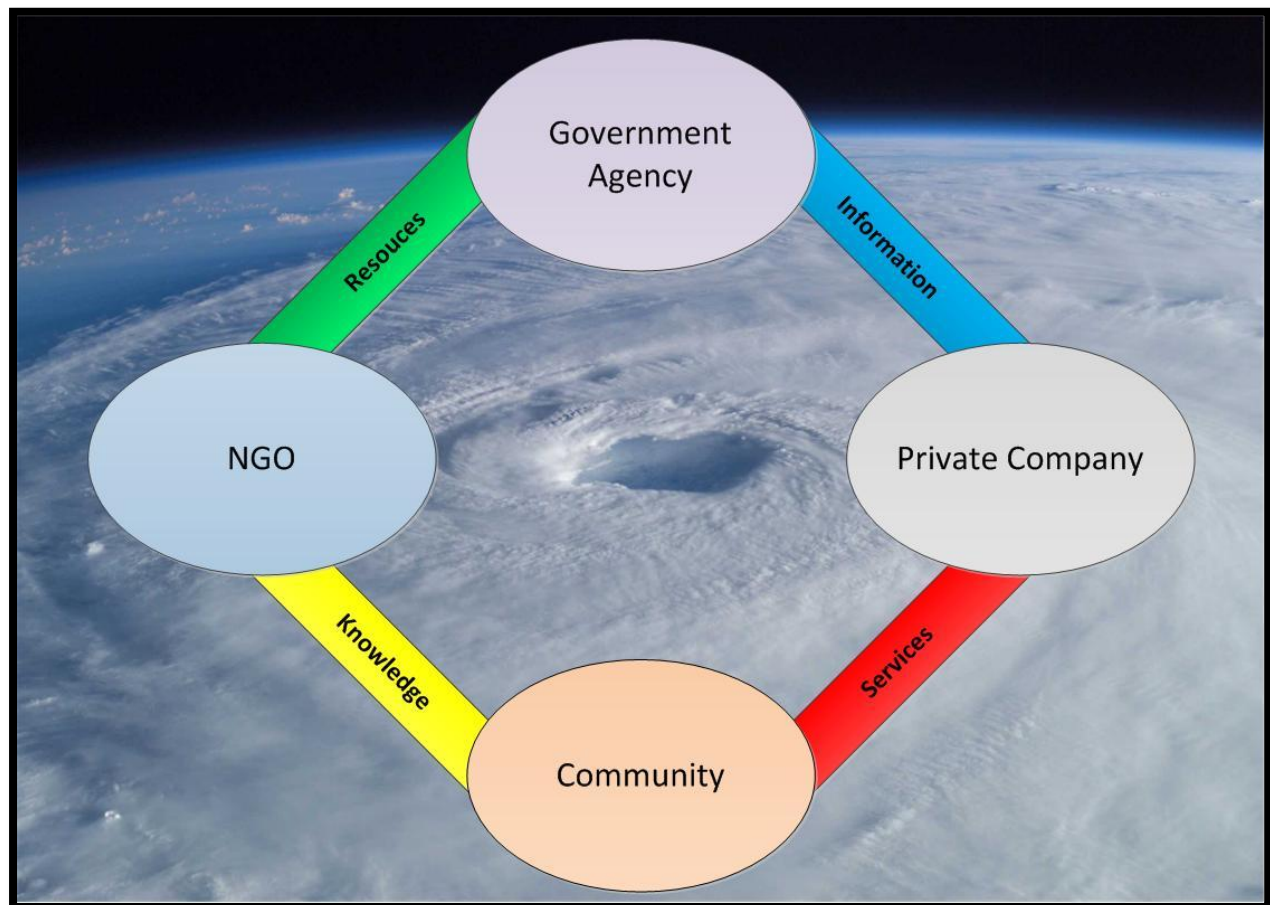


The Resiliency Web

How social-ecological resiliency networks can foster environmental justice in natural disasters



Cover photo:

Photograph: Hurricane Isabel from International Space Station 2003

Diagram: Resiliency Web framework *Source: Author*

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Abstract

There are considerable research gaps examining environmental justice in relation to natural hazards. Lower income is usually linked with natural hazard vulnerability due to its correlation with a lack of resources, services and political representation. Top-down disaster management structures can exacerbate these vulnerabilities. This report examines the theoretical concepts of environmental justice, vulnerability and resiliency and applies them to two case studies. The first case examines Hurricane Katrina in 2005 and the social issues and governance structures that led to the disaster situation which occurred in New Orleans. The second case examines disaster risk reduction projects ongoing in coastal Bangladesh involving stakeholders from the public and private sector distributing capital to vulnerable communities in a co-managed and bottom-linked governance structure. These streams of capital distribution are examined in what the author refers to as *RISK Pathways*, RISK standing for Resources, Information, Services and Knowledge. This form of disaster governance forms a resilient web of distribution channels into a social-ecological network, what the research calls a *Resiliency Web*. The *RISK Pathways* and *Resiliency Web* are used as a new framework for disaster governance that could help strengthen resilience of vulnerable communities.

Keywords: Disaster, Environmental Justice, Vulnerability, Resiliency, Governance, Capital, Social-Ecological Systems, RISK Pathways, Resiliency Web

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Abbreviations

RISK – Resources, Information, Services and Knowledge*

MDC – More developed country

LDC- Less developed country

IPCC – Intergovernmental Panel on Climate Change

HPI – Health Policy Institute

PAR – Pressure and Release Model (Blaikie et al. 2003)

SoVI – Social Vulnerability Index

DROP – Disaster Resilience of Place model

SES – Social Ecological Systems

FEMA – Federal Emergency Management Agency

CPP – Cyclone Preparedness Program

BWDB – Bangladesh Water Development Board

DRR – Disaster Risk Reduction

CMDRR – Community Managed Disaster Risk Reduction

NOAA – National Oceanic and Atmospheric Association

NGO – Non-governmental organization

PDRA – Participatory Disaster Risk Assessment

PMEL - Participatory Monitoring, Evaluation and Learning

WDMC – Ward Disaster Management Committees

UDMC – Union Disaster Management Committee

WASH – Water, Sanitation and Hygiene

TNO – The Netherlands Research and Technology Organizations

IVP – Information Value Provider

1. A Changing View of Natural Disasters

Natural disasters have long plagued human civilizations. The word *disaster* immediately invokes images of human tragedy, loss, despair and grief. The etymology has its origins in the unknown and unexplainable, describing supernatural forces beyond human control and comprehension. The word originates in Latin, referring to a celestial body in a negative way. *Dis* is the Latin prefix negating something or referring to an opposite, while *-aster* comes from *astro* meaning star (Murria 2004). This refers to the negative influence of a star, planet or other celestial body on events happening on earth. For example, the sudden appearance of a comet was seen as an omen foretelling great misfortune for people back on earth. These misfortunes were seen as a punishment by the gods for human arrogance and the sins of civilization. Today, this type of notion is seen as preposterous, the early attempts of primitive societies to understand and explain the unexplainable. However, maybe these early explanations aren't as preposterous as we might believe. Natural phenomena such as tropical cyclones are the result of natural forces but they can quickly become a disaster when they intersect with a society that is not resilient enough to absorb the impact. Sen (2009) writes "a calamity would be a case of injustice only if it could have been prevented and particularly if those who could have undertaken preventative action had failed to try" (p. 503). Many natural disasters could be avoided with proper preparation and response. To some degree, natural disasters could be seen as punishment for human arrogance. In some cases, it could be argued that they are a result of a lack of justice for vulnerable communities who are forgotten by those with the capacity to act.

Natural disasters are extremely prevalent in coastal zones around the globe. These areas generally face a multitude of hazards, including cyclonic storms, flooding, tsunamis and earthquakes. Historically, humans have settled in coastal areas due to their proximity to water and the open sea for trade opportunities. This trend is even more prevalent today; humans have been migrating to coastal cities at an unprecedented rate over the course of the past century (UN Habitat 2012). The rapidly increasing population and urbanization of coastal zones combined with the geographic vulnerability of these areas to multiple hazards creates a social-ecological relationship that could easily harbor a disaster scenario. Of these hazards, tropical cyclones are one of the most destructive and dangerous. A tropical cyclone can bring with it heavy rains, strong winds, storm surges and flooding (ADPC 2008). As scientists warn us about an impending increase in the frequency and intensity of tropical storms due to climate change, the world must adapt and determine how to live with these natural phenomena. In the natural world, tropical cyclones are immense and powerful storms that showcase the power of our planet's weather systems. In the human world, these phenomena are dangerous hazards and can quickly become disasters depending on how they affect our infrastructure, societal

framework and livelihood. “Disaster marks the interface between an extreme physical phenomenon and a vulnerable human population” (O’Keefe et al. 1976). But what exactly makes a human population vulnerable to these hazards, and how do these hazards become a disaster?

The idea of what a disaster is has changed historically as humans have attempted to understand how and why they occur. Furedi (2009) describes these shifts in thinking in three stages. More traditional cultures viewed disasters as *Acts of God*, thinking that the natural event was retribution for human arrogance. This can be seen in the etymology of the word described earlier and its origins in the Romance languages (Murria 2004). As society progressed and we understood more about the natural world, these events became *Acts of Nature*. Slowly, this idea that disasters are solely the cause of natural events is being replaced by the idea that they are resulted from *Acts of Men and Women*. More specifically, they are the result of the societal system in place and that system’s interaction with the extremes of the natural environment.

Elliot and Pais (2006) point out that natural disasters give us a rare glimpse of social identity and resource disposal, showing how society consists of “overlapping subsystems cross-cut by social and economic inequalities” (p. 296). When a disaster strikes, different sections of society are affected and respond differently based on their access to certain societal assets. The intensity of a tropical storm’s impact can vary, but it seems to be common case around the world that poor and marginalized communities suffer drastically more devastation. Because of lower financial assets and political influence, some areas lack proper resources, information, services and knowledge that would provide protection from tropical storms. This is not only evident in the less developed countries (LDCs) of the Global South, but also the more developed countries (MDCs) of the Global North. This observation will be explored more thoroughly in this research by looking at two case studies. The first will be Hurricane Katrina and its impact on the Gulf Coast of the United States, particularly New Orleans. The other case study will look at the current situation in Bangladesh in terms of tropical cyclones and disaster preparedness.

1.1. Highlighting Injustice in Hurricane Katrina

When Hurricane Katrina made landfall in 2005 on the Gulf Coast of the United States, the impact was heard nation-wide. The category three hurricane struck southern Louisiana and Mississippi on August 29th with sustained winds measuring about two hundred kilometers per hour and extending one hundred and seventy kilometers from the center eye wall (Fritz et al 2007). The unusually large storm brought with it a massive storm surge measuring seven to nine meters (Irish et al. 2008) that quickly moved towards New Orleans. As the hurricane entered the area around the city, the storm surge rode up the channelized waterways from Lake Borgne and struck the levees on the Industrial Canal, eventually collapsing them and flooding 80% of the city (Morse 2008). Most of these areas were poor with a predominately

African American population. Some of the poorer neighborhoods such as the Lower Ninth Ward were nearly destroyed while more affluent, white areas of New Orleans were spared most of the devastation (Morse 2008). The initial destruction of the hurricane and the subsequent governmental response highlighted the racial and class disparity that has been embedded in the social framework of New Orleans and the Gulf Coast for centuries (Eliot & Pais 2006; Morse 2008). In addition to the systemic social issues, Hurricane Katrina also highlighted how centuries of development and damming along the Mississippi River has drastically reduced wetlands in the Mississippi Delta and barrier islands along the Gulf Coast, both of which act as a buffer against coastal storm hazards (Travis 2005). Hurricane Katrina had an enormous impact on the United States, a country consistently battered by hurricanes year-after-year.

Normally, when a major natural disaster hits the United States or other more developed countries the destruction is measured in financial costs, often reaching billions of dollars. This seems to outweigh the number of deaths which rarely measure more than a dozen. However, Hurricane Katrina had an official death toll of over one-thousand people (Gabe, 2005). This number is often disputed because of context and time at which citizens may have died. In the media reports and the articles describing the hurricane, the death toll is the primary focus of the destruction, which is usually the method of reporting on natural disasters in less developed countries.

1.2. Cyclones in Bangladesh: An apex of vulnerability

The tropical storms of the Eastern Hemisphere are equal in size and strength to the tropical storms of the Western Hemisphere. However on average the loss of human life is much higher. Bangladesh in particular has the highest amount of deaths from natural disasters out of any country on the globe. Cyclone Gorky, which struck Bangladesh in 1991, killed an estimated 138,000 people. Although the death toll from this cyclone is staggering, it was not unexpected. Since 1960 nearly a million people have been killed as a result of eight different cyclones striking the vulnerable country, including Cyclone Bhola in 1970 which killed an estimated 500,000 people (Paul 2009). In response to the damage and loss of life a sophisticated early warning system became established and over three hundred large cyclone shelters with an estimated capacity of nearly 350,000 were built. Despite these efforts to improve disaster resistance the country remained highly vulnerable. Cyclone Gorky struck the coast fifty kilometers south of Chittagong on April 29, 1991 with sustained winds of two hundred and fifty-five kilometers per hour and a six meter storm surge. Even with the presence of an early warning system and the cyclone shelters the main factors contributing to the high mortality rates were the types of housing and the ability to seek adequate shelter in time (Bern et al. 1993).

The drastic loss of life demanded an immediate improvement of disaster preparedness and management in Bangladesh. On November 15, 2007 Cyclone Sidr made landfall on the southwestern coastal areas of the country with wind speeds of two hundred and forty-eight kilometers per hour and a storm surge of five to six meters (Paul 2009). Improved measures such as a better early warning system and improved emergency shelters created a more resilient situation and drastically reduced the number of lives lost. The official death toll caused by Sidr was 3,406; however the death toll was expected to be much higher (Bhuiyan 2008).

With a major decrease in fatalities between Gorky and Sidr, the government sponsored cyclone preparedness programs could be seen as a success. However, with the loss of life ranging in the thousands, there is still much room for improvement. Coastal Bangladesh is still a highly vulnerable area.

1.3. Becoming a disaster

There could be several systemic factors that increase the vulnerability of communities facing tropical storm hazards. The development of housing in flood-prone and vulnerable areas, the failure to provide adequate flood protection infrastructure or developing proper evacuation routes and services, the lack of public participation in local disaster management strategies, the destruction of ecological areas that act as buffers to coastal hazards can all increase vulnerability (Adger 2006, Travis 2005, Zamore 2008). These are factors that exist in both the developed and developing world, and all could be linked to the theory of environmental justice.

How does the notion of environmental justice tie into disaster management? In the United States, Hurricane Katrina highlighted historical settlement patterns of poor African Americans in and around New Orleans that left them exposed to flooding and other elements. An inadequate emergency response by the state and federal governments left thousands of survivors, mostly poor, stranded in a broken city. The injustices have been well documented in several governmental reports and third-party research. But what are the injustices present in Bangladesh, one of the more vulnerable countries in the world? In some of the districts on the coast nearly 50% of all families live below the poverty line (Government of Bangladesh 2008). Is the lack of emergency services and infrastructure a fault of the Bangladesh government? It could be the consumption patterns and excesses of the industrialized nations in Europe and North America; their contribution to global pollution and climate change far outweighs the contributions of less developed countries. Is it the responsibility of the wealthier and more developed nations of the Global North to provide services to the South that could protect them from the elements they have in theory exacerbated? Reviewing once again what was said by Sen, “a calamity would be a case of injustice only if it could have been prevented, and particularly if those who could have undertaken preventative action had failed to try” (2009, p. 503), it would seem that providing services to these nations would in theory be a just act.

Rectifying these injustices would entail undertaking actions that allow for communities to mitigate, absorb and recover from the impact of natural hazards such as tropical storms. However, this research argues that relying solely on governmental bodies is not the most efficient and effective way to foster resilience. Instead, a new strategy is analyzed that establishes relationships across different public, private and community sectors. This strategy crafts resilience in a unique way that could protect and empower even the most disenfranchised and vulnerable communities.

1.4. Research Aims

Why does the destruction from similar natural phenomena affect different people from different backgrounds so drastically? It is obvious that the circumstances surrounding each storm are different, but there are specific conditions and factors which could change the severity of the impact from each storm.

This report argues the main factor is the socio-economic framework of areas affected by natural disasters. This argument is supported by examining vastly different, but in some ways similar case areas. The first being the Gulf Coast of the United States, particularly New Orleans, and the destruction caused by Hurricane Katrina in 2005. This case will be used to highlight how socio-economic factors can influence how a community is affected by natural hazards and show an example of a top-down disaster management framework. The second case area will be the coastal area of Bangladesh. Known to be both geographically and socially vulnerable to natural hazards, Bangladesh is one of the most vulnerable countries in the world. Because of this, international organizations and companies have been cooperating with local and government authorities in Bangladesh to strengthen resilience at the community level. Using the example of the government structures and disaster management strategies that contributed to the disaster situation in New Orleans during Hurricane Katrina, we'll use the examples from Bangladesh provided in the research to show an alternative and more resilient disaster management framework.

The choice of cases in this report is not meant to be a comparative analysis. They will be used to examine the vulnerability of low-income communities to natural hazards in both more developed countries (MDCs) and less developed countries (LDCs). After examining the environmental injustices in both of these cases, this paper will attempt to establish a framework for a reduction of disaster risks through smart resilient strategies and strong social-ecological networks. The hope would be to bring global environmental justice to the forefront by showing that environmental injustices exist everywhere regardless of a designation as a rich or poor country. In addition the research will try to improve methods in lessening the impact of natural hazards to vulnerable communities.

The recent Intergovernmental Panel on Climate Change (IPCC) report on managing natural disasters references sufficient research gaps in advancing social and environmental justice at the local scale in both developed and developing countries (Field et al. 2013 p. 320), the post-disaster rehabilitation of livelihoods (Field et al. 2013 p. 301) and improved risk communication between governments and communities (Field et al, 2013 p. 304). The theories and case studies examined in this report will address each of these research gaps. By examining traditional top-down framework for disaster management, we can tie the issue of environmental justice to disaster vulnerability. This governance structure can lead to disparities among communities depending on income and social status. A major focus of this research will be to examine how this style of governance has led to environmental injustices and how these injustices can be lessened or removed through the establishment of social-ecological resiliency networks among various stakeholders.

1.5. Research Questions

The argument of this thesis is that natural hazards such as tropical hurricanes and cyclones can quickly become disasters through socio-economic inequalities.

The main research question asked in this report:

How can environmental injustices in natural disasters be remedied through social-ecological resiliency networks?

The research will examine this question by looking at two case studies using an established theoretical framework. In examining this question, several sub-questions will be answered.

- Why are communities of lower income and social status more vulnerable to disasters?
- What kind of role can the concept of social-ecological systems play into disaster resilience?
- How can bottom-linked disaster management strategies strengthen resilience in highly vulnerable communities?

To understand and begin to answer these questions, this report will first establish a theoretical framework. Using a comprehensive literature study, this framework will first analyze different theories regarding environmental justice to adopt a vision as to what this concept means in relation to natural disasters. Using environmental justice as the theoretical backbone, the research will delve into several academic theories regarding vulnerability and resilience so as to help in understanding how communities afflicted with natural hazards can succumb to a disaster situation. These concepts will be fleshed out further by going into theories regarding governance and social-ecological systems.

Once the theoretical framework is established, the research will move on to two different case studies. The first case is the devastation caused by Hurricane Katrina to New Orleans in 2005. By examining official governmental policy documents and the work of independent researchers the research will try to determine what type of socio-political circumstances aided in creating the disaster situation and how these circumstances align with our theories of environmental justice, vulnerability and resilience. From there the report will move to the second case study, Bangladesh. The research will begin by reviewing historical cyclones that have devastated the country in the past, specifically Cyclone Sidr. By reviewing official policy documents and independent researchers this report will attempt to determine the factors aiding in creating the vulnerable situation in the country. From there, the research will examine the current situation in Bangladesh, in particular different disaster risk reduction practices and projects ongoing in rural areas of the country. Using a literature study as well as interviews of stakeholders, this report will introduce a new concept in disaster management that attempts to create a framework to foster environmental justice in natural disasters.

2. Theoretical Framework

The following section will tie together several different theoretical concepts and attempt to answer some of the research questions. The first section will analyze the concept of environmental justice by looking at its historical roots, its present theoretical framework and how it relates to the disproportionate damage done to poor and marginalized communities from natural hazards. This will be explained through different ideas of vulnerability, particularly how vulnerability is a symptom of socio-economic processes. Vulnerability to disasters has often been related to social and political reasons but the concept of environmental justice is rarely integrated into vulnerability research. We will examine how governance structures can bring together these two concepts. Related to the concept of vulnerability is resilience, and ideas on how to build resilience to natural disasters will be combined with new theories on governance. The theoretical concepts presented here will be the base for a new framework of disaster management this paper will propose and analyze in later chapters.

2.1. Environmental Justice

Justice has been a major element of society since the beginning of human civilization. The idea of what constitutes justice and how it should be administered has been reshaped and transformed ever since. Today justice is established in our laws and legal systems, but our collective notion of justice begins subjectively. We use our value systems to guide our moral beliefs from which we base our system of justice. From our subjective notion of justice we try to collectively create an objective law or policy that focuses on an impartial fairness.

By incorporating the notion of justice into environmental issues, the goal is to elevate “concerns for the distributive and corrective effects of laws and decisions pertaining to health, the environment and natural resources, as well as concerns for the opportunities of those potentially affected to participate in such law-making and decision-making in the first place” (Ebbeson 2009 p. 1). By looking at the viewpoint of Ebbeson, we can begin to see that environmental justice is mainly centered on the idea of fairness, which is a sentiment long-established in justice theory (Sen 2009). But what exactly are we trying to make fair, and between whom? Although environmental justice is more-or-less a new concept, there are different policies and organizations which try to outline exactly what it entails. The Health Policy Institute’s (HPI) Morse states “In the legal realm, the goal of environmental justice is to secure for all communities and persons the same degree of protection from environmental and health hazards, and the same opportunity to influence the decision making process” (Morse 2008 p. 1). Morse’s definition is very similar to Ebbeson’s contributions to environmental law. Both viewpoints assign two main goals in order to reach a substantial level of equitable justice in the legal realm. The first goal, as Morse states is ‘...to secure for all communities and persons the same degree of protection from environmental and health hazards...’ By using the words

'legal realm' and 'secure', it is implied that protection from environmental hazards should be a goal of government to ensure this basic right for all citizens, rich or poor. This is similar to Ebbeson's definition, which states '...the distributive and corrective effects of laws and decisions...' Mentioning 'laws and decisions' infers that these protections should be provided from a legislative and political arena. This could mean protecting citizens from exposure to industrial pollution that could cause illness or from hazards of the natural environment such as flooding. The second goal according to Morse is 'the same opportunity in the decision making process' meaning that all citizens and communities have equal stake in what infrastructure and services are provided and where they are distributed. This is echoed by Ebbeson: 'opportunities of those potentially affected to participate in such law-making and decision-making'.

Deducing and simplifying the definitions provided by Ebbeson (2009), and Morse (2008), we can determine two goals for fostering environmental justice:

Goal One: Creating an equal share of environmental benefits and equal protection from environmental hazards among all citizens

Goal Two: All citizens having equal opportunity in the decision-making process to determine the distribution of these benefits and hazards

We will refer back to these two goals throughout the remainder of this report. The following section will look more in-depth into the history of environmental justice to understand the arenas where the concept can be applied today.

