost to the economy for rice production alone will be $229,454,940, or .33% of GDP.

However, the damage to production is still not yet entirely accounted for. For example, soil salinity negatively affects crop production due to BWE. At a baseline scenario with no climate change, the crop reduction attributed to these effects is a loss of 196,398 tons of rice[316]. Taking the most conservative scenario put forth, rice production is reduced by an additional 271,940 tons[317] resulting in further losses of $38,823,070, or .05% of GDP. Crop losses will also be associated with a .3M rise in sea level that will inundate 5% of the country's land surface, 95% of which is agricultural[318]. This reduces the country's production by 5%, leading to further losses to GDP that are now $165,128,249, or .24% of GDP.

The total losses in rice production alone now stand at 1.62% of GDP, or nearly half the devastation attributed to the floods of 1998. This is an understandably high number due to the fact that rice production makes up 94%[319] of total cereal production in a country heavily reliant on agriculture. However, when it is compared to the direct annual cost to the national economy of 0.5% -1% of GDP that natural disasters have had on *all* sectors of the economy over the past 10 years, the potential macroeconomic shock it could produce is staggering[320].

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[315] "FAOSTAT," *United Nations Food and Agricultural Organization,* www.unfaostat.fao.org 2009.
[316] Mohammad Habibullah, Ahsan Uddin Ahmed and Zahurul Karim, "Assessment of Foodgrain Production Loss Due to Climate Induced Enhanced Soil Salinity." In *Vulnerability and Adaptation to Climate Change for Bangladesh* edited by S. Huq, Z. Karim, M. Asaduzzaman and F. Mahtab (Dordrecht Netherlands: Kluwer Academic Publishers, 1999) 56.
[317] Habibullah et al., 58.
[318] Karim et al., 40-43.
[319] Karim et al., 40-43.
[320] Climate Change and Bangladesh, 9-11.

The reduction in rice production will have economy-wide ramifications, including a loss of jobs and income that will increase malnutrition levels as people are less able to purchase foodstuffs at current prices, even as prices rise due to reductions in supply. The potential impact on malnutrition rates for the under-five population is suggestive of the overall impact that the climate could have on Bangladeshi society. For example, the increase in cases of malnutrition at an emissions scenario of 550ppm has been estimated at 16%[321] for the South Asian Region. Taking this estimate and applying it to the 46% (8,694,000 of a total under-five population of 18,900,000)[322] of the under-five population who were underweight in Bangladesh as of 2007, an increase of 16% in malnutrition rates would cause it to jump by 7.4% to 53.4%. The additional cost of treating these malnourished children with traditional interventions (breastfeeding promotion, child survival programs, nutritional programs, and growth monitoring and counseling) that average $20.24 per child[323] would amount to .04% of GDP. Utilizing the same methodology for the expected regional increase in diarrheal disease rates due to climate change of 5.5% and applying it to Bangladesh, further costs can be calculated[324]. It should be noted that this estimate does not include the effects of precipitation on diarrheal disease as research has yet to quantify the amount attributable to flooding or drought. However, a 5.5% increase in the 20% of the under-five population that would need treatment at an estimated average cost per child of traditional interventions (breastfeeding promotion, rotavirus immunization, cholera immunization, measles immunization, and

[321] McMichael et al., 145-146.
[322] *United Nations Children's Fund,* www.unicef.org.
[323] Ebi, 5.
[324] McMichael et al., 143-145.

the improvement of water supply and sanitation) of $34[325] would cost the country .01% of GDP.

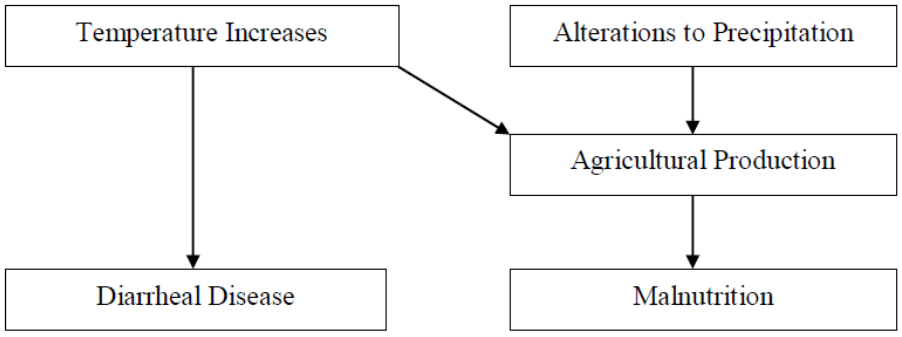
When these costs are taken in tandem with those incurred by reductions in rice yields, the country now faces annual costs equivalent to 1.67% of GDP. The central government's annual revenue is equivalent to approximately 10.4% of GDP[326], of which an average of 6%[327] is spent on all health expenditures. A rough estimate of the country's annual budget according to these figures is $7,039,760,000, with annual health expenditures of $422,385,600. With the increased costs due to climate change attributable malnutrition and diarrheal disease amounting to $35,223,249 and reductions in national revenue from crop losses lowering the annual health budget by 1.62%, 8.5% of the total government health budget would have to be devoted to fighting the increases in these two problems alone. This is simply not feasible as the country already lacks the ability to adequately respond to present rates of malnutrition and diarrheal disease. The addition of the incremental costs incurred due to climate change, combined with reductions in annual revenue, render the ability of traditional public health sector interventions to manage the scale of the problem highly doubtful.

[325] Ebi, 5.
[326] Bangladesh Growth and Export Competitiveness, 149.
[327] "WHOSYS," *World Health Organization,* www.whosys.who.int, 2008.

Table 5.1: Climate Change Impacts and Associated Costs

Impact	**Expected losses to GDP**	**Cost as a % of Health Budget**	**Reduction in National Budget**
Temperatures/Drought	1% ($737,807,070)		1%
Flooding	.33% ($229,454,940)		.33%
Soil Salinity	.05% ($38,823,070)		.05%
Sea Level Rise	.24% ($165,128,249)		.24%
Malnutrition	.04%	6.7%	
Diarrheal Disease	.01%	1.8%	
Total	1.67%	8.5%	1.62%

Figure 5.5: Direct and indirect pathways for increases in diarrheal disease and malnutrition due to climate change



Note: Despite their synergistic effects Increases in Diarrheal Disease and Malnutrition have been calculated independently of one another

Bangladesh Socio-economic Context

The likelihood of large macroeconomic shocks clearly demonstrates the vulnerability of the majority of Bangledeshi society. Much of this vulnerability is driven by abject poverty that forces the use of water systems contaminated with raw sewage. This contamination arises due to industrial waste, defecation practices, and unhygienic disposal of human waste, leading to coliform counts of most surface water sources unacceptable for domestic use. However, the reality of poverty renders its use necessary, thereby exacerbating the high levels of diarrheal disease and increasing the under-five mortality rate in Bangladesh[328].

Poverty and vulnerability is however obscured by national economic data that shows rising GDP and per capita income associated with a move away from heavy state intervention in the economy following the early years of independence. The resulting neo-liberal policies have created average annual GDP growth that was 4.65 % from 1991-1995, rising to 5.5 % from 1996-2000[329]. However, in spite of steadily increasing GDP, over 80% of the population still lives on less than $2 a day[330]. The effect of this poverty on the distribution of diarrheal disease within Bangladesh is evidenced by the relative risk (RR) of dying from diarrheal disease for the lowest wealth quintile, which is 1.7 times that of the wealthiest quintile[331]. The devastating effects of poverty are exacerbated by a growth in inequality within society demonstrated by Gini coefficients for the same time period that deteriorated from .388 in 1991/92 to .451 in 2000, with a pronounced

[328] Bangladesh State of the Environment, 22-23.
[329] Bangladesh NAPA, Ministry of Environment and Forests, 2.
[330] Climate Change and Bangladesh, 22.
[331] "Bangladesh mortality profile," *World Health Organization,* www.who.int, 2009.

effect in urban areas of .398 to .497[332]. In fact, rural areas, with 80% of the population, contributed 78% of the total decrease in national poverty while the urban sector contributed only 13%[333]. It is this rise in inequality, as well as the marked increase in poverty in urban areas, that is driving socio-economic vulnerability to diarrheal disease.

Urban health problems have grown larger as, despite the overwhelmingly rural nature of the country, urban centers have witnessed rapid growth. Urbanization began in earnest in 1950 and picked up steam when the country declared independence in 1971[334]. During the 1950s, the country experienced an incredible 44.63% increase in urban population as people migrated mainly to urban centers as a result of the British partition of India[335]. This wave of urban migration was followed by industrial development that pulled rural inhabitants from the countryside seeking a more stable existence. In recent years (1991-2001), average annual urban growth rates have slowed to 3.15 %, however, they are still double the overall rate of population growth[336].

Today, 26% of Bangladeshis live in urban areas with an extremely high slum to urban population of 85%[337]. In fact despite falling growth rates in recent years, slums still continue to grow at annual rates of 4%[338]. What is worse, while Bangladesh as a whole has among the highest population densities in the world (2,600 persons per square mile),

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[332] "Poverty Profile People's Republic of Bangladesh." *Japan Bank for International Cooperation*, 2007, www.jica.go.jp.
[333] Bangladesh Millennium Development Goals Report, 17-22.
[334] A. Kahn, "Rural-Urban Migration and Urbanization in Bangladesh," *The Geographical Review* 72, no 4 (1982): 380-384.
[335] Kahn, 380-384.
[336] Bangladesh NAPA, Ministry of Environment and Forests, 2-3.
[337] *United Nations Habitat,* www.unhabitat.org
[338] *United Nations Habitat,* www.unhabitat.org

the population density in slums is roughly 200 times greater[339]. Vulnerability to diarrheal disease is further aggravated by the fact that only 14% of slum dwellers have access to improved sanitation compared to 44% for urban areas as a whole[340]. These numbers reflect not only the failure of development progress for the population as a whole, but the very precarious state the majority of urban Bangladeshis find themselves in today.

In terms of food poverty and malnutrition, the poverty and inequality driving the vulnerability of urban inhabitants have resulted in lower levels of caloric intake in comparison with rural areas. Overall the country has seen a decrease of 4% of society who have fallen below a threshold caloric intake (2,122 kilocalories per person on a daily basis) from 58.35 million in 1983 to 56 million in 2005, which primarily took place in rural areas[341]. Reductions in caloric intake are one factor that can lead to malnutrition that has been shown to be extremely important for fighting diarrheal disease. However, taken in conjunction with the fact that the main crop produced in Bangladesh is rice, which has much lower nutritional content in comparison with other staple foods, it is not surprising that malnutrition is such a large problem for the country.

