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# The Political Determinants of the Impact of Natural Disasters: A Cross-Country Comparison

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**THE POLITICAL DETERMINANTS OF THE IMPACT OF NATURAL DISASTERS:**
A CROSS-COUNTRY COMPARISON

A Thesis

Submitted to the Graduate Faculty of the
University of New Orleans
in partial fulfillment of the
requirements for the degree of

Master of Arts
in
The Department of Political Science

by

Ezra Boyd

B.A., University of Chicago, 1999

December 2003

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Professor Marc Rosenblum deserves my deepest appreciation for his patient guidance and insightful analysis. Throughout this project, his wide-reaching grasp of the scientific method and his keen interest in comparative political science provided the light needed to travel this path of discovery. In addition, I am thankful for the advice and scrutiny of Professors Phil Coulter, Shirley Laska, and Brandon Prins.

Penny Hecker is my loving partner and strongest supporter. Her research assistance helped me in many ways.

Finally, my achievements would not have been possible without the sacrifices of my parents, Janet and Richard Boyd.

## Dedication

Dedicated to improving the lives of the many people whose exposure and vulnerability to natural hazards is increased by lack of resources, lack of education, and lack of political empowerment.

## Abstract

While people all over the world are vulnerable to natural disasters, the available data clearly demonstrate a great deal of cross-country variance in the impact of catastrophic events. For example, while Hurricane Mitch took an estimated 13,000 lives when it struck Honduras and Nicaragua, the stronger Hurricane Andrew took only 26 lives when it impacted the United States. What factors explain this difference? Thus far, disaster researchers have emphasized economic and social vulnerability as determinants of disaster impact; the conventional wisdom accepts that poor and underdeveloped countries are more vulnerable than wealthy, developed countries. I argue that the political institutions of a country also matter and then examine the relative importance of political vulnerability as a determinant of disaster impact. I present evidence from case studies and large-N statistical analysis that demonstrates that, like social and economic vulnerability, political vulnerability is an important determinant of the impact of a natural disaster.

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Forces of nature trigger disaster events, but can no longer be considered the main causes of disasters themselves. What other causes are there?

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*Natural Disasters: Acts of God or Acts of Man*

We are responsible of the deaths and we need to take measures... (Earthquakes) happen all around the world ... but no country in the world loses as many people to quakes as Turkey.

Turkey's Culture Minister Erkan Mumcu

[Many nations] cannot supply… that ounce of prevention or pound of response that is needed. And this sociopolitical variability… shapes the effect that disasters of similar initial content have in different countries.

Seitz and Morris
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[Disaster reduction is] about looking beyond hazards alone to consider the prevailing conditions of vulnerability. It is the social, cultural, economic, and political situation in a country that makes people vulnerable to unfortunate events.

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Introduction

Every year people around the world experience the deadly and destructive wrath of natural disasters. In the year 2002 alone, 66 different large-scale disasters affected the lives of over a 100,000 people each. These 66 events alone resulted in an estimated 33,756 deaths and close to $20 billion in damage. Looking at all natural disasters during this year, over 500 events affected the lives of 621,000,000 people, left at least 550,000 people homeless, and took the lives of 50,000 people[1].

Clearly, natural disasters disrupt the lives of individuals, the functioning of societies, and the productivity of economies. In addition to the tremendous number of lives lost, natural disasters also destroy homes, schools, farms, and businesses. Further, disasters can have an indirect impact on the institutions that bring order to daily life. For example, when an earthquake destroys a major hospital, the damage is not only physical but extends to the broader health care institution of the affected area. And, as this thesis examines, natural disasters push the capacity of governments to protect their citizens during emergency situations.

Importantly, a large cross-country variance can be observed in the impact of natural disasters. Whether impact is measured through the number of people affected, the number of people left homeless, the cost, or the number of lives lost, some countries are impacted much more than others. To understand this variance, researchers have

[1] Unless otherwise noted, reported data on disasters is taken from the CRED EM-DAT data available at http://www.cred.be. Appendix 1 provides a summary of definitions and categorizations of the EM-DAT.

developed a framework that isolates different sources of vulnerability.  For example, faults lines, volcanoes, and low-lying coastal areas represent physical (or environmental) sources of vulnerability.  However, the observed variance in disaster impact cannot be entirely explained by the observed variance in physical vulnerability.  For example, two earthquakes of identical magnitude, affecting similarly sized populations, may cause vastly different number of destroyed homes or people killed.  Thus, researchers and policy makers have also examined social and economic vulnerability, such as low income and education levels, as determinants of the impact of natural disasters.  This thesis examines the notion of political vulnerability as a source of vulnerability to natural disasters.  In a nutshell, are non-democratic, unstable, and/or young regimes impacted more by natural disasters when compared to democratic, stable, and experienced regimes?

Figure 1:  Direct impact of natural disasters.

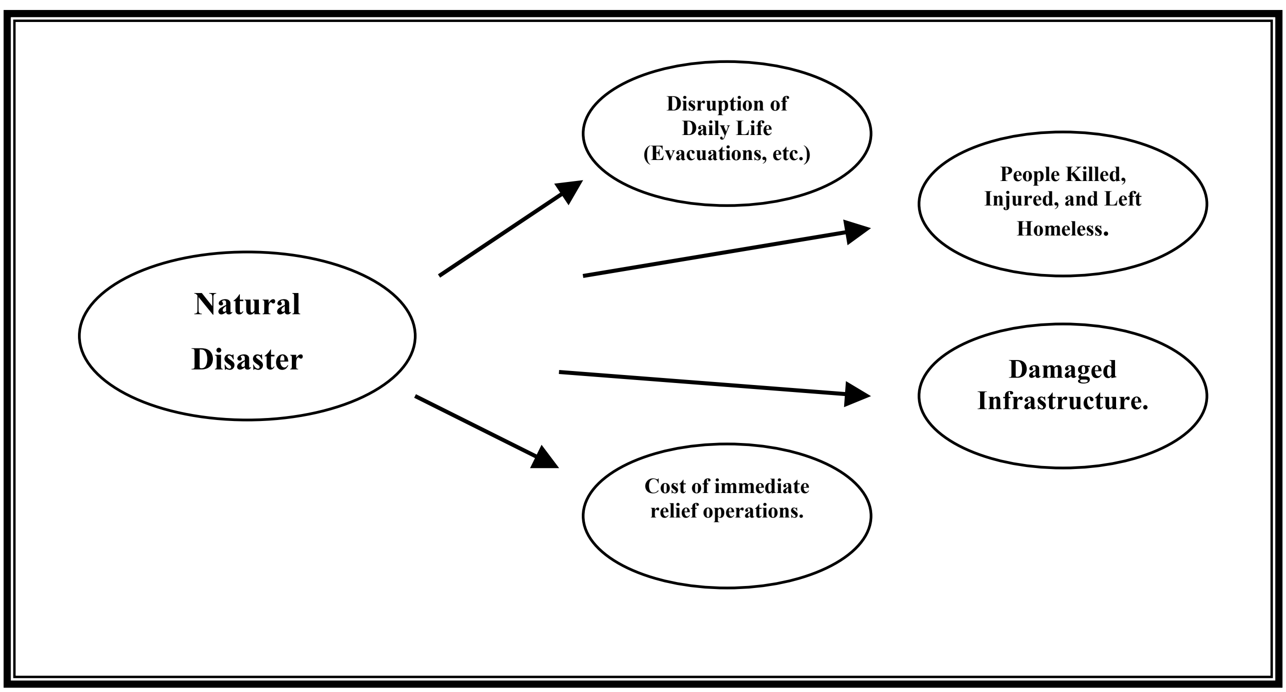


Figure 2: Timeline of annual total people affected.

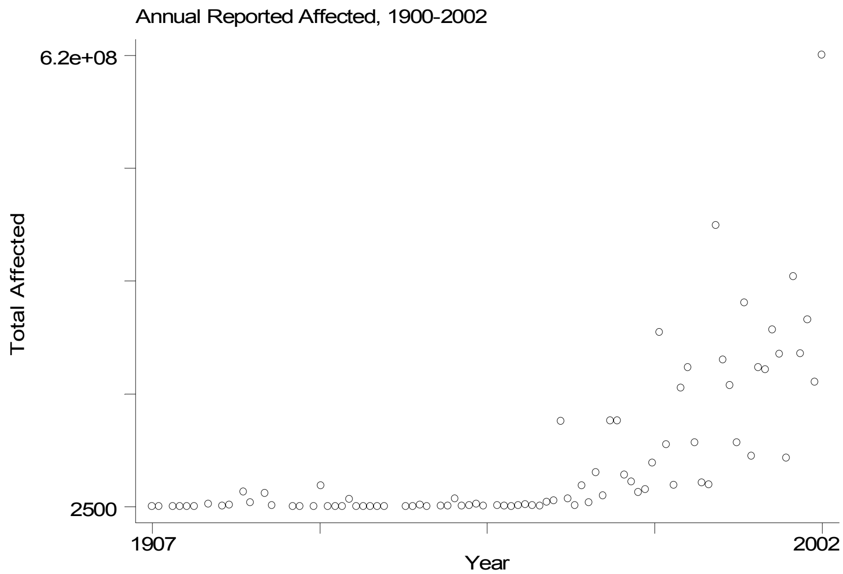
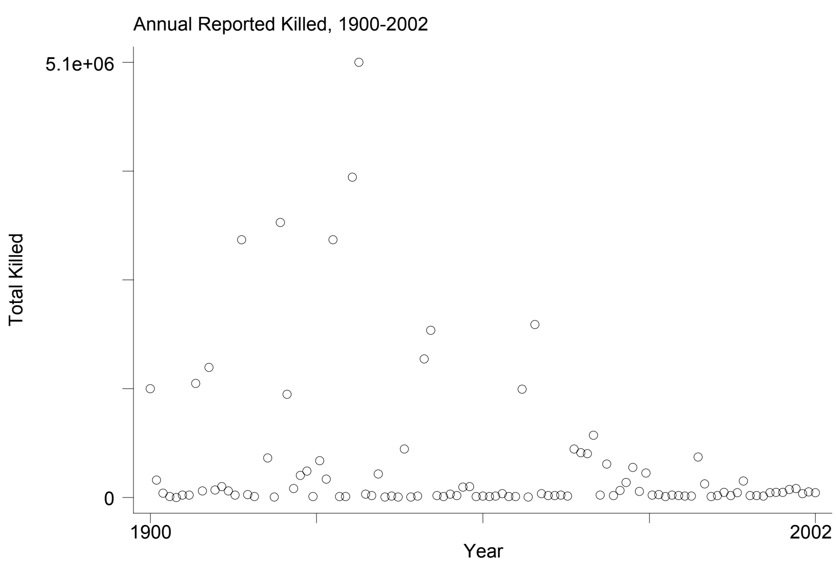



Figure 3: Timeline of annual total people killed.




Note: Due to missing data points in both sets of figures, each graph should be considered as representing different samples.

Figure 4: Timeline of total reported affected divided global population.