2.1.1. From Racism to Classism: A short history of environmental justice

The environmental justice movement began in the United States at a crossroads of the environmental and civil rights movements. It grew out of lawsuits and protests in the southern states which showcased the discriminatory placement of hazardous waste sites in black communities (Morse 2008). At its core, it is a social justice movement. The environmental justice debate in the US evolved from the idea of environmental racism, and since the end of the Civil Rights Movement it has become more of an idea of environmental classism. Although the environmental injustices are predominantly in minority communities, this is more likely due to having less financial resources and political influence rather than actual discrimination based on race. This brings up the debate as to whether these injustices are being placed directly upon these communities intentionally, as many who argue environmental racism will say, or if it is more likely that these communities grow around areas of poor environmental quality and high vulnerability because of lower property value, which is the argument for environmental classism (Elliot & Pais 2006). Both sides of the issue could be considered true and each viewpoint could be considered some form of injustice. Our society rewards success by providing wealthier individuals and families comfortable and luxurious living situations if it is in their

economic means. However, referring to the Rawlsian concept “justice as fairness” (Sen 2009) and relating them to our two goals of environmental justice stated earlier in the text (Ebbeson 2009, Morse 2008), responsibility to provide adequate equal protection from environmental hazards for any person, regardless of skin color or economic standing, is still an objective of a just society.

In the past, and especially in the United States, the concept of environmental justice focuses on the unfair distribution of environmental “bads” in areas of color or poverty (Agyeman 2001). The concept has been adopted globally to be incorporated into several different environmental disparity issues. An “environmental justice frame” has been constructed to try and battle unequal environmental exposures in developing nations, mainly focusing on the presence of massive industrial operations of extracting industries (mining, oil/gas) in less developed countries (LDCs). The concept can also be applied to the experience of natural disasters, and why LDCs tend to suffer drastically more in a natural disaster. It could be that levels of poverty in LDCs are statistically higher than in MDCs, which leads to less distribution of resources. The answer to this question is complex, but could be attributed to corrupt and weak states and unorganized civil societies (Roberts 2007).

2.1.2. Environmental Justice and Natural Disasters

Natural disasters occur at the intersection of the human and natural world when a vulnerable population intersects with an environmental extreme (Blaikie et al. 2003). Some of these environmental extremes can have a sudden onset. An earthquake that occurs in the middle of the Alaskan wilderness might damage some trees and cause a small landslide, but will be largely ignored by the general public because no people were affected. Other extremes can have a very slow onset, such as a draught in the African Sahara. However, if the same type of landslide occurs on a coastal town in Mexico, infrastructure could be destroyed and lives lost. If a drought destroys the potential yield for farms in rural India entire populations could go hungry and suffer famine. Natural disasters are very context specific, with a central natural element causing rippling effects throughout several different sectors of the human world.

In 1972 a relatively powerful earthquake struck the capital city of Nicaragua, one of the poorest countries in the western Hemisphere. Out of the population of 405,000, 4,000 lives were lost and 280,000 lost their homes (Alexander 2007). Due to the overall impoverished conditions of the city’s residents, a disproportionate number of casualties and damages occurred. This is an example of what is referred to as a “classquake” (Alexander 2007; Blaikie et al. 2003). The direct reference to ‘class’ can be linked with our theories of environmental justice and environmental classism (Eliot & Pais 2006) stating implicitly that the earthquake had a disproportionate effect on different classes. This was evident again in Haiti in January 2010, when an earthquake measuring 7.0 struck the capital city of Port-au-Prince, which left a

staggering death toll of approximately 230,000. Experts determined that the main cause for the high number of casualties was the poor infrastructure of the capital city (Bilham 2010). To compare, an earthquake of similar size struck the coast of Southern California only a few months later and created minimal structural damage and killed four people. The area is densely populated like Port-au-Prince, but the population has a substantially higher amount of wealth (Wei et al. 2011).

However there are other elements involved that go beyond just class and income. A massive earthquake struck off the coast of Japan in 2011, measuring 9.0 on the Richter scale. Japan, although highly resilient to earthquakes, still suffered greatly with over 10,000 deaths. This was mainly due to the subsequent tsunami that struck the western coastline after the quake. The tsunami also caused explosions and reactor meltdowns at the Fukushima Nuclear Power Plant, causing global concern over radiation levels (Norio et al. 2011). This disaster, among others listed in this section, highlights the potential for widespread issues and problems in the human and natural environments caused by a single natural event. We can conclude that disasters are in fact wicked problems.

2.1.3. Conclusions on Environmental Justice

Natural disasters, their causes and effects, are wicked problems. A single event can simultaneously disrupt and destroy multiple components of a social-ecological system (McPhearson 2013). The elements generating the disruption and destruction can be technical, socio-economic, ecological, cultural or psychological. These elements, crossing multiple disciplines and practices, cannot be fixed with simple technical solutions but require systems thinking. We have to examine the vulnerability of the affected components. Instead of searching for technical end solutions, we need to examine the processes involved. These include socio-economic processes that could make a population more vulnerable due to social standing or a lack of entitlements and resources (Adger 2006).

In this section we examined environmental justice and its relation to natural disasters. By examining different definitions of environmental justice we were able to determine two goals (Ebbeson 2009; Morse 2008):

Goal One: Creating an equal share of environmental benefits and equal protection from environmental hazards among all citizens

Goal Two: All citizens having equal opportunity in the decision-making process to determine the distribution of these benefits and hazards

By looking at historical natural disasters that devastated low-income areas and comparing them to similar natural hazards that damaged more affluent areas, we attempted to determine how the concept of environmental justice can relate to natural disasters.

It is difficult to assign blame to the extreme effects of tropical cyclones that are experienced among poorer populations, and even more difficult to remedy these effects. The best, but most impossible solution would be to increase the wealth and status of these populations. Instead we need to examine other methods that allow marginalized communities to absorb the pressures of natural hazards and respond effectively to them. First, we would need to understand the concept of vulnerability, and what exactly makes a population vulnerable.

2.2. Vulnerability

In order to further understand the idea of environmental justice in relation to natural disasters, we have to examine different ideas of vulnerability. Vulnerability has long been an established concept in ecological and social studies, but the concept is fuzzy where these two worlds intersect (Adger 2006). Vulnerability in human-environment interactions highlights the susceptibility of communities to suffer from environmental changes. Vulnerabilities can take the form of physical and/or societal conditions. Physical conditions could be associated with a particular geographic location or a lack of proper protective infrastructure. Societal conditions are more difficult to explain or identify, though in this report are argued to be the main factor in vulnerability. O'Keefe (1976) states that "The necessary concentration on the vulnerability of a population to future disaster can only be done successfully through an understanding of the marginalization process". Traditional strategies in dealing with disasters usually rely on technical solutions, whether it is more reliable prediction and early warning systems or strong protective infrastructure. While these are certainly very important tools, they are useless when the situations that make an area vulnerable in the first place are ignored, including factors related to socio-economic inequality.

Adger (2006) explains that vulnerability to natural hazards can be linked with the political economy and tied to resource use. He explains that in particular, a lack of entitlements is an antecedent to vulnerability. "Entitlements are sources of welfare or income that are realized or latent" (p. 270). This explanation focuses mainly on institutions of society and economy. This is the human and political ecology approach. Of course, this is not the sole cause of natural hazard vulnerability, as there has to be some form of natural element involved. Many of these natural factors are geographic in nature, having to do with location and exposure to environmental stressors. Social vulnerabilities create sensitivity to stressors from the natural environment, and when these sensitivities are crossed with a natural hazard it could create a disaster situation.

Cannon (1994) defines vulnerability as “a measure of the degree and type of exposure to risk generated by different societies in relation to hazards” (p. 16). Any area that is located in a center of cyclonic activity is vulnerable to natural hazards. Although there are technical solutions to mitigate the effects of these hazards, poorer communities are often settled in these areas of high exposure. Pumping stations built in the 1900s in New Orleans led to the draining of low-land swamps in the periphery of the city which were then settled by poor black communities despite being at a very high risk of flooding (Elliot 2006). Unemployed and dispossessed peoples in Bangladesh are forced to live in unplanned, insubstantial housing in extremely flood-prone areas (Cannon 1994; Mohit 2011). By quickly looking at these examples, we can begin to see that vulnerability is at the cross-section of social systems and ecological systems. These systems and their relationship to each other will be examined later in this chapter.

A population can avoid a settlement’s exposure to natural hazards by evacuation methods. However, socio-economic systems can directly and indirectly make it more difficult for citizens to evacuate and find shelter. Usually poor communities have less access to resources, including private motor vehicles, which could allow for quicker and less stressful evacuation of hazardous areas. Also, unfair distribution of resources can lead to unhealthy diets and behaviors in poor communities, leaving members, especially young children and the elderly, particularly weak. This in turn could make evacuation very difficult and often impossible (Cannon 1994).

It is not only the environment’s pressures on a settlement and population that creates vulnerability. The social system can also create deteriorated environmental resilience (Cutter 1994; Travis 2005; Adger 2006). Economic development can degrade certain environmental components and reduce ecosystem services which can lead to an increase in both social and ecological vulnerability. Wetlands and barrier islands are an essential part of delta systems and can act as a buffer against natural hazards such as storm surges. The draining of wetlands and the subsequent development leaves no place to store extra water from storm surges in the event of a tropical storm. River modification can also disrupt natural sediment deposition, leading to a decrease in barrier islands outside at the delta mouth. Barrier islands help in dissipating wave energy and can lower storm surge height on the mainland. It is estimated that construction of levees and dams on the Mississippi River has contributed to the disappearance of up to 100 sq km of barrier islands in the Mississippi Delta per year (Travis 2005). Although many different theories link vulnerabilities to poverty, it will be difficult to find a strict economic answer to these problems. The economic and social fabric is embedded in the natural environment, and current economic models tend to degrade the environment. Trying to reduce vulnerability through macro-economic means could in fact deteriorate the situation. There needs to be more of a focus on ‘people-centered development’ (Yamin et al. 2005) that incorporates resiliency strategies in both the economic and environmental sectors. People-

centered development will have less focus on increasing privately held revenues and expanding the built environment and focus more on increasing social and human capital (Mayunga 2009).

The best way to draft effective policy is to limit the degree of complexity. This would entail quantifying real world elements and factors into usable data for researchers and policy makers. In terms of vulnerability this can be extremely difficult; there are a myriad of considerable factors and no degree of certainty as to how these factors influence and weigh against each other. There are several different methods of measuring vulnerability using a variety of factors. Methods relevant to the subject of this report will be analyzed here. These different indices and models will be compared to get a more comprehensive and analytical idea of what constitutes vulnerability and why a community might be labeled as vulnerable. Linking ideas commonly associated with environmental justice to vulnerability indicators we can determine how these injustices increase the vulnerability of an area (Rygel 2006).

2.2.1. Pressure and Release Model

One of the most important vulnerability models for this report is the Pressure and Release (PAR) model developed by Blaikie et al. (2003). This model is meant to span the space between hazards and human/political ecology approaches. Political/human ecology argues that current analysis of natural disaster vulnerability focuses too much on engineering and technological approaches and less on the political and socio-economic structures embedded in society (Adger 2006). The PAR model classifies risk as a combination of vulnerability and hazard, and disasters are a result of the interaction between both (Blaikie et al. 2003). It attempts to explain how a natural phenomenon intersects with a vulnerable population and creates a disaster situation. This is the result of two intersecting forces; processes that create vulnerability as one force and a natural phenomenon or hazard as another.

The PAR model focuses on economic, political and demographic processes which it states are root causes for creating vulnerable populations. These *root causes* are described as “a set of well-established, widespread processes within a society and the world economy” (Blaikie et al. 2003 p. 24). These underlying causes are economic, demographic or political in nature and reflect the allocation and distribution of power and resources in a society (Blaikie et al. 2003). Marginalized communities will often be a low priority for government in regards to hazard mitigation. In order for these root causes to take effect they are channeled by *dynamic pressures* in to *unsafe conditions*. A dynamic pressure would be a contemporary pattern in societal framework. This could be something like neo-liberal capitalism, which in the 1970s and 1980s changed the structural functioning of many LDCs leading to the decline in public health and education services and the cutting of the social safety net. Another example is rural-urban migration. The *unsafe conditions* are the physical manifestations of vulnerability from the root causes and dynamic pressures. Examples of these manifestations could be settling in hazardous

areas such as floodplains, lack of disaster-proof infrastructure and/or access to resources (Blaikie et al. 2003).

Blaikie et al. argue that these unsafe conditions need to be labeled for what they are, and not be lumped into a general description of vulnerability. For example a building can be deemed unsafe or a dangerous location be labeled hazardous. This will allow the word vulnerability to be applied to populations only, and help in the analytical capacity of vulnerable populations. This allows for multiple elements to be influential in determining a society's vulnerability. E

Blaikie et al. (2003) provided 12 principles for managing disaster recovery which are listed here:

- Recognize and integrate the coping mechanisms of disaster survivors and local agencies
- Avoid arbitrary relief
- Beware commercial exploitation
- Avoid relief dependency
- Decentralize decision making when possible
- Recognize disasters as political events
- Recognize pre-disaster constraints
- Balance reform and conservation
- Avoid rebuilding injustice
- Accountability – the key issue
- Relocation is the worst option
- Maximize the transition from relief to development.

We can see a pattern in looking at these principles. Many of them are meant to be followed by individuals who experienced the disaster and have a stake in the area that has been affected. They also incorporate many political and social elements in to the process. Principle such as “recognize disasters as political events” and “decentralize decision making when possible” both intend to make readers aware of the social and political processes involved in disaster management. The principle “avoid rebuilding injustice” also stands out due to the word ‘injustice’ and its relevance to the research in this report. This principle can be directly related to an idea that will come up later in the chapter focusing on resilience. We will continue to refer back to these principles throughout the rest of this report. The next section will try to form a better understanding of social vulnerability.

2.2.2. Social Vulnerability Index

Cutter et al. (2003) explains that socially created vulnerabilities are difficult to quantify and assess, and therefore go largely ignored. The major factors influencing social vulnerability are a lack of access to resources, limited access to political power and representation, social capital,

beliefs and customs, building age, type and density of infrastructure and lifelines. Included with these are individual characteristics of the population, including age, gender, race and socioeconomic status (Cutter et al. 2003). These environmental factors and social characteristics are used to measure vulnerability in the Social Vulnerability Index (SoVI).

The derived score is determined by several different factors in a locality. The first and main factor is personal wealth which is based on per capita income. More wealth would affect the score positively while a lack of wealth would affect the score negatively. The next factor is age, with an overall count of children and elderly in a population affecting the score negatively. The third factor is the density of the built environment, which measures the amount of manufacturing and commercial establishments, housing units and new housing permits. This is mainly to project economic losses if a terrible disaster would take place. The fifth factor is also a measure of economic vulnerability and measures the rate of single-sector economic dependence. This analyzes if a community's economic resources are centered on one economic sector, such as fishing, which could be drastically affected if a disaster occurs. The quality and ownership of housing is also a vulnerability factor. This would analyze the types of housing available, such as strong resilient structures or weak hand-built shacks. The next two factors, race and ethnicity, are based on personal characteristics and demographics. This makes the assumption that ethnic minorities and immigrants tend to be in lower class groups and therefore in more hazardous zones. Occupations and employment make up the tenth factor, and measures the kind of employment an area is dependent on. An area with a high degree of low-wage employment would negatively affect the score. The final factor is infrastructure dependence and takes into account debt to revenue ratio and percent employed in public utility jobs. An area with a high revenue-generating capacity and a population not based on utility and infrastructure jobs will usually have better access to resources (Cutter et al. 2003).

These eleven different factors were weighed similarly as determining importance was difficult among the researchers. In comparing the social vulnerability scores of separate counties around the US Gulf Coast there was no significant statistical relationship between counties deemed as highly vulnerable according to the SoVI and the amount of disaster declaration per county. The conclusion was that social vulnerability is a multi-dimensional concept that helps us to identify those characteristics and experiences of communities (and individuals) that enable them to respond to and recover from environmental hazards (Cutter et al. 2003). Many of these dimensions are social circumstances. The first and most important factor in the index is wealth, which can be linked with Adger's (2006) ideas with entitlements and access to resources. We can begin to see that vulnerability is highly influenced by access to resources, and that a higher amount of wealth allows more access to resources which lowers vulnerability. Although a major point of this research is to examine social vulnerability and relate that to our idea of environmental, it is crucial to understand how these social circumstances can relate to the

natural systems they interact with. This will be examined in Turner et al. (2003) Vulnerability/Sustainability Model.

2.2.3. Vulnerability/Sustainability Model

Sustainability science tries to create an understanding of the human-environment relationship and tries to determine what pressures human development can have on the environment before it creates a radical change. It could be argued that one of the main goals for sustainability is to limit vulnerability of populations through an understanding of social-ecological systems.

This model proposed by Turner et al (2003) recognizes that focusing on stressors is insufficient for understanding impacts to social-ecological systems. The synergy between the human and biophysical subsystems is at the core of the vulnerability/sustainability model. The analysis includes multiple interacting stressors, exposure beyond perturbations and stressors, sensitivity of the system to the exposure, system's capacity to cope or respond, system's restructuring after the exposure and the nested scales of hazards and their coupled systems (Turner et al. 2003).

The framework suggested can be applied to localities using a place-based model which takes into account local human and biophysical conditions into the approach. The basic architecture of the framework consists of: 1) linkages to broader human and environmental conditions and processes; 2) perturbations and stressors that emerge from these conditions; and 3) coupled human-environment system of concern (Turner et al. 2003). These conditions are interactive and transcend scales. The social-ecological system in question is the place of analysis. The hazards are influenced from factors within the system, such as the sensitivity of a location to exposure, as well as outside the system. The framework highlights the complexity of interaction with different elements within the social-ecological system, and how the human environment can exacerbate hazards in the natural environment and vice-versa. Therefore, a successful vulnerability analysis must not only analyze the system in question, but the linkages that keep that system together. It directs attention to the vulnerability that is embedded within the social-ecological system, whether it is caused by societal or natural circumstances. It also analyzes the different scales of vulnerabilities and highlights the vulnerabilities attributed to a specific place. The main focus of the vulnerability/sustainability model is that an understanding of the vulnerability question is interlinked with human-environment interactions. Social-ecological resilience will be examined more in a later chapter.

2.2.4. Conclusions on Vulnerability

Taking into account each of these theories on natural hazard vulnerability, we can see several similarities and patterns. First, there is a common agreement that natural disasters occur at the

intersection of the natural and human environments. Secondly, several factors from each environment come together to create a vulnerable population. Exposure to natural hazards and stressors will always leave a population vulnerable. The theories continually relate to level of income as a major factor in defining vulnerability. Lower income populations are continuously labeled as the most vulnerable mainly because of a lack of access to resources and disproportionate exposure to hazards (Cannon 1994; Cutter et al. 2003; Turner et al. 2003; Blaikie et al. 2003; Adger 2006). These ideas all tie directly into our definition of environmental justice (Morse 2008; Ebbeson 2009; Sen 2009).

Poverty and an access to resources is an impossible problem to analyze and solve from an academic standpoint. The political and socio-economic forces that increase vulnerability mixed with the uncertainty and unpredictability of the natural extremes caused by tropical storms create a complex and wicked problem. There will never be a single or complete answer, a panacea (Ostrom & Cox 2010) for this issue. In order to limit or negate vulnerabilities, we have to examine the process that could increase resilience.

2.3. Resilience: Bouncing-forward to environmental justice

Resilience and vulnerability are often linked together as related concepts. They both initially developed out of ecological science. In 1973, Holling defined resilience as “the measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables” (Cutter et al. 2008 p. 599). Resilience is a symptom of a whole system, which implies that several different factors need to be considered in trying to foster and strengthen resilience.

For the sake of this report we will view vulnerability and resilience as two related, but separate concepts. While vulnerability is the study of the susceptibility of people to hazards, resilience is the analysis of how people cope with disasters and how they address their capability to cope (Gaillard 2007). This report will research vulnerability in relation to the first concept of environmental justice, providing equal and adequate protection from environmental hazards. We will view resilience more in terms of the second concept of environmental justice, having the same opportunities in the decision making process. In this case, allowing for public participation in disaster management and strengthening the ability for a community to respond in the face of a natural disaster (Gaillard 2007) and “bounce-forward” (Manyena 2011).

Adger (2006) states that resilience is the ability of a system to absorb a disturbance and retain its essential structures, processes and feedbacks. This refers to the ability of a community to “bounce-back” from a disaster (Manyena 2011). This means absorbing the impacts and preserving the pre-disaster social fabric (Gaillard 2007). This type of response would be called a return to a state of normalcy. Sometimes, this return to normalcy could re-create a situation

that caused the disaster in the first place (Manyena 2011). This form of resilience disregards that disasters have the ability to completely change the physical and social structure of a place, making the concept of bounce-back impossible. It is what Manyena describes as “single-loop learning”, or effectively responding to a crisis, then returning to an original position and waiting for the next crisis to occur. The problem with this model is that it does not embrace the dynamic elements that are present in nature and instead opts for a rigid view of a social-ecological system. We can refer back to Blaikie’s et al. (2003) principles for effective disaster recovery, specifically to “avoid rebuilding injustice”. This could be related to the idea of “bounce-back” rebuilding to similar pre-disaster conditions. In order for a society to be resilient, it has to embrace change as a necessity (Davoudi 2012).

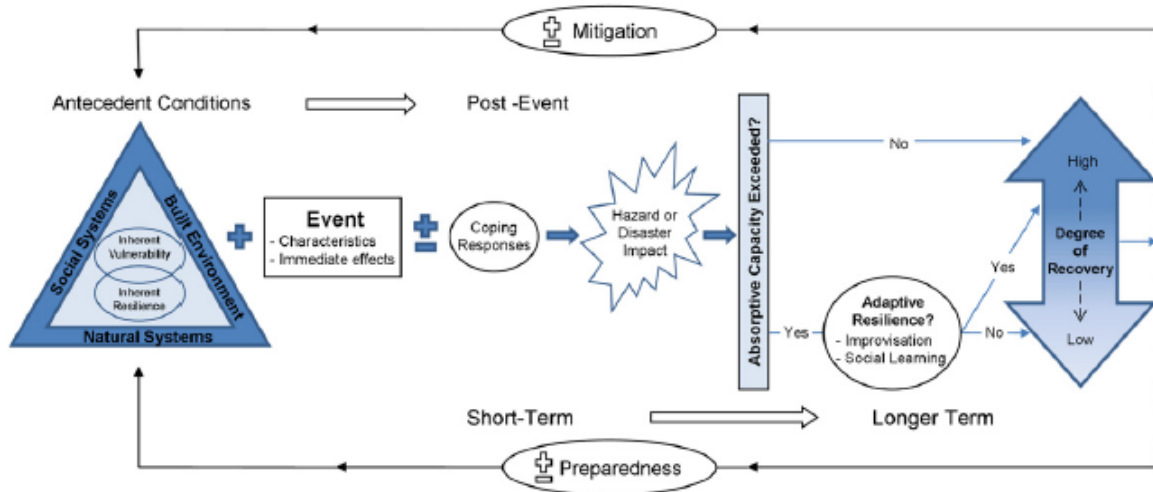
If we move to a different concept of resilience, one of organizational learning and “bounce-forward” strategies, we can begin to understand the problems that led to the disaster in the first place (Manyena 2011). The previous concept of vulnerability comes into play here; by understanding and rectifying problems that can cause vulnerability we can enhance resilience. The human-nature environment is highly dynamic and disasters bring with it an element of change. The concept of bounce-forward also embraces this element, and uses it to help strengthen a community’s resilience. Resilience itself should be viewed as the ability of a human-nature environment to absorb an impact, accept change and continue functioning.