The resulting impact of these factors on child mortality rates in urban areas is striking. While high under-five mortality rates are endemic to both rural and urban areas, the rate at which they are falling is very different. From 2000-2004, the rate in rural areas fell by 14%, while the urban rate fell by only 4.5%[342]. In addition, neo-natal mortality has

[339] *United Nations Habitat,* www.unhabitat.org
[340] *United Nations Habitat,* www.unhabitat.org
[341] Poverty Profile People's Republic of Bangladesh, 2-3.
[342] *Stat Compiler,* www.statcompiler.com.

actually increased in urban areas by 5%[343] while rural areas have seen a simultaneous decrease of 11%[344], suggesting a distinct challenge faced by urban communities. While some of this difference can be attributed to the work of Grameen Bank, BRAC, and other NGOs that primarily focus on rural populations, inequality, poverty, and environmental conditions within urban areas contribute heavily to these substantially different mortality rates.

The situation in Dhaka is illustrative of the plight that urban inhabitants face in Bangladesh. Inequality within the city has created a chasm between rich and poor as household consumption rates of families in the richest quintile are five times that of the poorest[345]. In terms of risk factors for diarrheal disease, high population density is evidenced by the fact that 30% of the city's population share 80% of the total residential area, while the remaining 70% share only 20%[346]. High population density is aggravated by the risky location of slums, which are primarily located in low lying areas near the river due to the haphazard nature of unplanned urbanization. Nearly 7,600 households live in slums located within 50 meters of the river and are at frequent risk of flooding[347]. The situation is further worsened by the fact that nearly 60% of slums have poor or no drainage[348]. As a result, during the 1998 flood 56% of greater Dhaka was submerged and 1.9 million people (30% of the population) were affected[349]. A survey of residents completed following the flood showed that only 40% had recovered completely, with

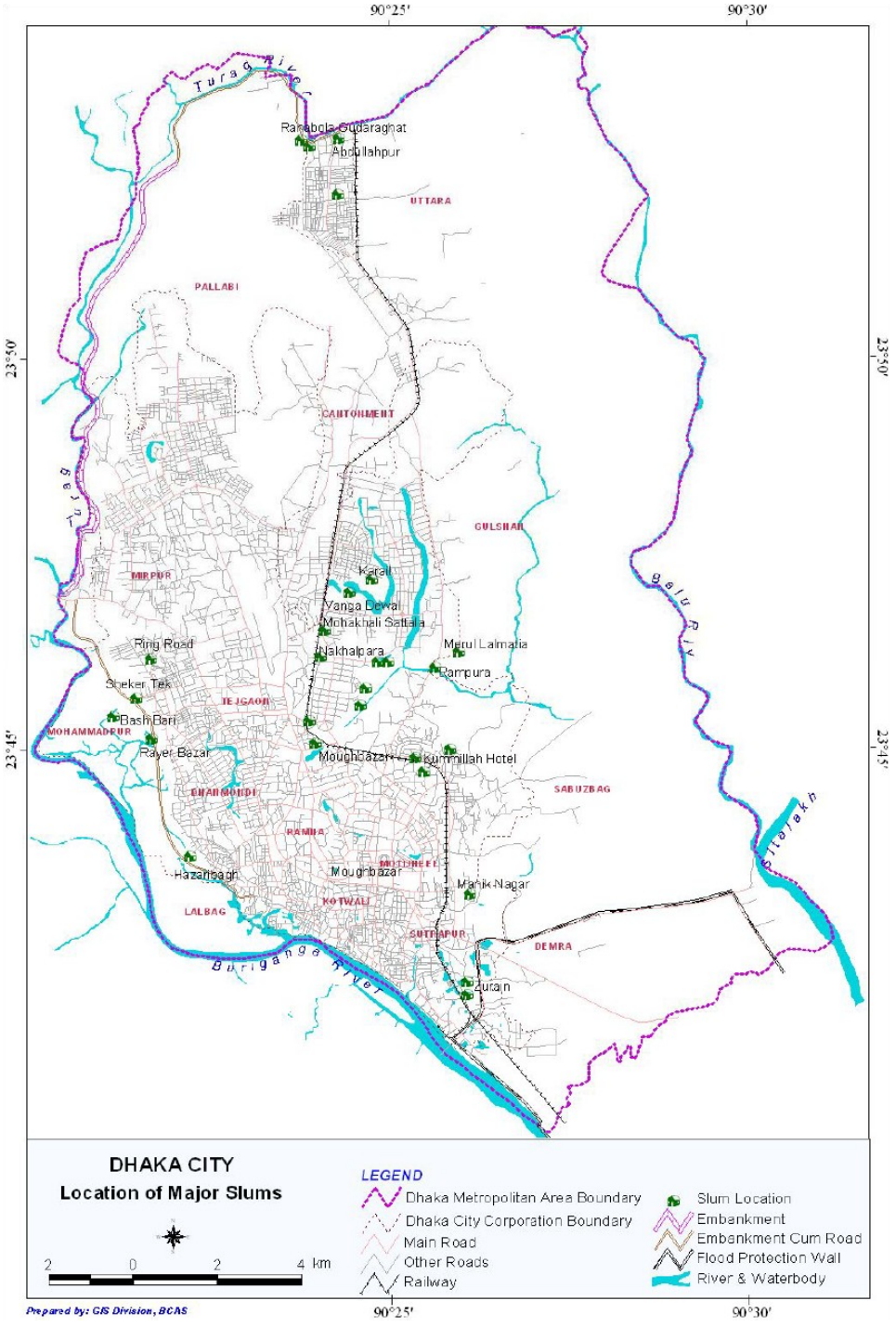
[343] *Stat Compiler,* www.statcompiler.com.
[344] *Stat Compiler,* www.statcompiler.com.
[345] P. Patel et al., "Dhaka: Improving living conditions for the urban poor," (*World Bank*, 2007), 2-13.
[346] Dhaka City State of the Environment,73-76.
[347] Patel et al., 2007, 14.
[348] *United Nations Habitat,* www.unhabitat.org.
[349] Mirza et al., 2005, 231-252.

16% unable to recover at all due to loss of income, assets, and health[350]. The major impact this has on human health has not been addressed by the city's urban development committee[351].

The risk this flooding poses to increased diarrheal disease is compounded by a lack of water and sanitation networks within the city. According to UN-HABITAT, only 44% of the overall population of Dhaka has access to "improved sanitation"[352]. The distribution of this meagerly allotted service is however highly skewed. In the poorest quintile of the population, 9% of households have a sewage line, while 83% of the wealthiest enjoy this service[353]. This is due to the fact that only one sewage treatment plant is in operation for the entire city, and it frequently experiences system failures[354]. The situation for the city's slum dwellers is even more bleak with only 2% of slums having a public toilet within 100 meters[355]. In addition to these problems, access to fresh water for hygienic purposes in the city is also limited. Currently 70% of households under the poverty line use tube wells as their main water source due to a lack of piped water[356]. However, high levels of ammonia in water supplies utilized by the Saidabad Water Treatment Plant create significant barriers to delivering water supplies that meet drinking quality standards for those areas that do enjoy piped water access.

[350] Mirza et al., 2005, 231-252
[351] Patel et al., 2007, 56-62
[352] *United Nations Habitat,* www.unhabitat.org.
[353] Patel et al., 2007, 14.
[354] Patel et al., 2006, 32-34.
[355] Patel et al., 2007, 14.
[356] Patel et al., 2007, 14.

Figure 5.6



Source: UNEP, 2005

In the case of sanitation, municipal wastewater collection and treatment are already the most costly element of infrastructure required to meet MDGs for health, water and environmental protection. Sewage treatment costs increase exponentially with the degree of purification required, making it possible for the cost of wastewater treatment to double[357]. For example, if climate change reduces stream flow by a certain percentage say 30%, the pollutant load must be reduced by an equivalent 30%. This has significant repercussions for health as surface water is of especially poor quality during the dry season when lower water levels reduce the dilution of contaminants that breed disease[358].

Despite the very real threat these urban conditions pose to health in the developing world, migration to Bangladeshi cities continues. In fact, a "highly developed migration process connects the rural southern districts of Bangladesh to Bangladeshi cities"[359]. This process, however, is not a result of urban opportunity as only 60% of the active workforce is employed[360]. It is perhaps more directly linked to the precarious state many rural inhabitants find themselves in as the land available for agricultural use rapidly diminishes in the countries rush towards urbanization[361]. In addition to this push factor, environmental risks posed by flooding and drought have forced small landholders to cover seasonal deficits by taking on expensive loans, which they are often unable to repay[362]. As a result, a downward spiral of debt develops that leads in many cases to the loss of the only productive asset rural inhabitants own; their land.[363] This process reflects

[357] Muller, 106.
[358] Patel et al., 2006, 7-10.
[359] Kuhn, 6.
[360] Climate Change and Bangladesh, 4.
[361] Bangladesh State of the Environment Report, 10-11.
[362] Kuhn, 6-8.
[363] Kuhn, 6-8.

the importance of push factors in rural to urban migration that Bangladesh, and all of South Asia, encounters as a result of poverty, a lack of rural employment, and environmental degradation[364].

A major concern is the likelihood that climate change will increase this existing migration as homes and land are lost to erosion and permanent inundation. The country's 2005 NAPA highlighted four categories of climate change impacts that will increase migration: riverbank erosion, coastal erosion, permanent inundation and sea level rise. The potential for increases in erosion, and thus displacement due to climate change, is highly likely as the net increase in discharge for the GBM river system at a 2 degree warming scenario is 12.5%[365]. The resulting riverbank erosion is already a serious problem for urban communities, and is highly pronounced in slums. From 1982 to 1992, over 1,060 kilometers of land eroded in the GBM river system; accretion resulted in the addition of only 190 kilometers, leading to a net reduction of 870 kilometers that displaced 350,000 people[366]. In addition, large population displacements are also occurring along the coastline due to frequent and intense storm surges, sea level rise, and coastal erosion[367].

Currently 46% of the population in Bangladesh is found in the Low Elevation Coastal Zone (LECZ), (defined as 0-10 meters above sea level) which is highly susceptible to the above processes[368]. Moreover, the population in this zone grew at

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[364] K. Roy, and C. Tisdell, et al., "Rural-urban migration and poverty in South Asia," *Journal of Contemporary Asia* 22, no 1 (1992): 60-62.
[365] Ali, 1996, 172-179.
[366] "Bangladesh Climate Change Strategy and Action Plan," (*Ministry of the Environment and Forests, Government of the People's Republic of Bangladesh*, 2008), 8.
[367] Bangladesh Climate Change Strategy and Action Plan, 13.
[368] McGranahan, 17.

double the national growth rate from 1990-2000, and was most pronounced in urban areas[369]. The vulnerability of this population is significant as it has been estimated that climate change will lead to a 32% increase in the number of cyclones hitting land in the Bay of Bengal. A 2 degree scenario will increase the intensity of these cyclones by 10%, leading to average storm surge heights of 9.1 meters, a 1.7 meter increase from the baseline[370]. To put this in perspective, the 1970 cyclone that caused 500,000 deaths experienced storm surges between 6.1-9.14 meters, while the 1991 cyclone that caused 138,000 deaths, experienced storm surges between 6.1-7.62[371]. The corresponding increase in inland penetration of enhanced storm surges has been estimated between 13 and 31%[372]. If the inland penetration of storm surge increases at the midpoint of this estimate, 22%, then it is reasonable to assume that roughly 16,056,898 people in the LECZ will be affected, or 10% of the population of the entire country.