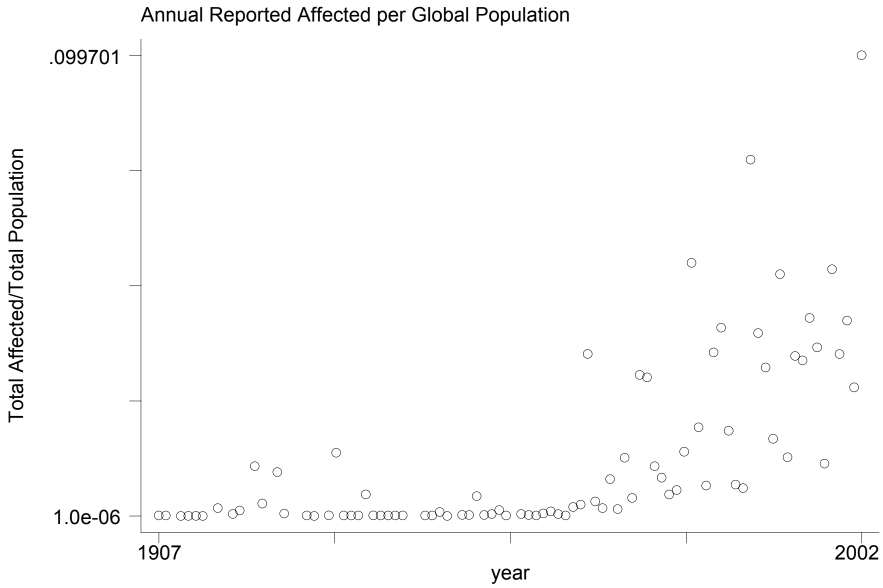
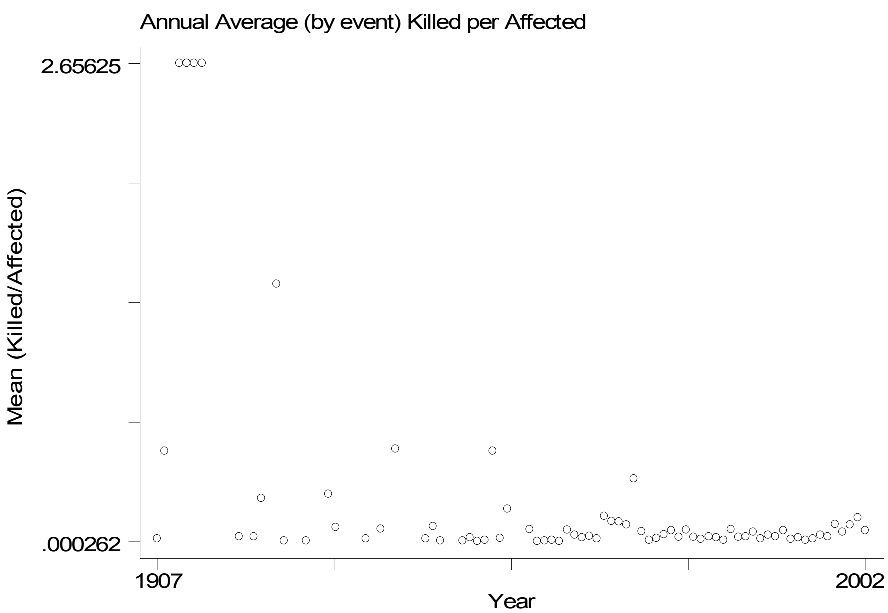



Figure 5: Timeline of annual mean of killed divided by affected.




Note: The data points presented above are averages of the respective ratio calculated using all data points for each given year. First the ratio was calculated for each event, then the annual average was calculated from the individual ratios in a given year. Population refers to the population of the country impacted by the disaster.

As figures 2-5 demonstrate, the global impact of natural disasters has changed over the last 100 years. Looking at absolute measures of disaster severity and impact, figures 2 & 3 show that while the annual total number of people affected by disasters has risen in recent years, the total number of people killed annually has decreased. However, for analytical purposes, the ratios presented in figures 4 & 5 are more revealing. Figure 4 reveals that when measured as a percentage of the global population, the number of people affected has increased. In fact, in 2002 nearly 10% of the global population was affected by natural disasters. This figure indicates that on a global scale disasters have become more numerous and severe. However, as a measure of the relative impact of a disaster, the ratio of people killed to people affected shows a downward trend, indicating that a larger percentage of the affected population receives sufficient protection and survives the disaster.

Consider as a broad overview the regional variance in the impact that natural disasters have on populations in the different continents. For example, of the 3994 recorded disasters that have occurred since 1990, over 1400 (nearly 40%) have occurred in Asia. When considering different disaster types, other regional distributional patterns emerge. Again, looking at the recorded disasters since 1990:

- Nearly 43% of the 277 recorded droughts occurred in Africa.
- Over 51% of the 320 recorded earthquakes occurred in Asia.
- Over 57% of the 603 recorded epidemics occurred in Africa.

- The occurrence of floods is the most equally distributed. While nearly 38% (of 1283 total floods) occurred in Asia, 24% occurred in the America's, 20% occurred in Africa, and 16% occurred in Europe.

- Nearly 41% of the 1099 recorded windstorms occurred in Asia while close to 35% occurred in the Americas. Europe experienced 15% and Africa experienced 6%.

While nature most likely explains the variance in the occurrence of natural disasters, nature alone cannot explain the great deal of observed variance in the impact of natural disasters. For example, when comparing disaster-related mortality figures in Asia and in Europe since 1990, the mean for Asia is 397 while the mean for Europe is 61. In other words, the average disaster in Asia kills over six times as many people as the average disaster in Europe. Likewise, when comparing the number of floods and windstorms in Asia and Africa, one notices a perplexing anomaly. During the nineties, Europe experienced 50 windstorms (excluding tornadoes and winter storms) and 107 floods. In comparison, Africa experienced 30 windstorms but over 140 floods. If floods are associated with windstorms one should expect a roughly constant ratio of floods per windstorm. From the observation that Africa experiences more floods per windstorm than Europe one might conclude that African countries lack the capacity to prevent flooding during windstorms while the European countries are better able to mitigate and control flooding during windstorms.

When measuring the impact of disasters through the mean number of people left homeless by a disaster, Asia suffers more than the other continents. While for all other continents this number is less than 7,000, for Asia this figure is over 80,000. Clearly,

Table 1: Regional variance in relative mortality rates by disaster type.

| **Mean of Ratio of Killed to Affected (all recorded events since 1990.)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Continent** | **All Types** | **Earthquake** | **Epidemic** | **Famine** | **Flood** | **Slide** | **Volcano** | **Wild Fire** | **Wind Storm** |
| Africa | .179 | .003 | .352 | .003 | .002 | .113 | .001 | .001 | .001 |
| Americas | .007 | .006 | .012 | | .004 | .064 | .001 | .001 | .007 |
| Asia | .027 | .007 | .128 | .013 | .004 | .056 | .001 | .001 | .011 |
| Europe | .026 | .003 | .017 | | .027 | .122 | | .011 | .016 |
| Oceania | .007 | .001 | .016 | | .001 | .104 | .000 | .000 | .003 |
| All | .058 | .006 | .238 | .006 | .008 | .077 | .001 | .003 | .009 |

while Asia suffers the most events it also suffers the worst impact per event. Some explanation of this observed difference in disaster impact can be found in nature. For example, Asia experiences the highest number of earthquakes, which are the most destructive to homes. However, differences in the strength, number and type of natural disasters cannot completely explain the observed difference in the impact that they have.

Utilizing the ratio of people killed to people affected as a measure of the effectiveness of disaster response, Table 1 above provides a regional overview of the effectiveness of disaster response. Based on the assumption that the number of people affected provides a valid proxy measure of the severity of the storm, this ratio expresses the disaster impact, measured as the number of people killed, relative to the disaster severity. A high ratio indicates that the impacted population was not adequately protected, and the response to the disaster was ineffective in preventing deaths.

When considering all types of disasters, clearly the relative mortality rate is highest in Africa, an indication that African countries lack the response capacity of other countries in the world. Likewise, the low ratio for the Americas and Oceania indicates that countries in these regions are better able to respond to natural disaster and protect their citizens. The variance observed in the other columns of this table indicates a regional variance in responding to disasters of identical type and demonstrates that variance in disaster type does not completely explain the variance in the impact. While this table does not directly control for variance in magnitude and location the assumption that the number of people affected depends on these two variables provides an indirect control for these variables when comparing mortality figures through the ratio of killed to affected.

Toward explaining this variance in the impact of natural disaster, a number of disaster researchers have noticed a connection between disaster impact and two characteristically human variables: wealth and development. For example, in the *World Development Report, 2000/2001: Attacking Poverty,* the World Bank observes that "developing countries… suffer the brunt of natural disasters. Between 1990 and 1998, 94 percent of the world's 568 major natural disasters and 97 percent of all natural disaster-related deaths occurred in developing countries" (World Bank 2001, p. 170). Likewise, The Secretary-General of the United Nations notes that "poverty and population pressures increase the costs of natural disasters" and that "unsustainable development practices also contribute to the rising impact of natural disasters" (Annan 1999, p. 6).

This thesis builds on the previous research on the socio-economic determinants of disaster impact by looking at potential political determinants. In particular, I examine whether levels of democracy, political stability, or regime durability explain some of the observed variance in the impact of natural disasters. I argue that these three characteristics contribute to a country's political vulnerability. Further, I attempt to demonstrate that political vulnerability is just as real as physical vulnerability. In other words, while fault lines pose an earthquake hazard, I argue that bad politics increases the associated risk to lives and livelihoods.

I present the case for such a connection between political regime characteristics and the impact of natural disasters in the three chapters that follow. In the literature review section I provide a multidisciplinary review of relevant natural disaster research. While a dearth of "nuts-and-bolts" literature exists along with numerous studies of disasters from sociological and development viewpoints, very little of the available political science literature addresses the questions that surround natural disasters and the impact they have on countries and citizens. However, in noting that natural disaster relief can be considered a public service provided by states similar to programs on public health and education, I review the available literature on the relationship between public service provision and political institutions and then relate these findings to disaster response. Finally, I review a recent United Nations policy document on disaster response. Utilizing the framework of analysis presented by the United Nations International Strategy for the Reduction of Natural Disasters along with the findings of previous research, I present the theoretical argument for associating the impact of natural disasters with the political regime characteristics of countries. I conclude this chapter by presenting three hypotheses regarding an expected causal relationship linking the impact of a natural disaster with the level of democracy, political stability, and regime durability in the country where the disaster occurs.

The next two chapters present an empirical examination of the relationship between disasters and political institutions. In chapter 2, four comparative case studies demonstrate consistency with the three hypotheses. Next, chapter 3 examines the validity and generalizability of the hypotheses using a multivariate, large-N statistical analysis of the determinants of natural disaster impact. Data from the Center for Research on the Epidemiology of Disasters provides indicators of natural disaster impact that are then compared to standard compared, social, economic, and political indicators.

Overwhelmingly, the data presented here shows that ineffective and non-responsive political institutions comprise an important source of natural disaster vulnerability. In a comparison of five earthquakes, the highest mortality rates were observed in non-democratic countries where corruption hindered the disaster response significantly. Comparing three floods in three democratic countries, one finds evidence of the political will to confront the flood threat in all three, but only the durable and stable regime possesses the capability to effectively respond. Analyzing the trends in democracy and trends in disaster impact for Nicaragua and Honduras over the last thirty years, one notices that the impact of natural disasters decreased faster when democracy increased fastest. In a final case study consisting of nine countries selected based on rigorous selection rules, the evidence shows that democracy explains cross-country variance in disaster impact when the development variable cannot.