The following sections will examine different models and theories regarding resilience that have been developed in recent years. First we will look at Cutter’s et al. (2008) Disaster Resilience of Place (DROP) Model along with the ideas of inherent versus adaptive resilience. Following that we will take a more in-depth look at social-ecological systems, and how a resilient place can be created through the use of systems thinking (Adger 2005; Folke 2005). Once we understand more of the human-environmental system, the research will examine a resilient system based on capital (Mayunga 2009). Different forms of capital have different effects on communities, and the research will examine how capital can influence disaster resilience in a place. Mayunga’s (2009) capital-based approach needs a governance model which ensures that capital is distributed in a way that is in line with our goals for environmental justice (Ebbeson 2009; Morse 2008). We will look into the concept of bottom-linked governance (Pradel et al. forthcoming) as a potential method of ensuring these goals can be reached.

2.3.1. Disaster Resilience of Place Model

Cutter et al. (2008) explains that there are two different forms of resilience, inherent and adaptive. Inherent resilience is engrained within the society in question, and means that the system functions well during non-crisis periods. Adaptive resilience is flexibility in response to disaster situations. This flexibility allows for the absorption of impacts and the ability to deal with the acute and drastic changes. If a society is able to grow with these changes, that could

be an example of bounce-forward resilience (Manyena 2011). This is adaptive capacity, or the ability of a system to adjust to change, moderate the effects and cope with the disturbance (Cutter et al. 2008).



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Figure 1: DROP Model Source: Cutter et al 2003

This type of strategy cannot function correctly in a top-down governance framework, but would be most effective at the community level that recognizes how humans fit into the natural world around them. Cutter et al. (2008) explains this by viewing resilience as a proactive and positive expression of community engagement with natural hazard reduction. Resilience needs to be fostered at the local level in what they call the Disaster Resilience of Place model (DROP)(Figure 1). In the model, social resilience is used as a focus and natural systems, social systems and the built environment are all interconnected (Cutter et al. 2008). The model assumes that each place has a type of adaptive capacity threshold that is moderated by the level of antecedent conditions inherent in a community. The conditions are similar to the antecedents described by Adger (2006). The antecedents interact with certain hazard characteristics and if the absorptive capacity of a place is overwhelmed a disaster can occur. What is important in this model is the idea of social learning, and that a community is able to improvise and adapt during the different stages of the disaster to try and keep the impacts within the absorptive capacity (Cutter et al. 2008). This social learning tries to promote strong local cohesion and becomes a mechanism for collective action. This can be used in post-disaster recovery and integrated into different institutional policies through feedback loops created in the networks. These feedback loops are essential to foster bounce-forward resilience. This type of interconnection that allows for feedback loops between community members, organizations and government agencies are only possible through social-ecological networks.

2.3.2. Social-Ecological Systems

We have been referring to social-ecological systems throughout this report. By viewing natural disasters at an intersection where a natural hazard and vulnerable community meet, we can view the entire system as a complex interaction between humans and their environment. Knowing that one will always affect the other and both systems work constantly to adapt to each other, we can begin to build resilient communities based on the idea of a social-ecological system. Adger (2006) explains that it is pointless to try and separate the two in studies of vulnerability and resiliency since “human action and social structure are integral to nature and hence any distinction between social and natural systems is arbitrary” (p. 268).

In a social-ecological system, the actors involved have the capacity to respond to changing conditions and acute disturbance events by adapting to the new characteristics of their environments. This type of system calls for a strong network and distribution of different forms of capital. This includes networks, strong leadership and trust between each other, including between citizens and their governing bodies (Folke et al. 2005). Strong local leadership is also important for a resilient community. Local leadership is able to sustain local resources and ecosystem services that may be essential for resisting disaster circumstances, such as a loss in livelihood (Adger et al. 2005). This could include access to flood-preventing infrastructure or methods of evacuation for families without their own means of transportation. Also, this allows for more control over maintaining local ecosystems, such as large wetlands and swamps that could retain water in the case of a storm surge or flood.

Creating strong networks can also help in strengthening resilience, for example networks between government and communities, communities and professional experts or organizations and governments. Locals are usually the most knowledgeable of the local resources, natural or unnatural, that a community possesses, and there is large potential in combining this locally acquired knowledge with scientific expertise that could help maximize the potential of those resources (Folke et al, 2005). These networks will also help in understanding the linkages between human and natural systems, creating a better understanding of factors that increase vulnerability. Strengthening these networks will also lead to heightened capacity for individuals to act for themselves. This type of self-organization will create less of a need for outside help from international sources (Adger et al. 2005), which follows one of the principles for managing disaster recovery discussed in the previous chapter (Blaikie et al. 2003). By promoting participation and power sharing, communities can begin to create a system of adaptive governance. This system based on community resilience forms a set of networked adaptive capacities (Norris et al. 2007). Through the promotion of a strong social-ecological network, we can begin to see where certain forms of capital are located, and determine methods in allocating that capital to areas that could help foster and strengthen disaster resilience. The

next section will examine more closely the role different forms of capital play in disaster management.

2.3.3. Capital

We have determined that vulnerability can be the result of a lack of resources due to a lower income status and lack of political representation (Cannon 1994; Cutter et al. 2003; Turner et al. 2003; Blaikie et al. 2003; Adger 2006). This can be described as different forms of capital, which could be used individually or collectively to strengthen the resilience of a place (Cutter et al. 2008; Mayunga 2009). These different forms are human, social, physical, natural and financial capital. Mayunga believes that creating different capital gains at the community level is the key to adaptive capacity, which contains both resiliency and mitigation strategies. These different forms of capital need to be present during each phase of the disaster cycle. During hazard mitigation phases, regulations need to be developed, protective features of the natural environment need to be preserved and infrastructure needs to be strengthened. During the preparedness phase warning systems need to be enacted and activities promoted that enhance the effectiveness of emergency operations. During the disaster, early warning systems need to go into effect and the population needs to be evacuated and sheltered in a safe location. Search and rescue operations need to be prepared and resources such as food and services such as healthcare need to be provided. The recovery phase needs to have both short-term and long-term strategies, and the feedback loops discussed earlier need to be enacted to ensure that the situation that created the disaster can be mitigated and avoided in the future (Mayunga 2009).

All of these activities require some form of capital to be engaged. Structural improvements, warning systems, response teams need the financial, social, physical and human capital to be realized. An increase in capital can also lead to an increase in livelihood and wealth of an area, which would address the socio-economic vulnerabilities that may be present there (Mayunga 2009).

It is not only essential to create strong social networks and strengthen social capital, but natural capital as well. Human populations rely upon ecosystem services for things such as food and fresh water. These services can be abruptly altered by the impact of a strong natural hazard. If these services are impacted to the point where they aren't able to provide then that can lead to harsh post-disaster impacts such as water-borne illnesses and famine (Costa & Saddeque 2012). Some ecosystems provide direct benefits to coastal ecosystems and can help lessen the impact of natural hazards. Mangrove forests and coral reefs can absorb energy from wind, storm surges and tidal waves. Keeping these eco-resources intact not only helps retain healthy ecosystems, but also provides protection.

Once this capital can be distributed at the community level we can begin to foster resilience. However, we have established that in many scenarios low-income and marginalized communities lack the access and political representation to obtain these resources. In order for these different forms of capital to be distributed equally, we need to create a system of governance that allows for the facilitation of this distribution.

2.3.4. Governance

Top-down disaster management has been the standard for many societies who are at risk of natural hazards. This type of structure depends heavily on technological advancements and engineering to reduce risk. This could be in the form of hard constructions such as dikes and sea walls to limit storm-surge intensity and floods. These technological fixes have been proven to be successful in reducing impact but are not a silver-bullet answer to limit risk. In some ways they often make a society more vulnerable to hazards. Communities near embankments and dikes have been known to have a false sense-of-security from hard constructions which limit their response to a hazard warning (Morse 2008). These hard constructions are rigid and difficult to modify if needed. Some international and national institutions and strategies can undermine local efforts to strengthen resilience. This could disrupt and sometimes worsen the condition of the community. These institutions are created in good faith but usually try to plan interventions for the communities instead of trying to work with them (Yamin et al. 2005).

Strategies that operate from a top-down framework are usually the creation of actors in a national or transnational setting. Policies are shaped around a narrow definition of well-being and safety crafted by government officials or financial donors. Response strategies are then applied to all different types of places and can conflict with each other and waste valuable aid. This type of development is focused on economic well-being and less on a ‘people-centered development’ (Yamin et al. 2005). Top-down disaster management is usually applied to a post-disaster situation and is mainly focused on relief and recovery. Once the recovery is “completed”, the actors involved with disaster management usually leave. Usually a recovery state is one that is similar to the situation before the disaster; a ‘bounce-back’ recovery (Manyena 2011). There is not too much room outside of the construction of large infrastructure projects for top-down disaster management when a disaster hasn’t occurred.

Bottom-up disaster management is the response to criticisms of top-down governance. This model argues that disaster management should be handled at the local level with little interference from national governments, international relief organizations and NGO’s. Proponents of this model suggest that authorities and organizations can limit a community’s resilience and sometimes block its attempts to engage in risk-reducing behavior (Gaillard 2005). The idea is a resilient community is able to identify and remove vulnerabilities through their own means without the use of outside aid or assistance. However, society dictates that a

community cannot rely on itself completely, especially if the hazard is so severe that it goes over the threshold of even a very resilient community to absorb the impact and therefore causes a disaster. In these cases outside help will be necessary to help the society recover. The next section examines a recent idea for governance called bottom-linked which could address these issues.

2.3.5. Bottom-linked governance and social innovation

Adaptive governance requires the cooperation of several horizontal and vertical organizational levels. The collaboration of local knowledge of resources with scientific expertise and governmental capabilities can lead to resilient and locally dependent communities. This idea is called adaptive co-management, and is the “sharing of management power and responsibility...involving multiple and often polycentric institutional and organization linkages among...communities, government agencies and nongovernmental organizations” (Folke et al. 2005 p. 463). This concept is also known as multi-level governance and is strengthened by the collaboration of all stakeholders. These systems will be more adapt at dealing with change, especially high levels of acute change such as those brought by a natural disaster.

In order for resilience building to take place, individuals and collectives need the capacity that allows them to create alliances with different actors from different sectors. An adaptive, co-managed governance structure needs to support and facilitate these relationships without blocking them. These relationships can allow for innovations and practices in resilience building to occur at any level and then be directly distributed to individuals and communities who are in need of those forms of capital that are being created. Although top-down management can set up a bureaucratic structure that slows this distribution, individuals and collectives at the community level might not have the resources or knowledge in order to build resilience. These forms of capital can come from other actors at different levels, for instance private companies, major universities or regional governments that may not have any contact or connection with vulnerable communities. In this case, bottom-up governance might not be the best answer either. A system of governance that isn't dependent on centralized authority needs to be established which allows for social innovation and capital distribution to take place at every level (Pradel et al. forthcoming). This type of governance is defined as “bottom-linked” which combines bottom-up initiatives with top-down policies and allows for different channels of participation and interaction (Eizaguerre et al. 2012). The hope of this governance is the “creation of new mechanisms for the provision of resources” (Pradel et al. forthcoming p. 4). However, it is not just resources that this governance structure can help distribute. Information, services and knowledge are all especially useful regarding natural hazard resilience. Scientific information on the environment, insights into disaster preparedness from experts and flexible technological fixes can all be developed by larger agencies and bodies and distributed to

individuals and communities. Bottom-linked governance opens up the policy process to non-state actors by giving more room for them to intervene in the design and implementation of policies (Pradel et al. forthcoming). This type of social innovation can meet social needs by equal capital distribution, empower marginalized populations and reduce social exclusion by transforming social and governance mechanisms (Pradel et al. forthcoming).

Pradel's ideas towards social inclusion, innovation, multi-level "bottom-linked" governance can be applied to disaster resilience, especially Mayunga's (2009) ideas about capital-based resilience. Combined with Mayunga's idea, we not only have a system that identifies the specific types of capital that can build resilience but also a system in which those different forms of capital can be distributed to communities efficiently.

2.3.6. Conclusions on Resilience

It is important to remember that resilience building is more about the process than it is about the final outcome. Focusing too much on the final outcome defeats the purpose of resilience and the idea that there is no final outcome. Both the natural and human environments will continually change because of pressures from both internal and external forces. It is important to facilitate the capabilities of a community to respond to these changes. Natural disasters can radically change and transform a place. In order to be able to prepare for, endure and recover from these disasters a community must have the capacity to respond themselves. This includes the provision of capital (Mayunga 2009) through bottom-linked governance that allows for easy distribution of capital (Pradel et al. forthcoming) that can address the antecedent conditions of a place (Cutter et al. 2003) and the dynamic pressures placed upon society (Blaikie et al. 2003).

2.4. Conclusions

The theoretical framework of this report has attempted to frame the argument that environmental injustices form the base of vulnerabilities to natural hazards. These vulnerabilities can be directly linked with disparities in socio-economic status among different communities, which lead to higher exposure to natural hazards and less capacity to prepare for and respond to these hazards (Cannon 1994; Cutter et al. 2003; Turner et al. 2003; Blaikie et al. 2003; Adger 2006). These vulnerabilities can be addressed through resilience building at the local level through bottom-linked governance (Pradel et al. forthcoming). This form of governance allows for the distribution of human, social, physical, natural and financial capital (Mayunga 2009) from different actors without the need of a central authority to direct and facilitate the distribution. These distribution channels are necessary to address the environmental injustices that are present in natural disasters for a specific place, the idea that poor and marginalized communities suffer more than communities of wealth with political connections.

Remember our goals for fostering environmental justice:

Goal One: Creating an equal share of environmental benefits and equal protection from environmental hazards among all citizens

Goal Two: All citizens having equal opportunity in the decision-making process to determine the distribution of these benefits and hazards

A main argument here is that top-down disaster management is too rigid of a governance structure to deal with natural disasters, and is not an effective way to create and harbor resilience in vulnerable communities. With the allocation of resources, information, services and knowledge being controlled from a central entity, some communities could be skipped over due to a lack of political influence. The goal of the research will be to provide examples of how this form of governance can be detrimental to communities facing hazards of the environment, specifically tropical storms, and how a new form of disaster management can help provide the resources, services, information and knowledge to communities who otherwise do not have the capacity to absorb the impact of natural hazards. The next chapter will explain the methodology involved in the research.

3. Methods

The hypothesis of this thesis takes a strong stance and makes the assumption that people and communities of lower income suffer drastically more in natural disasters compared to more affluent communities. By standing by this assumption and using it to guide the research, it is possible to further investigate the causes as to why this is a reality in areas around the world. This assumption is validated by researching theoretical concepts of vulnerability and how vulnerability can be tied to a lack of resources or entitlements (Adger 2006). By integrating the concept of environmental justice and remembering its goals (Ebbeson 2009; Morse 2008), these vulnerabilities can be seen as a fixable problem rather than simply an outcome of our hierarchical societal structure. It is a goal of this research to investigate ways to lesson vulnerability by increasing resilience through local capacity building. The following chapter describes the methods used in tying these theoretical concepts together and integrating them into the practical examples where they can be investigated more thoroughly. A step-by-step plan of analysis is outlined to describe how the data was gathered. This plan of analysis includes a review of the literature used in the research as well as an introduction to the case studies. The following sections will give a more in-depth review of the literature used and the interviews conducted for further analysis into the case studies. Through these investigations a framework of disaster management will be formulated and analyzed. This framework, called the Resiliency Web, will be better explained in a later chapter.

3.1. Plan of Analysis

The theoretical framework of this report began with a literature study of the concepts of environmental justice. This included research into the philosophical perceptions of the idea of justice and what exactly justice means in the 21st century. Included with these philosophical texts was a literature study of the history of environmental justice and how the modern philosophical concepts of justice can be applied to promote better social and environmental health for relegated communities. From environmental justice we move to the limited research on environmental justice and natural disasters. This section was supplemented by the already extensive research conducted on disaster vulnerability and resilience. The research on vulnerability consistently reflects the notion that impoverished communities are more often than not at higher risk from natural hazards than those which have more wealth (Adger 2006, Blaikie et al. 2008). However this notion is rarely viewed as a form of injustice, but merely an observation of past disasters. Moving on to the idea of social-ecological resilience, we determined that the idea of establishing a strong network of actors within their social-ecological system creates a more flexible and robust system.

Using the theoretical framework provided from this literature review we move onto real-life examples of environmental injustices in relation to disaster management. The first case study is

Hurricane Katrina and New Orleans in 2005. There is already extensive research done on Hurricane Katrina and its effects on poor and minority communities. This includes criticisms of racial disparity embedded in the societal framework in the Gulf Coast region as well as the lack of a sufficient response from the federal government. The literature was used to frame the argument that environmental injustices were a factor in worsening the impact of Hurricane Katrina on the Gulf Coast region, particularly New Orleans. This was done using a demographic study of the impact of Katrina and how it affected lower income and minority communities disproportionately to more affluent communities. This included research into the median household incomes of the different neighborhoods in New Orleans and a comparison of this data to information regarding the storm's impact on different sections of the city to determine if there was actual disparity present between different social classes and the impact of the storm. Other indicators of vulnerability were used, such as the settling of communities in low-lying, flood prone areas and the methods of evacuation provided. Research will also be conducted on the response of the government before, during and after the disaster. The failures of the government have been documented extensively by news organizations, social scientists and even the government themselves. An analysis into the failures of government was conducted to examine why traditional top-down disaster management frameworks might be ineffective in responding to the needs of communities at the ground level who experience these disasters. This analysis was done mainly by analyzing different policy documents and academic articles on the subject. This analysis was supplemented with an e-mail correspondence from a member of the New Orleans Planning Authority (Neville 2014).

Moving from the New Orleans, we go to the coastal area of Bangladesh for the main core of the research. An analysis of former cyclones and the disasters they caused will be used to examine the status of the current situation in Bangladesh today in regards to disaster risk. This analysis included academic articles as well as official government reports investigating the impact of Cyclone Sidr in 2007 provided by the Government of Bangladesh (2008). Bangladesh has the attention of several international organizations and foreign governments because of its vulnerability both geographically and socio-economically. This attention has led to the formation of several projects that try and reduce disaster risk and strengthen resilience at the community level in accordance with the Hyogo Framework for Action 2005-2015. The Hyogo Framework for Action is an international agreement adopted by UN Member States which reduce disaster losses substantially by 2015. A major focus of this framework is ensuring community participation in disaster risk reduction efforts (ISDR 2005). The projects investigated in this report adopt this focus as a primary goal.

The projects analyzed in this report are mainly the result of cooperation between public and private entities. This cooperation is entirely between Dutch and Bangladesh agencies and organizations. The Netherlands has shown special interest in the situation in Bangladesh due to

the countries geographical similarity and the water management expertise of the Dutch. Many of the natural hazards facing Bangladesh are water related, including floods and tropical storms. Several policy documents from organizations working in Bangladesh were reviewed to determine the strategies used in local Disaster Risk Reduction (DRR). The main strategy analyzed is Community Managed Disaster Risk Reduction (CMDRR), a broad framework developed by Caritas Bangladesh and Cordaid that creates a set of guidelines for the DRR projects ongoing in Bangladesh. The analysis of these policy documents will be supplemented with interviews from representatives of these organizations as well as interviews from their partners who have a stake in the projects.

Through the analysis of the theoretical concepts and their relation to the case studies, a framework for disaster management was developed that could be useful in addressing our two goals of environmental justice. This concept is called a Resiliency Web, and is based off the establishment of *Resource, Information, Services and Knowledge Pathways* between stakeholders. This concept will be applied to both case studies. In the case of Hurricane Katrina in New Orleans we'll see a breakdown of these pathways, exacerbating the disaster situation. In Bangladesh we'll examine how these pathways have been established within the CMDRR framework as well as two specific DRR projects. The Resiliency Web and *RISK Pathways* will be explained more in the chapter four.

3.2. Literature Background

One of the core sources of information from this report comes from an extensive literature review. There were two types of literature used, one being academic articles, journals and books which covered a topics ranging from philosophical concepts of justice to etymological research to scientific measurements of storm surge levels. The second types of literature reviewed were policy documents.

The majority of the literature used in the research comes from academic researchers. The idea of "justice as fairness" is a Rawlsian concept explained in the book "Idea of Justice" by Sen (2009). This concept of justice is compared to ideas brought forth by Ebbeson (2009) on environmental law, which helped form our two goals for environmental justice listed earlier in the text. From this point the research looked into several academic articles based on theoretical concepts of vulnerability and resilience. Most of these articles were published in books and academic journals and also included two dissertations by Mayunga (2009) on a capital-based approach to resilience and Zamore (2009) on racism in Hurricane Katrina. One article by Pradel et al. on bottom-linked governance is forthcoming as of the publication of this report.

The other forms of literature used were official policy documents and government reports. Some of these documents helped form our theoretical concepts (Field et al. 2012; Morse 2008),

however the majority mainly used to gain practical insight into the case studies. Policy documents are important because of the objective view they take on certain issues. They were an important source for the demographic data used in this research. This demographic data is important to show any sort of racial and class disparity in disaster reports so we can relate them to our goals of environmental justice. A list of the policy documents used in this report is listed below.

Title	Main Author(s)	Affiliation	Relation to research
“Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation”	Field, C.B. Barros, V. Stocker, T.F. Dahe, Q.	IPCC	Theoretical framework
“Hyogo Framework for Action 2005-2015”	International Strategy for Disaster Reduction	United Nations	Theoretical Framework and Bangladesh case study
“Environmental Justice through the Eye of Hurricane Katrina”	Morse, R.	HPI	Theoretical Framework and Hurricane Katrina case study
“Hurricane Katrina: Social-Demographic Characteristics of Impacted Areas”	Gabe, T. Falk, G. McCarty, M.	United States Congress	Hurricane Katrina case study
“Cyclone Sidr in Bangladesh”	Government Bangladesh	Government Bangladesh	Bangladesh case study
“CMDRR – a step to change the community”	Costa, S.S. Sadeque, A.Z.M.	Caritas and Cordaid	Bangladesh case study
“Contingency Plans Bangladesh”	Cordaid	Cordaid	Bangladesh case study

Table 1 - *Source: Author*

The literature review was supplemented by interviews with individuals who are directly involved with the case studies in a professional capacity.

3.3. In-depth interviews

In-depth interviews were conducted in order to obtain valuable information into the separate case studies. This form of field research is referred to as qualitative research, which is a form of observational research for data that is not easily reduced to numbers (Babbie 2010). The table

below lists the names of the interviewees, the organization they are affiliated with and the method of how the interview was conducted. The list is organized in the chronological order they were conducted from top-to-bottom.