In addition, at a 2 degree temperature change, migration is expected to increase along existing routes anywhere from 5-10%[373]. This estimate is conservative in the case of Bangladesh, due to the fact that coastal inhabitants will likely flee the devastating effects of increasing storm surge at much higher rates. However, taking the midpoint of this estimate (7.5%), and applying it to the 10% of the population that will experience these increased climate events, an increase of 1,204,267 will likely be seen in urban centers. Applying the slum to urban ratio of 85% to this population, a likely 1,023,626

[369] McGranahan, 26.
[370] Ali, 1999, 110-114.
[371] Ali, 1999, 110-114.
[372] Ali, 1999, 110-114.
[373] Brown, 28.

new slum inhabitants will lack access to water and sanitation infrastructure, health services and education.

In addition to the migration caused by storm surge, a .3 meter sea level rise will lead to a loss of 5% of coastal land, where one-fourth of the population (39,666,250) currently resides[374]. Sea level rise therefore leads to a rough displacement figure of 1,983,312 or 1.2% of the total population. The resulting displacement due to sea level rise and increased migration from coastal areas facing increased storm surge is now 3,187,579, or 2% of the entire population. If those displaced by sea level rise follow the current rural/urban distribution of the country, 515,661 new urban migrants will join the 1,204,267 created by increased storm surge, resulting in 1,719,928 people, or a 4.2% increase in urban inhabitants. The conservative nature of this estimate is further enhanced by the fact that it does not take into account the effects of climate processes on long term migration from agricultural areas outside of the coast. There is a high probability that the actual increase in urban inhabitants will be much higher. Given the high rates of urbanization that currently exist, as well as conditions that can only be described as squalor that the majority of these inhabitants face, the challenge of responding to the added stress of climate change-induced environmental migration is daunting.

[374] Ali, 1999, 110-114.

Bangladesh Institutional Context

The institutional context of the country is vital for mediating the macroeconomic shock of a loss of 1.5755% of GDP, as well as increases in urban inhabitants of 4.2%. Unfortunately, the government has not demonstrated the institutional capacity to adequately respond to current levels of impact. This has been partially offset by the very large presence of NGOs working within the country. However, their presence will not serve to directly mediate the impact for those segments of society that are most vulnerable to climate change, namely slum communities. This is largely due to the fact that the focus of human development programs and essential health service packages, have mostly targeted rural areas[375]. That is not to say that the strengthening of rural livelihoods won't stem the tide of urban migration; however, the direct impacts of diarrheal disease and malnutrition that will be felt in urban areas, necessitate an urban focus.

The lack of infrastructure and services currently provided is linked to the governments' ability to generate and spend tax revenue in appropriate ways that reduce the population's vulnerability. In Bangladesh, this is severely hampered by high levels of corruption that constrain economic development[376]. This underscores the vacuum that is being created by a lack of effective governance.

Again the plight of poor residents in Dhaka serves to illustrate failures in providing basic public infrastructure to citizens. In Dhaka, the municipal government is unable to maintain public services due to budget constraints. This has resulted in

[375] Poverty Profile People's Republic of Bangladesh, 2-4.
[376] Bangladesh Growth and Export Competitiveness, 28-31.

inadequate waste collection that has forced 91% of slum dwellers to dispose of their waste into low-lying lands, near railway tracks, drains, canals, or on the streets[377].

In order to meet the massive level of demand for the provision of basic services the government is unable to provide, local "entrepreneurs" known as Mastaans have begun to illegally procure these services, offering them to slum inhabitants for exorbitantly high prices. This system has arisen due to a lack of property rights where slum settlements arise, leading the government, NGOs, and donors to deny service in these areas. Mastaans then exploit the poor by leveraging patronage from local and national political leaders, in the process becoming the only providers of service. The resulting rates can be as high as 15 times the official rate, while water collection can take up to 2 hours.[378] The lack of water for hygienic purposes and long waits for inadequately maintained latrines lead to poor hygiene that further contributes to morbidity and mortality due to diarrheal disease[379].

Environmental conditions created by this situation are compounded by a lack of awareness about the importance of hygiene in disease prevention. This is evidenced by the inequality in access to education in the city. Currently, a meager 26% of poor communities have a government school[380], and only 40% of household heads among the poor receive more than 5 years of schooling[381]. NGOs have attempted to respond to the

[377] "Dhaka City State of the Environment," (*United Nations Environmental Program,* 2001), 73-76.
[378] Patel et al., 2007, 15-17.
[379] Patel et al., 2007, 15-17.
[380] Patel et al., 2007, 15-17.
[381] Patel et al., 2007, 51-59.

government's failure to provide for the poor by operating schools. Their efforts have resulted in 76% of slum schools being run by NGOs[382].

In addition, dropout rates for primary schools are substantially higher in urban areas, primarily due to slum evictions and the need for income generated by child labor. A recent survey of slum areas in Dhaka reported that on top of a lack of access to schools, 58% of 6-7 year olds do not attend school due to a variety of poverty-related factors, including a lack of income for tuition, and a migratory lifestyle[383]. As of 2004, the RR for diarrheal disease in individuals lacking a basic primary education was 1.25 that of those who did have education, and 1.67 that of those who had a secondary education[384]. These risk levels have actually increased from 1.14 and 1.34 in 2000[385], suggesting that a lack of education is magnifying the problem of diarrheal disease in urban areas.

Access to healthcare is in much the same miserable state. Only 54% of the city's households report access to health facilities, and only 7.3% of slums have access to a public health clinic[386]. This is a result of the low levels of expenditure ($12 per person per year[387]) that the government makes on health; in comparison, low-income countries generally spend $21 per-person per-year[388]. The hospitals and clinics that do exist are rarely located close to slum areas, resulting in extremely long wait times and limited access. On top of these problems, supposedly free services often require substantial

[382] Patel et al., 2007, 51-59.
[383] Patel et al., 2007, 51-59.
[384] *Stat Compiler,* www.statcompiler.com.
[385] *Stat Compiler,* www.statcompiler.com.
[386] Patel et al., 2007, 51-59.
[387] Bangladesh NAPA, Ministry of Environment and Forests, 15.
[388] Bangladesh NAPA, Ministry of Environment and Forests, 15.

amounts of 'speed money' to obtain care from a doctor, or medical supplies[389]. As a result, only 12% of the urban poor obtain medical services from government service centers[390]. Just as NGOs have stepped in to help fill the gaping hole left by the government in education, they have also stepped in to provide health care. NGOs provide 20% of slums health clinic access, despite the fear of eviction and the resulting loss of infrastructure[391].

These inadequacies at the municipal level are compounded by the complex administrative structure of the city. This structure includes a number of different local and metropolitan authorities with various levels of overlapping responsibilities. The confusion this situation causes, creates a lack of coordination between different national, regional, and municipal government bodies in government planning and resource allocation for urban management. The inadequacy of this structure is aggravated by resources and power that are centralized in national level agencies, in spite of the declared governmental policy of decentralized administrative and economic development introduced in the 1980s[392]. The absence of a relatively equal distribution of resources and power to lower levels of government has helped to further constrain local governments throughout the country[393].

Despite the large failures of urban governments such as Dhaka to provide their citizenry with adequate levels of public goods, the country as a whole does show examples of properly identifying and responding to urgent needs. Over the past 30 years,

[389] Patel et al., 2007, 51-59.
[390] Patel et al., 2007, 51-59.
[391] Patel et al., 2007, 51-59.
[392] Dhaka Disaster Risk Management Profile, 3CD City Profile, 11.
[393] Dhaka Disaster Risk Management Profile, 3CD City Profile, 11.

the national government has invested over $10 billion in flood management, embankments, coastal polders and cyclone shelters capable of housing approximately 2 million people[394]. Much of this activity has involved local communities located in coastal areas most vulnerable to flooding and storm surge. In 2007, the cyclone shelters built by the government, along with a community-based early warning system, limited fatalities to a fraction of those lost to the 1991 cyclone[395]. This program demonstrates that in spite of many of the failures of both municipal and national governments, the country has the potential institutional capacity to respond to climatic changes.

This potential is, however, constrained in two vitally important areas: bi-lateral cooperation with regional neighbors, and cooperation between national ministries. Many of the regional problems over shared water supplies have arisen from bi-lateral negotiations that have trumpeted nationalistic water development ideals at the cost of regional cooperation and benefit. This is exemplified by India's implicit foreign policy of bilateral agreements between riparian countries. This policy seeks to subvert smaller countries attempts at forming a regional bloc as a counterweight to its domination of the subcontinent. This has severely hampered regional cooperation, and led to significant tensions between Bangladesh and India. These tensions are perhaps highest in relation to the Farrakam Barrage. Despite these issues, India and Bangladesh did succeed in signing the 1996 Ganges Water Treaty; a 25-year agreement over the dry season flows of the Ganges River that includes a tentative agreement for future cooperation on augmentation

[394] Bangladesh Climate Change Strategy and Action Plan, 1.
[395] Bangladesh Climate Change Strategy and Action Plan, 1.

of that flow[396]. However, agreements like this simply reinforce regional power inequities and undermine the ability of less powerful nations to adapt to climate change.

The regional body tasked with cooperative action, the South Asian Association for Regional Cooperation (SAARC), has not been able to adequately respond to issues of asymmetry and mistrust since its inception in 1985[397]. The body has attempted to respond to climate change by creating an action plan that seeks to bolster cooperation in many areas, including adaptation and financing[398]. This commitment was adopted by the Dhaka Declaration, which further agreed to initiate, and implement, adaptation programs[399].

In spite of recognizing the vital importance of environmental and poverty linkages, the bloc has made very little progress in achieving tangible results on its many proclamations[400]. The large doubts that regional actors have over the ability of this body to facilitate cooperative efforts is likely to lead to unilateral actions taken to build resiliency to climate change. This will ultimately undermine the vulnerability of Bangladesh, as it is at the mercy of these unilateral actions.

The other significant problem that the country faces is cooperation between national ministries. It has, thus far, initiated a number of governmental activities aimed at rectifying this situation, including the creation of a national climate change cell, national climate change fund, and the NAPA process[401]. While these are important steps, the manner in which they have been undertaken poses potential problems. Originally, the

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[396] B. Crow and N. Singh, "Impediments and innovation in international rivers: the waters of South Asia," *World Development* 28, no 11 (2000): 1991-1912.
[397] Q. Ahmad, "SAARC: Envisioning the Future," *South Asian Survey* 9, no 2 (2002): 191-192.
[398] *South Asian Association For Regional Cooperation,* www.saarc-sec.org.
[399] *South Asian Association For Regional Cooperation,* www.saarc-sec.org.
[400] Ahmad, 188-191.
[401] Bangladesh Climate Change Strategy and Action Plan, 23-31.

NAPA process was undertaken by the Ministry of Environment, while the PRSP was undertaken by the Ministry of Finance. While the country has taken steps to rectify this situation, the recent introduction of the climate cell, which is meant to provide a centralized focus for the government's climate change related work, is operating as a unit of the Department of Environment. This cell is tasked with identifying climate change impacts, and adequately preparing the nation through national development planning. However, there is a very real likelihood of problems relating to funding, as it is isolated from the ministry of finance.