In addition, a statistical analysis of more than 1500 disasters shows that political vulnerability matters just as much as social and economic vulnerability. Indeed, as expected, the impact of natural disaster is less when democracy is greater and when stability is greater. Contrary to expectations the regression results indicate that disaster response actually gets worse as a regime exists longer. Still, consistent with the case-studies, the large-N regression shows that political institutions matter when a country is confronted with the threat of a natural disaster.

# Chapter 1: Literature Review

Despite its clear policy importance, natural disasters are not a common topic of political science researchers. In contrast, natural disasters and group responses have been analyzed by sociologists, some of whom have focused on the behavioral sources of vulnerability. From a more practical viewpoint, both relief fieldworkers and development policy analysts agree that the impact of natural disasters is not determined purely by nature. In *Living with Risk,* The United Nations International Strategy for Natural Disaster Reductions provides a comprehensive review of disaster reduction initiatives from around the world and along with a conceptual framework for analyzing the impact of natural disasters. Importantly this framework identifies and defines social and economic sources of vulnerability along with physical and environmental sources of vulnerability. Finally while education and public health are not identical to natural disaster response, these are all services that the government provides to develop social capital. Thus, political science literature on education and public health can be related to natural disasters.

## *Disasters and Disaster Relief: Lessons from the Field*

An important discourse in the literature on "natural disasters" asks if the very term is somewhat of a misnomer. Indeed, the people with the most direct experience in responding to natural disasters agree that the "human" factors are just as important as the "natural." Anders Alexander, an experienced Red Cross relief worker, notes that "many would argue that 'natural' hazard is a misleading term, as very little is natural about phenomena in which the danger results largely from human decision-making, land use, and socio-economic activities" (Alexander 2000, p. 10.) In this regard, it is important to note the consensus regarding some human causes of natural disasters. For example excessive logging can lead to mudslides and development along low lying coastal lands puts people at risk to flood and storm related disasters. However, other human causes of natural disasters continue to be debated, for example the relationship between human activity, global warming, and the occurrence of devastating storms and floods.

Likewise, one can dissect the other half of the term natural disaster and ask what takes an event of nature (in terms of its *direct* causes), and makes it into a disaster? As Wijkman and Timberlake note, "a distinction must be made between the 'trigger events' – too little rain, too much rain, earthshocks, hurricanes – which may be natural, and the associated disasters, which may be largely man-made" (Wijkman 1984, p. 11.) For example, seismologists often point out to engineers that earthquakes don't kill people, poorly constructed buildings near fault lines do.

In this regard, the field of disaster response and relief deals with mitigating the devastation of natural disasters. From the public health aspects of emergencies to the logistics of delivering relief supplies to building earthquake resistant homes, this discipline is as rich in the literature as it is diversified in the fieldwork[2]. While many of the technical details found in this literature remains beyond the scope of the present study, a number of general themes are pertinent. Coordination between relief agencies has been identified as a major obstacle to providing effective relief following a disaster (Calvi-Parisetti 2003, web). Likewise, the reliability of early warning systems (Glantz 2001) and the security of relief workers (IFRC 2002) are top concerns to people involved in disaster response. Finally, the development of standardized methods of assessing disaster impact and response from the field is another important topic that appears in this literature (UNOCHA 2003, SPHERE 2003)[3].

The activities of two major international organizations involved in disaster response help make the concept of disaster response more concrete. One aspect of disaster response relates to post-disaster relief to victims. For example, the IFRC reports that during 2002 it spent $41 million on disaster response to provide aid to a target population of over 2 million people (IFRC 2003, p. 7). Relief supplies delivered by the IFRC include quilts to nearly 48,000 flood victims in China (IFRC 2003, p 15), providing food, temporary shelter, and basic hygiene items to nearly 2000 victims of an earthquake in Indonesia (IFRC 2003, p 1), and food assistance to 20,000 drought victims in Uzbekistan (IFRC 2004, p. 1.) One can imagine the overwhelming financial, logistical, social, and cultural obstacles that had to be overcome to facilitate the delivery of these supplies. One can also imagine a number of political obstacles that Red Cross workers encounter on a daily basis.

In contrast to disaster relief, disaster preparedness is an aspect of disaster response that occurs before the disaster occurs and focuses on increasing a community's capacity

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[2] Self-described as serving "the needs of the international humanitarian relief community", ReliefWeb (www.reliefweb.org) provides a large number of field reports from disaster relief workers along with a dearth of other nuts-n-bolts information on disaster relief.

[3] While this study deals an overall measure of impact a follow-up analysis could take a more detailed look at impact by, for example, distinguishing the numbers of deaths that occurred during the immediate flooding emergency versus the number that died later as a result of malnutrition, poor hygiene, and/or inadequate water treatment.

to respond when a disaster does occur. Like disaster relief, disaster preparedness involves numerous field activities that are crucially linked to the social, political, and economic context. For example, CARE International's immediate response to a destructive cyclone in India in 1999 was followed by a long term disaster preparedness program that focused on building cyclone shelters and providing disaster education (CARE 2000, p. 25.) As CARE notes, the success of this program hinges on the cooperation of the Indian government, indicating that political institutions do matter.

*A Sociological Perspective on Disasters*

Reflecting the above-cited practitioners of disaster relief, a number of social scientists have examined the role of social systems in contributing to disasters. Indeed, by studying the way groups and individuals respond to disasters, both organized and spontaneous, many sociologists have concluded that both severity and the final impact of a natural disaster depends on the humans response just as much as it depends on the natural hazard.

In an *Annual Review of Sociology* on the subject of disasters from 1977, Quarantelli and Dynes note that "other critics have argued that disasters are inherently political phenomena" and goes on to argue "that a disaster is primarily a social phenomenon" (Quarantelli 1977, p. 24.) Likewise, in an Annual Review published 7 years later, Kreps applauds the "overdue reflection about how disasters should be interpreted as a social problem" (Kreps 1984, p. 317.)

Partly, this result follows from revisions in the definition of disaster, while, partly, this result follows from early data-based surveys of the impact of natural disasters.

Conceptually, Fritz in 1961 advanced a definition that explicitly notes the social aspects of disasters: "Disasters are (a) *events* that are designated in time and space, which have (b) *impacts* on (c) *social units* [which] in turn enact (d) *responses*" (Kreps 1984, p. 311). Thus, no longer considered just random events determined solely by nature, social units and their responses are now explicitly linked with the standard sociological definition of disasters and their impacts. These conceptual developments in the sociological study of disasters gained support from a number of surveys conducted in disaster areas. In this regard, the Disaster Research Center (established in 1963) has been a pioneer in collecting and classifying data on disasters, their impact and the responses of the social units. Although these early studies were limited by selection bias and other methodological issues, they overwhelmingly support the conclusion that natural disasters are inherently social phenomena.

*International Development Policy and Disasters*

Beyond just an academic question, the international development community has adopted the causes and implications of natural disasters as an important policy issue. To a large extent this literature focuses on two related issues: i) developing/poor countries are impacted far more than developed/wealthy countries and ii) natural disasters hinder development and disaster response encourages development. For these reasons, disaster mitigation has become an important development policy issue.

In *World Development Report 2000/2001*, the World Bank notes "poverty and lagging development amplify the adverse affects of natural disasters. Developing countries are particularly vulnerable, because they have limited capacity to prevent and absorb these effects" (World Bank 2001, p. 172.) Both the World Bank and the United Nations note that over 95% of disaster related deaths occur in developing countries and developing countries lose a higher percentage of GDP to disasters when compared to developed countries.

Examining the link between economic development and disasters vulnerability further, Yates, et. al. note that "the evidence clearly shows that natural disasters are a key factor in setting back the development process." Further, they argue "disasters are a crucial element in determining whether poor people escape poverty, remain poor, or become even poorer" (Yates, p. 2.) In preparation for the recent World Summit on Sustainable Development, the United Nations Department of Social and Economic Affairs presented a background paper on natural disasters and development in which they write "the escalation of severe disaster events triggered by natural hazards… are increasingly posing a substantive threat to both sustainable development and poverty reduction initiatives (UNISDR 2003, p. 2.) Likewise, in the *Human Development Report 1994: New dimensions of human security*, the United Nations Development Program argues, "disasters are an integral part of poverty cycle," and, hence, pose a threat to human security (UNDP 2003, p. 29.)

Finally, in a World Bank working paper, Freeman, et al present the following policy recommendation for using disaster management to encourage development: "risk management must be a formal component of development planning for countries with high natural catastrophe exposure. Through planning, countries can reduce some of the negative impacts on development and improve the situation of poor people during and after crises."

*The Political Context of Disasters*

Despite the very clear policy importance of natural disasters and disaster response, very little political science literature covers this topic. While a handful of case studies are available, only one cross-national, systematic study of the determinants of impact of natural disasters exists. Again the consensus agrees that human factors, specifically government attentiveness and effectiveness, play a large role in determining the impact of natural disasters.

Some researchers have used the devastating 1999 earthquake in Turkey as a case study on the political context of disasters. Measuring 7.4 on the Richter scale, this disaster took the lives of over 17,000 people and left nearly 250,000 homeless. Noting the ineffective state response to this disaster, Kinzer observes that "although Turkey lies above some of the world's most dangerous geological faults and is shaken by earthquakes every few years, its government had no plan for dealing with them, no disaster-relief agency, no civil-defense network, not even an official designated to take charge at such moments." (Kinzer 2001, p 42.) Kinzer concludes that for many Turks the devastation was "the result of a political system that tolerated corruption and contempt for human life" (Kinzer 2001, p. 45.) In contrast, Jalali offers a slightly more favorable assessment of the official response to the earthquake. Characterizing the initial response as "utterly inadequate" (Jalali 2002, p. 124), she also writes, "in the ensuing months, state ability to aid earthquake victims improved considerably" (Jalali 2002, p. 127.) Further observing that media coverage of the devastation encouraged more effective state response, she argues that "an ideal response system… can only be based on state-civil society relations that are both collaborative and adversarial" (Jalali 2002, p. 121). Naturally one can ask about the regime characteristics that best facilitates such a balanced state-civil society relationship.

Two interesting assessments of the “lessons learned” by two Central American countries following Hurricane Mitch go so far as to link state failure in providing effective disaster assistance with the failure of global economic policies. In both studies the authors conclude that neo-liberalism’s emphasis on the free market and a weak state has reduced both state capability to mitigate the effect of disasters along with government readiness to “intervene” during times of crisis. Rocha and Christoplos note that despite comprehensive and constructive critiques of the government’s response to Mitch, recent disasters demonstrate that appropriate policy changes have not been implemented (Rocha 2001, p. 248). The authors place the “blame for the destruction firmly at the feet of neo-liberalism” (Rocha 2001, p. 249). Likewise, Wisner observes “to understand why the lessons of Mitch were not internalized by El Salvador’s central government permanent state apparatus and translated into action, one must understand the current government as a reflection of a neo-liberal state” (Wisner 2001, p. 258.) However, their conclusions should be countered with evidence from Chapter 3 that indicates that the “institutional learning” hypothesis of government response effects is not valid.