Respondent	Organization	Method
Seegers, G.	Cordaid	In-person
Neville, J.	New Orleans Planning Authority	E-mail
Schuurmans, T.	ProPortion Foundation	Skype
Swank, A.	Text To Change	Skype
van den Berg, K.	Akvo	Skype
Cumiskey, L.	Deltares	Skype
von den Homberg, M.	TNO	Skype and E-mail
Geurts, M.	Cordaid	Skype and E-mail

Table 2 - *Source: Author*

All of the interviews with the exception of Neville are related to the Bangladesh case study. Correspondence with Neville was conducted through a series of e-mails related to New Orleans, specifically the community response to the disaster (Irazábal & Neville 2007; Neville 2014). The remaining interviews were conducted either in-person or through Skype with some follow-up questions for Homberg and Geurts conducted through an e-mail correspondence. Each interviewee was asked for consent to be recorded and for their name to be used in the publication of this thesis. Each interview was semi-structured and based off of a list of questions based on the theoretical concepts of the research, the interviewee's and their company's area of expertise and background information obtained on the projects or programs they were involved with.

The purpose of these in-depth interviews was to gain more insight into the case studies and how they relate to the theoretical concepts of this research. They were conducted either in-person, by telephone or using Skype. The interviewees are all directly involved with projects ongoing in Bangladesh. They were semi-structured and were based off a series of similar questions but rely on the in-depth answers of the interviewees. The interviews were conducted to gain more insight into why these projects were initiated, what the main goals are, how these projects operate on the ground and the nature of the relationships between the stakeholders of each project. With the information and data gathered from the interviews we can relate back to our theoretical concepts of environmental justice, vulnerability and resilience. By analyzing how these concepts relate to the cases, we can see how the projects are able to meet our goals of environmental justice by addressing vulnerabilities and strengthening resilience.

3.4. Considerations for Research

Several ethical questions are raised in the research. Since the main focus is environmental justice, which tends to separate people of different income, race and class, the categorization of individuals could raise ethical questions. Groups in the study could be unhappy with being labeled “poor” or “impoverished”. Frank Furedi (2009) also makes a statement about the concept of vulnerability, and that it is a professionally derived term and in certain areas that are considered highly vulnerable, this concept does not exist. Locals could reject the concept all together, thinking that it is a notion created by the outside world or researchers who are out of touch with the situation on the ground.

There are several limitations in this research. A major issue is the inability to gather information from communities in both case study areas since the field research is limited to the Netherlands. This makes it difficult to gain a comprehensive view of the cases since a crucial element of this research depends on what happens at the community level. This limitation to the Netherlands will also exclude non-Dutch organizations that are also working on similar projects in Bangladesh. However the strong presence of Dutch organizations in Bangladesh still makes the research conducted here strong and relevant. Since the concepts developed here are in their infancy and by the author’s opinion have potential to be helpful for natural hazard resiliency there is considerable room to expand upon the concepts developed here in further research.

4. Data Collection and Analysis

This chapter will take an in-depth look at two case studies. Prior to going into detail about the cases, we will first view the conceptual framework for the Resiliency Web and *RISK Pathways*. This framework will be applied to both case studies and visualized in models created by the author. The models are meant to create a better understanding of the relationships that form our bottom-linked governance structure which strengthens resilience and helps achieve our goals of environmental justice. The first case study is Hurricane Katrina and its impact on New Orleans in November 2005. The second case study investigates the current situation in Bangladesh in regards to disaster resilience. This is done by researching tropical storms that have struck the country in the past and how organizations have responded with different projects that are meant to strengthen community resilience to natural disasters. We will apply the Resiliency Web to both case studies, but will be analyzed mainly in the Bangladesh case study.

4.1. Conceptual Framework and The Resiliency Web

An understanding of the ideas of environmental justice could help explain why certain communities are vulnerable to natural hazards. Many different vulnerability indices list poverty as a main factor, but do not do much to explain the conditions related to poverty that create the vulnerability. This report will try to use examples of environmental injustices towards marginalized and poor communities that lead to vulnerabilities. It is possible to argue that many of these injustices and vulnerabilities are a direct result of the failure of government and society to provide for certain citizens and communities. Examples of these would be the placement of poor and substandard housing in hazardous areas such as floodplains, failure to provide an efficient and effective early warning system, failure to provide proper evacuation routes and ineffective recovery efforts and policies that return to previous unacceptable disaster conditions (Boettke et al. 2007; Manyena 2011; Mohit 2011; Morse 2008; Sobel & Leeson 2006). By using the case study of Hurricane Katrina and New Orleans in 2005, we can highlight these examples and others in reality. By showing that the major source vulnerability to natural hazards are directly linked with poor societal conditions that can be and ineffective governments, these vulnerabilities will be directly linked to the concepts of environmental justice.

Resilience is the opposite side of the coin. Understanding what makes a population vulnerable can help strengthen resilience. This report will make the argument that the most effective way of solving the vulnerability issue is not through top-down management, which is argued to have contributed in creating the vulnerabilities in the first place. Resilience is best strengthened with capacity building through social-ecological networks. Projects focused on community empowerment, capacity building, livelihood improvement, hazard protection and capital

distribution can foster resilience at the local level (Costa & Sadeque 2012). These communities can become empowered by an increase in different forms of capital (Mayunga 2009). These forms of capital can be increased through different distribution pathways.

4.2. *RISK Pathways and The Resiliency Web*

These various forms of capital can be managed and distributed through what this research calls *RISK Pathways*. *RISK* stands for Resource, Information, Services and Knowledge. The idea behind this originates from the theoretical framework and research conducted on Community Managed Disaster Risk Reduction (CMDRR) projects ongoing in the coastal region of Bangladesh. The main focus of these pathways is centered on distribution. The literature consistently associates vulnerability to a lack of resources. Examples of these resources could be financial capital, professional experts, protective infrastructure or technical tools such as an effective early warning system (Mayunga 2009). But vulnerability also comes from a lack of information, services and knowledge regarding natural hazards. Information could be related to the predicted path of a tropical storm and the communities that are at risk of being hit. Services could be using public transportation vehicles as a method of evacuation for communities lacking access to motor vehicles (Kiefer & Montjoy 2006). Knowledge could be related to emergency procedures that could lower the chance of perishing in a disaster (Costa & Sadeque 2012). These can all be treated as a form of capital (Mayunga 2009) that can be used to foster resilience at the community level. They are also a means of increasing livelihood and empowering communities. However, how do you distribute this capital to vulnerable groups that might not have the necessary means to acquire it themselves? An attempt to answer this question is done through the analysis of the case studies and the formulation of the Resiliency Web and *RISK Pathways*. This concept will be illustrated in the different projects researched for this report.

These pathways are established among different groups of stakeholders, including but not limited to different levels of government, non-governmental organizations, private companies and the communities and citizens themselves. The formation of the *RISK Pathways* establishes a network among these entities that go beyond hierarchical management. These relationships can be formed directly between the separate entities without the need of first going through an authority or agency. The formation of these relationships would eventually form what we will call a *Resiliency Web* with the different pathways forming the different strands in the web to create an overall resilient network based on shared resources, information, services and knowledge. The Bangladesh case study will be used to illustrate an example of a *Resiliency Web* by using ongoing projects at the community level implemented by a mix of different international organizations, government agencies and local citizens.

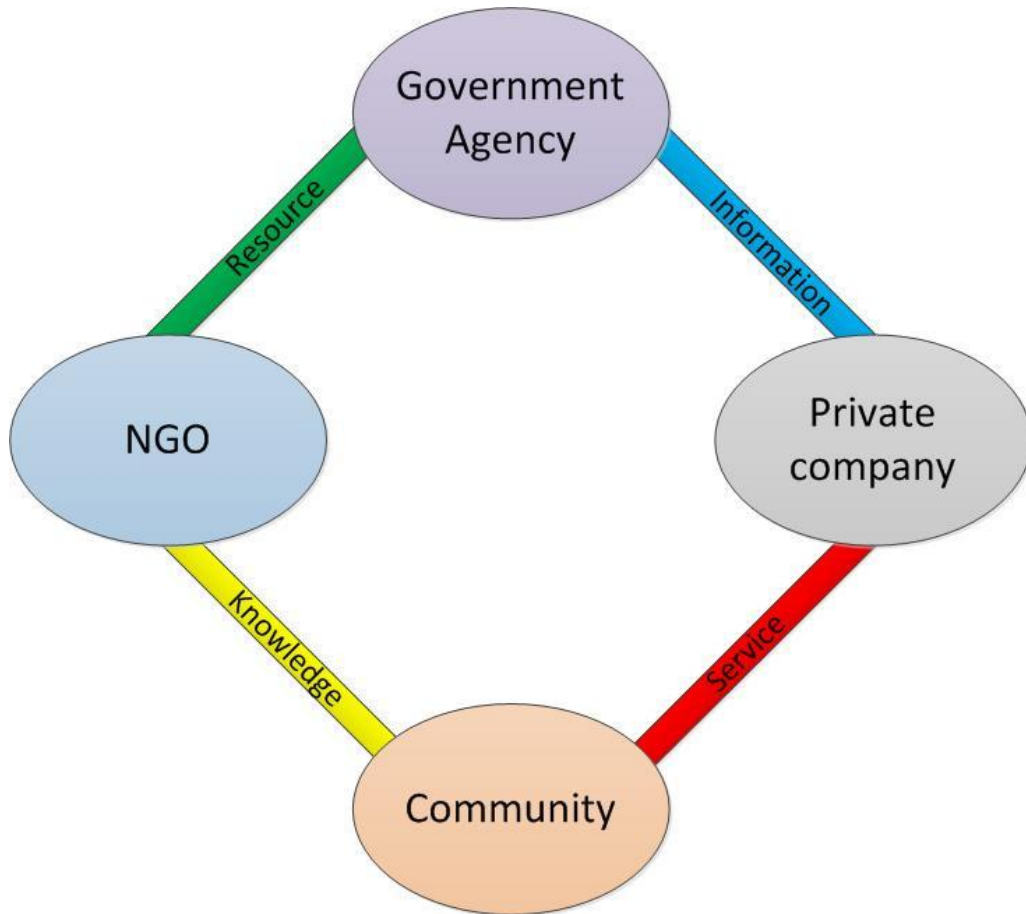


Figure 1: Resiliency Web framework
Source: Author

Figure 1 shows an example of the Resiliency Web and the *RISK Pathways*. The different pathways are established between each of the stakeholders. The pathways are meant to allow the distribution of resources, information, services or knowledge between the two stakeholders. This model will also serve as a legend for the subsequent figures that will appear later in this chapter. The Resiliency Web is a form of stakeholder analysis, it is meant to mainly show the relationships between the stakeholders and how capital can be distributed openly in order to create resilience (Mayunga 2009). By distributing different forms of capital we hope to lower vulnerabilities and foster environmental and social justice.

4.3. The Case Studies

The first part of this report tied together theoretical concepts of environmental justice and natural hazard vulnerability. Vulnerability is often directly linked with levels of income; in particular a lower level of income makes you more vulnerable to natural hazards because of a lack of entitlements and access to capital (Adger 2008; Mayunga 2009). At risk populations are

burdened by different political and socio-economic ‘pressures’ which can be ‘released’ by environmental hazards and create a disaster situation (Blaikie et al. 2003; Cutter et al. 2003). Although these stressors are important to understanding vulnerability, it is important to understand the relationship between the vulnerable population and their natural environment. This human-environmental relationship (Turner et al. 2003) is important to our understanding of social-ecological resilience.

The point of the following analysis is not to compare the two case studies, but to provide examples of different methods of disaster management and how these methods relate to our idea of environmental justice. The first case of Hurricane Katrina is meant to show how experts and researchers have pointed out that embedded and systemic poverty can make populations more vulnerable to natural hazards and the failings of a top-down disaster management structure in disaster response and recovery. This case will provide examples of environmental injustices in natural disasters and highlight instances where our two goals for fostering environmental justice are not met. The second case looks at Bangladesh and is meant to show a different type of governance structure, a rather new structure described as “bottom-linked” (Pradel et al. forthcoming). This governance structure can be used to address issues of vulnerability, foster social-ecological resilience and environmental and social justice in the face of natural hazards.

4.4. *When the Levee Breaks: Hurricane Katrina*

The following sections will investigate the case study of Hurricane Katrina. To fully understand the impact the tropical storm had on the city of New Orleans, the geographical and historical conditions of the area must be taken into account. New Orleans is physically vulnerable to natural hazards such as floods and tropical storms due to its location near the coastline of the Gulf of Mexico, a hotspot for hurricane activity, as well as the local topography of the area. New Orleans sits in an inundation situated below sea-level and surrounded by natural and man-made levees (Morse 2008; Pastroika & Jonkman 2010). Along with the geographical conditions, historical settlement and societal conditions played a major role in the devastation of Hurricane Katrina. New Orleans has a long history of racism and injustices towards minority communities, some of these have manifested themselves in environmental injustices (Elliot & Pais 2006; Morse 2008). These conditions will be analyzed in this section. The research will analyze how these historical and geographical conditions laid the groundwork for the disproportionate impact of Hurricane Katrina on poor and minority communities. Following the detailed description of the hurricane the research will relate the conditions and circumstances back to our theoretical framework.

On the morning of August 28th, 2005 Hurricane Katrina made landfall on the Gulf Coast of the United States between the major cities of New Orleans, Louisiana and Biloxi, Mississippi. The

two states were ill prepared for the devastation that followed. New Orleans received a massive blow when its infrastructure failed to prevent the storm surges from entering the populated areas of the city. Katrina brought with it sustained winds exceeding two hundred kilometers per hour and storm surges as high as eight meters in some locations (Fritz et al. 2007). At 07:30 local time the storm surge buckled the levee walls of the western side of the Industrial Canal and sent water into the areas of the Upper Ninth Ward, Bywater and Treme. At approximately 07:45 two sections of the levee on the eastern side of the southern portion of the Industrial Canal collapsed, allowing floodwaters to pour across three hundred and fifty meters of breached levees into the Lower Ninth Ward. Along Lake Pontchartrain, levees ruptured at London Street and 17th Street, flooding areas of Gentilly, Lakeview, Carrollton, Broadmoor and Mid-City. Floodwaters continued to pour into these areas for twenty four hours, and by the time the storm passed and dissipated over 80% of the city was flooded (Image 1) (Image 2) (Morse 2008). What followed is described in official government reports and independent studies as a series of bureaucratic failures, organizational confusion and governmental missteps in the response and recovery efforts by the appropriate authorities (Boettke et al. 2007),

leading to the question of if the relevant authorities are the necessary entities to respond to these types of scenarios.

The situation in New Orleans was unprecedented in the United States, never before had a major city been completely devastated and the near total of its residents evacuated for an extended period (Elliot & Pais 2006).

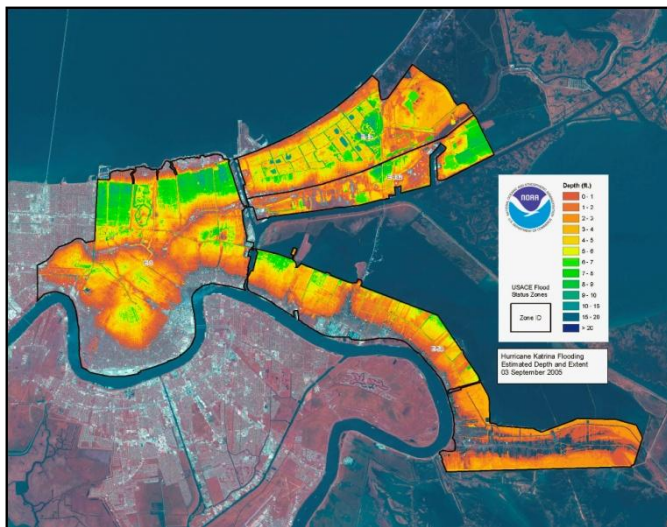


Image 1 (Above) – Map of flooded area of New Orleans *Source: NOAA*

Image 2 (Right) – Photograph of flooded New Orleans post-Katrina *Source: Trinity College*



Although the scale of the disaster might have been unprecedented, many of the factors that helped create the disaster situation were highlighted in advance of the storm, in some cases

many years before. Leuttich of the University of North Carolina, Chapel Hill modeled ways in which hurricanes could flood New Orleans. In the year prior to Katrina, using an advanced model to simulate storm surges, Leuttich and others determined the levees around New Orleans, on average five meters high, would not prevent flooding from a category three hurricane (Travis 2005). Louisiana State University's Center for Public Health Impacts of Hurricanes led a multi-disciplinary team in 2002 researching the possibility and effects of a direct hit from a major hurricane on the city. In a random survey of New Orleans residents, they determined that 21.4% of the population would stay in the city despite a mandatory evacuation because they lacked the means to escape (Travis 2005). The knowledge that this disaster was very probable was well known among scientists, civil engineers and political representatives; the infrastructure was outdated and insufficient and the parts of the population were not prepared.

The flooding of New Orleans caused widespread destruction throughout the entire city. A report by the Interagency Performance Evaluation Team estimated about \$16 billion in damages to residential properties and another \$7 billion in damages to public infrastructure and utilities (Patriska & Jonkman 2010). The area suffering the highest level of destruction was the Lower Ninth Ward, a predominantly poorer section of the city compared to other areas. Hurricane Katrina highlighted several inherent injustices in the social and political fabric of New Orleans and the United States federal government. Prior to Hurricane Katrina, Louisiana ranked second in the nation in terms of state poverty rates, exceeded by only its neighbor Mississippi (Morse 2008). The poverty rate of the affected areas was about 21% with a national average of 12.4% (Gabe et al. 2005). The median household income for New Orleans was \$27,000, while the national average was \$42,000. Altogether, 28% of all families in New Orleans were below the poverty line (Boettke et al. 2007). With the widespread and cataclysmic damage, "Hurricane Katrina likely made one of the poorest areas of the country even poorer" (Gabe et al. 2005 p. 13). The following sections will take a more in-depth look into the situation prior to the hurricane which caused this disproportionate impact.

4.3.1. Geographical characteristics of New Orleans

The city of New Orleans has very high geographic vulnerability. The Gulf Coast is highly vulnerable to hurricanes, experiencing on average six per year (NOAA 2011). Sitting directly on the Gulf Coast, New Orleans is situated in the Mississippi Alluvial Plain between the Mississippi River in the south and Lake Pontchartrain in the north (Patriska & Jonkman 2010). The city sits in a bowl-like inundation that is primarily below sea level (Burnside 2006). New Orleans was founded in the early 18th century when French-Canadian explorer Jean-Baptiste Le Moyne discovered that Lake Pontchartrain provided a shortcut from the Gulf of Mexico to the Mississippi River. Settlement was situated on natural levees formed by low-velocity deposits of

sediment on a bend on the Mississippi River (Morse 2008). Most of the city is situated below sea level and is entirely protected by man-made levees (dykes). The geographic and environmental conditions of the city make it naturally vulnerable to environmental hazards. For the last several hundred years, the development practices during human settlement of the area has increased this vulnerability.

4.3.2. Historical settlement

To understand the complexity of the social structure which contributed to the disaster situation of Katrina, the history of New Orleans must be briefly analyzed. The Gulf South region of Louisiana has a long complicated history of race relations. The Deep South of the United States has strong roots in slave labor and agriculture. During the early days of British settlement wealthy aristocrats who could afford slaves settled in large plantations in the south. This is opposed to the larger urban centers of the Northeast, such as Boston and New York, which were populated by poor, religious refugees. This created two distinct socio-economic distinctions between the northern and southern United States which in some way remains to this day (Elliot & Pais 2006). While cities in the northeast grew through industry and entrepreneurship, the aristocratic urban centers of the south grew to depend on the money and wealth controlled in the northern parts of the country. In the mid-20th century, heavy migration occurred from the populated and expensive cities of the northeast to cities such as Charlotte, Atlanta and Miami. The historic Gulf Coast was mainly ignored during this migration, including New Orleans. There was little demographic change in these cities, as well as little economic growth (Elliot & Pais 2006). Because of this relatively small influx of immigration and lack of economic growth, New Orleans has had a net loss in population of about 30% since 1960 (Irazábal & Neville 2007). With little interference from migratory populations and other influencing factors, the strong racial and class tensions originating from slavery and through the civil rights era of the mid-20th century remained in New Orleans.

After the end of the Civil War, settlement patterns around New Orleans were largely dictated and organized by the ruling aristocracy, mainly white land owners. They forced black communities to live in undesirable areas that suffered from flooding and had inadequate public infrastructure (Morse 2008). Public housing was segregated legally and the black private housing projects occupied flood-prone low-lying land while the white housing projects were built on higher elevation closer to the main areas of the city. In 1896, swamps on the periphery of the city were drained and white residents began moving to areas along Lake Pontchartrain that restricted black residents (Elliot & Pais 2006). Construction of the Industrial Canal began in 1918 which isolated the Lower Ninth Ward from the rest of the city. The man-made levees around the public works structures such as the Industrial Canal and the Mississippi River Gulf

Outlet (MR-GO) were usually made of sheet-pile and ranged between four to six meters (Morse 2008).

The historic development of New Orleans led to indirect pressures on the city and environment. The man-made levees would prevent the natural deposition of the soil along the river banks, which led to land subsidence throughout the city. Some estimates say that portions of Central City and the Ninth Ward have subsided up to one hundred and thirty centimeters the past forty years (Morse 2008). The historic damming of the Mississippi River also reduced the amount of sediment that will naturally deposit into the Gulf of Mexico from the river mouth, allowing for the protective barrier islands to slowly disappear, by some estimates nearly on hundred square kilometers per year (Travis 2005). The wetlands continue to disappear from the impact of development, subsidence and erosion. The MR-GO is estimated to have contributed to the loss of nearly 27,000 acres of wetlands in the St. Bernard Parish in the decades since its construction (Morse 2008).

4.3.3. Evacuation procedures

The settlement practices of New Orleans laid the groundwork for the injustices that occurred when Hurricane Katrina struck the city in 2005. These injustices were very visual after the hurricane had dissipated and New Orleans was in a continual emergency state with many of its population suffering for days or even weeks following the hurricane. The following sections will give a detailed description of the evacuation procedures and relief and recovery efforts provided by the authorities.

Evacuation practices are a key factor to the survival of a population when a strong tropical storm is predicted to hit an area. Although Hurricane Katrina was meticulously tracked and analyzed on its approach to the Gulf Coast, public officials waited to give the evacuation notice. The mayor of New Orleans waited 15 hours to order the mandatory evacuation after receiving the warning that Katrina will hit New Orleans (Sobel & Leeson 2006). Although the evacuation was mandatory nearly a quarter of the city's residents would remain in the city for various reasons (Travis 2005).