A similar situation occurred on a global level when the United Nations Environmental Program (UNEP) was created in Nairobi, Kenya. Originally, it was designed to empower southern governments within the international community; however, with the locus of funding, resources, and ultimately power, still residing in Geneva, New York, and Washington, the organization was marginalized and suffered from budget constrains many times larger than other United Nations programs[402].

The wisdom of the placement of the climate cell creates a high possibility of similar problems. The national climate change strategy and action plan, espoused by the Ministry of Environment, is estimated at $500 million for the first two years, with a total program cost for five years of $5 billion, or 7% of GDP[403]. In comparison to the $10 billion the country has spent over the past three decades on climate resiliency, adequate funding is highly doubtful.

[402] , J. Speth and P. Haas, *Global Environmental Governance*, (Washington: Island Press, 2006), 137-139.
[403] Bangladesh Climate Change Strategy and Action Plan, 23-31.

The body has secured additional funding through its linkage to the international negotiations of the UNFCCC. However, adaptation funds available under the GEF-LDCF are dreadfully inadequate in comparison with the cost of this program as well as the additional costs outlined in the previous sections. The country's ability to secure funding through ODA is also doubtful as the international community has shied away from aid in recent years. This is reflected in the amount of ODA the country has received declining from $137,000,000 in 1997, to $57,000,000 in 2003[404].

In the absence of outside sources of financing, the country's ability to generate revenue for these programs is vital. Even assuming that problems related to cooperation between agencies were resolved, the country would still face significant challenges in raising the levels of resources needed from domestic taxation. In 2008-2009, over half the country's budget (54.5%) was derived from tax revenue[405]. This means that with an annual budget of 10.4% of GDP, the contribution of tax revenue was $3,836,669,200. The increased expenditures needed for diarrheal disease and malnutrition alone amount to 8.8% of this revenue.

Historically, like many other developing countries, Bangladesh relied on tariffs and quantitative restrictions to raise revenue, which still account for roughly 40% of its total tax revenue[406]. The possibility of raising this additional revenue from increased import taxes is highly doubtful as import tariffs and average customs duties are slated to decrease over the coming years[407]. Politically, it would be very difficult for the country to

[404] Bangladesh Growth and Export Competitiveness, 149.
[405] *Bangladesh Ministry of Finance,* www.mof.gov.bd.
[406] *World Bank,* www.worldbank.org.
[407] *World Bank,* www.worldbank.org.

reverse this trend, due to its heavy reliance on the readymade garment export sector. The bulk of trade conducted in this sector occurs primarily with the United States and the EU, both of which hold economic leverage over Bangladesh[408]. The possibility of raising this revenue from income taxes is also doubtful as large scale macroeconomic shocks to agricultural production will decrease demand for labor, and therefore income. The situation poses a large dilemma for the country, as it attempts to fund the activities of the climate change cell, as well as respond to increasing health threats from climate change.

[408] Bangladesh Growth and Export Competitiveness, 149.

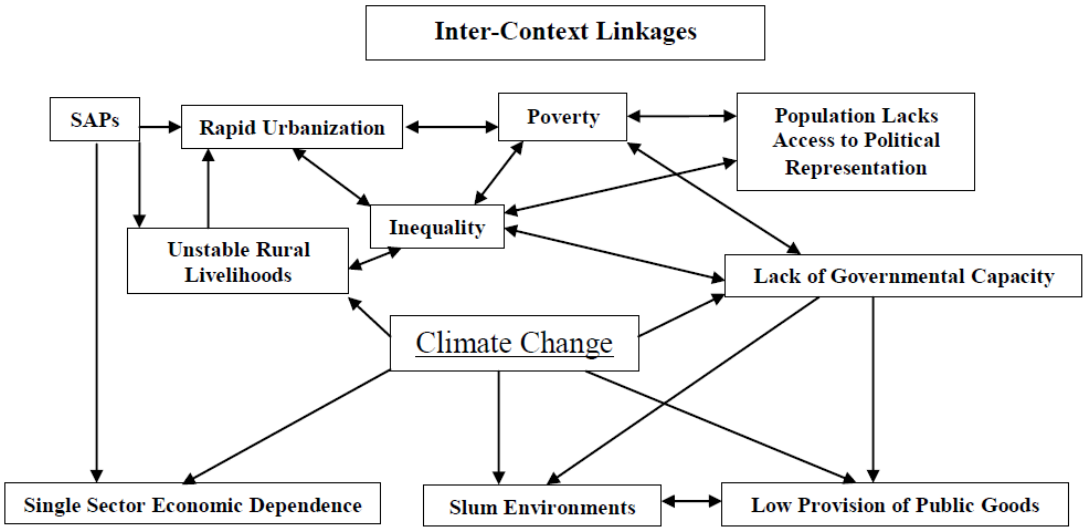
Chapter 6: Adaptation Policies

The 2 degree warming scenario outlined above has clearly demonstrated the potential scale of challenges that climate change poses. Even given the conservative nature of this warming scenario, the costs of climate change-attributable diarrheal disease and malnutrition are 80% of the total government health budget. If these costs occurred in isolation it is possible that policymakers could continue to respond in a manner similar to that which has been traditionally advocated, including hygiene awareness, oral rehydration therapy (ORT), breast feeding promotion and other cost effective mechanisms for diarrheal reduction. However, given the multiple pathways through which climate change will increase this disease burden, following this "band-aid" approach will be, at best, an exercise in futility.

These interventions are simply unable to address the fundamental drivers of vulnerability, including inequality and poverty that will continue to create conditions that not only breed the disease, but breed vulnerability to the disease. While aspects of the traditional approach are necessary, even integral components of adaptation policies for diarrheal disease, their use alone isolates health interventions from broader problems in society that significantly increase disease burden. Failing to acknowledge, and act upon, these structural components of health, renders health interventions ineffective, as wider policymaking efforts, and debates, have tremendous effects on health.

The 2 degree warming scenario demonstrates that it would be far more effective for policymakers to decrease levels of societal vulnerability to diarrheal disease. This proactive approach to disease prevention will also benefit society in a myriad of ways, as the spillover effects of vulnerability reduction yield benefits to other sectors of society. This reduction in societal vulnerability is a no-regrets solution that allows policymakers to respond to the uncertainties of climate change scenarios and predictions by increasing societal resilience, whatever level climate change impacts may be.

Figure 6.1



Targeted areas for adaptation policies in bold

1)Build Institutional Capacity

Planned adaptation policies begin with efforts at building institutional capacity. Improved institutional capacity will allow the country to better manage the flow of scarce resources so that it benefits those members of society most vulnerable to climate change. In Bangladesh, this process has already begun with the completion of the NAPA, and the

Climate Change Strategy and Action Plan. The Climate Change Strategy and Action Plan has thus far incorporated efforts at reducing societal vulnerability into the maintenance of food security, social protection, and health. However, without strong efforts towards fulfilling its sixth pillar, capacity building and institutional strengthening, the well meaning intentions of this plan will not occur[409].

Building institutional capacity has been a primary factor in the ability of low-income countries, such as Costa Rica, China, Cuba, and Sri Lanka, to provide positive health outcomes despite resource constraints. The WHO's commission on the social determinants of health identified community participation in decision-making processes relevant to health, and inter-sectoral linkages, as institutional factors that greatly aided in these outcomes[410]. In addition to these general institutional components, the management of water resources, regional cooperation, and the securing of international funding sources, are vital for ensuring the success of adaptation activities.

In terms of inter-sectoral linkages, the capacity building efforts of the national government must still address the isolation of the climate cell from the Ministry of Finance. In order to empower adaptation efforts, the cell should be relocated to the Ministry of Finance. This allows adaptation efforts to gain direct access to funding, which is vital for the success of these efforts. This should be complimented by the creation of individual climate cells in each of the national ministries. This will allow for inter-sectoral linkages between the planning, and action, of ministries. This will reduce

[409] Bangladesh Climate Change Strategy and Action Plan, 23-31.
[410] CSDH, *Closing the gap in a generation: health equity through action on the social determinants of health. Final Report of the Commission on Social Determinants of Health* (World Health Organization, 2008) 33-34.

overlaps in resource expenditures, and allow ministries to identify cross-cutting measures that address linked issues. This is especially important to adaptation strategies that must be integrated with development strategies in national planning efforts and resource allocation.

In relation to diarrheal disease, this will prove extremely helpful for the ministry of health which receives a measly 6% of the annual budget. The increased levels of expenditure needed to treat diarrheal disease and malnutrition alone demonstrate the need for reductions in the drivers of these diseases. While the country must increase its level of health expenditure - which is far below that of regional neighbors at similar levels of economic development - it doesn't need to redirect vast amounts of resources to the Ministry of Health in order to do so. It is far more sensible for the country to allocate scarce resources to the broader drivers of health vulnerability through the inter-sectoral linkages created by locating climate change cells in all government ministries.

For example, resources directed at adapting agriculture to climate change can provide indirect benefits to health through decreased societal vulnerability to malnutrition. This strategy is difficult to quantify in terms of benefits that directly aid diarrheal disease, however, the spillover effects to a variety of societal problems are large enough to warrant it. Indeed, without the concerted efforts of actors from a wide array of sectors, many of the indirect pathways through which diarrheal disease and malnutrition affect health simply cannot be adequately addressed.

Build Capacity of Local Governments & Decentralize Power and Resources

Adaptation measures should be specific to particular locations and situations. What may work in one location, with one socioeconomic group, may not be feasible in another. Therefore, it is not possible for a national government to create a "one size fits all" adaptation approach. It is imperative that national policy efforts improve the ability of local communities to adapt to climate change. However, despite the necessity of localized adaptations, national policy strategies are essential as adaptation measures are unlikely to be implemented unless they are consistent with broader management decisions embodied in national policies and institutions[411].

It has been shown that efforts at decentralization actually exacerbate inequalities at local levels; thereby increasing societal vulnerability if adequate levels of planning and capacity building are not included. Bangladesh must build upon its network of climate cells at the national level by creating a network of climate cells at local levels linked to the central climate cell in the Ministry of Finance. This can be accomplished by building upon existing disaster relief networks in coastal communities, as well as securing internet and communications links that increase the flow of information from local to national levels.

Chittagong provides an example from which the country can build in order to successfully decentralizing responsibilities to lower levels of government. One of the institutional mechanisms that enables the city's responsive capacity to natural disasters is the standing orders for disaster management. These orders have been formulated by the

[411] Smit & Pilifosova, 2003, 23-25

national government, and are designed to clarify roles and responsibilities at all levels of government. This provides clear delineation of powers and duties to each level and can help to mediate the confusion and competition between government agencies that Dhaka experiences[412]. Adaptive capacity is much greater if social, cultural, and political institutions ensure that the allocation of power, and access to resources, are distributed equitably[413]. Empowering local governments through a more formal, and clear, delineation of responsibilities allows this process to occur.