In what appears to be the most comprehensive study on the political context of disasters, Davis and Seitz employ a cross-national statistical analysis to examine “why do disasters of the same type sometimes differentially impact various countries?” (Davis 1982, p. 547.) In the introduction they note that “human complicity is observable even in the causal agents of disasters” (Davis 1982, p. 548), and then they go on to examine potential social, economic, and political determinants of disaster impact. Their study

Table 2: Regression of disaster impact (measured as number killed.)

| | Overall $R^2$ | Regression Coefficient for Government Instability | Social Context | Resources | Government Effectiveness |
|---|---|---|---|---|---|
| **Accident** | .23 | 0 | .53 | .27 | -.50 |
| **Volcano** | .33 | .42 | .04 | .16 | 0 |
| **Earthquake** | .30 | .57 | .10 | .05 | -.07 |
| **Storm** | .03 | .06 | .11 | -.02 | 0 |
| **Drought** | .85 | .31 | -.24 | .07 | .24 |
| **Epidemic** | .67 | .27 | -.82 | -.51 | .66 |
| **Flood** | .02 | -.03 | -.14 | -.08 | 0 |
| **Landside** | .00 | 0 | 0 | 0 | 0 |
| **Fire** | .00 | 0 | 0 | 0 | 0 |

*Source:* Davis, Morris and Steven T. Seitz. "Disasters and Governments." *Journal of Conflict Resolution*. Vol. 26, Iss. 3, p. 563 (1982.)

employs a structural model that posits government effectiveness, government instability, available resources, and social context as independent variables and disaster impact (operationalized using number of people killed) as the dependent variable. An important aspect of their research design is to separately analyze disasters of different types. In all they consider earthquakes, floods, accidents, landslides, volcanoes, fires, storms, epidemics, and droughts. The authors find significant correlations for each of the four independent variables with at least one disaster type. They also identify drought and epidemic as best explained by the model. Interestingly, they find that for most disasters government stability and effectiveness are more important than the available resources in determining the impact of the disaster (Davis 1982, p. 593.) In other words their results show that, in a general sense, the impact of a disaster is influenced, sometimes heavily, by the politics of the affected country.

While methodologically innovative this study is also limited by the failure to control for the strengths of the disaster when explaining the mortality figures. In a significant contribution to the disaster research literature, the authors illustrate the use of standardized disaster data[4] in assessing and comparing the impact of disasters. Further, they strengthen their analysis with a detailed discussion of the reliability and validity of disaster data. However, despite the many achievements of this piece the final conclusion is limited by the fact that neither the mortality figures nor the model control for the magnitude or location of disaster as a determinant of the impact. Perhaps, severe earthquakes occurred more often in politically unstable countries. As explained in Chapter 3, this obstacle can be overcome by using the number of people affected as a proxy for the type, magnitude and location of the disaster.

As an aside, it should be noted that in regards to the predictive capacity and use as a planning tool, the presentation of this study is limited by the omission of standard errors or t-scores for the coefficients. While not the primary focus of the present study, this application of regression results is discussed in Appendix D.

*International Strategy for Disaster Reduction: A framework for analysis*

Reviewing a number of case studies that illustrate the connection between the impact of disasters and the underlying social, economic, and political context, the United Nations International Strategy for Disaster Reduction (ISDR) presents a number of basic guidelines in their preliminary version of the document *Living with Risk: A global review of disaster reduction initiatives.* In addition to a section on the political context of disaster reduction, many of the suggestions contain a number of explicit and implicit political factors. Further, this document provides a sound framework for analyzing natural disasters and identifying their human causes.

[4] They utilize the Office of US Foreign Disaster Assistance Disaster History Update Program as their source for disaster data.

To begin with, ISDR defines a number of key terms related to disasters and disaster response (UNISDR 2002, p. 23-24.)[5]:

- Disaster: A serious disruption of the functioning of a community or society causing widespread human, material, economic or environmental losses that exceed the ability of the affected community/society to cope using its own resources.

- Hazard: A potentially damaging physical event, phenomenon, or human activity which may cause loss of life or injury, property damage, social or economic disruption or environmental degradation.

- Vulnerability: A set of conditions and processes resulting from physical, social, economic, and environmental factors, which increase the susceptibility of a community to the impact of hazards.

- Coping Capabilities/Capacity: The manner in which people and organizations use existing resources to achieve various beneficial ends during unusual, abnormal, and adverse conditions of a disaster event or process.

- Risk: The probability of harmful consequences, or expected loss (of lives, people injured, livelihoods, economic activity disrupted, or environment damaged) resulting from the interaction between natural or human induced hazards and vulnerable/capable conditions.

In addition to defining these basic terms, the ISDR postulates the following relationship between risk (R), hazard (H), vulnerability (V), and capacity (C),

[5] The ISDR reports that one of its functions is to provide interested researchers and policy makers with a

$$R = H \times (V/C). \qquad \text{(i)}$$

They further note, “disaster is a function of risk” (UNISDR 2002, p. 25.)

Within this framework, *Living with Risk* examines and highlights a number of steps that can reduce the impact of disasters by reducing vulnerability and increasing capacity. They begin by listing a number of factors of vulnerability using four broad categories of vulnerability (UNISDR 2002, p. 47.):

- Physical: density levels, remoteness of the settlement, its sitting, design and materials used for critical infrastructure and for housing.
- Social: levels of literacy and education, public health, peace and security, human rights, good governance, social equity, positive traditional values, customs and beliefs, and collective organizations.
- Economic: Gross and individual income, economic reserves, national debt, access to credit and insurance, economic diversity, infrastructure.
- Ecological: Resource depletion, resource degradation, resilience of ecological systems, biodiversity, exposure to toxics and pollutants.

While they do not explicitly list “Political Vulnerability” as a category, a number of political factors are present in this list. For example, they write, “social vulnerability is also linked with… the state of domination and power relations in the concerned society” (UNISDR 2002, p. 47.) Further, social factors such as peace and security, human rights, and good governance are perhaps better listed as political factors. In addition, scholars of

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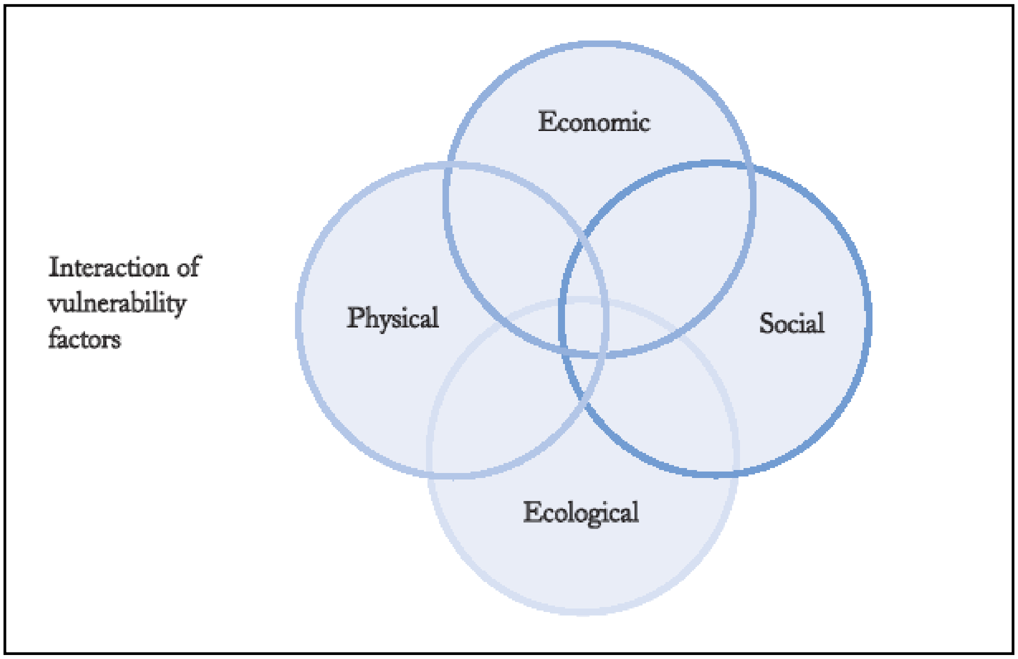
uniform and homogenous set of definitions for disaster related terms.

Figure 6: Factors of vulnerability.

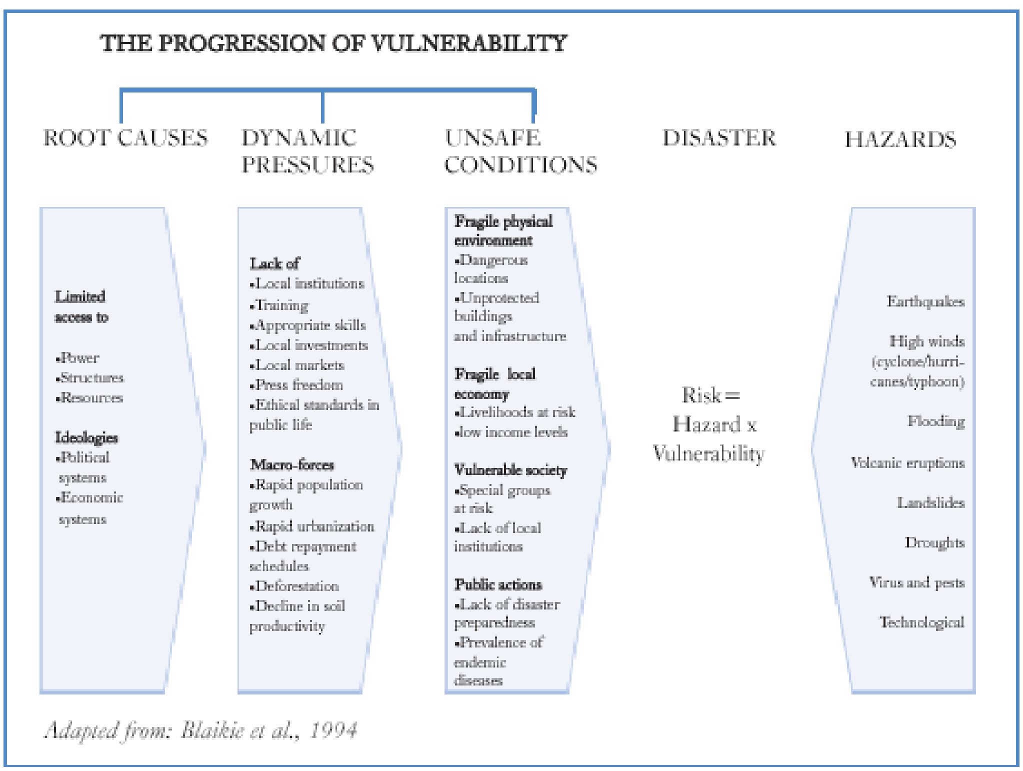



*Source:* The United Nations Inter-Agency Secretariat for the International Strategy for Disaster Reduction. *Living with Risk: A global review of disaster reduction initiatives.* Geneva: The United Nations (2002).

political economy have noted the factors such as income, debt, and infrastructure reflect not just economic conditions, but also political conditions. Finally, controlling resource depletion and degradation, preserving ecological systems and biodiversity, and limiting exposure to toxics and pollutants requires both political will to enact such legislation and state capability to enforce it. Thus, while the ISDR does not explicitly list political determinants of disaster impact, they do seem to indicate that political vulnerability to natural disasters is just as important as social, economic, ecological, and physical vulnerability. Indeed, defining politically vulnerability as the set of political institutions and conditions that increase a community's susceptibility to the impact of natural disasters, this model is improved with the inclusion of cluster of political variables that comprise the political dimension of vulnerability.