New Orleans has a very immobile population (Kiefer & Montjoy 2006). The car-centric development model prevalent in the United States allocates most federal and state transportation funding to the development of highways for private motor vehicles. On average this is about 80% of total funding, leaving less than 20% for public transportation (Morse 2008). In New Orleans, most of the 1.5 million evacuees used a private motor vehicle to leave the city. It is estimated that somewhere between 100,000 and 150,000 people did not or could not evacuate (Zamore 2009). There are many reasons why people stayed behind. Some groups are less likely to evacuate than others, including the elderly, sick, families with young children,

families of low-income and minority groups (Zamore 2009). Although many wanted to leave, they couldn't because they didn't have access to a motor vehicle. It is estimated that nearly 150,000 residents did not have a private motor vehicle or access to one (Zamore 2009) including about 60% of all African American households (Morse 2008). Many of the residents of New Orleans rely on public transportation for their daily commutes. Despite this reality, there was no plan to evacuate residents using public transportation (Zamore 2008). The city's Comprehensive Emergency Plan did not make use of the five hundred and fifty municipal buses or the hundreds of school buses owned by the city. The day before the storm hit, city buses were directed to pick up the elderly and poor at a dozen checkpoints around the city, but the effort failed mainly because the checkpoint's locations were hard to determine and were not clearly marked (Morse 2008). Also, the national train company, Amtrak, had offered the city the opportunity to evacuate residents but officials declined for reasons this research could not uncover (Morse 2008, Sobel & Leeson 2007). The Comprehensive Emergency Plan did determine that at least 100,000 citizens would need shelter, and had determined that the New Orleans Superdome, home of the New Orleans Saints American Football team, would shelter the evacuees (Gabe et al. 2005). In the Superdome and other evacuee shelters around Louisiana and Texas, researchers and public officials were able to understand the demographic nature of the evacuated population through public surveys.

It was determined that over 700,000 people were acutely impacted by Hurricane Katrina, with nearly 645,000 displaced within New Orleans alone (Gabe et al. 2005). Nearly all of the evacuees in the main shelters were New Orleans residents, and over 90% were African American. When this figure is compared to the overall black population of New Orleans, around 67%, a pattern of race-based vulnerability emerges (Brodie et al. 2006). Reports from the U.S. Coast Guard stated that over 60,000 people were rescued from rooftops after the city was flooded (Morse 2008). Half of those rescued were rescued by the government or military, the other half by family. Many residents spent up to three days on the street, on a highway overpass or trapped in their homes or on random rooftops waiting to be rescued (Brodie et al. 2006). Some residents, who even tried to leave New Orleans on foot, were not allowed to leave the city. In one specific and widely circulated case, nearly two hundred Katrina victims tried to cross the Mississippi River on Highway 90 over to the nearby municipality of Gretna. They were met by armed Gretna police forces ordering them to turn around. Gretna city officials reasoned this to be because the city was on lock down because of looters (Morse 2008). Though this example is a rather extreme case of authority denying proper relief to victims of Hurricane Katrina, there are other examples of administrative failures provided by the research that can be related to our ideas of environmental justice.

4.3.4. Administrative Failures in the Aftermath of Hurricane Katrina

Official government reports and independent studies point to a severe mismanagement of resources, poor allocation of emergency personnel and a disrupted, overly bureaucratic management process in the official response to and recovery from Hurricane Katrina (Boettke et al 2007, Elkenberry et al. 2007). The recovery effort was so disorganized and ineffective that international non-governmental organizations provided aid for the first time ever in United States history. Groups like Oxfam, UNICEF and the International Rescue Committee all sent personnel to help in the crisis (Elkenberry et al. 2007).

The goals of disaster relief are to reduce physical, social and economic vulnerability and to facilitate the effective provision of short-term emergency assistance and long-term recovery aid (Elkenberry et al. 2007). Recovery requires three robust institutions, economic/financial, political/legal and social/cultural (Boettke et al. 2007). Each of these institutions is embedded within each other, and if one of these institutions fails the other two have a strong potential to fail as well.

The main recovery effort was coordinated and guided by the Federal Emergency Management Agency (FEMA). FEMA is a national organization meant to coordinate the recovery process if an area is declared a disaster zone. This declaration can only be done by the President of the United States. FEMA cannot be activated, and therefore federal funding cannot start flowing until this declaration is made. President Bush declared an emergency for the states of Louisiana and Mississippi the day before the hurricane struck. However, because of the political climate of New Orleans, resources and personnel were mobilized slowly (Sobel & Leeson 2006).

Politically, New Orleans has had a long history of corruption within its government (Boettke et al. 2007). This corruption has fostered a general disdain within the population towards elected officials. Some believe that the government is actively trying to destroy part of the population (Neville 2014). In the 1927 floods, the local government intentionally blew up a levee to try and protect New Orleans but ended up flooding St. Bernard Parish. Part of this disdain could have aided in the general disregard of the mandatory evacuation notice. This pattern of corruption was maintained during the recovery effort for Katrina, as there was an estimated \$2 billion in misappropriated funds from fraud and abuse documented (Boettke et al. 2007). Once a president declares a disaster, large amounts of money from the federal government flow in. The money goes to several different sectors for various different reasons. The chaotic atmosphere of the disaster area allows for little oversight over how the money is spent and who receives it. New Orleans reputation for corruption and cronyism was so widespread that there was a 'government hesitancy' to send aid to the affected areas. They were so cautious to send personnel and supplies that a Canadian search-and-rescue team arrived days before most FEMA and military personnel (Sobel & Leeson 2006).

There were two ways in which the government and administration failed in the Katrina response. First, there was perceived failure of all levels of government to the immediate needs of those affected in the disaster. Second, there was a failure to plan for and coordinate the non-profit, NGO and private sector relief efforts (Boettke et al. 2007; Elkenberry et al. 2007). These failures were either caused by being overly cautious in some scenarios or completely underestimating the severity of others (Sobel & Leeson 2006). FEMA failed to coordinate the relief efforts of the entire operation, and in some cases even blocked organizations from helping due to bureaucratic red-tape. Even other agencies of the government, such as the coast-guard, had to circumvent FEMA and the law to provide aid to those who needed it and rescue victims stranded in the city (Sobel & Leeson 2006).

Another example involves two different local law enforcement agencies thousands of kilometers away. Both Sheriff Warren Evens of Wayne County, Michigan and Sheriff Dennis Randle of Carroll County, Indiana had both loaded up trucks full of supplies ready to send to the disaster area. All supplies going into the disaster area need to be approved and coordinated by FEMA. Sheriff Randle sent his request to FEMA, and never received a reply. His supplies never made it to New Orleans. Sheriff Evens decided to ignore FEMA and his supplies made it to the city the next day (Sobel & Leeson 2006).

The catastrophe ensnared national attention and drew the opinions of large and powerful groups within the United States. Some questioned whether to rebuild the city at all. However, New Orleans was determined to recover. Mayor Nagin instituted the Bring Back New Orleans plan which identified many areas in need of immediate rebuilding. These areas were mainly affluent Lakefront white communities. Poor black communities were predominantly left out of the plan (Morse 2008). Some parts of the city were to be permanently destroyed to allow areas to be flooded in case of another levee breach. Neighborhoods had to prove 'viability' in order to be kept out of this discussion (Morse 2008; Neville 2014). After intense public opposition to city hall's proposed plans, the Unified New Orleans Plan was established which would rebuild all neighborhoods.

The recovery efforts were met with a strong reaction from the people of New Orleans. New Orleans has always been a city of culture, especially within the lower-income black communities. There has always been a very strong place-attachment to the city through the strong historical and cultural significance of these communities. Once it was obvious the needs of the many affected communities were not being met, neighborhood groups and communities began to take an active role in their local recovery. These actions were called 'invented citizenship', where disenfranchised communities created their own opportunities, terms of engagement and identified as citizens of their own areas instead of citizens defined by a type of governing body (Irazábal & Neville 2007). There is a strong legacy of 'self-help' in New Orleans

that materialized into different social and economic needs (Neville 2014). The lower income communities already participated in many insurgent community behaviors, including street celebrations and festivals, impromptu second-lines and jazz funerals (Image 3) and the maintenance of neighborhood-based social-aid organizations (Irazábal & Neville 2007). These communities began to help themselves in the recovery effort.



Image 3 – Second Line parade in New Orleans Source: *gaphotos.com*

Hurricane Katrina brought to light the systemic racial and class disparities that have been ingrained in New Orleans culture for centuries. These disparities were aided by a series of administrative failures at the local, state and national level. In the following section, we'll take a closer look at how these disparities and administrative failures relate to our theoretical and contextual framework.

4.3.5. Analysis of Hurricane Katrina

This section will look more in-depth to the circumstances surrounding Hurricane Katrina and relate back to our theoretical concepts. This will be followed by an analysis of the situation using our Resiliency Web and *RISK Pathways*.

Several justice issues arise in the historic settlement of New Orleans, including the discriminatory practice of settling low-income black communities in low-lying, flood prone land. The inherent racism and classism were strong social and political pressures that left these

communities highly vulnerable to floods and tropical storms (Blaikie et al. 2003). These areas, including the Lower Ninth Ward, would be some of those hit hardest during Hurricane Katrina (Pastrika & Jonkman 2010). The development violations fail to meet our first goal of environmental justice (Ebbeson 2009, Morse 2008). By segregating public housing communities and placing black housing in low-lying flood-prone areas while locating white housing on higher elevations there is a noticeable inequality in the protection from environmental hazards, a disparity clearly dependent on race. This placement gives an advantage to white communities if a flood is to occur in an area. Although this type of segregation is now illegal in the United States and Louisiana, it was still present prior to Hurricane Katrina (Eliot & Pais 2006).

It is also important to note the loss of wetlands and barrier islands due to development. The loss of these important ecosystems is a loss of natural capital (Mayunga 2009). The important ecosystem services provided by wetlands and barrier islands to the human-environmental system are ignored. According to Turner's (2003) vulnerability/sustainability model, this makes the social-ecological system vulnerable. The natural flood buffers and barriers were replaced with man-made dykes, levees and water pump infrastructure meant to drain the water if an area is flooded. These structures, meant to protect the population, actually indirectly increased vulnerability as they provided a false sense of security (Morse 2008) to the population of New Orleans, which was a factor in the eventual evacuation of the city.

The evacuation situation is relatable to many of our theoretical perceptions of environmental justice and vulnerability. The near entire evacuation plan being based on private motor vehicles, when it is estimated that almost half of the population does not have access to one, is inherently biased towards poor minority groups. This violates our first goal of environmental justice, to provide adequate protection from environmental hazards (Ebbeson 2009, Morse 2008). Our second notion of justice, allowing equal opportunity in the decision-making process to determine the distribution of benefits and hazards, is also relatable here. It is possible that many of the city's residents could have fought for more public transportation opportunities had they would have known that they would be virtually unavailable and underutilized in the case of a catastrophe on the scale of Katrina. This can be traced towards other major administrative and political failures of the local, state and federal government in the response and recovery of the disaster.

We can see the antecedent conditions and pressures that were present before the hurricane struck and how the impact was felt disproportionately among black and poor citizens. The disproportion is relatable to our ideas of vulnerability (Adger 2006; Blaikie et al. 2003; Cutter et al. 2003) in that populations of lower income are more vulnerable to natural hazards. The placement of low-income housing in low-lying, flood-prone areas (Eliot & Pais 2006) and the

lack of any plan to evacuate citizens without access to a motor vehicle (Morse 2008; Sobel & Leeson 2007) both affect poor communities more than more affluent ones.

In New Orleans there was a communication and distribution breakdown because of the hierarchical structure of disaster management. Declaring a zone a disaster area is important because it allows for FEMA to be activated and federal money to be pumped into the zone for recovery purposes. The only issue is all other relief efforts from other organizations have to go through FEMA before it can get to the people. This type of bureaucratic red-tape only serves to block resources, information, services and knowledge from the people who need it immediately. Top-down disaster management is simply too rigid a system to allow for the kind of flexibility a resilient society requires. It makes it difficult to achieve our goals for environmental justice. Individuals and groups who exist at the ‘bottom of the pyramid’ lack the political representation to be provided adequate protection from natural hazards and the ability to influence the decision-making process that allocates those protections (Ebbeson 2009, Morse 2008). The social vulnerabilities that were present in New Orleans were inadequately addressed by the official agencies responsible.

In Figure 2, we can see an example of the administrative top-down disaster management framework that was established in the recovery effort for New Orleans.

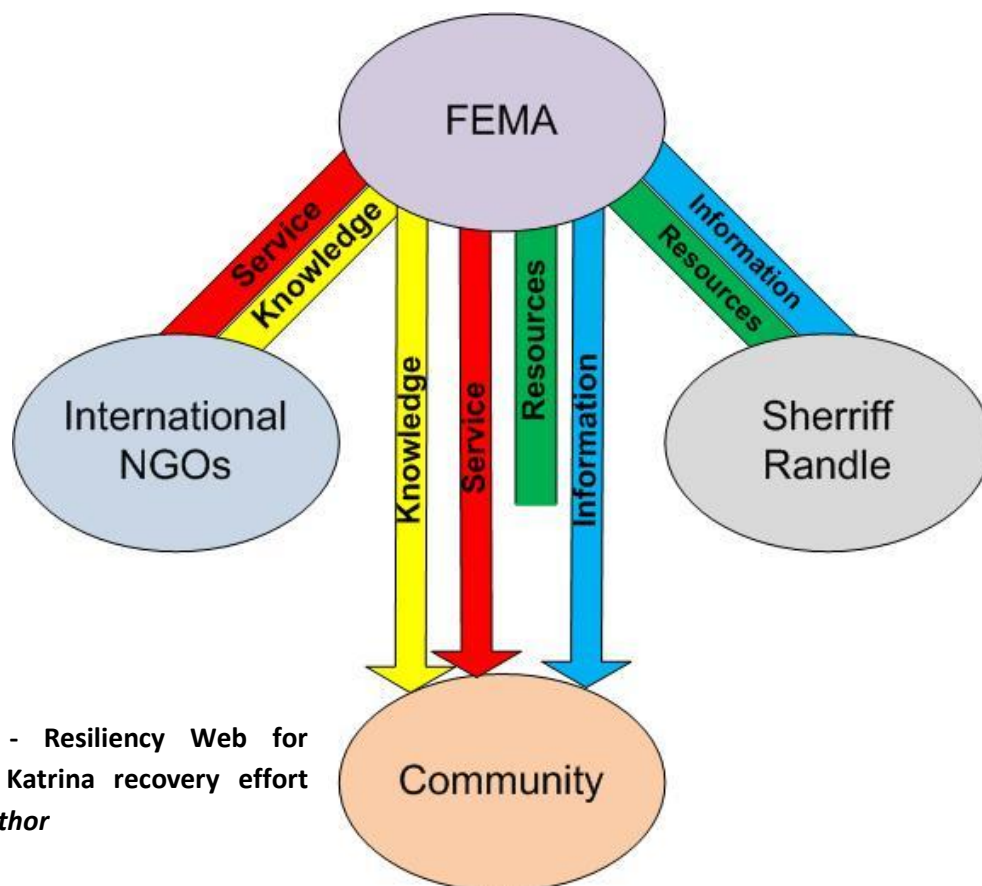


Figure 2 - Resiliency Web for Hurricane Katrina recovery effort
Source: Author

You can see how all of the *RISK Pathways* have to go through the central authority FEMA before they can be distributed to the communities in need. The International NGOs that were dispatched to Katrina had to be approved and coordinated by FEMA before they could begin to help. This is meant to make sure that relief is not being doubled in some places and neglected in others. However we can argue that this slows down or hampers the recovery process. This is true if referring to the examples of the Sheriff Randle who decided to wait for approval from FEMA to provide relief and resources but inevitably never heard a response (Sobel & Leeson 2006). We can see how a *Resource Pathway* moves from the sheriff's department to FEMA only to never make it to the community in question. It is possible that the resources could have made it to the community if it never had to move through a central authority, but this is only a hypothetical assumption. It is also important to note that the *RISK Pathways* from FEMA to the community are one-way pathways. There is no feedback loop from the community back to FEMA. This is an example of the 'single-loop learning' described by Manyena (2011) and a common occurrence in a top-down disaster management model. FEMA controls the resources, services, information and knowledge and uses them to return the area to a state of normalcy. Once that occurs they withdraw and the area returns to the same pre-disaster conditions. There is no 'bounce-forward' resilience or social learning that could create a better and more resilient society with stronger absorptive capacity (Cutter et al. 2008).

During the rebuilding process, many of the poor citizens of New Orleans were not represented in the plans (Irazábal & Neville 2007). Their neighborhoods were left out of the plans to rebuild, and in some cases were planned to be demolished to make room for water. By transforming a built area for a natural one that can retain water during a flood; this type of plan in fact adheres to some ideas of Turner's et al. (2003) Vulnerability/Sustainability model. However, by ignoring the needs of the communities whose neighborhoods would be destroyed, it leans towards ecological sustainability more than social. It ignores our second goal of environmental justice, to provide citizens an equal opportunity in the decision making process. Only after the plans were made public were citizens able to mobilize and stop them (Irazábal & Neville 2007) and more pro-active rebuilding plans were initiated that began to listen to the marginalized communities. Recovery efforts from the bottom-up are more focused on sustainable redevelopment, with a strong focus on both social and ecological systems, as the communities want to rebuild a better living situation for both humans and the environment. This is a type of 'organic recovery', because private citizens with a stake in the outcome are best situated to lead their own recovery (Boettke et al 2007).

The eventual 'self-help' (Neville 2014) of the affected communities does meet our second goal of environmental justice (Ebbeson 2009; Morse 2008), although it is interesting because this

justice is created from the bottom-up. These groups were able to establish and recover themselves by taking matters into their own hands without the help from the local and national governments. They created their own fair representation in the local political process.

4.3.6. Conclusion

Hurricane Katrina has become a famous case for environmental justice, which is interesting because it is located in the area where the concept was originally created so many years prior (Morse 2008). The antecedent conditions (Adger 2006; Cutter et al. 2008) that perpetuated racism throughout the area existed for centuries before the disaster struck. Katrina not only brought these conditions to light, they intensified them through the administrative failures of government agencies in charge of recovery. These antecedent conditions and administrative failures fail to meet our two goals for environmental justice (Ebbeson 2009; Morse 2008). The antecedent conditions of racism are deeply embedded in the society of New Orleans and would be incredibly difficult to rectify. The administrative failures of the top-down disaster management system could however be transformed into a framework that could at least address the lack of entitlements at the 'bottom-of-the-pyramid' and help strengthen resilience. Communities have a strong willingness to protect themselves and their livelihoods, as we saw in the 'self-help' communities of New Orleans (Irazábal & Neville 2007; Neville 2014). This bottom-up willingness needs to be complimented by a governance structure that can give these communities the resources, information, services and knowledge they need to protect themselves. Interestingly, this has in some way been happening in Bangladesh, one of the most vulnerable countries in the world.

4.4. Help on the Way: Bangladesh and CMDRR

This section will examine social vulnerabilities to natural hazards in modern day Bangladesh by examining the effects of the geographical considerations and cyclones that have struck the country in the past. Specifically the research will look at Cyclone Sidr which struck the southwestern coast in November 2007, taking with it over 3,000 lives and costing nearly \$2 billion in damages and losses. By examining policy documents from the Government of Bangladesh as well as independent studies by academic researchers we will try to relate these vulnerabilities to our concept of environmental justice. It is important again to understand the history of a place to understand the present. Knowing how cyclones have affected Bangladesh in the past will give us an understanding of the vulnerabilities present there. Following the historical analysis, we will look at the present-day situation in Bangladesh regarding Disaster Risk Reduction (DRR). This will be done by examining the practice of Community Managed Disaster Risk Reduction (CMDRR), a series of programs and pilot projects spearheaded by international NGO's, mainly from the Netherlands. By examining these projects we will apply

our concept of *RISK Pathways* and the *Resiliency Web* to show how the distribution and creation of different forms of capital is occurring through bottom-linked governance processes.

4.4.1. History of Bangladesh Cyclones

“Bangladesh is one of the most disaster prone countries in the world” (Costa & Sadeque 2012 p. 8). Its geographic location, topography, geology and climate allow for a myriad of different natural hazards. This coupled with a high population density and a high rate of poverty among its citizens creates a very vulnerable population. Bangladesh is one of the most densely populated countries in the world with an average of about 1,045 people per square kilometer (Government of Bangladesh 2008). Nationwide, the country has a poverty rate of about 40%, however it should be noted that this estimate was made in 2005 (Government of Bangladesh 2008). The socio-economic situation coupled with the geographic vulnerability contributes to a high susceptibility to disaster situations caused by natural circumstances.

Floods are the most common natural hazard in Bangladesh, which ranks first on the list of countries most at risk of flooding. Sometimes nearly 75% of the country is flooded (Cordaid 2013). The flooding comes from overflowing rivers and heavy rains, monsoons or storm surges caused by tropical storms. Monsoon season runs from June to September and tropical cyclones peak immediately following the monsoon season in October (Cordaid 2013). The average number of tropical depressions in the Bay of Bengal per year is twelve or thirteen, with about five of those eventually becoming cyclones (Paul 2009). Although Bangladesh has been hit by about 5% of recorded cyclone activity worldwide in modern records, in total it has about 80-90% of all of the losses in terms of lives. Over half of all tropical storms worldwide that have claimed more than 5,000 lives have occurred in Bangladesh (Paul 2009). Cyclone Bhola struck Bangladesh in 1970 and killed at least 300,000 people (Cordaid 2013). In 1991 Cyclone Gorky struck and killed over an estimated 140,000 people (Paul 2009). These two disasters prompted the government to become much more pro-active in disaster resilience. The Cyclone Preparedness Program (CPP) was introduced in 1972 after Cyclone Bhola caused widespread devastation to the coastal area. It was jointly set up by the Bangladesh Ministry of Disaster Management and Relief (MDMR) and the Bangladesh Red Crescent Society (BDRCS). They are in charge of three different institutions: a cyclone early warning system, public cyclone shelters and shelters to provide protection to cattle during storm surges (Paul 2009). The CPP has their headquarters in Dhaka, with offices in six different zones and over thirty-two sub-districts. There are over 43,000 CPP volunteers in different areas all over Bangladesh but are mainly concentrated in the coastal regions (Paul et al. 2011).

The CPP is a good way to disseminate information from the weather forecasts provided by the Bangladesh Meteorological Society (BMD) to other factions at lower levels. The Storm Warning Centre (SWC) provides warnings at the national level once a tropical depression forms in the

Bay of Bengal. Warnings are issued to the National Coordination Committee which is chaired by the prime minister and includes representatives of the CPP. From there, the CPP volunteers spread throughout Bangladesh issue warnings at the community level (Paul & Dutt 2010). However, there are still gaps in the flow, or pathways, of information. There are issues with the “last-mile” for some of the more rural communities (Geurts 2014; Schuurmans 2014), although this has more to do with more inland villages located on rivers that are more at risk for floods rather than communities in the coastal areas.

Once a warning is issued for an oncoming cyclone, CPP volunteers are tasked with warning their local communities by megaphone, bicycle-mounted loudspeakers or house-to-house contact (Paul 2009). They also assist in the evacuation process, and organize communities to evacuate to the nearest cyclone shelter. There are other issues regarding cyclone shelters and evacuation behaviors that make the population of Bangladesh vulnerable. Many of these reasons are documented in civil surveys and interviews conducted by Bimal Kanti Paul (2007; 2010; 2011), a researcher out of Kansas State University, after Cyclone Sidr struck the coast in 2007.