It is still unlikely that the national and local levels of government will be able to address the deeply-rooted problems of poverty and inequality alone. In addition to efforts in urban areas, the country must leverage the large number of NGOs active in rural areas to help build capacity at local levels. The necessity of this cooperation is shown by the achievements of civil society actors in reducing child malnutrition[414]. The government must seek formalized arrangements with these actors to ensure that their efforts follow national level policy and development efforts, coordinated through the national climate cell. This will help the country avoid the duplication of efforts and resources, as well as allow it to utilize these actors towards national development strategies.

[412] Tanner et al., 5-9.
[413] Smit & Pilifosova, 22-25.
[414] Bangladesh Millennium Development Goals Report, 42-45.

Improve Regional Cooperation Over Resources

The country should leverage these improvements in institutional capacity at a national level to improve regional cooperation between Bangladesh and its riparian neighbors. These efforts should be multilateral in order to reduce the destructive nature of bilateral negotiations that India has sought in the past. Bangladesh should approach other riparian nations in the hopes of signing a regional agreement that emphasizes holistic, basin-wide management, rather than the management of resources within an individual country's boundaries[415]. This is the only way to effectively manage a trans-boundary resource that is vital to all parties involved, and is subjected to increasing levels of stress[416].

While it has not proven the most effective mechanism in the past, SAARC is the best option for achieving regional cooperation, as the institutional framework has already been laid. SAARC has shown a commitment to improving the wellbeing of children, the environment, and poverty reduction, thus providing a strong framework for the beginnings of a regional response to climate change. The importance of these three interlinked issues in relation to diarrheal disease cannot be overstated, making the body a potential platform for adaptation efforts. However, SAARC cannot be successful unless bilateral relations among concerned countries are conducive to a multilateral process. Therefore, Bangladesh must address the negative effect India's policy of bi-lateral agreements is having on regional cooperation[417].

[415] Crow, 1913-1917.
[416] Wolf, 1999, 34-36.
[417] Ahmad, 193-195.

Utilizing SAARC is beneficial for a number of other reasons, including knowledge sharing and communication. It has established regional centers for the exchange of agricultural, migration, meteorological, health, and human resources related information that will be vital for adaptation efforts, particularly in resource constrained countries. In addition, the inclusion of civil society actors in the track II dialogues has helped to facilitate collaborative research and advocacy undertaken jointly by academics, social workers, journalists and others outside the governments of the bloc countries. The inclusion of civil society actors in the SAARC process helps to make it more transparent and accountable to the populations of all countries involved[418].

Ultimately, these efforts are essential to reducing diarrheal disease, as reductions in future dry season water supplies will magnify the spread of the disease. Without adequate domestic water supplies for hygienic purposes, the gravity of the situation will be greatly compounded. However, in addition to the importance of regional cooperation to secure water supplies, cooperation will have numerous spillover effects for other sectors vital to both adaptation, and national development. Despite what may seem a policy stretch in relation to diarrheal disease, these efforts are essential for achieving broader success in adaptation efforts.

[418] Ahmad, 196-198.

Improve Management of Domestic Water Resources

The country must also improve the use of water resources within national boundaries in order to ensure adequate supplies for domestic use. This means Bangladesh should improve efficiency in sectors that utilize the majority of the countries water supplies, namely agriculture. There are many ways to do this at a national level, including legislation that caps the allocation of water resources to agricultural users, and efforts aimed at efficiency. Both of these policies should include measures that preclude negative effects on the activity of this critical sector, such as the subsidizing of appropriate technologies in order to ease transition.

Capping the allotment of water supplies to agricultural users, and reducing it by a small percentage each year for as specified time period, would force agricultural users to become more efficient. This would be beneficial to both industrial and domestic water users. However, following this policy has the potential for exacerbating rural inequalities by forcing small scale, and subsistence farmers into higher levels of debt and instability. This policy, therefore, needs to be accompanied by government interventions that provide subsidized technologies and social safety nets such as insurance schemes to ensure that national policies do not harm the rural poor, or the productivity of the sector in general.

Ultimately, this policy will provide greater benefits than costs, as increases in efficiency are desperately needed. Current levels of GDP production per cubic meter of water used in the GBM basin are $3.47 compared with the world average of $8.6[419]. This inefficiency is very costly for a poor country that relies so heavily directly, and indirectly,

[419] M. Babel, and S. Wahid, *Fresh Water Under Threat South Asia,* (Bangkok: United Nations Environmental Program, 2008), 13.

on this sector. Government adaptation efforts can increase efficiency through the use of drip irrigation, the introduction of less water intensive crops, as well as other water-saving technologies[420]. Regional information networks maintained by SAARC can greatly aid the country in determining the most appropriate technologies for achieving increases in water efficiency.

In addition, the government should create and maintain laws that restructure water use during the dry season. An obvious example are laws on water allocation that prioritize different uses of water at different times, such as "summer water" and "surplus flow"[421]. Organized drought restrictions are institutional mechanisms that can manage variability by prioritizing different water uses during times of supply stress. These measures should be accompanied by social safety nets like the subsidizing of water delivery for poor areas during the dry season. The net effect of these measures will be a more efficient use of water resources.

Secure Resources and Funding for Adaptation

Institutional capacity building will enable the country to secure additional sources of funding, and revenue, for adaptation efforts. The costs outlined in the macroeconomic analysis clearly demonstrate the fact that adaptation costs will require vast amounts of long term adaptation funding to radically augment human and financial resources[422]. Domestic sources are woefully deficient for providing these additional resources. It is,

[420] Postel, 99-114.
[421] Muller, 104.
[422] Ebi, 3-9.

therefore, critical that the country utilizes its institutional capacity to secure outside sources of adaptation funding.

While the NAPA process has been heavily criticized on numerous fronts, it is an important first step for the country in securing international sources of adaptation funding. By beginning this process, the country now has institutional linkages to the UNFCCC and the Global Environmental Facility (GEF). Annex II countries, like Bangladesh, party to the UNFCCC can secure adaptation funding through the GEF, which has $3 billion for climate change related activities. These funds are managed through the Kyoto Protocol Adaptation Fund, the Special Climate Change Fund, and the LDC fund. Since 1991, $1.3 billion in grants have been allocated from the GEF trust fund for climate change activities. While much of this investment has been targeted at renewable energy and energy efficiency projects, the need to earmark funds for adaptation purposes is becoming apparent[423].

In spite of the current lack of emphasis on adaptation, there are a number of reasons why Bangladesh should continue its institutional linkages to the UNFCCC and the GEF. Adaptation to diarrheal disease will require numerous efforts that align with the principles of GEF adaptation funding. For example, the GEF funds macro level measures that enhance adaptive capacity, as well as adaptations to natural climate variability that do not need to be separated from the effects of climate change. Institutional capacity building that enables the better management of dry and wet season water resources is, therefore, qualified for this funding. Furthermore, the GEF supports efforts at

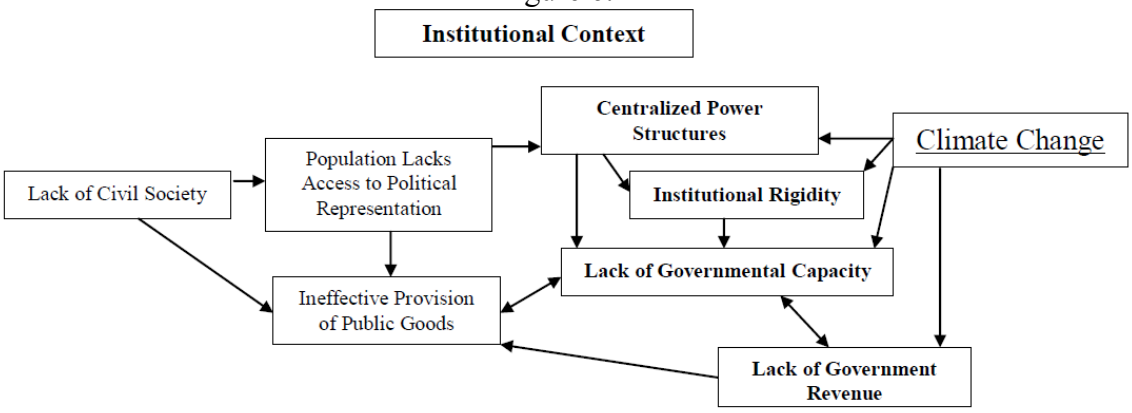
[423] Verheyen, 165.

institutional capacity building that enable the integration of adaptation goals into general policy planning[424].

In addition to these GEF requirements, a closer look at the requirements and stipulations of the UNFCCC agreement shows a number of ways for Bangladesh to secure funding. To begin with, Article 4.4 of the FCCC stipulates that Annex II parties "shall also assist developing country parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects"[425]. Article 4.8 provides a list of "specific needs and concerns" that may qualify countries as particularly vulnerable. One item from this list is the degree to which a country is prone to natural disasters. Bangladesh is irrefutably prone to natural disasters, making this stipulation of the agreement a leverage point for the country. Finally, both the SCC fund and the adaptation fund are meant to finance improved monitoring of diseases affected by climate change to improve institutional capacity. Ultimately, the ability of the country to access these sources of funding depends upon maintaining institutional ties to these processes, as well as following adaptation strategies aimed at building institutional capacity and reducing societal vulnerability to climate change[426].

[424] Verheyen, 165.
[425] *United Nations Framework Convention on Climate Change,* www.unfccc.int.
[426] Verheyen, 163-170.

Figure 6.2



Target areas for adaptation policies in bold

2)Diversify the Economy

The stability of the macroeconomic environment is a principal concern of adaptation policymaking. Macroeconomic shocks produced by reductions in rice yields, can severely affect the country's relatively undiversified economy, leading to several outcomes that will aggravate diarrheal disease. In order to stabilize the macroeconomic environment, the country must therefore diversify its economy to ensure that no single sector, or crop, is overly responsible for the welfare of the country.

Reduce Reliance On Rice Production

Crop diversification allows for more nutritious staple crops to be grown, providing reductions in malnutrition. The crops introduced must be water and saline tolerant as both of these traits will help to create robust crops in the face of climatic impacts. If the country were to diversify the $737,807,070 in losses that the midpoint

(21%) of the climate change scenario predicted for rice production, to a crop that was more climate resilient, significant savings can be achieved. For instance, if 10% of rice production (24,569,000) were diversified to another crop that has an equivalent market value, but that is sufficiently climate resilient so that it only faces reductions at the low point of this estimate (10%), the potential monetary savings would be $38,647,037 ($664,026,363 + $35,133,670=$699,160,033, $737,807,070-$699,160,033=$38,647,037). This is equivalent to 138% of the increased malnutrition costs.

A similar methodology can be applied to rice losses due to flooding and salinity. Assuming that 10% of rice production is diversified to a crop that only suffers half the losses due to flooding that rice would, the potential savings are equal to $11,472,747, or 41% of malnutrition costs. For losses due to salinity the savings would be $1,880,021, or 6.71% of malnutrition costs. The total savings of a conservative 10% diversification are 185.71%. However, if the crops chosen were a more nutritious substitute, and crop production increases decrease the cost of food, this policy would have even further positive effects on reducing malnutrition.