Moving beyond a static model of risk, Balkie et al, in figure 6, develop a dynamic model where risk results from a series of steps that progressively increase vulnerability. Figure 7 shows some of the political factors that influence vulnerability and risk throughout the progression. As root causes, both limited access to power and political ideology both political vulnerability. As dynamic pressures, political vulnerability is present as lack of local institutions and lack of press freedom. Finally as unsafe conditions political vulnerability relates to dangerous locations, unprotected buildings, and lack of public actions. Indeed, though not explicitly listed, political vulnerability is an important variable in the dynamical processes that results in natural hazards becoming risks to human populations.

Figure 7: The progression of vulnerability.




*Source:* The United Nations Inter-Agency Secretariat for the International Strategy for Disaster Reduction. *Living with Risk: A global review of disaster reduction initiatives.* Geneva: The United Nations (2002).

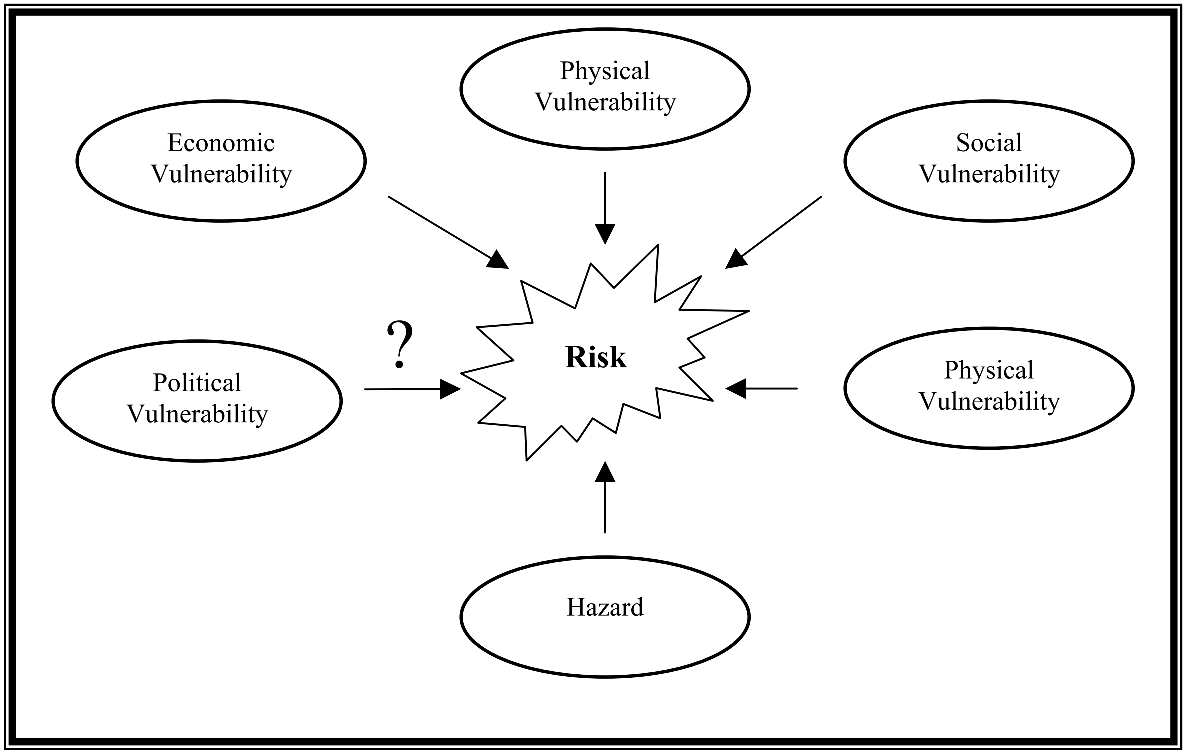
In addition to the theoretical framework just described, *Living with Risk* also contains a number of policy recommendations for reducing natural disaster risk. Among many of the policy recommendations, the ISDR recommends developing institutions that encourage disaster mitigation. They write:

> "Coherent and comprehensive approaches to building institutional frameworks, at both national and local levels, are essential if one is to speak seriously of a sustained commitment to disaster risk reduction… The vitality and effectiveness of the resulting organizational frameworks and operational capabilities remain based on the understanding and motivations of public interests" (UNISDR 2002, p. 112.)

However, it is important to note that not all governments seek to understand or be motivated by the public interest. Further, when the political will and concern for the public interest does exist, the government does not always possess the operational capabilities to implement effective disaster reduction policies.

In summary, while the risk framework presented by the ISRD does not explicitly list political vulnerability as a source of risk to natural hazards, perhaps they should. They do note a number of political factors and political vulnerability describes some aspects of Blakie's progression of vulnerability. Further, several of the policy recommendations described in *Living with Risk* require certain political prerequisites. Thus, as a modification to figure 6 above, I offer figure 8 below.

Figure 8: Sources of vulnerability, hazard, and risk.




*Public Service Provision and Political Institutions*

While they have not yet considered natural disaster response directly, political scientists interested in domestic political economy and its outcomes have reached conclusions that are applicable to the question of the effectiveness of disaster response. To begin with, this literature follows the realist tradition and assumes that the state acts as a rational, self-interested actor and provides certain public goods, such as public health and education, to advance the goal of long-term economic and political interests. In this context the state uses disaster response to protect both physical and social capital, i.e. its tax base. Thus disaster response bears this similarity to state sponsored education and public health programs. While many differences exist between disaster response, education and public health, the research on the political aspects of the latter does shed some light on the political aspects of the former.

Providing a solid foundation for a rich research discipline in political science, Olson develops a realist theory of domestic political economy and the reinforcing relationship between democracy and capitalism. His conclusion: “The conditions necessary for a lasting democracy are the same necessary for the security of property and contract rights that generates economic growth” (Olson 1993, p. 567.) In reaching this conclusion, Olson first assumes that in a primitive, anarchic society, economic activity is hindered by a political system that encourages competitive theft among “roving bandits.” Olson then notes that a “stationary bandit,” i.e. a dictator who gains a monopoly on theft through violence and taxation, enjoys a competitive advantage in the form of limited protection of investment when compared to the “roving bandit.” However, he points out this advantage is limited by the insecurity of autocratic regimes which forces the dictator to take a short term view toward optimizing revenue through taxation at the cost of long term investment. Finally noting that a secure government that respects individual rights provides the strongest investment incentive, Olson concludes that the conditions necessary for democracy -- secure rights and the rule of law -- are also the conditions necessary for long term economic growth. As central variables of Olson’s argument, investment uncertainty and incentive provide the link between political institutions and economic outcomes.

In a similar manner, Lake and Baum consider public services, specifically public health and education, as an outcome of the political system. Assuming first that states “produce services in exchange for revenue,” they argue that their “monopoly on the legitimate use of force… gives states a comparative advantage in producing goods where collective actions problems… and other barriers to voluntary exchange would otherwise create market failures" (Lake & Baum 2001, p. 590.) They also note "the state's ability to earn rents, in turn, is a function of the public services produced for citizens" (Lake & Baum 2001, p. 592.) Finally, they conclude that since the political market is more competitive under democracy than under autocracy, "democracies will provide higher levels of public services to their citizens than autocracies" (Lake & Baum 2001, p. 598.)

In addition to developing a rigorous theory of domestic political economy, Lake and Baum also provide strong statistical tests of the hypothesis that democracies provide more public services than autocracies. First, they utilize a cross-sectional ordinary least squares (OLS) analysis positing that the level of public service depends on the level of democracy along with other control variables (Lake 2001, p. 606.) Calculating the OLS coefficient and significance levels for various indicators of education and public, they conclude that the data demonstrate a robust association of levels of public services with levels of democracy. Secondly, in pooled time-series cross-sectional (TSCS) model they posit additional terms to account for changes in democracy levels and a general upward trend in education and public health (Lake 2001, p. 611.) Again, they find evidence for a significant association between numerous indicators of social service provision and levels of democracy (Lake 2001, p. 612.) Finally developing this analysis further, Baum and Lake investigate the indirect economic effects of democracy through the state's provision of public service. They argue that by increasing human capital, the provision of public services encourages economic growth, and since democracies provide more effective public services, they exert an indirect benefit to the economy through human capital

(Baum 2003, p. 333.) Using a system of two equations, one that posits public service provision as dependent on democracy and another that posits growth as dependent on public service provision (the Baum 2003, p. 340), they conclude that "the effect of democracy on economic growth is subtle, indirect, and contingent on levels of development" (Baum 2003, p. 345.)

Since disaster response is similar to public health and education in a number of ways, one can use these research results to theorize on the political context of natural disasters. Importantly, like public health and education, disaster response contributes to the available capital of an economy and the tax-base of the state. While public health and education constitute an investment of future human capital, disaster response protects physical and human capital from natural disasters. In other words, disaster response is a form of insurance for the rational, self-interested state. Likewise, since different regimes types employ different strategies toward building and protecting human and physical capital, we can expect that the regime type of a state will have some impact on the level and effectiveness of disaster response in that country. Further extrapolation of Baum and Lake's conclusion suggests that democratic governments provide more effective disaster response than non-democratic governments.

*A Summary and Three Hypotheses*

To summarize the above literature review from a variety of viewpoints the consensus agrees that the impact of natural disasters is determined not just by nature but also by people and social arrangements. In this regard, social and economic vulnerability have been isolated as sources of risk and are considered just as real as physical and ecological vulnerability. Clearly, the available research suggests a fourth source of vulnerability: political vulnerability.

Conceptually, we can link political institutions with disaster response through two intervening variables: political will and state capability. If a country possesses both the political will and the state capability to respond to natural disasters, then we can expect that disaster response will effectively mitigate the impact of natural disasters. If either or both conditions are missing, we can expect that political vulnerability will decrease the disaster response and increase the impact of natural disasters. For example, many disaster preparedness steps, such as planning evacuation routes, enforcing building codes, and building early warning systems, require both the political will and the capability to take these steps. As another example, we can expect that the security and coordination of relief workers improves when the government possesses the political will and capability to provide security and infrastructure for coordination. Considering the security of relief workers further, a regime characterized as democratic but unstable might possess the political will to provide security for relief workers but not the capability to prevent banditry and similar sources of insecurity. In this case, political vulnerability results in a decrease in response capacity and an increase in disaster impact. Finally, it should be noted that for countries that lack the state capacity to respond, a number of international aid organizations are willing to assist if the will of political leaders allows such assistance.

Like other actors involved in disaster response, the state is faced with a collective action problem when deciding on the level of disaster response it will provide. Investing in disaster response is costly and the payoff is uncertain. For example, implementing housing codes that reduces the vulnerability of homes costs the state both politically and economically. Building inspectors and enforcers require salaries while builders and investors are unhappy when their costs rise. And since no one knows if a disaster will ever strike everyone is uncertain of whether the cost and effort will pay off. Which leads to the important question of why would the state choose to bear the costs of reducing vulnerability to natural disasters?

Following the realist tradition of domestic political economy, the state behaves as a rational, self-interested actor and strategically implements policies with specific goals and interests. Variance in a policy outcome, for example disaster response, is explained in terms of variance in the goals of the state and the decision-making environment. To a large extent states share two identical goals: i) continued existence as the legitimate authority, and ii) increased tax revenue. By protecting citizens and assets disaster response advances both goals. Thus for sake of political survival and economic gain the state has an interest in protecting their citizens against natural disasters.