4.4.2. Cyclone Sidr

Cyclone Sidr was a major category four cyclone with winds up to two hundred and forty kilometers per hour when it made landfall on the southwestern coast of Bangladesh on November 15th, 2007 at 21:00. It was first noticed as a tropical depression on November 9th. After becoming a cyclone on November 13th, the CPP was activated and went into action warning villages in the directed path (Paul 2009). Sidr made landfall on the Barisal coast during an ebb tide with a diameter of nearly one thousand kilometers (Government of Bangladesh 2008). The storm surge ranged anywhere between three to six meters, measuring approximately five and a half meters at the Baleswar River, five meters at the Sharankhola and Bagerhat Rivers and three and half meters at Hiron Point (Government of Bangladesh 2008). The high storm surges breached coastal and river embankments and flooded the low-lying areas, causing extensive damage to housing, roads and bridges. Electricity and communication were all knocked out. After it was over, Sidr was the second most destructive cyclone to hit Bangladesh the previous fifteen years (Government of Bangladesh 2008).

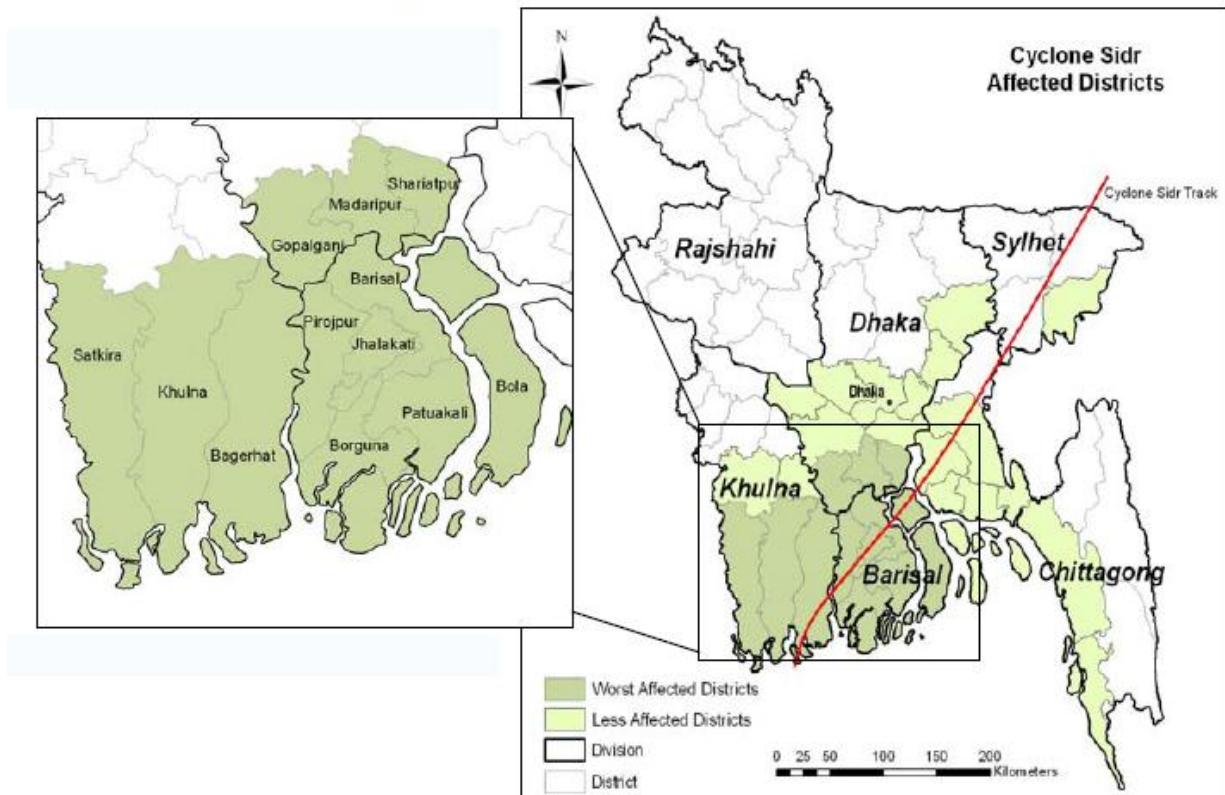


Image 4: Cyclone Sidr Affected districts
Source: Government of Bangladesh (2008)

The total destruction of Sidr was estimated at approximately \$1.7 billion and was highly concentrated in housing and private assets instead of actual economic losses. The total amount of damage done to housing is estimated at about \$839 million. The quality of the housing was a primary reason for this. Of the districts affected, nearly 84% of the housing is described as “semi-Pucca”. “Pucca” means of permanent quality, usually being composed of brick and cement. The majority of the semi-pucca housing is constructed from a combination of corrugated galvanized iron sheets (C.I. sheets), wood and earthen materials. The C.I. sheets are dangerous in relation to the strong winds associated with tropical cyclones, as they have been known to be picked up and turned into dangerous missiles by the wind (Blaikie et al 2003). In the 12 most affected districts, 540,000 of the over three million total households were completely destroyed and another 854,000 damaged. This left approximately nine million people without shelter (Government of Bangladesh 2008).

Of the economic losses sustained, the majority was in the agriculture sector, which is the primary income and main source of livelihood for most poor rural communities. About 75% of the rural population consists of landless laborers and marginal farmers (Government of

Bangladesh 2008). In total about 2.2 million farming families were affected by Sidr with about \$412 million in total losses. Livestock was devastated in the four worst affected districts, with up to 80% of all farm animals perishing in the storm. There is known to be a lack of *killas*, or livestock shelters, in these affected areas. *Killas* are essentially raised earthen mounds that cattle stand on during a storm. This doesn't provide much protection from wind but will save them from flooding. Many of these *killas* are not properly maintained and have been overgrown by flora (Paul 2009). The total amount of damage and losses represents 2.8% of the country's Gross Domestic Product (Government of Bangladesh 2008). However, since most of the damages and losses are concentrated in rural, poor areas, this number is not proportional to the damages sustained in those areas. Most of the country's GDP is produced in Dhaka and Chittagong City, which were affected by Sidr much less than other districts.

The primary sources of protection for most residents in the coastal districts are the cyclone shelters. Cyclone shelters are usually two to three stories tall and made of reinforced concrete. They can usually accommodate 1,500-2,000 people (Paul & Dutt 2010). There has never been a fatality among people who have evacuated to a cyclone shelter. In 2009, there were approximately 4,000 cyclone shelters in fifteen different coastal districts. This is compared to only five hundred and twelve not even twenty years earlier (Paul 2009). However, at that time it was determined that 1,576 shelters, approximately 39% of all cyclone shelters, were damaged or abandoned and not usable (Paul 2009). It is estimated that there needs to be at least 10,000 cyclone shelters available to be able to appropriately protect the vulnerable populations (Blaikie et al. 2003). At the time of the cyclone, Barisal, the worst affected district, had about fifty-seven useable cyclone shelters, accommodating for only 5% of the population of that district. Khulna, the second worst affected district, had only thirty-four and accommodated for only 3% of the population (Shamsuddoha & Chowdhury 2007). These two districts are also two of the poorest in the country as well. The wealthier and more urbanized districts of Chittagong and Cox's Bazar on the eastern coast of Bangladesh have nearly 1,000 shelters between the two districts. Chittagong, home to the country's second largest city, can accommodate 15% of the population in their shelters. Cox's Bazar can accommodate over half (Shamsuddoha & Chowdhury 2007). Some officials in Bangladesh claim that the location of cyclone shelters can be extremely political and areas with a larger share of the GDP and more representatives in the central government will always have more shelters of better quality (Paul 2009).

Another important source for flood and storm surge protection are the embankments which line the coastal area as well as the edges of rivers. There are about one hundred and twenty-five polders in nineteen districts in the coastal area covering an area of about 13,000 square kilometers (Government of Bangladesh 2008). Surrounding the polders is a 5,000 kilometer system of embankments and dykes and about 2,500 water control structures. The

embankments are the first line of defense against storm surges, however many of the embankments are in a state of constant disrepair. Sea facing embankments are around six meters high and were not overtopped during Sidr. However estuarine and river embankments were lower and were overtopped (Paul 2009). Sidr affected about 2,290 kilometers of the embankments in fifteen different districts. Three hundred and sixty-two kilometers of embankments were completely destroyed while virtually all of the remaining embankments were at least partially damaged. Total damages to the embankments and water control infrastructure was approximately \$71 million, with the majority of the damage being to the actual embankments themselves (Government of Bangladesh 2008). An average kilometer of embankments costs about BDT2-2.5 million, or \$30,000. This is based off of Bangladesh Water Development Board (BWDB) estimated costs and uses current design standards, but also incorporates new acquisition of land, staff operating costs and consultancy services (Government of Bangladesh 2008).

There are cheaper methods of strengthening coastal protection while at the same time strengthening bio-diversity, environmental quality and ecosystem services. Mangrove forests have been proven to be effective against the effects of tropical cyclones and can help combat erosion and other natural hazards. The southwestern coast of Bangladesh is home to part of the Sundarbans, the largest mangrove forest in the world. The Sundarbans stretch across the southwestern coast of Bangladesh and West Bengal in India taking up about 6,000 square kilometers. Most of the forest lies within Bangladesh and extends eighty-five kilometers north of the Bay of Bengal and is bordered by the Baleswar River on the east and India on the west (Paul 2009). This is the least densely populated area of the country, with the southern part of the forest remaining virtually unpopulated. Since the 1960s, the government has sponsored a very successful reforestation project to help build back parts of the forest that has been lost to fisheries and aquaculture production (Paul 2009). Sidr struck the eastern part of the Sundarbans and covered about 30% of the total area of the forest. 30,000 acres of the forest resources were severely affected and another 80,000 acres partially affected (Government of Bangladesh 2008).

4.4.3. Analysis of historical cyclones

The next section will go more in-depth into the details of the effects of Cyclone Sidr on Bangladesh and how these relate to the theoretical framework of our research.

Although the death toll from Cyclone Sidr was high, many authorities expected it to be much higher (Government of Bangladesh 2008, Paul 2009). This has been attributed to an improved early warning system, coastal afforestation projects, an increase in cyclone shelters and embankments (Government of Bangladesh 2008). The government is credited with many of these improvements to the country's disaster risk reduction efforts. The early warning system

was able to provide adequate warnings ahead of the storm, and the CPP was able to go into action to warn the rural communities which stood in the storm’s path. However, many chose not to evacuate, even with the standing order being issued. The evacuation rate for Sidr was approximately 33% although in a public survey nearly 86% of the respondents stated they were aware of the cyclone warning and subsequent evacuation orders (Paul 2009). “Sidr clearly shows that evacuation rates were well below what most emergency management authorities in developed countries would consider satisfactory” (Paul et al. 2011 p. 98). In several surveys investigating the reasons for the low evacuation turnout, it was determined that even though most residents in the affected areas heard the evacuation order, they still decided to stay away from cyclone shelters and remain at their homes (Paul 2009, Paul et al. 2011).

Paul determined that there were many different reasons people did not evacuate when the order was given. The often poor condition of the shelters discourages some people from evacuating there. Many shelters are without toilets and running water (Paul & Dutt 2010). Due to the low amount of usable shelters, there are problems with overcrowding. They are often uncomfortable. There were other instances where there was simply no public shelter around, or the distance to the public shelter was too far (Paul et al. 2011). Some reasons are cultural. Bangladesh is predominantly Muslim, and there are issues involving sharing space between men and women. In Bangladesh culture, it is improper for men and women from different families to be under the same roof together. Many of the shelters do not accommodate for this and do not separate men and women, despite most shelters having more than one level.

DISTRICT	NUMBER OF SHELTERS	PERCENTAGE OF DISTRICT RESIDENTS WHO CAN BE ACCOMMODATED
Bagerhat	82	11
Barguna	70	17
Barisal	57	5
Bhola	208	24
Candpur	5	>1
Chittagong	492	15
Cox’s Bazar	455	52
Feni	106	18
Jhalokathi	26	8
Khulna	34	3
Laxmipur	110	15
Noakhali	202	16
Patuakhali	196	27
Pirojpur	42	8
Satkhira	48	5
Total	2,133	

Table 3 – Cyclone shelters in Coastal Bangladesh Source: Shamsuddoha & Chowdhury 2007

According to some recent reports, there are also instances of sexual harassment occurring in the crowded shelters (Seegers 2014). This practice of not separating men and women violates cultural norms and our goals for environmental justice (Ebbeson 2008; Morse 2009). The shelters do not provide adequate protection from both natural and human elements, to more vulnerable groups (Cutter et al. 2003). Many residents stated that they felt safer at home, and were scared to leave their few possessions behind that could be burglarized once they left.

The coastal districts most affected by the hurricane, meaning the highest number of lives lost and property damaged, were Barisal and Khulna. These two districts are also two of the poorest (Government of Bangladesh 2008). This relates back to our theories of vulnerability being related to income (Adger 2006; Blaikie et al. 2003; Cutter et al. 2003). It is also worth noting that these two districts have two of the lowest amount of cyclone shelters relative to their populations (Table 3). This violates both of our goals for environmental justice (Ebbeson 2009; Morse 2008). There seems to be more priority to build cyclone shelters in the wealthier districts of Chittagong and Cox's Bazar compared to the poorer districts of the western part of the country. There is an unequal level of protection between different parts of the country, not based on population but based on financial means and political representation (Paul 2009).

There were residents who never heard any warning message. A popular method of delivering the warnings to rural areas is by megaphones. Although this method was hailed as being incredibly important to saving lives, it still has some drawbacks. Those being downwind of the message may not hear it at all (Seegers 2014). It will be up to the CPP volunteers to make sure this message is heard by all villages within their volunteer area. In one instance, a village in Patuakhali was never informed of the oncoming cyclone and nobody took refuge in the cyclone shelter. Out of the village's 1,043 inhabitants, seventy-four perished (Paul 2009). This violates our first goal of environmental justice by not providing an early-warning system that can reach everyone, including the 'last-mile' (Geurts 2014; Schuurmans 2014). All sections of the population are not being adequately protected from natural hazards.

Most of the damage done by Sidr was to private housing. The total destruction of Sidr was estimated at approximately \$1.7 billion and was highly concentrated in housing and private assets instead of actual economic losses. The total amount of damage done to housing is estimated at about \$839 million. This showcases how this cyclone disproportionately affected lower income groups and was concentrated in areas of poverty (Government of Bangladesh 2008). Instead of the majority of damage being done through the disruption of macro-economic processes, instead it is overwhelmingly felt by communities. Some may determine that a benefit of the cheap, semi-permanent housing allows for a quick rebuilding of shelter. However, this is a 'bounce-back' idea that is argued against in our definition of resilience (Manyena 2011). After Sidr, the amount of money estimated to be used in rebuilding housing is close to \$200 million. Once a comparable cyclone hits the same area, this money will be needed again to rebuild to pre-existing conditions. Data shows that the average construction of a home costs less than \$145 (Mallick & Vogt 2009). Constructing better quality housing that is resilient against both floods and cyclonic winds would save both financial capital as well as human lives. Some recommendations for improved housing are building reinforced structures and the development of low-cost mass produced standardized housing components that raise the first

floor above frequent flood levels and strengthen the walls against wind (Government of Bangladesh 2008).

By analyzing the reports on the destruction caused by Cyclone Sidr, we can determine some pressures (Blaikie et al. 2003) on the Bangladeshi population. The high rate of poverty is an immediate and obvious contributor to social vulnerability (Cutter et al. 2003). What is also particularly important is not only the rate of poverty among the citizens but also the country as a whole. Bangladesh frequently relies on outside aid not only in times of disaster but virtually year-round and in every field of development. They are what some refer to as a “donor darling” (Seegers 2014). The reliance on outside aid is another pressure, as this type of aid is usually reliant on grants and subsidies of foreign governments that could end suddenly.

A major issue regarding disaster risk reduction in Bangladesh that is echoed from many different sources is the need for a middle ground that can extend resources, information, services and/or knowledge to the ‘last mile’ (Geurts 2014, Schuurmans 2014, Seegers 2014). This last mile refers to the community level and the individual, especially in the most rural areas of the country. The central government is technologically prepared to identify and track natural hazards such as tropical cyclones and floods and can issue warnings to the areas of the country that need it. However, it is noted that many times this message is incomplete or inaccurate and leads to distrust of the message (Paul et al 2011). The resources, information, services and knowledge available at the national level does not have the means to make it to the ‘last-mile’.

4.4.4. Conclusions

The work of the Bangladesh government and the CPP should be commended in the drastically lower loss of life from Cyclone Sidr compared to cyclones of similar size and strength in the past. Less than two decades before, Cyclone Gorky claimed over 100,000 lives. However, there are other reasons for this difference. Gorky struck the eastern part of the country, notably the much more populated areas of Chittagong and Cox’s Bazar. The higher population and the fact that the cyclone made landfall in the middle of the night could have played a major role in the drastic loss of life (Paul 2009).

With a determined network of natural hazard preparedness programs, Bangladesh is becoming more resilient to natural disasters; however there are areas that need to be improved. Many of the rural communities need to be empowered to protect themselves, the protective infrastructure needs to be maintained regularly and a better early-warning system that reaches the ‘last-mile’ needs to be enacted. Projects ongoing in Bangladesh that addresses these needs will be analyzed in the next sections.

4.5. Considerations

While preparing this thesis, the initial intention was to focus on the danger of tropical storms to Bangladesh. Although they are a major threat to the coastal regions of the country, and have taken millions of lives, it would be counter-productive to focus on just one natural hazard, given the geographic context of the country itself, and the theme of the framework proposed in this report. Bangladesh is vulnerable to several natural hazards, the two biggest being floods and tropical storms, but also earthquakes and landslides among others. To focus on only one of these hazards would only weaken the country's resilience in the long-term. In our social-ecological system approach to disaster resilience, it does not make sense to only focus on one definitive threat or hazard. When viewing the whole country as a system, we have to prepare for all necessary threats or hazards in that system. In this case, we try to incorporate the idea of multiple hazards into our *Resiliency Web*, or at least be able to adapt the framework into a multi-hazard scenario.

4.6. Community Managed Disaster Risk Reduction

The main focus of this analysis will be ongoing projects supported by NGO's, mainly Dutch based development aid organization Cordaid as well as its partner organization Caritas Bangladesh. These organizations were initially chosen because of their long-term and continual efforts in Disaster Risk Reduction (DRR) in Bangladesh. Of particular importance is their focus on Community Managed Disaster Risk Reduction (CMDRR) and how this type of disaster management is highly appropriate in meeting our two goals of environmental justice (Ebbeson 2009; Morse 2008). This relationship will be further analyzed in a later section.

In the past, the role of NGO's in Bangladesh has primarily been focused on disaster relief. Relief and Rehabilitation (R&R) Activities has been a primary concern for groups like Caritas Bangladesh and Cordaid since the devastating 1970 cyclone that took nearly half a million lives. Some R&R activities include providing immediate food, distributing clothes and household materials, distributing seeds, construction and repairing shelters and low-cost houses, and the construction of cyclone and flood shelters. Since 1999, these activities have coincided with the priority to build the capacity of various different stakeholders in disaster management (Costa & Sadeque 2012). CMDRR is a "community-led approach in which community support systems and sustainable coping strategies are reinforced and collective knowledge and capacities applied to reduce the adverse impacts of recurring disasters" (Costa & Sadeque 2012 p. 10). Many of the initial DRR programs instituted by the government and other NGO's were very top-down in their structure (Seegers 2014). Recently there has been a new shift towards capacity building at the community level implemented by Caritas with funding and support from Cordaid. This shift is meant to meet the goals of the Hyogo Framework for Action (ISDR 2005).

The main objective of the program is to reduce the loss of lives and damage to properties of vulnerable people from probable disaster situation (Costa & Sadeque 2012).

Cordaid developed a specific process on implementing a CMDRR plan for communities. They first try to identify the most vulnerable communities by identifying the various natural hazards present at the national level and identifying the locations where these hazards are mainly concentrated. After determining the most vulnerable communities in those areas, they begin to build rapport with members of that community which allows them to establish and maintain a purposeful relationship. Through the forging of this relationship, community leaders will emerge and a core group of DRR representatives will form. After an assessment of disaster risk using the input of community members through a Participatory Disaster Risk Assessment (PDRA), a DRR strategy is drafted. The strategy is based on several factors: the hazards facing the community, the vulnerabilities present within the community that could increase the impact of these hazards and the available capacity to mitigate the threat of these hazards. This strategy also aids in organization development and risk reduction through Participatory Monitoring, Evaluation and Learning (PMEL). Members of the community are encouraged throughout the process to contribute to the overall strategies. Once the strategy is finalized, an action plan is developed based on strategy-specific needs of the community and improvements in hazard prevention and mitigation, individual survivability and community readiness (Costa & Sadeque 2012). The community is then coached on preparedness, learning how to cope and what to do if a flood occurs or a cyclone warning is issued. They need to know where to hide, where the closest cyclone shelters are and the quickest way to evacuate to those shelters. Mock drills are performed and swimming lessons are given to increase this preparedness and increase chances of survival in worse-case scenarios (Seegers 2014). Throughout the development process, the community leaders and organizers are brought into full management roles. After about a year, a phase-over will take place and the community resumes full responsibility for the ongoing CMDRR program (Costa & Sadeque 2012).

The CMDRR program trains on two levels, it trains the project staff and the community organization. At the community level, Ward Disaster Management Committees (WDMC) are formed to conduct needs assessments by using participatory tools which gather feedback from other community members. It is important to use the local knowledge in the development of the plans. "Even the most vulnerable people have knowledge and techniques that help them to survive" (Costa & Sadeque 2012 p. 19). Prior to these CMDRR programs, many communities focused primarily on the family unit in regards to preparedness (Seegers 2014). The systematic preparation of the CMDRR plans was usually met with enthusiasm and success. By 2011, a total of two hundred and seven CMDRR plans were prepared at the community level (Costa & Sadeque 2012). The WDMC serves as a liaison between the community and members of the government, particularly the Union Disaster Management Committee (UDMC). The UDMC is

not very active at the community level, and the WDMC works to fill in that gap. They also provide their CMDRR plans to the UDMC and the two committees meet regularly to improve and coordinate the community level plans with the national level plans.

In addition to the WDMC, community level Task Forces are created to address crucial aspects in relation to DRR. These task forces have specific roles, including Early Warning Message Dissemination, First Aid and Rescue, WASH (Water, Sanitation and Hygiene) and Shelter Management (Costa & Saddeque 2012). The team members of each task force receive the necessary training in the respective areas of that specific task force. They learn rescue techniques for specific situations and basic first aid in case of an emergency, including how to make life jackets and stretchers out of local materials. WASH is a particularly important program and teaches communities about water-borne illnesses and other hygiene related issues that could arise following a disaster.

There are some other particular DRR practices and techniques ranging from the improvement of physical structures to the fostering of social networks and the practice of life-saving techniques. Housing continues to be a major issue in regards to natural disasters, as illustrated in the extensive damage to housing caused by Cyclone Sidr. Since many of the houses are only semi-permanent and are made from a mixture of natural and scrap material, they can be easily knocked down by storm surge or heavy wind. CMDRR programs try to implement better building practices by strengthening the walls of houses using earth-made bricks in addition to the materials normally made in constructing homes (Government of Bangladesh 2008). Villagers are also instructed to construct high roofs and to cover the roof with fishing net to hold materials in place. Another popular practice is referred to as 'plinth raising'. Plinth raising is a practice to raise the bottom level of houses to avoid flood waters. This is done using excavated earth and mud, similar to dwelling mounds used in the Netherlands.