Reducing reliance on rice production will also stabilize macroeconomic conditions. Despite the fact that the crop is not destined for export markets, it can still increase vulnerability to currency attacks and debt obligations. The growing debt the country has incurred over recent years demonstrates the potential problem of debt overhang. Reductions in a staple crop that constitutes 94% of total cereal production would undoubtedly reverberate throughout the economy, as the other primary sectors are still heavily reliant on stable agricultural production. Significant reductions in crop yields would, therefore, create unstable macroeconomic conditions that can reduce the value of

domestic currency, as well as the value of export revenue from the readymade garment sector. Diversification of agricultural production, as well as the economy as a whole, is therefore a policy necessity.

In addition to diversifying agricultural production, the country should diversify other sectors of the economy that are reliant on agricultural products, as well as sources of income[427]. The country can achieve development of sectors not linked to agriculture through a strategy similar to that followed by the Highly Performing East Asian (HPAE) nations. These nations - South Korea, Japan, China, and Taiwan -deliberately sought out selective industrial policies that protected domestic manufacturing through tariffs, subsidies, and export promotion, while actively exacting the maximum in technological spillover effects from foreign direct investment[428]. The maintenance of tariffs will be especially important for their contribution to the incremental costs of adaptation and climate change. The country should, therefore, revise the scheduled reduction in tariffs that is currently underway.

Maximizing spillover effects from foreign direct investment is a particularly useful strategy that China has employed to great benefit. Bangladesh should follow this strategy and attract more foreign business partners to the readymade garment sector. It could achieve this by designing special economic arrangements for a specified timeframe in another city, perhaps Kulna, in order to reduce its reliance on production from Dhaka. The government must be careful to stipulate in these arrangements that human, technological, and financial resources are utilized to train the local workforce and create

[427] Kelly & Adger, 332-348.
[428] Chang & Grabel, 106-150.

technology transfer. This will allow domestic actors to continue operations once the contracts expire.

In order for this diversification to be successful, the national government must play a large role in coordinating, planning and implementing, these activities through climate cells in order to ensure that vulnerability is not increased by the promotion of climate sensitive industries. This "big push" strategy will require improvements in institutional capacity previously outlined, and should seek to promote education, infrastructure, public investment, and technological improvements[429]. Additional funding for this push can come from the GEF, which has specified economic diversification as one of its target areas for adaptation.

Adaptation Forces

As a part of economic diversification, the country should simultaneously promote Keynesian notions of full employment, aimed at implementing adaptation initiatives throughout the country. These 'adaptation forces' should be employed by local climate cells that are funded by the national climate cell. They could be charged with carrying out the activities mapped out by local climate cells in order to ensure locally appropriate adaptations, while creating a formal mechanism for attracting international adaptation funds.

For example, the country has already invested billions of dollars in disaster preparedness and afforestation campaigns. The Community Based Adaptation to Climate

[429] Chang & Grabel, 53-202.

Change through Afforestation program has already received $3 million from the GEF, or 1% of the $280 million it has distributed[430]. If the country can increase this funding to 2% of GEF adaptation funding, it could secure a further $5,600,000. This is equal to 1.3% of the total health budget. Moreover, the formal creation of these forces will help to provide a labor intensive industry that will take advantage of the fact that almost half of the population in Bangladesh is below fifteen years of age and unemployed[431].

An adaptation force can be trained in a variety of needed fields, including disaster preparedness, agricultural adaptation, and most importantly for diarrheal disease, health promotion. This population would then be considered a skilled labor force whose human capital could enable institutional capacity building. This economic diversification stands in stark contrast to traditional economic growth strategies that seek labor intensive industries due to the low cost of labor, and the inability of workers to form unions.

In relation to diarrheal disease and malnutrition in urban areas, these forces can be utilized to reduce drainage congestion and increase vegetation. The government is already in the process of recovering drainage canals from development, which adaptation forces should be employed to aid. This will reduce the severity of flooding events, thus reducing fecal contamination and diarrheal disease. Important waterworks that adaptation forces can provide are canals, tunnels and pipelines, which create water supply and offer resiliency, as multiple sources enhance the security of water supplies[432].

In addition to these activities, adaptation forces should be employed in "climate proofing" national infrastructure, particularly water and sanitation networks in urban

[430] "Financing Adaptation Action," *Global Environmental Facility,* 2007, http:gefweb.org, 5.
[431] Bangladesh State of the Environment, 10.
[432] Muller, 101-102.

areas. In the face of uncertain sea level rise three options have been put forth: protection, accommodation and retreat[433]. At a .3 meter sea level rise, protection and accommodation are the most likely options. In Dhaka, for example, future construction projects will need to be elevated in accordance with sea level rise predictions, while dikes will need to be constructed, and existing structures raised and strengthened[434]. The creation of embankments will help obstruct the penetration of surge water and greatly reduce the level of water that crests the embankments[435]. These activities must be extended to slum areas in order to reduce their high vulnerability to flooding.

These forces can further reduce diarrheal disease by providing hygiene awareness and health promotion activities in conjunction with NGOs. These measures reduce diarrheal cases by up to 45%[436], and have a profound effect on morbidity and mortality rates. Fortunately, educational interventions and adaptations are also among the most cost-effective measures for curbing morbidity and mortality related to diarrheal illness[437]. For example, hygiene education including hand washing with soap, costs a mere $3.35/DALY saved, and can lead to a 43% reduction in morbidity, as well as a 48% reduction in life-threatening cases[438]. In contrast, oral rehydration therapy costs over 300 times as much ($1,062/DALY)[439].

Cooperation between civil society and adaptation forces should also extend to the task of allocating water supplies during the dry season to poor communities that lack water

[433] Cruz et al., 491.
[434] Cruz et al., 491.
[435] Ali, 1999, 114-115.
[436] Water Sanitation and Hygiene Fact Sheet, 1-2.
[437] *Disease Control Priorities Project,* www.dcp2.org.
[438] Cairncross & Valdamanis, 1-4.
[439] *Disease Control Priorities Project,* www.dcp2.org.

infrastructure. Dry season water supplies can be further augmented in slum areas by the creation of community water storage techniques that capture and store rainfall. The design and construction of these water storage mechanisms can be facilitated by interactions between the national climate change cell, SAARC, and the UNFCCC in order to identify appropriate low cost technologies. Once these have been identified, adaptation forces, in conjunction with NGOs, can help create and deliver appropriate storage mechanisms.

A final task for adaptation forces, and one of the most immediate and useful adaptation strategies, is the protection and massive replanting of mangrove forests along the breadth of the coastal belt[440]. Replanting mangrove forests helps to reduce inundation and vulnerability to flooding events[441]. In addition, it will provide poor communities with a means of building social capital that is vital for adaptations and disaster preparedness. This activity should be augmented by raising awareness about the dangers of natural disasters, including those due to climate extremes, amongst coastal populations[442]. Hygiene awareness and hand washing could also be integrated into such programs, further increasing their effectiveness. The argument for this adaptation is all the more resounding due to the ability of forests to sequester carbon dioxide.

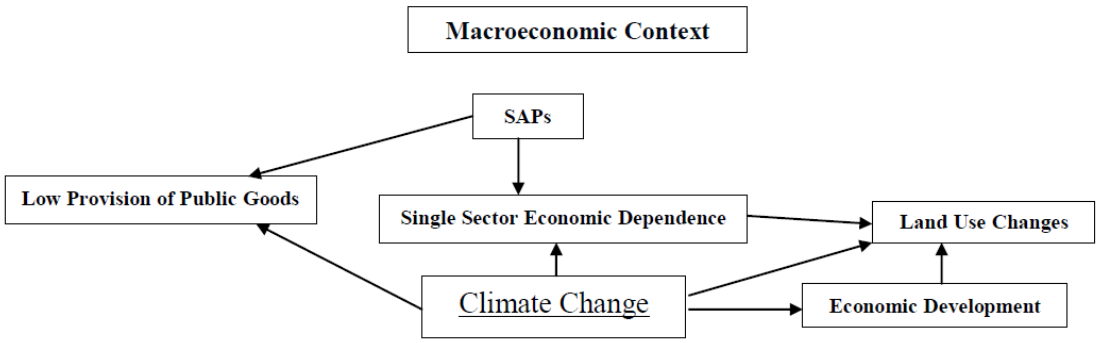
Finally, creation of these forces will reduce inequality within society as members of the adaptation force receive education and skills training that enable them to gain employment both within, and outside of, the country. The potential for these forces to provide adaptation services or other labor intensive services for developed countries is

[440] Huq and Asaduzzaman, 1-10.
[441] Huq and Asaduzzaman, 1-10.
[442] Cruz et al., 490-492.

high, and could be utilized as an informal mechanism to boost household income through remittances. The national climate cell could promote this skilled labor through the UNFCCC and other international mechanisms, as well as through the international connections of many large NGOs working in the country. The potential revenue generated by this activity is large, as remittances have amounted to $30.4 billion over the past 30 years and have been increasing by $3.8 billion annually[443].

Ultimately, adaptation forces are merely a way for the country to employ its surplus labor in the key tasks of adaptation. Due to a lack of economic opportunity, these forces do not compete with other sectors for labor needs. Moreover, they are a community-based mechanism that helps to build social capital and institutional capacity at local levels.

Figure 6.3



Target areas for adaptation policies in bold

[443] T. De Bruyn, and U. Kuddus, et al., "Dynamics of remittance utilization in. Bangladesh" (*International Organization for Migration,* 200), 2.

3)Reduce Poverty and Inequality

In order to ensure the success of adaptation, socio-economic factors affecting the country's ability to absorb or respond to changes in the natural system must be accounted for[444]. Many of the problems arising from societal inequality have a demonstrable effect on health. However health sector interventions generally do not extend to the structural drivers of poor health, namely inequality and poverty. This has led many to trumpet the cause of economic development to reduce these fundamental problems. Unfortunately, many of the programs aimed at economic development have actually increased inequality to striking levels. Ultimately, economic growth provides the opportunity to provide resources for the health sector, but without appropriate social policies, it brings no benefit to health outcomes[445].

The importance of national policy in mediating the effects of growth, and distributing them throughout society, is readily apparent in the very different health outcomes that the United Kingdom and the United States experience in comparison to Nordic countries. Nordic health improvements since the latter part of the 19th century emphasized the importance of civil, political, and social rights, as well as a commitment to universal health coverage, full employment, gender equity, and low levels of social exclusion. The result of these policies was low levels of inequality in income distribution and a telling absence of differences in living standards between socio-economic groups of society[446].

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[444] Mirza et al., 2005, 231-252.
[445] CSDH, 37-39.
[446] CSDH, 33-34.