While all states want to effectively mitigate natural disasters, not all of them do it effectively. Indeed, when the state lacks the political will to bear the costs of protecting against natural disasters or when the state does not possess the capability to respond, the goals of legitimacy and taxes do not translate into reduced disaster impact. It is the decision-making environment that determines the effectiveness of disaster response.

In particular, the decision-making environment of the state varies in three key areas that, in turn, influence the political will and state capability to confront natural disasters. While this list is not all-inclusive, three regime characteristics influence the decision-making environment: regime type, the present level of legitimacy, and the size of the state apparatus. As Olson describes, the type of regime influences how the state weighs long-term benefits versus short-term costs, and thus impacts the decision-making environment of the state. Likewise, as low levels of legitimacy present immediate threats to the survival of the state, the decision-making environment also changes with this regime characteristic. Finally, the decision-making environment also varies with the number of years that the regime has existed, as this regime characteristic influences the state's capability to implement policy.

Thus in a rational choice theory of the state and natural disaster response, all states attempt to reduce the impact of natural disasters to advance the goals of increased legitimacy and increased revenue, but the decision-making environment determines the level of political will and state capability to pursue this goal and thus directly influences the effectiveness of disaster response policies. As a result, we can hypothesize the desire and ability of a government to implement effective disaster response policies depends on three regime characteristics: level of democratization, political stability, and durability. By postulating that democratic, durable, and stable regimes experience a decision-making environment that encourages both the will and capability to effectively protect citizens from natural disasters, we can connect the impact of a natural disaster with the underlying political institutions of the impacted country. Thus, I offer the following three hypotheses relating regime characteristics to the impact of natural disasters:

H1: Democratic states are impacted less by natural disasters.

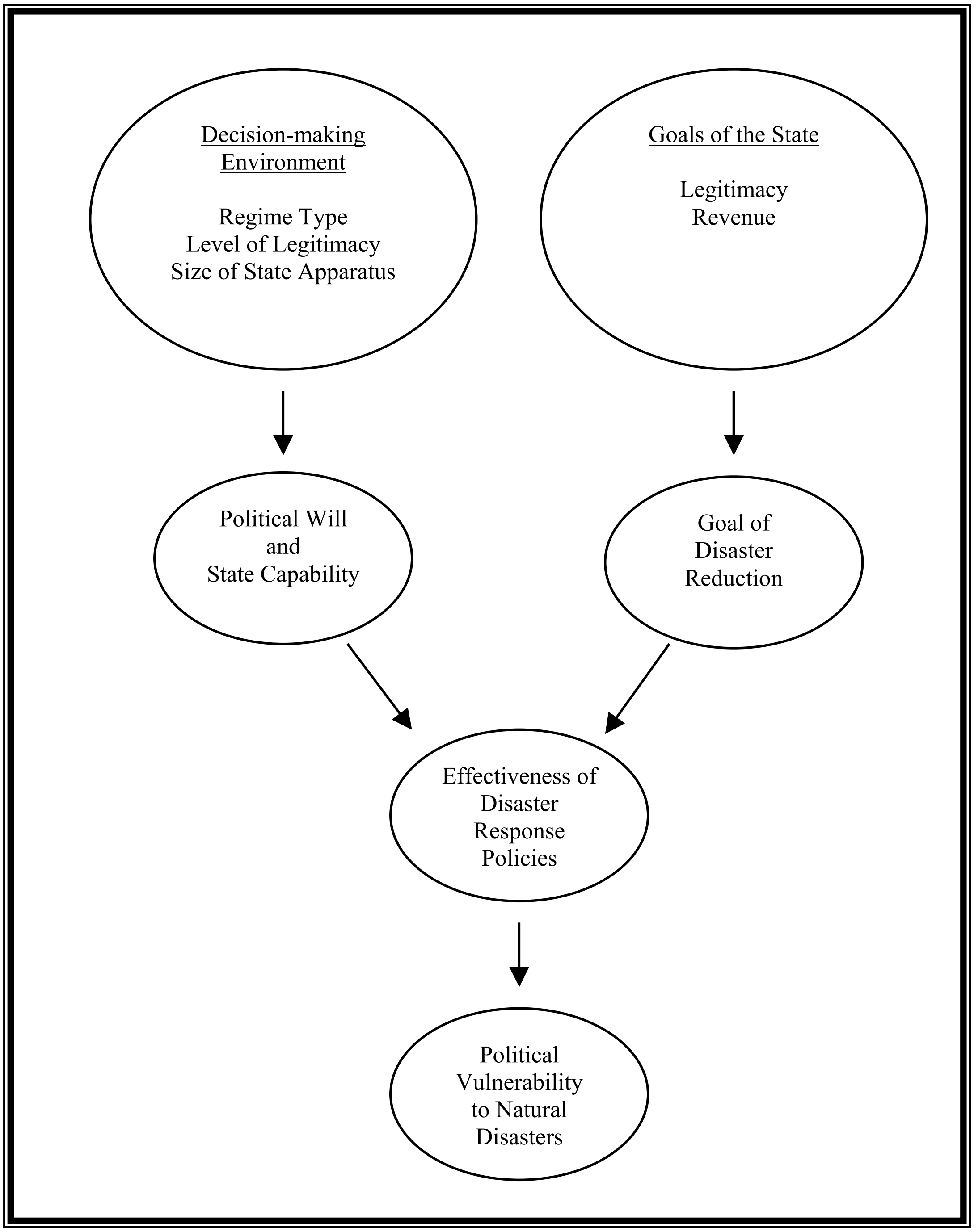
H2: Politically stable states are impacted less by natural disasters

H3: States with durable governments are impacted less by natural disasters.

The remainder of this thesis is an empirical examination of these hypotheses through case studies and statistical analysis. In what follows, case studies demonstrate consistency while the statistical analysis tests validity and generalizability.

As an aside, a statistical model of disaster impact that provides accurate and precise predictions of impact indicators, such as people killed, would equip disaster relief planners with important information before, during and immediately following a disaster. While developing such an early warning system is not the focus of this thesis, the risk/vulnerability framework provides a solid foundation for such an endeavor. The statistical analysis of chapter 3, which focuses on hypotheses testing rather than forecasting, does represent a step in this direction. Such an application of these results is presented in Appendix D.

Figure 9: A rational choice theory of the state and disaster vulnerability.



Chapter 2: Case Studies

In this chapter, I present four sets of case studies that demonstrate consistency with the three hypotheses relating the impact of natural disasters to the regime characteristics affected country. In each set of case studies, disaster events are the unit of analysis and I focus on the impacts and contexts of these events. In the first set, I compare five recent major earthquakes and conclude that corruption in non-democratic governments can hinder disaster response. In the second set, I compare three recent floods and observe that while democracy is associated with the political will to respond, political instability can hinder the actual response. In the fourth set, I compare changes in levels of democracy with changes in the relative impact of disasters in Nicaragua and Honduras and conclude that the observed patterns are consistent with the predictions of the risk equation and the concept of political vulnerability. In the fourth and final case study, I attempt to overcome the case selection shortcomings of the previous case studies by employing rigorous case selection rules that control for human development when associating disaster response with democracy. While the first three case studies "tell the story" that link political institutions with the impact of natural disasters (i.e. to establish consistency with the hypotheses), the analysis of a large-N dataset in the next chapter provides a more robust assessment of the validity and generalizability of the hypothesis. Finally, the fourth case study acts as a bridge between the two assessments.

*Earthquakes around the world: Mexico, Japan, Turkey, India, and Algeria*

This set of case studies examines five major earthquakes that have occurred within the last twenty years. Except for one, all of them occurred in developing countries. In each of these disasters, mortality figures are in the thousands. However, the ratio of people killed to people affected shows a great deal of variance. In fact this ratio -- an indication of the government's ability to protect and rescue its citizens during natural disasters -- is lowest for the two countries that are most democratic. Noteworthy, allegations of corruption engulfed the other three governments following the disaster.

The Disaster Context

On September 19, 1985, Mexico City rocked from the tremors of an 8.1 Richter earthquake on the edge of this populated town. This disaster affected over 100,000 people and left between 8,700 and 9,500 people dead. The disaster injured 40,000 people and caused an estimated $4 billion in damage. The health care system for this city was hurt badly from the unfortunate collapse of a hospital during the earthquake.

A 7.2 Richter earthquake impacted the Japanese port city Kobe on January 17, 1995. Causalty figures range from 5,500 to 6,400. Between 200,000 and 300,000 people were left either temporarily or permanently homeless following the disaster. Ensuing fires destroyed 800,000 square meters. Over 100,000, or one out of five, buildings were destroyed. Extensive damage to the port contributed to direct economic damage estimated at $147 billion.

On August 17, 1999, warnings by seismologist regarding the physical vulnerability posed by fault lines in western Turkey became horribly true when a 7.8

Richter earthquake hit the Izmit Bay region south of Istanbul. An estimated 17,000 people died, an estimated 20,000 buildings were destroyed, transportation and communications networks were severely damaged, and an oil refinery burned for three days.

A staggering 20,000-30,000 people died when a 7.7 Richter earthquake impacted the Gujarat state of India on January 26, 2001. Like Turkey and Mexico, India suffers from overpopulation and a concentration of poverty in urban shanties. This was particularly true for the impacted area of the earthquake where 16 million people were affected (a particularly high number for Earthquakes of this magnitude[6].) The United Nations Development Program estimated that more than one million homes were destroyed (UNDP 2001.)

Recently, a 6.7 Richter earthquake devastated the Algerian capital of Algeria on May 21, 2003. According to the Government of Algeria the earthquake resulted in 2,268 dead, 10,147 wounded, 200,000 homeless, and $5 billion in repair costs. Another assessment points out that the earthquake destroyed 40-50% of health structures in the affected area.

## The Response Context

Of these five cases of major earthquakes, three were followed by allegations of corruption and state ineffectiveness, while two were not. In Mexico, Turkey, and Algeria, the both lay people and scholars agree that the disasters did not have to be as devastating as they were. In these countries poor building code regulation is largely seen

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[6] For all recorded magnitude 7.0 or higher earthquakes recorded since 1900, the mean number of people affected is 1.2 million.

as the cause of the extensive physical damage while uncaring and ineffective state disaster response efforts hindered rescue efforts after the disaster. Rampant state corruption in a one-party government is considered the underlying factor that increased the devastation of these earthquakes.

In contrast, assessments of the earthquakes in India and Japan do not mention state corruption or ineffectiveness as important factors that contributed to the damage. One assessment of the Kobe disaster notes that the Japanese building codes had a major revision for concrete-frame buildings and a more limited revision for steel-frame buildings in 1981 and that effective enforcement of these building codes reduced the potential damage (EQE 2003, website) and that without the enforcement of this building code the disaster would have been much worse. Likewise, the ISDR observed the sustained national effort to develop response capacity (UNISDR 2002, p. 83) in India and the use of a vulnerability atlas that included earthquake hazards to guide development and land-use decisions (UNISDR 2002, p. 228). Still these countries are not without their problems. Enforcement of buildings codes was a serious problem in India before the quake and poor security of relief workers and supplies hindered immediate relief efforts. Regarding the Kobe earthquake, one assessment concludes "the Kobe Earthquake dramatically illustrates the damage that can be expected to modern industrialized society from earthquakes. Most of what happened could have been predicted, and much of the damage was preventable" (EQE 2003, web).