An important part of the CMDRR program is to find ways to improve the livelihood of individuals in the communities. Improving livelihood could involve providing jobs that increase financial capital or providing education in trade and skills that could lead to a job. Increasing livelihood would therefore lower their vulnerability and increase their personal capacity to deal with natural hazards. This strategy target usually constitutes a social-business approach and is extremely beneficial to the sustainability of a resilient community. Caritas and Cordaid use their expertise in climate change adaptation, agricultural production, food and livelihood security, natural resource management, farming-as-a-business, and water security to create smart business plans for communities in disaster prone areas. Cordaid also helps informing communities about government sponsored social aid programs that they did not know existed (Seegers 2014).

4.6.1. Analysis and Resiliency Web

The CMDRR program tries to address several different aspects of vulnerability. The specific strategies attempt to release some of the pressures of the environmental and social conditions that could create a vulnerable population (Blaikie et al. 2003). These pressures include the use of sub-standard housing, a lack of information regarding cyclone and flood early-warning, a lack of relief services such as proper healthcare and a lack of knowledge of disaster preparedness procedures (Costa & Saddeque 2012; Seegers 2014).

CMDRR has a strong focus on distributing knowledge and services from those with the capacity to give it to those that need it. There is a strong establishment of *Knowledge* and *Information Pathways* between the NGO's Cordaid and Caritas and the individual communities. A *Resource Pathway* is established between Cordaid and Caritas, as Cordaid is a funding partner of the project. This relationship is established directly with no interference from government agencies or other authority figures. On the contrary, the Government of Bangladesh instead cooperates with the NGO's and another exchange of *Knowledge* and *Information Pathways* occurs. There is also feedback from local communities to the NGOs; practices such as plinth rising of houses and latrines practiced by locals of one community can be transferred to other communities via the organizations. Normally the communities do not exchange ideas between each other. Traditionally disaster risk reduction has been practiced at the family level with not much exchange of ideas past the household (Seegers 2014). In the future, it would be advisable to try and establish these *RISK Pathways* between the communities themselves. This would cause an increase in social capital among the communities.

The technical knowledge used for improving the local infrastructure increases the physical capital of a community, thereby strengthening its resilience based on Mayunga's (2009) capital-based approach. This is done using both *Resource* and *Knowledge Pathways*. The knowledge comes from the different DRR strategies experts from Caritas and Cordaid have developed and then share with the vulnerable communities. The resources are either brought in by Caritas or provided by the local community and are used to directly improve the infrastructure in a community. The Task Forces specifically target areas of disaster resilience that can be handled at the community level. Simple emergency procedures that are widely known by health experts can be taught to even the most vulnerable populations instead of them having to wait for relief agencies to handle all of their medical emergencies. These task forces increase the human and social capital (Mayunga 2009) of a community through *Knowledge Pathways*. By empowering individuals with this information and knowledge, we have a strong increase in the social capital.

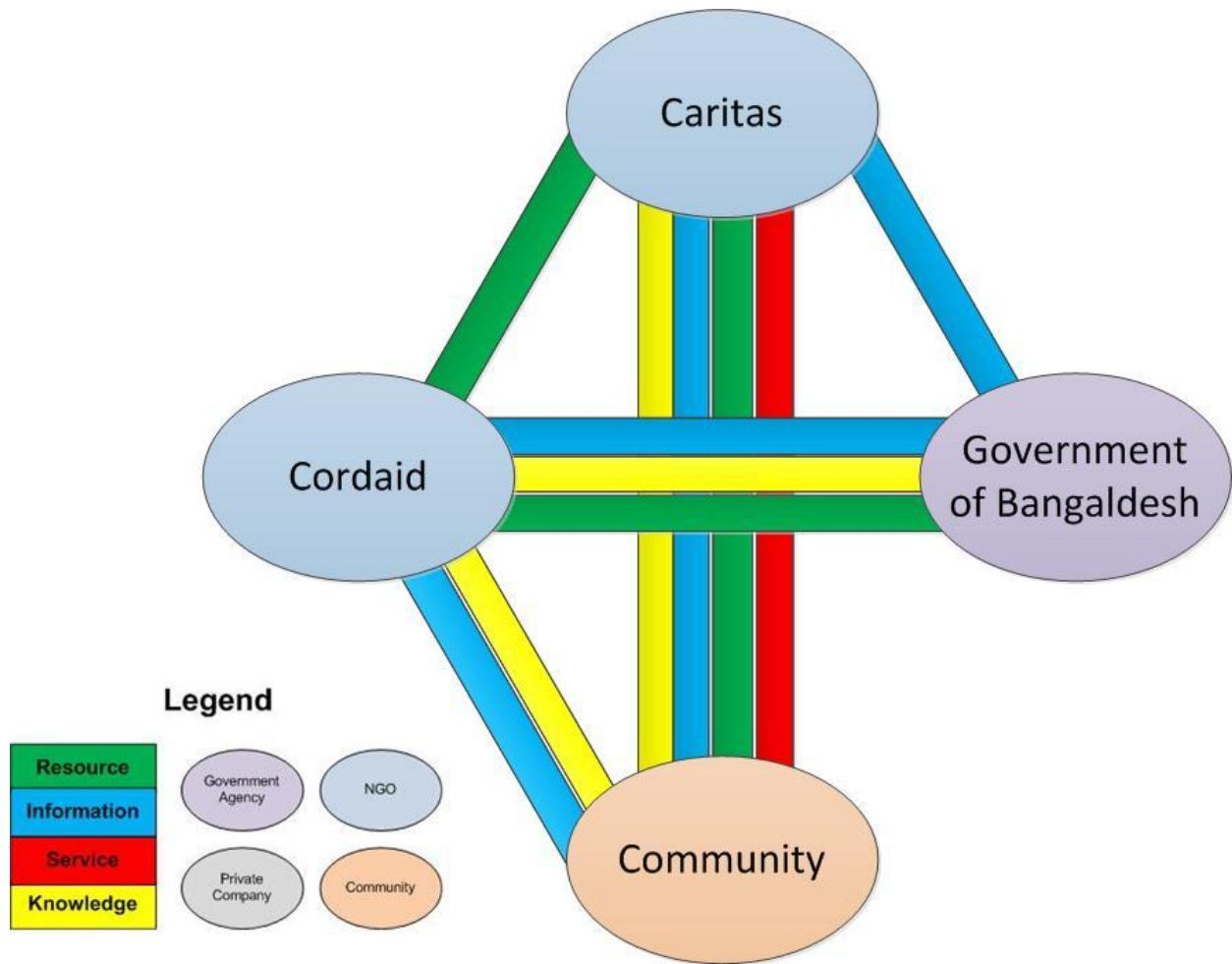


Figure 3: CMDRR Resiliency Web
Source: Author

The CMDRR program sets up a basic functioning of our *Resiliency Web*. The four main entities involved in the basic program are Cordaid, who operates in a funding role; Caritas, which implements the programs on the ground; the Government of Bangladesh who cooperates with the organizations and exchanges information; and the communities themselves which receive the disaster risk reduction programs and strategies. Looking at Figure 3, you can see the establishment of the particular *RISK Pathways* and the formation of the Resiliency Web for the CMDRR program. Cordaid shares its resources in the form of financial capital with both Caritas and the Government of Bangladesh to help create, develop and implement the programs in vulnerable communities. The Government of Bangladesh shares an *Information Pathway* with both organizations in order to help locate the vulnerable communities and other information that could be helpful in DRR. This is a feedback pathway, meaning that information is exchanged in a two-way stream. Cordaid and Caritas share their strategies with the

Government of Bangladesh. Through the implementation of the program, Caritas establishes *Resources, Information, Service and Knowledge Pathways* with the communities. Resources could be any type of physical and natural capital distributed to these communities. Information could be in the form of flood and cyclone warnings. The information happening on the ground in the communities is also relayed back to Caritas to allow the program to remain flexible and adaptable to current situations. If an area experiences a natural hazard, information on what went right and what went wrong can be relayed to the NGOs for future DRR strategies. This is in line with our 'bounce-forward' resilience strategy of Manyena (2011). Caritas performs many services to the communities in question especially regarding training in DRR methods. The communities in turn provide a service to Caritas by working with them in creating the specific strategy plan for their community. These plans rely substantially on local's knowledge regarding their area and feedback between individuals and the organizations. The local's knowledge of their environment works with Turner's et al (2003) Vulnerability/Sustainability model. Knowledge of the local environment can help strengthen resilience in social-ecological system.

The feedback knowledge is important to our bottom-linked resiliency strategy (Pradel et al forthcoming). Our strategy facilitates the ability for any stakeholder to assist in whatever capacity they can. In a top-down disaster management framework, this is usually not the case. Feedback channels between the bottom and top are not fixed. In the CMDRR bottom-linked strategy, communities play a vital role in the creation of their own resilience through the creation of the PDRA and PMEL (Costa & Saddequ 2012). Their local knowledge of the environment combined with the CMDRR strategy creates a place-based resiliency framework that understands the human-environment interaction (Turner et al. 2003). This relates to adaptive resilience in the Resilience of Place Model (DROP) (Cutter et al. 2003). These feedback channels create a flexible and adaptive resilience strategy that tries to address some of the antecedent conditions (Adger 2006) that are present in a community. The rural villages of Bangladesh are usually poor and rely on subsistence farming for livelihood. Protecting these livelihoods, and in some ways strengthening them, are extremely important. Having a single source of income for a community is one of the elements of Cutter's et al. (2003) Social Vulnerability Index. It would be important to try and adopt new sources of income to these areas, but until then the protection of agricultural livelihood is extremely important.

The CMDRR strategy allows for social learning to occur. The participation of the communities is able to address our second goal of environmental justice, offering the opportunity to participate in the decision making process (Ebbeson 2009, Morse 2008). This is done through the use of the PDRA and PMEL, both which incorporate local knowledge into developing a resiliency strategy (Costa & Saddequ 2012).

The CMDRR project is vast and encompasses nearly all of the DRR projects ongoing in Bangladesh. In the next section we will look more in-depth at two of these projects and how they plan on addressing two issues, embankment repair and early warning systems, in a bottom-linked manner.

4.7. *Specific projects: Sustainable Dyke Program and TamTam Alert program*

There are other projects associated with the CMDRR program that are more specific in their focus, but are both examples of bottom-linked governance (Pradel et al. forthcoming) The following section will go more in-depth into the CMDRR program by analyzing two different projects ongoing in Bangladesh that strengthen resiliency at the community level. We'll examine how these projects add to the CMDRR model as well as address systemic justice issues while increasing livelihood. They are both relevant to the construction of our *Resiliency Web* and show the benefits of fostering a network of stakeholders each with their own capacity to act in a specific way in order to create a resilient social-ecological system.

4.8. *Sustainable Dyke Program*

Although hard construction infrastructure is sometimes discouraged in modern day water management; embankments, dykes and levees are a crucial and necessary component for protection from floods and storm surges. Bangladesh, with its growing population and susceptibility to climate change hazards such as increased tropical storm intensity and sea level rise, is no stranger to this fact. However, in Bangladesh “nothing is permanent” (Seegers 2014). Building permanent sea dykes and embankments has been somewhat of a futile effort, the coastline is constantly changing from processes of erosion and the embankments bombarded and destroyed every summer from storm surges (Seegers 2014). Cyclone Sidr destroyed nearly four hundred kilometers of embankments and damaged another two thousand in only one night (Government of Bangladesh 2008). The amount of financial capital, resources and manpower needed to repair destruction of this magnitude is enormous, and once they are repaired they could be easily destroyed again by another cyclone or flood. These types of repairs would also have to get approval and funding from the central government and then passed down to the BWDB in order for repairs to begin. This is an example of the top-down disaster management that this report argues against. These bureaucratic procedures are both time and resource consuming.

A new project sponsored by Cordaid is trying to remedy this issue. The project is called the Sustainable Dyke Program, and it uses a new type of technology created by the Dutch company Green Soil Bags. The bags contain a mixture of soil and seeds and could be used to repair broken dykes and embankments. A collection of bags are placed in an area of an embankment that has been destroyed or in need of repair. Within three to four days after watering the seeds

inside the bag sprout. As the grass grows up, the roots of the grass grow down and grip onto the surrounding bags and the topsoil, anchoring and stabilizing the new section of the embankment (Seegers 2014).

Cordaid contacted the entrepreneur with the idea to deploy the bags in Bangladesh. Green Soil Bag Company and Cordaid forged a partnership and launched the project in November 2013. They decided to use three different kinds of grass that are endemic to Bangladesh. The largest and most important was *Pennisetum purpureum*, otherwise known as elephant grass (Image 6). Elephant grass has a strong root system that acts as an anchor. The roots grow out of the bottom of the bag and grip the other bags and eventually the soil on the embankment. The other two types of grass are used as fodder for livestock. Cordaid trains local embankment groups in maintaining and taking care of the new sustainable dykes. The idea to integrate dyke awareness education is being planned to educate small children about the importance of dyke maintenance. There is an idea to translate the Dutch story of Hans Brinker so that children can understand how important these embankments can be to their safety and the safety of their community. The green soil bags are now affectionately being called “brinkers” (Image 5), referring to the Dutch legend (Matt 2014).

The first application of the project was in the Kalapara *upazilla* in Patuakhali district (Seegers 2014). It was launched in November 2013 to repair embankments that were damaged during Cyclone Maheson. Cordaid along with Caritas identified two areas that needed repair. Green Soil Bag Company, along with students from TU Delft, arranged the purchase of local materials and began creating the ‘brinkers’. Cordaid hired four hundred laborers from the local villages to aid with the construction.

**Image 5 – Green Soil Company
“brinker” Source: Cordaid**



**Image six -- Sustainable dyke in Bangladesh
Source: Cordaid**



The government is not directly involved with the Sustainable Dyke Program, but they are interested in the development of the project. Cordaid determined that to repair three hundred and thirty meters of embankments at the height of one meter using the 'brinkers' they spend about €100,000. The Government of Bangladesh spends nearly €1 million for an equal amount of repair. They are interested in integrating this into their coastal protection strategy as it will save them money.

4.8.1. Analysis and Resiliency Web

Cordaid and Caritas are again two of the major stakeholders. Along with the NGO's, the project employs the service and resources of the Green Soil Bag Company. This relationship strikes up two of our pathways, an *Information Pathway* and *Resource Pathway*. Cordaid provides the information to Green Soil Bag Company of areas where their product could be applied successfully. Green Soil Bag Company goes to those locations along with students from TU Delft and provides the resources necessary to repair the embankments. Both the information and resources are also shared with the local communities who will be benefiting from the 'brinkers' in the form of increased flood and cyclone protection. The Green Soil Bag Company and TU Delft also form a *Service Pathway* between them and the communities by building and applying the 'brinkers' where they are needed. Cordaid establishes a *Knowledge Pathway* in the form of education on the importance of dyke maintenance to the communities. The Government of Bangladesh is interested in the project; if the 'brinkers' are successful they could be used by the BWDB as a cheaper method to repair broken embankments. Cordaid keeps the government updated through an *Information Pathway*. As of now, the project is being called a success and expansion in new parts of the country is already under way (Matt 2014). If the BWDB plans on purchasing the bags directly from Green Soil Bag Company, there is potential for a *Resource Pathway* to be established between the company and the BWDB.

The repaired embankments help strengthen the physical capital of the area with improved flood protection infrastructure. Natural capital is improved as well with the green nature of the dykes themselves (Mayunga 2009). This creates a better aesthetic quality of the embankments, which traditionally tend to be made of earthen material. The communities have stated that they really enjoy the green nature provided by the 'brinkers' (Seegers 2014). There is also an increase in livelihood with the cash-for-work programs instituted by the World Food Program. Here we have an established *Resource Pathway* between the WFP and the communities in the form of increased financial capital (Mayunga 2009).

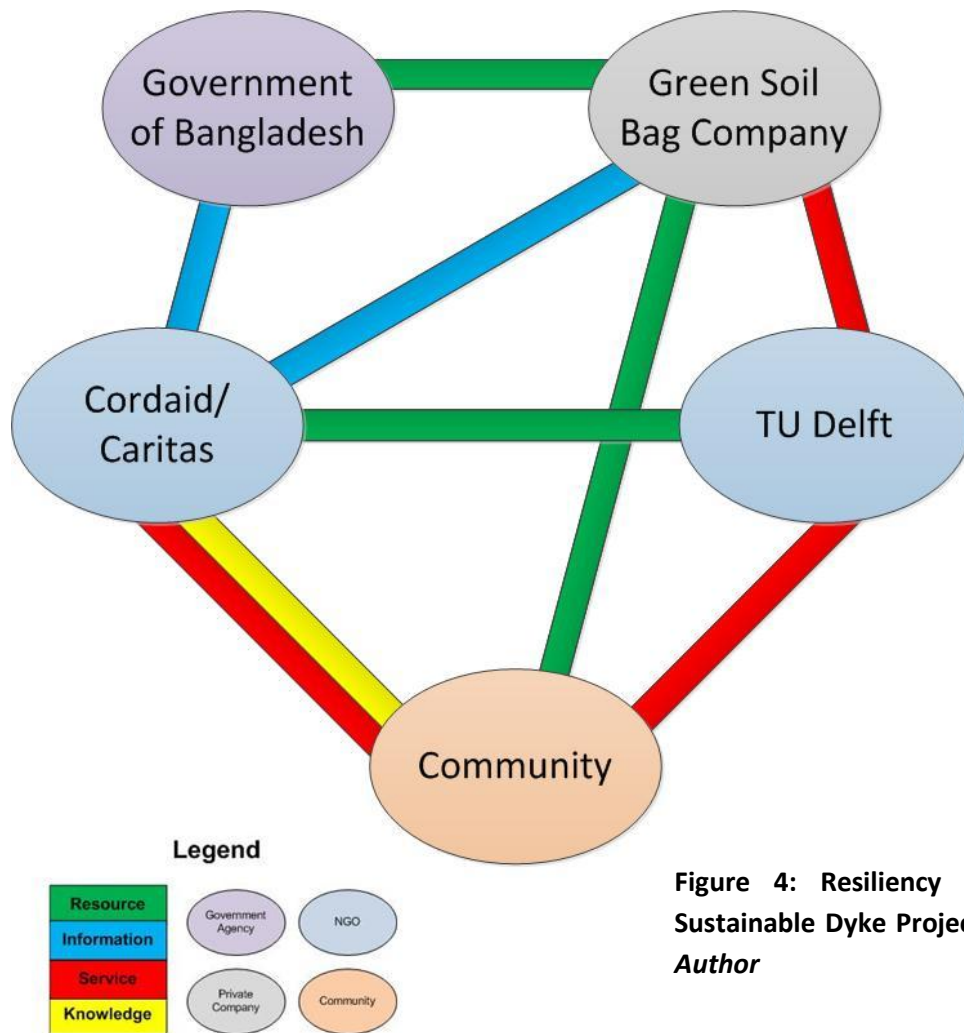


Figure 4: Resiliency Web for Sustainable Dyke Project *Source: Author*

The Sustainable Dyke Program incorporates another important aspect of our bottom-linked *Resiliency Web*. The idea of social innovation is important to bottom-linked governance (Pradel et al. 2014). Innovative ideas from an entrepreneurial company (Green Soil Bag Company) is brought directly to places where it is needed using the knowledge of separate entity. Streamlining this distribution pathway is important in creating an efficient and effective disaster management strategy.

Cordaid hired four hundred laborers from the local villages to aid with the construction. The laborers that were chosen were all males 50 years or older. The elderly are a target group for Cordaid and men around this age are still able-bodied and want to work but are usually passed over for manual labor for younger, more agile laborers. The World Food Program became involved as well and will do a cash-for-work program, employing more elderly men to aid in the construction of sustainable dykes. This is a method of livelihood improvement for a targeted vulnerable group (Seegers 2014) that helps address a major issue in Cutter’s (2003) Social

Vulnerability Index; having one source of income for an area. Increasing the financial capital of a vulnerable group also strengthens the human capital of the community.

This project meets both of our goals for environmental justice (Ebbeson 2009; Morse 2008). Providing the innovative technology to the communities and educating them how to re-create the technology gives them the capability of determining where these protective measures can be applied and distributed, meeting our second goal. Giving them this power equalizes the playing field; communities that might not have the political representation to acquire the resources needed to repair embankments can now provide these protections themselves without the need to appeal to a relevant authority. This meets our first goal of environmental justice, equal protection from natural hazards.

The Sustainable Dyke Program is an important project in distributing resources to communities who are in need of them. The ‘brinkers’ are easily replicated and applied to embankments which are in need of repair. Empowering the communities to repair these embankments themselves is important to our resiliency strategy and the CMDRR program. There are other issues in disaster preparedness in Bangladesh, however, and this mainly has to do with reaching the ‘last-mile’ in an early warning system.

4.9. TamTam Alert Project

A large part of disaster resilience is having an efficient and accurate early warning system. These are applicable to mainly weather-related disasters such as cyclones or floods. The CMDRR program in Bangladesh also works to improve the flood and cyclone early warning system, which has steadily improved since the 1970 cyclone. The main goals of an early warning system are to inform communities of hazards, the identification of the person(s) who are at risk, advise for means of protection and preparedness and to instruct how to deal with the impending hazards (Costa & Sadeque 2012).

Cordaid has launched a new and interesting project that brings together a variety of stakeholders from both the public and private sector. The TamTam Alert project began in a meeting between the Dutch Ministry of Foreign Affairs, the BWDB, Deltares, Cordaid and many other organizations. The topic of the meeting was to discuss improvements to the flood early warning system. At that point, there had been great improvements in the central government’s flood warning system. The only problem was that it had difficulty reaching the ‘last-mile’ (Geurts; Schuurmans 2014). This ‘last-mile’ mainly refers to the remote rural villages along the river banks. Warning messages could not get to these villages in time for individuals to take the proper measures to protect themselves, their families and property. There were even some cases where the relevant government bodies were sending warnings by post. The warnings will contain very accurate information for the incoming three or four days but would not be

delivered in time (Schuurmans 2014). The goal was to develop a new system that could reach this 'last-mile' and warn the most vulnerable communities.

The project was spearheaded by Cordaid with funding from the Dutch Ministry of Foreign Affairs. Bringing together several different organizations and companies, Cordaid began to assemble a consortium of stakeholders to launch a partnership in order to realize the goals of the TamTam Alert project. The consortium is made up of government bodies from Bangladesh and the Netherlands along with several Dutch companies. Cordaid acts as the leader of this consortium and facilitates cooperation among the other stakeholders (Geurts 2014). ProPortion Foundation, an organization that incubates social enterprise, was brought on to the project to help develop a sustainable business model for the program. ProPortion specializes in design thinking and targets people living at the 'base of the pyramid' (Schuurmans 2014). By tapping into the people, resources and knowledge of these communities, they develop social business models that can be ran by an entrepreneur. They try to create a viable business model that can generate income for the community rather than rely on donors and grants. For TamTam Alert, they are advising Cordaid on developing this type of model.