In addition to this strong case for equality in reducing negative health outcomes, reducing inequality is a cost effective adaptation for resource constrained countries[447]. Decreases in inequality that lead to reductions in the under five population suffering from moderate and severe malnutrition which is currently 46% to a realistic 36% would decrease the annual costs of treating malnutrition by $38,283,600. A similar decrease in the 244,000[448] under five deaths that occur every year would also lead to significant savings. If the current 20% deaths due to diarrheal disease were reduced to 10%, the lives of 24,400 children would be saved and the country would save $1,659,200 annually. The total savings for these policies would be 13.5% of the total health budget. These calculations are likely to be extremely conservative as only mortality is accounted for in relation to diarrheal disease. In addition, disease burden reductions are taken in isolation despite the fact that reductions in malnutrition would likely affect diarrheal rates and vice versa. Therefore, it is essential that adaptation strategies address inequalities in health outcomes that are direct results of systems that distribute power and resources at unequal levels throughout society. These systems must be challenged, and ultimately restructured, if the many complex pathways that affect diarrheal disease are to be addressed and societal resilience increased[449].

This echoes the conclusion of the WHO's commission on the social determinants of health. The commission found that the improvement of the daily conditions of life, and the tackling of the inequitable distribution of power, money and resources that are the structural drivers of those conditions of life, are the key principles needed in order to

[447] Bangladesh State of the Environment, 23.
[448] *United Nations Children's Fund,* www.unicef.org.
[449] Kelly & Adger, 332-348.

rectify social health inequities[450]. In slum areas these conditions have created horrific living situations, as a result of their exclusion from basic public goods, a lack of economic opportunity and income, high population density, and their location in relation to natural disasters. For true adaptation to occur, Bangladesh must address inequalities at all levels of society.

The diversification of the economy through the use of adaptation forces can begin the process of vulnerability reduction. However, in order to sustain it, longer term goals require increased investments in education, along with national policies that regulate the accumulation of power and resources. This is not an argument for a centralized communist state; merely, it is the logical acknowledgement that concentrations of power and wealth tend to reinforce themselves at the expense of society as a whole[451]. Therefore, economic development should be pursued, but with a socially-oriented development policy, created by state institutions and marked by high levels of human capital, which seek to harness the positive side of economic development and distribute it more or less equally to all members of society. Polices such as these, which challenge the causes of the mal-distribution of resources, will lead to poverty reduction and the promotion of collective security; thereby reducing societal vulnerability to climate change[452].

[450] CSDH, 26.
[451] Todaro, 209-273.
[452] Kelly & Adger, 332-348.

Education

The country's 2005 NAPA identified the mainstreaming of climate change adaption into policies and programs in the health sector, as well as the inclusion of climate change issues in the curricula at secondary and tertiary educational institutions[453]. The full cost of the two strategies was estimated at $1.5 million with the design phases accounting for $50,000[454]. These two strategies were among the most cost effective of all the strategies proposed by the NAPA team. They underscore the importance of education and awareness in combating the deleterious effects of climate change on human health.

These policies should begin with holistic education efforts that include health messages, such as hygiene education and nutrition awareness, but that also stress the basic educational achievement of literacy. Recent studies in Dhaka suggest that educational activities that focus on the promotion of hygienic environmental conditions are desperately needed in combination with income generating opportunities, in order to reduce the burden of child mortality[455]. The current adult literacy of 54%[456] is simply unacceptable, and greatly increases the burden of disease associate with diarrhea, as well as societal inequality.

Educational efforts linked to adaptation must avoid the same pitfalls that vertical programming of climate change efforts in national ministries faces. One of the most serious pitfalls is the possibility of achievements in one sector being wiped out by failures in another. If education does not provide a means for relieving poverty and inequality,

[453] Bangladesh NAPA, Ministry of Environment and Forests, 23-42.
[454] Bangladesh NAPA, Ministry of Environment and Forests, 23-42.
[455] Hussain et al., 5.
[456] *United Nations Children's Fund,* www.unicef.org.

then the positive effects of hygiene awareness and hand washing are nullified. Education must therefore be provided on an equal basis to all urban and rural areas.

Educational efforts promoted by the government should also be linked to the work of civil society actors in order to rectify rural/urban inequities. NGOs have done a remarkable job in providing public services to rural areas, however urban areas have been neglected. Government and civil society efforts must, therefore, be aligned in order to rectify this imbalance. Improving efforts in slum areas would greatly reduce the burden these populations bear from poor environmental conditions, a lack of health care facilities, and a lack of general knowledge on the origin of sickness and proper treatment methods[457].

The current relative risk of under-five mortality for those with no education in relation to those with secondary education is 1.667[458]. Educating slum and urban poor populations regarding the cause of diarrheal disease as well as proper hygiene is therefore a fundamental adaptation to climate change. Shastho Shebika is an example of an NGO sponsored program that could utilize such interventions to immediately improve the health of the urban poor. The BRAC sponsored program sends health volunteers door to door in poor communities to treat and recognize ten of the most dangerous, and common, diseases in Bangladesh[459]. While the volunteers provide a desperately needed service, they receive no salary, earning income solely through the sale of essential health commodities, such as drugs, contraceptives, birth delivery kits, iodized salt, hygienic

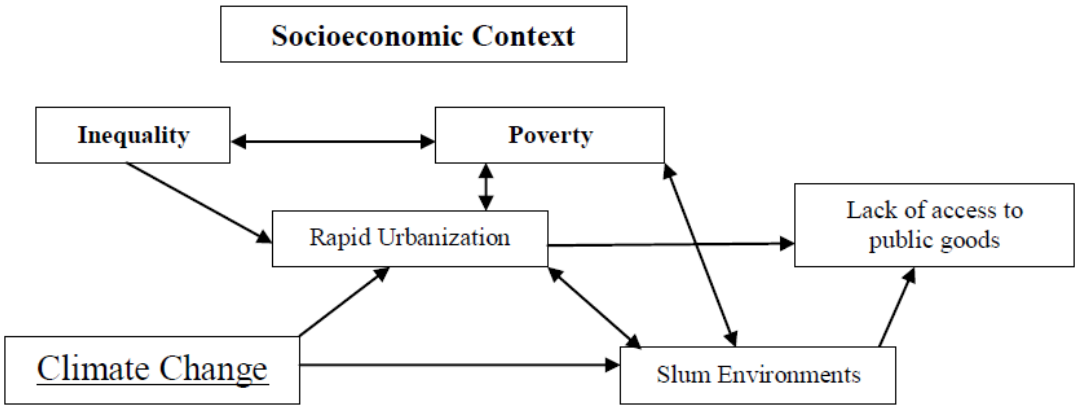
[457] Hussain et al., 5-6.
[458] *Stat Compiler,* www.statcompiler.com.
[459] Patel et al., 2007, 51-59.

soap, sanitary napkins and vegetable seeds[460]. With government or donor assistance secured through climate change adaptation funding, programs such as these could become entirely subsidized public goods provided to poor communities.

In addition to educational efforts that specifically target health promotion and diarrheal disease, urban areas will benefit in the long-term from educational efforts that build human capital, thus enabling a reduction in vulnerability by providing political empowerment. Urban poor and slum communities must be empowered to participate in decision making processes at local levels of government. Their exclusion is a large reason they lack access to education, health services and water and sanitation networks in the first place. Increased levels of education and awareness about these issues can provide a means for them to effectively participate in lower levels of government and demand property rights for informal settlements[461]. This, of course, is linked to institutional capacity building and reductions in corruption, again demonstrating the need for a "big push" strategy that enables many of these adaptations to occur simultaneously.

[460] Patel et al., 2007, 55.
461 Tanner et al., 5-9.

Figure 6.4



Target areas for adaptation policies in bold

4)Reduce Problems Associated With Urbanization

Improve Urban Environments

One of the most direct influences that local governments have on vulnerability is through their provision of water, sanitation, drainage, solid waste collection, and public health improvement[462]. The risk of diarrhea is greatly enhanced in the absence of these efforts, as it heavily depends on improved environmental sanitation, hygienic practice and medical treatment facilities[463]. An analysis of 144 studies showed that by improving water quality and sanitation, child mortality fell by 55.5%[464]. Cost-effective adaptations to these environmental health threats in Bangladesh can save as much as 3.5% of GDP[465].

462 Tanner et al., 5-9.
463 Cruz et al., 478.
464 Hussain et al., 6.
465 Patel et al., 2006, 15.

Adaptations focused on improving the allotment of these goods are therefore necessary[466].

Nearly all future vulnerability will result from the increasing occurrence of climate related hazards already well known in Bangladesh, including floods, and cyclones[467]. These events will likely have significant impacts on sewage and water infrastructure that will lead to further fecal contamination. Cost-effective arguments are difficult to make as infrastructure requires large sums of capital that provide future benefits. Improving the existing sewage and drainage system in Dhaka alone is projected to cost about $100 million[468]. However, the total economic cost of the poor management of water resources in Dhaka is estimated at $670 million annually, including its impacts on human health[469]. Therefore "climate proofing" infrastructure for the delivery of sewage and water by funding improvements in current infrastructure, as well as providing more stringent guidelines regarding the construction of future lines, is not only needed, but cost-effective.

Improving urban environments is integrally linked to institutional capacity. In well governed cities drainage structures that greatly reduce the severity of flood events can easily be built into existing urban environments. In poorly governed cities where urban planning and the enforcement of zoning laws does not occur, buildings and infrastructure are often located in areas that disrupt drainage channels and increase the

466 Bangladesh NAPA, Ministry of Environment and Forests, 8-18.
467 Bangladesh NAPA, Ministry of Environment and Forests, 8-10.
468 Patel et al., 2006, 32.
469 Patel et al., 2006, 32.

severity of flooding[470]. The ability of local levels of government to provide these services is hampered by a lack of financial resources and power. This is often exacerbated by international donors and development banks that reinforce the power of national governments by moving resources through a centralized national government[471]. In order to rectify this situation, local levels of government must be strengthened to improve the provision of vital public goods by creating, and securing, channels that allow resources to flow from national to local levels more effectively. The creation of climate cells at each level of government will help to provide one level of resource and communication flow. This, however, must be augmented with a formalized mechanism for communication and resource transfer that can be greatly aided by internet and communications technologies.

Adequate resources allocated to local levels are only one side of the problem faced by municipal governments. In Dhaka, interviews conducted by the World Bank with donors, government agencies and NGOs revealed three major constraints to providing public services to slum areas: a lack of government policy giving slum residents rights and access, the eviction of slum residents, and the role of maastans in the absence of formal government structures. These interviews reveal the fact that local governments, bolstered by increased resources, must address the weaknesses of existing urban planning efforts that create societal vulnerability. In many cases existing laws are not enforced due to a lack of institutional capacity and oversight. Enforcing these planning laws would restrict the further exploitation of slum communities by providing them with property rights and formalized access to water and sanitation networks.

470 Tanner et al., 5-9.
471 Tanner et al., 5-9.

However, in many urban areas, slum communities do not fall within municipal boundaries. It is, therefore, critical to redraw these boundaries to include slum areas[472].