One way to assess and compare the effectiveness of the response to these different disasters is to compare the relative impact of the disaster using the ratio of the number of people killed to the number of people affected. This figure provides a way to compare

Table 3: Comparison of the level and effectiveness of disaster response.

| | Magnitude | Affected | Killed | Relative Impact |
|---|---|---|---|---|
| **Mexico** | 8.1 | 100,000 | 8776 | 0.0878 |
| **Japan** | 7.2 | 1,500,000 | 5502 | 0.0037 |
| **Turkey** | 7.4 | 715,000 | 17,127 | 0.0240 |
| **India** | 7.7 | 15,900,000 | 20,005 | 0.0013 |
| **Algeria** | 6.7 | 210,000 | 2268 | 0.0108 |

the impact of the disaster (number of people killed) but controls for the potential severity of the disaster (number of people affected.) The basic rationale is that two disasters of roughly equal severity will affect roughly equal numbers of people, but that the number of people killed will vary depending on the response. Table 3 provides this figure for the five earthquakes just described. This table shows that while the Earthquakes in Japan and India affected more people than the others, the relative mortality rate is less than the other two countries. This result indicates that response efforts in Japan and India were more effective than in the other countries.

## The Political Context

As noted above, the earthquakes in Mexico, Turkey, and Algeria were all followed by serious charges of corruption. This fact underlies other similarities between the governments of these three regimes during the time period of the disaster. To a large extent Mexico in 1985 and Algeria in 2003 were non-democratic countries with one-party rule over the government. While the Turkish government has some elements of institutional democracy, the military heavily influences the government and the state regularly limits civil and political liberties.

These three governments also differ in many ways. In Mexico, the Institutional Revolutionary Party (PRI) enjoyed 70 years of uninterrupted rule after first coming to power in 1929. In other words, while the Mexican political system was not democratic in 1985, it was stable and highly durable. In comparison, the Turkish government exhibited durability but not stability. This well established state co-exists with a turbulent civil society characterized by continual social protest, political cleavage, and civil conflict. Finally, the Algerian government cannot be characterized as either stable or durable. This young regime also suffers from protest, cleavages, and conflict.

In contrast with Mexico, Algeria and Turkey, both Japan and India were considered well-established democracies at the time of the earthquakes. Freedom House characterizes both countries as free, parliamentary democracies. In addition both governments originated following World War II, implying similar levels of durability. However, while the Japanese government enjoys a high degree of political stability, India's highly pluralistic society exerts many regional and ethnical strains on the democratic state resulting in continuous low level political instability.

## Conclusion

One conclusion of this comparison can best be summarized through the following quotes:

- Mexico: "The earthquake highlighted government corruption, when it became clear that cronies of the ruling party had evaded safety regulations in the construction industry."

- Algeria: "Algerians are blaming rampant corruption, and the resulting violations

Table 4: Democracy, corruption, and disaster response.

| | Fully Democratic | Accusations of Corruption | Disaster Response |
|---|---|---|---|
| **Japan** | Yes | No | Effective |
| **India** | Yes | No | Effective |
| **Turkey** | No | Yes | Not Effective |
| **Mexico** | No | Yes | Not Effective |
| **Algeria** | No | Yes | Not Effective |

of building codes, for much of the massive death toll and devastation of the earth quake."

- Turkey: "If our leaders cared about human life, they would have been ready for this earthquake, but it just isn't a priority for them."

While these comments exemplify the tragedies in these three non-democratic countries, a review of the literature in the two democratic countries did not uncover major accusations of corruption or government ineffectiveness following the earthquakes in those countries. Comparing the levels of democracy with the number of people killed relative to the number of people affected definitely supports the hypothesis that democratic countries protect their citizens during natural disasters better than non-democratic countries. In addition, this comparison indicates that high-level corruption in non-democratic countries severely limits both the political will and the state capability to respond to natural disasters.

*Mozambique, Bangladesh, Germany: Massive Flooding*

Between the 1998 and 2002, Germany, Bangladesh, and Mozambique all experienced extensive flooding. As opposed to Bangladesh and Mozambique where hundreds of people died from the floods, less than one hundred people died in the "hundred year flood" of Germany. While all three countries are considered at least somewhat democratic, the stability and durability of Germany far exceeds that of Bangladesh and Mozambique. These cases show that in some democratic countries the political will to respond to natural disasters exists while the state capability is limited by political instability.

## The Disaster Context

In Bangladesh, the annual monsoon season from June to September always brings massive flooding. In 1998, the devastation was particularly bad. Two months of rain flooded the Ganges, Brahmaputra, and Megna rivers and left nearly 70% of the country covered with floodwaters. The floods affected 12% of the population and caused over 2 million in damage, left 35 million homeless, and resulted in 600 to 1000 mortality cases. In the aftermath of the flood severe agricultural losses lead to food shortages and malnutrition, poor sanitation helped diseases spread, and this deadly combination of hazard and vulnerability resulted in epidemics. At least a million people suffered from dysentery, fever, bronchitis and similar illnesses. The International Federation of Red Cross and Red Crescent Societies (IFRC) assessed the situation as follows:

> "Three quarters of a million hectares of agricultural land are currently submerged and most of the autumn rice crops are ruined. The effects of the flood, in particular on the health and economic conditions of the population, will persist long after the water recedes, with the worst period being until the next crop has been harvested." (Rekenthaler, web.)

Like Bangladesh, Mozambique is also prone to flooding. The Save and Limpopo rivers both flooded in February 2000, impacting the country profoundly. Over 1,500,000 people (10% of the total population) were affected, over 800 people died, over 200,000 people lost their homes, and 473,000 required food aid. The World Bank estimates $272 million in direct damage costs, $215 million indirect damage costs, $65 million in relief costs, $11 million in damage to health infrastructure, and around 500 (8% of total) primary schools were affected by flooding. The FAO estimates that close to 80% of livestock in the affected areas has been lost. Malnutrition followed, and two epidemics affected over 18,000 people.

While Germans who live along the Elbe River are familiar with minor flooding, the floods in August 2002 made significant news around the world. Dubbed a "hundred year flood" by many, this flood caused over $9.2 billion dollars in damage. Luckily for residents here, 42.5% of the damage was covered by insurance (UNISDR 2002, p. 12.) Compared to Bangladesh and Mozambique, the floods affected a comparatively small number of people. In total, 330,000 people, only .4% of the German population, were affected by the floods. As a result of the floods, twenty-seven people died in Germany and 109 through out Europe. No epidemics followed the flooding.

## The Vulnerability/Capacity Context

For Bangladesh, major physical sources of vulnerability include geographical location, climate, and geomorphology. In addition, high population density and poverty create social vulnerability. Likewise, the agricultural economy is highly vulnerable to disruption as a result of flooding and the underdeveloped public health system does not possess the capacity to respond. The 1998 floods overwhelmed local capacity and international assistance was required.

In Mozambique the floods also overwhelmed local capacity and the government appealed for international assistance (GOM 2003, web.). Initial response efforts focused on using boats and helicopters to rescue people stranded by the floods. However, an official from the Mozambique Disaster Management Institute reported that "we need more helicopters and more fuel" (Disasterrelief.org 2003, web.) Despite these limitations, the Mozambican navy and local fire brigades did help save 45,000 vulnerable stranded people. (IFRC 2003, p. 61).

German response capacity was not overwhelmed in the 2002 flooding. While the IFRC did supply relief aid to many surrounding countries, Germany did not require international assistance. The german government provided $500 million in immediate aid and pledged another $6.9 billion in long-term assistance.

Interestingly, despite the different capabilities of these three governments, they all demonstrate some level of political will to confront disasters. Each government had an established flood plan and some emergency response capability. In fact, the ISDR notes successful disaster preparedness efforts in each country (UNISDR 2002, pp. 7, 69, 83-87, 98-100, 104, 126-29, 139, 145, 179, 191-93, 196-97, 212, 240, 246-47, 251.)

## The Political Context

In 1998, Freedom House characterized Bangladesh as a partially free, parliamentary democracy (Freedom House 2003, Web.) However, the current democratic regime is recent and 1998 was characterized by political instability as a major opposition party boycotted the parliament and staged numerous protests. Political violence also increased during this year (Shehabuddin, web).

Freedom House classifies the Government of Mozambique as a partly-free presidential-parliamentary democracy (Freedom House 2003, web.) The Government of Mozambique claims that civil war ended in 1992 and “was followed by multi-party elections in 1994” (GOM 2003, web.) However, corruption continues as a problem and police were observed looting evacuated private homes during the disaster (IFRC 2003, p. 65).

Freedom House describes the German government as a free, parliamentary democracy (federal) (Freedom House 2003, web.) Free and fair elections are regularly held and political parties are strong. The current German regime has been in place since the end of World War II and political violence has not been very common.

## Other Contexts

Because of its geography and physical climate, Bangladesh is more vulnerable to natural disasters than any other country in the world. Likewise, poverty, over population, poor public health, and an unindustrialized economy create sources of vulnerability and increased natural hazard risk for this country. Continuous natural disasters overwhelm local capacity, resulting in long-term development setbacks. While 1998 may have been a bad year for Bangladesh, it is part of a natural disaster cycle that heavily influences this country.

In Mozambique, geography and climate both create natural hazards. Likewise, poverty, international debt, poor sanitation, lack of education all increase vulnerability. Internal and external security threats are a problem that limits state capacity. Finally, left over landmines that are moved by mudflows increase the risk to people.

Compared to Mozambique and Bangladesh and most other countries, Germany is highly developed socially, economically, and politically. The German economy is highly productive and the country is very industrialized. Germany also possesses effective education, health, and welfare systems.

## Conclusions

Despite the differences in their political systems, the Governments of Bangladesh, Mozambique, and Germany all demonstrated the political will to confront natural disasters in their countries. Assessments of these disasters did not contain charges of corruption imbedded in the political system of the countries as factors that contributed to the impact of these disasters. Further, unlike Turkey following the earthquake, officials in these countries did not turn down or impede international assistance when it was needed. Finally, the ISDR notes the numerous disaster preparedness and relief programs and plans by all three governments.

However, differences do exist in the effectiveness of the disaster response within these countries. While all three events are considered “Great Floods” for their area (an indication of relative strength), the “Great German Flood” affected fewer people, both in absolute terms and relative to population, than the “Great Bangladeshi Flood” or the “Great Mozambican Flood.” Likewise, in Germany fewer than 50 people died, while in both Bangladesh and Mozambique close to a thousand people died. Germany is considered free, durable and stable while both Bangladesh and Mozambique experience constraints on democracy, some degree of political instability, and the current regime's are young. Comparing the differences in impact with differences in the political variables shows that the observed impact in these three countries is consistent with the three hypotheses.

Indicative of a potential general trend is the observation that in all three of the countries some degree of democracy is associated with the political will of elites to respond to natural disasters. But each of the two young unstable regimes suffered from a limited capacity to respond.