Other organizations are more involved with providing the necessary technology and services that could support the program. The idea is to make TamTam Alert a mobile-based alert system that can reach vulnerable communities via smartphone technology, SMS or voice-response (Swank 2014). This type of communication would be handled by two different companies based out of the Netherlands, Text to Change and Akvo. Text to Change is a social enterprise working in both social-marketing and data collection using mobile phone services such as SMS and voice-response. Using SMS they provide people with correct information regarding health-issues, agricultural data and even training courses (Swank 2014). They run social-media campaigns by asking a population a quiz question regarding a certain topic and tell them to respond via SMS with their answer. They also work with data collection where individuals respond to specific questions and are then asked for clarification and feedback. "The idea is to spread education and training on one side, and on the other to gather valuable field data that would be difficult to reach using traditional survey methods and provide that data to NGO's, governments and other organizations who could be interested" (Swank 2014). In the TamTam Alert project Text to Change will work in two ways, as a large scale flood warning system and as an aggregator of field data that can be shared with the organizations working within the consortium. The warning system will include training as well as awareness campaigns on the dangers of flooding and the risks involved. This will be done on a large-scale that goes beyond just one or two villages or even a whole province. As a data aggregator, they will involve individuals on the ground and have digital interaction with communities that can provide information and opinions.

The other organization within the consortium working on the technological side of information dissemination is Akvo. Akvo develops different tools for the development sector to increase transparency, efficiency and accountability using open data. Akvo is also a Dutch company based out of Amsterdam, and is composed of about 50 people working out of the Netherlands, UK, USA, Kenya and India. The company produces four different products, and relevant to TamTam and this report is the product AkvoFLOW. AkvoFLOW is an Android application, a data gathering tool which collects real-time evidence-based data from the field. It was built as an online dashboard where users can create and post different surveys asking different kinds of questions using GPS, photos and other data. Their role in the TamTam project will be to gather data from the field from individuals that at this stage in the project are called TamTam Heroes. These will be community members with access to Android phones that can send updates and information to the dashboard to help visualize the situation on the ground (van den Berg 2014).

Other companies involved in the consortium have more experience and knowledge working with high-level stakeholders, and want to connect communities on the ground to government officials and national agencies. Deltares, an international research institution specializing in delta regions, was present in the original meeting between the Dutch Foreign Ministry and the Government of Bangladesh. They have since been working on another type of mobile-based warning system that is being developed alongside and parallel with TamTam. The role of Deltares is to involve and work with the national level stakeholders in further developing their flood early warning system. For TamTam to be successful the last-mile connection needs to be established but that can only happen with cooperation from national level stakeholders. Deltares works with the Forecasting and Warning Center, which is part of the BWDB and the Department of Disaster Management (Cumiskey 2014). Once the project has become established, the government agencies will have more direct involvement with its implementation. Another company working closely with Deltares is TNO, the Netherlands Research and Technology Organization. Their main goal is to be an Information Value Provider; collecting Big Data and converting that data into useful information that will be valuable to the communities at risk of flooding. This data is directly linked with their livelihood and would include data on livestock numbers, amount of type of crops present, health concerns and the primary method of communication (van den Homberg 2014).

Together these groups make up the TamTam consortium. They are the chief organizations working on the development of the project. The idea is to create a viable business model for the product to be able to fund itself rather than being dependent on government grants and subsidies. This would involve having customers pay for the service. ProPortion has been staging workshops with communities to determine if this type of system is viable. So far, the communities are skeptical that they should pay for a service that hasn't been proven to be effective. A new idea is to promote the tool as a way to protect livelihood, especially for

farmers wanting to protect their crops. ProPortion is hoping to enlist the support of larger dairy companies that rely on the cattle of rural farmers for their products. Convincing the companies that it is in their interest financially to want to protect the cattle owned by rural farmers, they in turn could subscribe to the service for the farmers who sell them products (Schuermans 2014). This relates to the goal of livelihood protection and improvement that is a main focus for resiliency building (Costa & Sadeque 2012).

4.9.1. Analysis and Resiliency Web

The consortium is working towards creating the necessary pathways and connections from the top levels of government down to the communities on the ground in order to reach the entire vulnerable population and warn them of natural hazards. This includes the ‘last-mile’ (Geurts 2014; Schuurmans 2014) or the most remote communities. Through its CMDRR program, Cordaid has established relationships with these communities and they remain ongoing. ProPortion is providing a service to the consortium by working on creating the business model. With the help of Text to Change and Akvo, information will be exchanged through modern technology between the stakeholders with the capacity to act and those in need of the specific action provided by those stakeholders. Deltares is working towards establishing the connection of the national level stakeholders to the communities while TNO is gathering Big Data at the community level in order to share with the other stakeholders. TamTam could be extremely helpful in establishing these relationships and this large resiliency network. This is important to our bottom-linked resiliency model (Pradel et al. forthcoming).

The TamTam Alert project brings several different private company stakeholders into the practice of CMDRR and highlights the importance for social entrepreneurship. Social entrepreneurship is the process of pursuing innovative solutions to social problems. Instead of measuring their success in profits and returns, success is measured in the amount of social benefit a product or service creates (Dees 2001). This practice is important to our bottom-linked governance model and idea of social innovation (Pradel et al. forthcoming). The actors who care to make a positive change are directly linked to vulnerable communities which would benefit the most from their product or service. Cordaid acts in a special role by facilitating the relationships between stakeholders.

The Resiliency Web for the TamTam Alert project is by far the most complex of the specific projects reviewed in this report. There are several different stakeholders from several different sectors working together to make the final goal a reality. This is helpful in the visualization of the diagram in Figure 5. All of the complex relationships between the stakeholders actually beings to form a web-like structure, hence the name Resiliency Web. The main goal of the entire project is the sharing and dissemination of information in regards to floods. Since the project is still in a development phase, we will examine *RISK Pathways* involved with the

development as well as the ideas on how the system will function once it is running in the future.

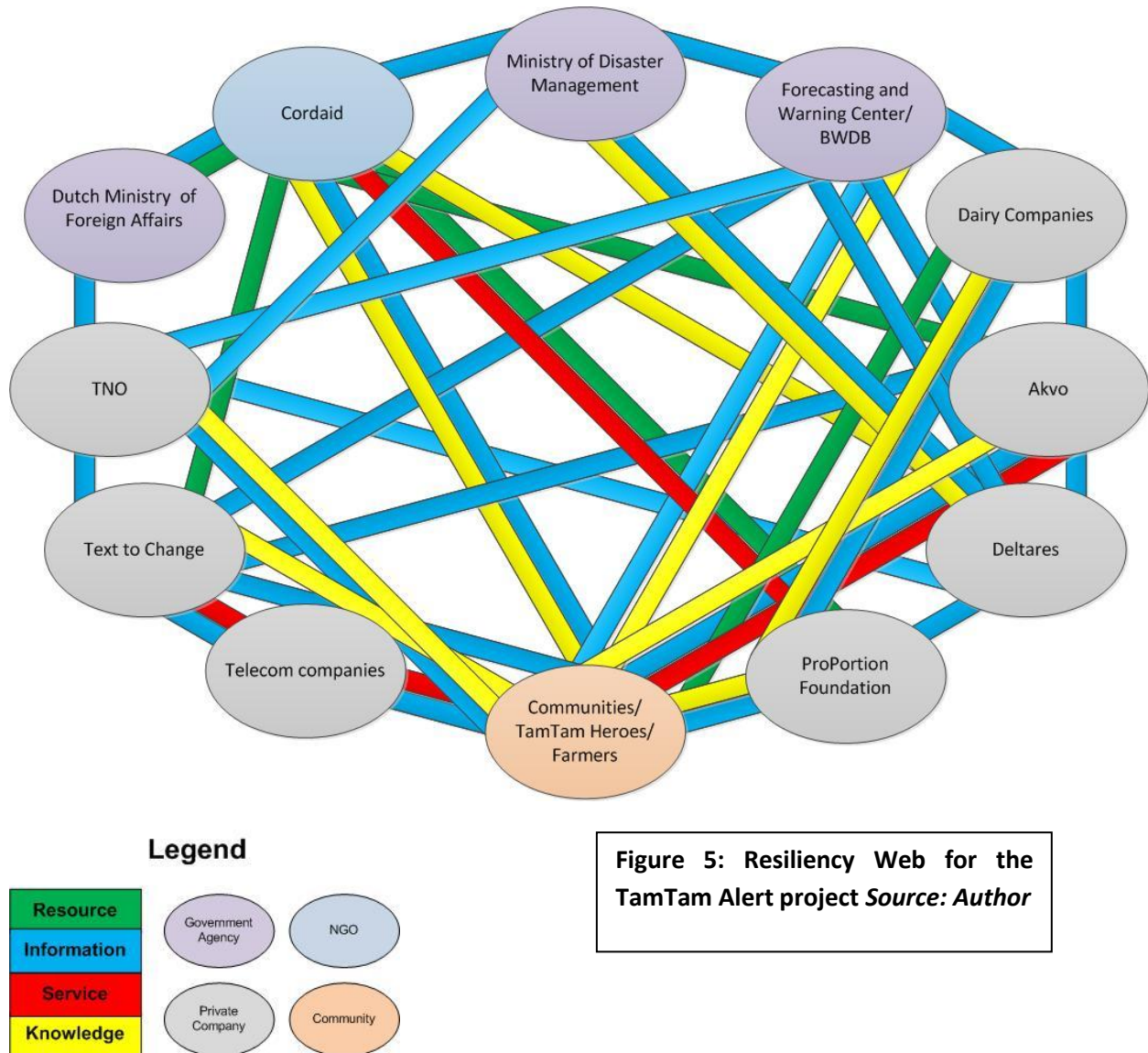


Figure 5: Resiliency Web for the TamTam Alert project *Source: Author*

A *Resource Pathway* is created between the Dutch Ministry of Foreign Affairs and Cordaid in the form of financial capital which funds the development phase of the project. Cordaid then uses this financial capital to enlist and fund the services of each different company in the consortium through more *Resource Pathways*. Proportion Foundation establishes a *Service Pathway* with Cordaid as they use their expertise in social innovation and entrepreneurship to build a viable business model for the project (Guerts 2014; Schuurman 2014). ProPortion works with the communities and dairy farmers and exchanges ideas through *Information* and *Knowledge Pathways* to determine if the communities and farmers would be willing to pay for the service (Schuurmans 2014).

The *Information Pathway* is more-or-less established between all of the stakeholders. The mission of the consortium is to provide a functioning and efficient early-warning system through the use of information dissemination, therefore every stakeholder. Therefore the most common pathways are *Information* and *Knowledge Pathways*. It could be argued that the establishment of a technologically advanced warning system needs both the establishment of an *Information Pathway* and *Service Pathway*. The most important ones, however, are the *Information Pathways* between the Forecasting and Warning Center, the BWDB and the communities themselves. These pathways are created using a service provided by both Akvo and Text to Change. Akvo creates a *Service* and *Information Pathway* between the forecasting center and the 'TamTam Heroes', or those who opt into the TamTam project and have access to the Android service AkvoFLOW (van den Berg 2014). The *Information* and *Service Pathways* established between Akvo and the Communities works both ways, information at the community level is very valuable. For example details of damage following a flood can be uploaded to AkvoFLOW. If resources are needed for a specific area to provide relief, this service will streamline the process in order to get those resources to the area where it is needed most through a *Resource Pathway*. Text to Change establishes more *Information* and *Service Pathways* through telecommunication companies who have the network infrastructure established in Bangladesh. This service will distribute the necessary information to other stakeholders who are using the SMS-based or voice-response service. The telecommunication companies then continue the *Service Pathway* to deliver the warning to their customers who subscribe to the service. The *Information* and *Service Pathways* are very important because they allow for feedback to occur. Real-time information about current disasters can be relayed to the proper authorities extremely efficiently. Resources can be directed where they need to go almost immediately. This would also help in fostering 'bounce-forward' resilience (Manyena 2011), as these feedback channels will help educate stakeholders as to what went wrong during a disaster, and how that can be remedied in the future.

Deltares establishes a *Knowledge pathway* between themselves and Cordaid. Deltares has knowledge of working with large national level stakeholders while Cordaid has several established relationships with local communities through their CMDRR program that Deltares does not have. Deltares works closely with both the Forecasting and Early Warning Center and the Ministry of Disaster Management (Cumiskey 2014). . The Forecasting and Early Warning Center is part of the BWDB.

TNO is concerned with "Big Data" (von den Homberg 2014). They want to become an information value provider (IVP). In TamTam they hope to collect data from the communities through *Information* and *Knowledge Pathways*. They hope to extend these pathways to the Ministry of Disaster Management and BWDB so that the data about the communities can be accessed at the national level easily. This will help streamline the warning efforts by easily

locating the communities most at risk from a specific hazard detected by the national authorities. The big data aspect would be packaged and sold to the national authorities in order to support the business model (Schuurmans 2014; van den Berg 2014).

Reaching the ‘last-mile’ is important to addressing our first goal of environmental justice, equal protection from hazards of the environment (Ebbeson 2009, Morse 2008). “The TamTam proposition is about connecting those communities with solution partners” (Schuurmans 2014). This connection is the basis for our Resiliency Web and helps to address many issues regarding vulnerability and justice. Communities located in rural areas of Bangladesh who do not have access to adequate early warning systems are more vulnerable than those who live closer to urban areas and are able to hear these warnings. The entire project is based on information dissemination of natural hazards in order to protect lives and livelihoods (Cumiskey 2014; Geurts 2014; Schuurmans 2014; Swank 2014; van den Berg 2014; von den Homberg 2014). This helps address goals for the CMDRR program as well, in particular livelihood protection and effective early-warning systems (Costa & Saddeque 2014). By protecting livelihoods, we can protect capital and essentially resiliency (Mayunga 2009).

TamTam could be better at convincing those who do not normally trust warning systems by not only providing them with more real-time info, but allowing them to add and therefore be part of the warning system. Contributing to the effectiveness and accuracy of a new technology or practice could increase the overall acceptance of that new technology or practice. This could help with some of the issues regarding evacuation practices and the distrust of early warning messages experienced by individuals in the coastal zone of Bangladesh (Paul et al. 2011) and any place that suffers from frequent natural hazards. The ability to contribute to the data in real-time could help strengthen social and human capital, as the ability to be directly involved with the collection of data could empower individuals to contribute. This addresses our second goal for environmental justice, the opportunity for individuals to participate in the decision-making process (Ebbeson 2009; Morse 2008).

This move to create a viable business model that has the vulnerable population pay for the service could be seen as violating Blaikie’s et al. (2003) principles for managing disaster recovery, in particular avoiding commercial exploitation. A foreign company approaching a vulnerable group and asking them to pay for a service is in some way exploiting a vulnerable group commercially. However, it is important to view the business model not as exploitation but as sustainable. A successful project that relies entirely on grants could suddenly lose funding and disappear. A successful project that funds itself will remain a part of the system indefinitely (Schuurmans 2014). If you look back at Figure 5, you see a *Resource Pathway* between the communities and dairy companies. The dairy companies receive much of their products from the communities, and the communities receive money from the selling of their

products. Remembering back to Cyclone Sidr, livestock populations were devastated (Government of Bangladesh 2008). Dairy companies would be interested in protecting their products, which in turn would protect the farmers' livelihoods. It is important that this *Resource Pathway* remain open and unobstructed.

An issue that arises with all of these projects is that they are only realized with funding from NGO's and foreign governments. In our examples of vulnerability theory, this use of outside aid is a form of vulnerability. It violates another principle proposed by Blaikie et al. (2003), avoiding relief dependency. This is why increasing livelihood is important for all of these projects. If a community is able to sustain its resiliency programs, that ability to sustain is its own form of resilience. Incorporating the business model idea into TamTam so that the project will be able to sustain itself is a way to address this issue (Schuurmans 2014).

TamTam has mainly been developed for communities alongside the major rivers who are at risk of flooding and not necessarily the coastal communities at risk of both flooding and tropical cyclones. This report has been mainly focused on tropical cyclones, but as stated before regarding the theme of social-ecological systems and Bangladesh, it would be futile to only examine one potential natural hazard without incorporating others in a country with so many different threats. This could just as easily be stated for New Orleans and other vulnerable coastal regions around the globe. While the target groups for TamTam remain those vulnerable to floods in the northern areas of the country, it is the opinion of this report that it would be beneficial to expand to a national setting and incorporate multiple-hazards into its system. In Bangladesh, the cyclone early-warning system is more advanced than flood-early warning but it is still with its own weaknesses. Some of these weaknesses can be addressed by the TamTam Alert. Livestock are extremely at risk in coastal Bangladesh, according to reports Cyclone Sidr destroyed over 80% of the livestock population when it struck the coast (Government of Bangladesh 2008). This is a major blow to livelihood development, and therefore our research suggests it is a major blow to the fostering of our bounce-forward resilience strategy (Manyena 2011). Cordaid at this point has no plans to address the issue of livestock protection from tropical cyclones (Seegers 2014). The tools present in TamTam could be used to help farmers develop an evacuation strategy for their livestock to a protected area, in this case a *killa* or livestock shelter. This can be uploaded to an AkvoFLOW dashboard to ensure proper cataloguing of cattle both before and after a tropical storm impact.

The TamTam project could also be combined with the previously mentioned Sustainable Dyke Project to further enhance resiliency on the coast. Individuals on the ground can upload pictures of broken embankments with their location via GPS coordinates to regional and national level stakeholders who could then provide the necessary resources in the form of 'brinkers' to fix the broken embankments. This would be an example of a direct *Information*

and *Resource Pathway* feedback strategy, where information regarding the need for specific resources in a specific location can be determined, and those resources delivered in an efficient manner by the appropriate organizations.

The TamTam Alert project is still being developed as of the publication of this report. The conceptual framework for this report, the Resiliency Web and *RISK Pathways* could be established and realized if they are adopted into the framework of the project. TamTam is meant as a way to exchange information, but could also be used to exchange resources, services and knowledge among stakeholders. A digital network could be established that forms a bottom-linked governance structure, where those with the capacity to act can be directed towards those who need their services. There is a large potential for this project to have a large impact in Bangladesh and other vulnerable areas. It could empower communities to foster their own resilience, and in turn meet our two goals of environmental justice by allocating and distributing the resources, information, services and knowledge themselves without the need of a centralized authority.

4.10. Conclusions and further thoughts

These projects were chosen because of their direct involvement with communities on the ground. They are examples of the 'bottom-linked' resiliency strategy (Pradel et al. forthcoming). They bring actors with the capacity to make change together and give them the opportunity to make that change.

A major issue with all of the CMDRR projects is that they are based nearly entirely on aid organizations. Residents or rural Bangladesh do not have the financial means to harbor and manage these programs themselves. The Bangladesh government, although staffed with nearly 50,000 volunteers in the CPP, could also not coordinate and manage these efforts, though it was shown in this report that the United States government has trouble managing disaster situations as well. This returns to our idea of natural disasters as a 'wicked problem' (McPhearson 2013). There are no panaceas (Ostrom & Cox 2010) to increase disaster resilience and foster environmental and social justice. Resilience needs to be place-specific, referencing Cutter's et al. (2008) DROP model. The Resiliency Web and *RISK Pathways* would be much more effective if they were modeled over the total disaster resilience efforts of an entire place rather than a specific project. This would give a better understanding and view of the level of resilience a place has established and the network of stakeholders present in disaster risk reduction. In addition, once a Resiliency Web has been established for a place, it would be important to witness how strong it is in the face of actual natural hazards.

5. CONCLUSION

It has been argued that environmental justice has been more effective in the fight for sustainability than the actual concept of sustainability (Agyeman 2001). Environmental justice appeals to the social pillar of sustainability more than the environmental or economic pillars. In appealing to the social side, and therefore the human elements of these issues; ideas and innovations are usually more acceptable and resources more efficiently arranged. This includes ideas of social innovation, such as 'bottom-linked' governance (Pradel et al. forthcoming).

This report attempted to relate the concept of environmental justice to natural disasters as a way to appeal to the social side of sustainability. At this moment, we stand at a point in history where we have the technological resources and scientific knowledge to truly pull the 'base-of-the-pyramid' up to the apex. It is a matter of arranging the economic means and political will to truly foster social justice in our global social-ecological system. This report was an attempt at creating a framework to assist in this goal. This was done through an analysis in to what environmental justice is meant to achieve, how it can be related to vulnerability to natural disasters and how it can help foster resilience at the community level. These theoretical concepts were explored, prodded, criticized and eventually applied to real case studies where the natural elements have truly disrupted our way of life. In this analysis, the research developed a framework to try and manage disaster situations during all stages of the disaster cycle. An attempt was made in developing a dynamic framework that can continually improve an area bombarded by the elements even after the skies have cleared, the waters have receded back and the houses have been rebuilt. It is an attempt at transforming the disaster situation into just a slight shift in direction of our continually evolving civilizations.

I believe that the research conducted was able to support my initial argument and answer my research questions. The projects in Bangladesh and our Resiliency Web showed ways in which social-ecological resiliency networks can strengthen and empower individuals at the 'base-of-the-pyramid'. The theoretical analysis into environmental justice and vulnerability helped clarify as to why communities of lower-income generally suffer more in natural disasters than communities of higher income. This type of notion can sometimes be brushed-off as common knowledge, but in doing-so lessens the chance that something will actually be done to rectify it. With another look at our Resiliency Web framework, we can see how bottom-linked disaster management processes can help foster resilience to even the most vulnerable communities.

5.1. Discussion and Reflection

The idea of the Resiliency Web and *RISK Pathways* was created rather organically as the path of the research started to drift away from the initial conceptual model. It was never the plan for the research to be a simple prescriptive analysis into why disasters affect lower-income groups

more than higher-income groups. Those types of analyses have been done before by academic researchers and governmental agencies. It was always a goal to try and develop a type of analysis that could benefit the disenfranchised communities who have to endure the epitome of the dramatic force of Nature.

However, the plan of analysis had included the potential to travel to Bangladesh to truly assess the situation there and acquire real empirical data. When this plan began to dissipate, the research needed to find something to produce. While reviewing the projects of Cordaid, the idea of the Resiliency Web began to form. Since vulnerability was always linked to a lack of resources, than surely a method of resource distribution could help lessen these vulnerabilities. It was also determined that vulnerability was not just a lack of resources, but also information, services and knowledge as well. This was how the idea for the Resiliency Web was first created.

There are several weaknesses in the approach used in this thesis, which is understandable given the complexity of natural disaster management. The idea of bottom-linked governance sounds strong on paper, but if a community does not have the initial resources to establish the *RISK Pathways* with the actors who could potentially help them, then the whole idea falls apart. For the most vulnerable and disenfranchised communities to receive aid, the framework needs to be coordinated by some type of higher agency with the capacity to provide it. In the projects analyzed in this report, this was done by an International NGO operating all over the world. If this NGO was not present, then these projects would never have existed. This is a major shortcoming in the conceptual framework of the Resiliency Web. It would be important to flesh out this concept further and have it be applied to a place and analyzed more deeply.

5.2. Final thoughts...

A very interesting reflection about this research was that it was successfully conducted for two case studies both thousands of kilometers away. This can be attributed to the capabilities of modern technology and the ever-shrinking global society of which we are apart. The projects in Bangladesh that were analyzed all originated from Dutch organizations and companies. These companies and organizations being stakeholders for relief projects in a country half-a-world away proves that the world is simply getting smaller and more connected. The fact that these companies and organizations are willing to put forth the effort to truly bring hope and improved livelihood to people they've never met is a positive and enlightening observation. It helps support the idea that humans are becoming more mindful of others regardless of background, that we are becoming more mindful of the concepts of universalism popularized by minds like Einstein and Sagan, and the fact that we are all have to live here together on this speck of cosmic dust suspended in a sunbeam.

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