Issues regarding access are of paramount importance as the creation of infrastructure will do nothing to reduce the under-five mortality rate if poor communities cannot access its benefits. In order to ensure equitable access, local governments should implement a policy of urban poverty reduction that provides the mandate for working in slum areas[473]. This must be closely followed by the strengthening of the role of local municipalities to deliver services[474]. In fact, by integrating this policy with the advocacy of lower connection charges, and continued surveillance of drinking water, for only $46/DALY dramatic improvements can be achieved[475].

To help achieve this pro poor strategy, the country should engage multiple actors to help provide services to low-income communities in urban and rural settings. Civil society actors are the obvious target, however much of the vulnerability in urban areas is created by private sector actors that operate without supervision from the government. Therefore, public-private partnerships (PPPs) that help to create urban infrastructure in a sustainable manner are vital to any adaptation strategy. These partnerships have historically been accused of being antidemocratic and excluding already marginalized urban groups[476]. This does not mean they should not be utilized, it merely means they must be improved. It is not possible to address the structural drivers of negative health outcomes without engaging the actors who are helping to create these outcomes. Again,

472 Patel et al., 2007, 56-62.
473 Patel et al., 2006, 82-89.
474 Patel et al., 2006, 82-89.
475 *Disease Control Priorities Project,* www.dcp2.org.
476 Tanner et al., 5-9.

the success of these partnerships depends greatly on the ability of poor groups to access local levels of government and demand their rights. It also depends on the ability of local levels of government to secure adequate resources and human capital to improve regulation of municipal partnerships and activities.

An example of a current strategy that could be tailored to fit these policies is the Dhaka governments' implementation of a pro-poor strategy for water and sanitation that began operation in 2005. The program identifies extremely poor households based on a set of eligibility criteria and provides a generous subsidy for the installation of water and sanitation services. The program mandates that drinking water facilities provide 20 liters per-capita per-day, and that the water source should be within 50 meters of households[477]. Households are expected to contribute 50% of what non-poor households would contribute to a government project of this magnitude, with a cap of Tk. 500[478]. Despite the good intentions of the program, there is a distinct lack of attention given to the urban poor, as rural populations receive the majority of its benefits. Given the tremendous rates of urbanization, along with climate change impacts specific to urban areas, programs such as these desperately need to adapt, in order to assure equitable access to vulnerable populations.

477 Patel et al., 2007, 58.
478 Patel et al., 2007, 58.

Strengthen Rural Livelihoods

Recognition of the broader drivers of diarrheal disease necessitates a focus on sustaining rural livelihoods, as well as improving urban areas. Urbanization in the country is driven by rural poverty caused by an unsustainable rural economy that has witnessed an extreme contraction in the rights of the majority of the peasantry[479]. Grameen Bank and BRAC have made laudable progress at improving rural livelihoods; however, it has not helped to reduce migration to urban areas. Without concrete achievements at stemming the rural push factors driving migration, the possibility of climate induced drought driving higher levels of migration is very likely.

However, previous studies have highlighted the fact that migration still greatly depends on the socio-economic status of those concerned. A study in Northern Ethiopia found that people residing in marginal regions have developed a great variety of adaptation mechanisms that strengthen their ability to respond to slow climatic changes as well as extreme climatic events[480]. It is therefore important to compliment this ability through adaptation efforts that improve land tenure rights, reduce concentrations of land in rural areas, and provide insurance schemes for subsistence farmers negatively affected by environmental or economic stresses.

Micro-finance institutions and international donors have focused much of their efforts on the alleviation of poverty by allocating resources to labor abundant sectors and activities. They have provided training and credit support for the landless in rural areas as the impoverished nature of rural inhabitants is primarily due to limited access to land and

479 Mirza et al., 2005, 231-252.
480D. Kniveton, and K. Schmidt-Verkerk, et al., "Climate Change and Migration: Improving Methodologies to Estimate Flows," *International Organization for Migration*, 2008), 33-34.

agricultural technology. While income generation is important, the primary focus of rural adaptation efforts should be restructuring of land tenure rights and access. This will help to reduce concentrations of land and resulting inequalities in income and health.

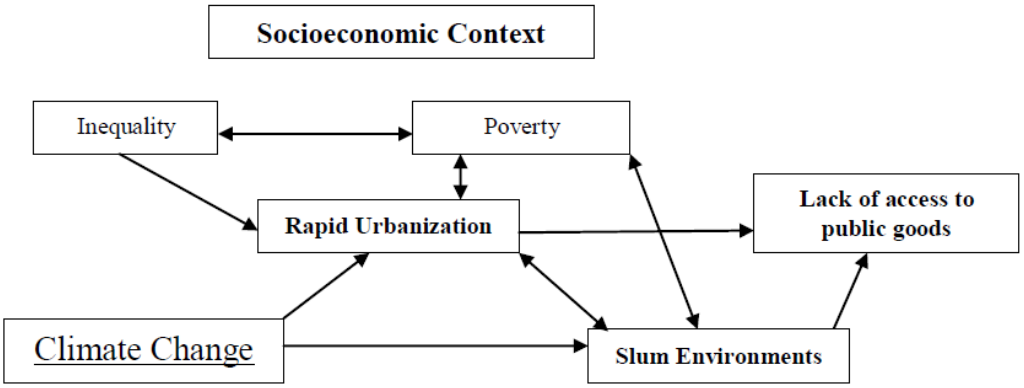
Providing the rural poor with better access to land is a difficult task that requires basic educational initiatives in order to increase literacy, as well as educational initiatives that empower the poor to participate in political processes. As levels of educational attainment are very low in rural Bangladesh, the countries climate cell should establish a primary level educational curriculum that not only educates the rural poor on the dangers of climate change, but empowers them through literacy training and awareness-raising on their ability to participate in local levels of political decision making.

In addition to these efforts, the country must introduce a comprehensive rural insurance scheme that covers the poor in case of crop failures. As migration has been shown to be linked to the need to cover debt obligations incurred in the dry season due to reductions in crop yields, such a scheme will help mitigate urban migration. Insurance schemes have been mentioned by numerous authors in relation to climate change and should be an integral component of climate change adaptation for the country. Knowledge and enrollment of the schemes should be linked to primary level education activities in order to maximize coverage.

Both of these activities must be undertaken in partnership with civil society actors who have proven to be very effective in reducing poverty in rural areas. In particular, Grameen bank would be an important partner as it already has an educational program that promotes 16 principles that are integrally linked to the promotion of health. The bank already benefits from a special relationship with the government that allows it to operate

as a nonprofit organization, despite the fact that for all intents and purposes it is a bank. It is, therefore, a prime candidate for partnership efforts. By partnering with the bank, the national climate cell can more effectively and efficiently reach the rural poor through the community groups the bank has already formed for lending purposes[481]. Ultimately, these partnerships will enable the resource constrained government to carry out adaptation activities that would be impossible without the aid of civil society.

Figure 6.5



Target areas for adaptation policies in bold

Table 6.1: Selected Adaptation Policy Savings

Impact	**% savings of Malnutrition costs**	**% savings of Health Budget**	**% savings of Diarrheal Disease costs**
Rice Production Diversification	185.71%	12.5%	
Reductions in Inequality	136%	13.5%	23.5%
Secured International Funding		1.3%	79.22%
Total	321.71%	27.3%	102.27%

481 *Grameen Bank,* www.grameen-info.org.

Chapter 7: Conclusion

Bangladesh vividly demonstrates that vulnerability to climate change arises from a complex web of biophysical, social, and economic forces[482]. Access to water and sanitation, health care, and education, all hallmarks of development efforts, can help cost-effectively mitigate these forces, and provide demonstrable benefits to the population. However, despite the potential benefits these public goods can provide, traditionally advocated public health interventions do not have the ability to respond to the coming storm. In order to respond to the magnitude of climatic impacts, adaptation policies have been advocated on the principle that reducing societal vulnerability to climate change is the most effective adaptation response to climate change. This offers Bangladesh a no-regrets solution, as even in the absence of climate change impacts these policy proposals yield substantial benefits to society.

Traditional health interventions based on cost-effective criteria may be beneficial in the short-term; however, such actions undermine sustainable achievements if economic rationales that focus on short-term cost-efficiency are not eventually revised. Moreover, the long-term destructive nature of industrial activity presently dictated by economic expansionism helps to create the overwhelmingly poverty experienced by the developing world. In the long run, the short-sightedness of this economic paradigm will destroy the

482 Bangladesh NAPA, Ministry of Environment and Forests, 8-18.

basis of human health and well-being in slum, and urban elite populations. The necessary investments for adaptive and sustainable future outcomes simply do not equate with this world view.

While it is very easy to make moral decrees on the equity of human life, there can be very real barriers to implementing this equity. A lack of resources has left many countries in the unenviable position of using cost-effectiveness as criteria for saving and improving lives. However, social and economic forces that create inequality are the result of a set of interactions created by society that define class structures and income levels. It is these factors that have been viewed throughout history as immutable, and yet provide perhaps the most effective means of adaptation for low-income countries such as Bangladesh.

Social, political, and economic equality resulting from structural changes and mandated policies, can be viewed as perhaps the most effective low-cost solution. It strictly monetary terms, altering the social and political interaction between humans that creates poverty, morbidity and mortality can cost nothing. However, it is very costly in terms of social and political organization that will be needed to overcome powerful entrenched interests that block meaningful systemic reform. Ultimately, adaptations that are realistic and cost-effective almost to a fault, are ineffective as structural problems of inequality and poverty persist and worsen. Only solutions that reflect the wisdom of committed and sustained systematic reform that creates equality within, and between, nations will render the global community as strong as its weakest link. Adaptation policy does not therefore require moral indignation, but a pragmatic understanding of reality.

Convincing policymakers of the wisdom of this pragmatism is difficult as societies tend to be reactive. Nowhere is this more obvious than the gulf between talk and action in mitigation as evidenced by the many scathing critiques of the Kyoto approach. However, in the case of adaptation, inaction is more aptly described as a yawning chasm. As policymakers begin to face the harsh reality of impending climate change, implementation becomes *the* challenge facing adaptation. It can not wait as politicians, business interests, and lawyers iron out the details of complex international treaties that avoid the underlying causes of the crisis.

What is more dramatic and disconcerting is the institutional inertia present in the developed world, which is largely responsible for the emissions and lifestyle that has created the crisis. If the focus of mitigation and adaptation efforts remains centered on proximate rather than underlying causes, even the best-case scenarios for implementation of adaptation efforts in undeveloped countries will prove ineffective as extreme scenarios become reality. Adaptation required for these scenarios requires a level of courage that no nation on earth has shown the courage to implement.

Sadly, the ability of humanity to adapt is highly questionable. The underlying state of environmental degradation outside the realm of climate change, largely ignored in the policies and programs implemented by nations around the world, is a direct result of the increasing gap between humanity's development and the wisdom needed to properly guide that development. This gap is what simultaneously drives human relations that leave the bulk of humanity struggling to survive on less than $1 a day. Morally this is reprehensible, however in pragmatic terms of the continued existence of a society or civilization, it is ignorant and shortsighted to a degree that is inconceivable. Effective

adaptation, as with all policies, requires a wisdom which humanity has not yet proven itself capable of wielding.

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