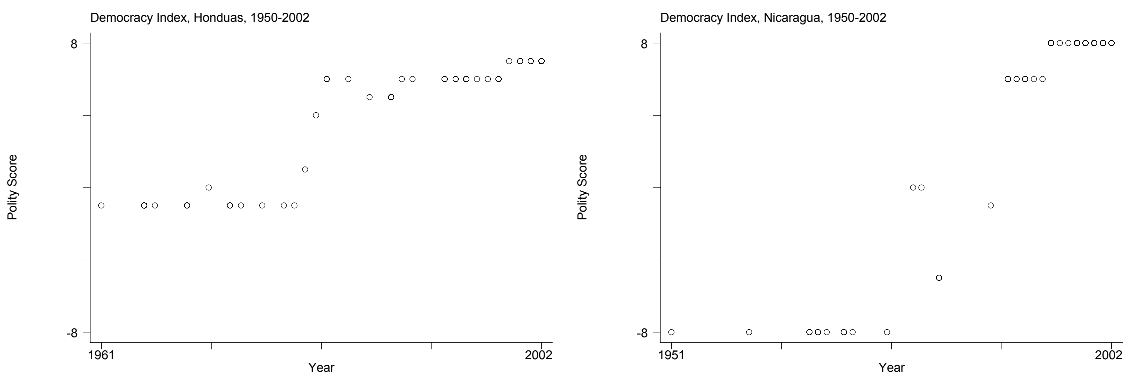
*Nicaragua and Honduras: As democracy increases, disaster impact decreases.*

As neighboring Central American countries, Nicaragua and Honduras share exposure to similar natural hazards. They also share a similar drive toward democratization during the last half century. Though the following comparison is brief, these two countries, and others in the region, provide an excellent opportunity to investigate the links between political change and changes in the impact of natural disasters. Comparing the change in democracy along with the change in relative disaster impact between these two countries, it is apparent that when democracy increases the impact of natural disasters decreases.

A context of change

Examining figures 10-13, it is clear that both countries show a general upward trend in democracy as measured by their Polity score[7] and a general downward trend in the relative impact of disasters as measured by the ratio of people killed to people affected. Importantly, the two countries differ in their respective rate of change for these two variables. Using the regression coefficient with time as the independent variable as a measure of the rate of change of these two variables for each country, Table 5 shows that the rate of change in relative disaster impact is greatest for Nicaragua where the rate of change of democracy was also greatest.

Figures 10& 11: Democracy in Honduras and Nicaragua




Figures 12 & 13: Disaster Response in Honduras and Nicaragua

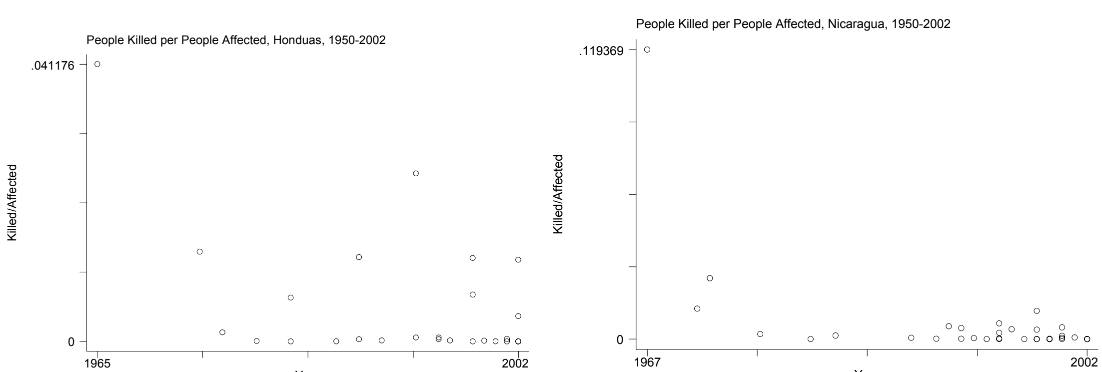


Table 5: Regression with Time as Independent Variable.

| | Polity | Killed/Affected |
|---|---|---|
| **Nicaragua** | .482 (±.024) | -0.0012 (±.0003) |
| **Honduras** | .241 (±.016) | -0.0004 (±.0001) |

Modeling Change with the Risk Equation

When viewed in a dynamic sense, the risk equation allows us to model and predict the change in risk as hazards, vulnerability and capability change. While preliminary, the following analysis takes the observation of the previous sub-section one step closer to building an empirically verifiable, dynamic model of risk.[8] Recall the risk equation

$$R = H \times (V/C) \qquad \text{(i)}$$

which can be rearranged to yield

$$R/H = V/C. \qquad \text{(ii)}$$

In this formulation, the variable "Risk per Hazard" equals the variable "Vulnerability per Capability." Importantly, both quantities depend on time and using some basic assumptions, we can derive simple relations that allow us to compare observed changes in risk per hazard with democracy over time. The first assumption is that risk per hazard trends linearly with time. The second assumption is that vulnerability per capability is proportionally to the level of democracy of the country (P). The third assumption is that

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[7] This commonly used measure of democracy is explained in more detail in the next chapter.
[8] For a more thorough qualitative discussion of the complex dynamics of hazard and risk see Pelling, Mark, Ed. *Natural Disasters and Development in a Gobalizing World.* London: Routledge (2003.)

polity trends linearly with time. Mathematically, these assumptions yield the following equations

$$R/H = a + \alpha t \qquad \text{(iii)}$$

$$V/C = \chi \text{ x } P \qquad \text{(iv)}$$

$$P = b + \beta t \qquad \text{(v)}$$

where $\alpha$, $\beta$, and $\chi$ are unknown parameters. While the last assumption is questionable in a general sense, it does appear valid for these two cases. Since R/H equals V/C, the time derivatives of these two variables are also equal. Taking the time derivatives of the above equations yields

$$\alpha = \chi \text{ x } \beta. \qquad \text{(vi)}$$

In order to develop this analysis further, a further set of assumptions is necessary. Equations (iii) and (v) above represent country specific dynamical processes, thus when comparing the evolution of R/H and P between two countries the coefficients in these equations would be different for the two countries. In contrast, to the extend that equation (iv) represents a general rule of human behavior, we expect this coefficient will not change between countries. Thus, the assumption that $\chi_{Honduras} = \chi_{Nicaragua}$ while $\alpha_{Honduras} \neq \alpha_{Nicaragua}$ and $\beta_{Honduras} \neq \beta_{Nicaragua}$ leads to the following relationship between the rate of change of R/H to the rate of change of P

$$\alpha_H/\alpha_N = \beta_H/\beta_N\ . \qquad \text{(vii)}$$

Since a test of the above equation provides an indirect test of the assumptions upon which the equation rests, testing the hypothesis that these ratios are equal provides an indirect test that V/C depends on P.

Using the ratio of killed to affected is a valid indicator of risk per hazard, the ordinary least squares regression coefficients in Table 5 provide reliable estimates of $\alpha$ and $\beta$ for Honduras and Nicaragua and allows for a basic test of the validity of the above hypothesis. From Table 5, the ratio $\alpha_H/\alpha_N = .33(\pm.22)$ while $\beta_H/\beta_N = .50(\pm.06)$ where the errors are derived based on the assumption that the standard errors propagate linearly[9].

Since $\alpha_H/\alpha_N$ is not significantly different from $\beta_H/\beta_N$, we cannot reject the hypothesis that these ratios are equal nor can we reject the assumptions upon which this hypothesis is based. While this analysis fails to control for other possible explanations of the approximate equalities of the two ratios, the finding is consistent with the notion of political vulnerability. Though not possible at present, the next step in such a model would be to include terms for other sources of vulnerability in equation (iv). Indeed, given the opportunity, one could follow these steps and use the risk equation to develop a fully dynamic model of vulnerability and risk.

*Sample Selection Rules and A Sample of Nine Countries.*

While the previous case studies focused on "telling the stories" that link political institutions with disaster response and disaster impact, the cases presented in this section follow a more rigorous case selection procedure which controls for the levels of development when associating disaster response with levels of democracy. The findings based on 9 cases that as a whole span a large range of values of both development and

[9] Let $f = \alpha_H/\alpha_N$ and let $\Delta f$ equal the error in f. The assumption that the standards errors in $\alpha$ (represented as $\Delta\alpha$) propagate linear implies that $f \pm \Delta f = (\alpha_H \pm \Delta\alpha_H) / (\alpha_N \pm \Delta\alpha_N)$. After algebraic manipulation, this yields $\Delta f = (\alpha_H/\alpha_N) \times [(1 \pm \Delta\alpha_H/\alpha_H)/ (1 \pm \Delta\alpha_{N/}\alpha_N) - 1]$, the equation used to estimate the uncertainty in the ratios.

Figure 14: Expected relationship between democracy, development, and disaster response (inside boxes.)

| | | Democracy: High | Democracy: Low |
|---|---|---|---|
| Development | High | High | Medium |
| | Low | Medium | Low |

democracy demonstrate that some of the observed variance in disaster impact is better explained by variance in democracy than by variance in development. As noted in Chapter 1, level of development is commonly associated with the level of disaster impact and disaster response. In addition, in this chapter it was hypothesized that level of democracy also influences with the effectiveness of disaster response. These two simultaneous hypotheses allows use to construct a 2 x 2 table that shows the expected disaster response as a function of both development and democracy. A comparison of this expected 2 x 2 table with a 2 x 2 table of observed values tests the validity of the two hypotheses.

The observed table is constructed using Human Development Index, the polity score and the ratio of people killed to people affected. A composite index of a state's level of income, education, and health care, the Human Development Index (HDI) published by the United Nations Development Program provides a standardized indicator of a state's overall human development. As before, the Polity Index is used to measure levels of democracy and the ratio of people killed to people affected is used to assess a state's disaster response. The data used here are from the year 2000.

To obtain an adequate sample, the following case selection rules were applied in sequence:

1) A group of countries were chosen that are low in both democracy and human development.

2) A group of countries were chosen such that their i) levels of democracy are approximately equal to the levels of democracy of the previously chosen group and ii) levels of human development where considerably higher.

3) A group of countries were chosen that are i) comparatively high in democracy, but ii) similar to the first group with regard to level of human development.

4) A group of countries were i) similar to the previous group in democracy, but ii) similar to the second group regarding development.

These selection rules produced a sample of nine countries that range in democracy, development, and (importantly) effectiveness of disaster response. For each of these cases the level of disaster response was calculated as the mean of the ratio of killed to affected for all events (for which data were available) in 2000. Consistent with the hypothesis that democracy improves disaster response, for the countries with a high polity score the mean of killed to affected was low, while the countries with low democracy had a high mean ratio. Contrary to the alternative hypothesis that development improves disaster response is the observation that the mean ratio did not increase with the HDI.

Using the data in Table 6, it is possible to construct the observed 2 x 2 table for these countries. Upon comparing it is clear that for this sample the ratio of people killed to people affected decreases as democracy increases, regardless of development. Further, this table shows that for the sample the ratio of people killed to people affected increases with development, regardless of democracy. This finding is consistent with the

Table 6: Selected cases and indicator values.

| | Country | Polity Score | HDI | Mean (# of obs.) |
|---|---|---|---|---|
| High Democracy High Development | Philippines | 8 | .75 | .009 (12) |
| | Brazil | 8 | .76 | .001 (5) |
| | Panama | 9 | .78 | .001 (1) |
| High Democracy Low Development | Bangladesh | 6 | .47 | .009 (10) |
| | Madagascar | 7 | .46 | .00006 (3) |
| | Botswana | 9 | .4 | .00003 (1) |
| Low Democracy High Development | Saudi Arabia | -10 | .75 | .288 (2) |
| Low Democracy Low Development | North Korea | -9 | LOW (a) | .014 (2) |
| | Sudan | -7 | .49 | .066 (3) |

(a) Note: While the Human Development Index is not available for North Korea, it is well accepted that the country ranks low in all dimensions of the HDI.

Figure 15: Observed relationship between democracy, development, and disaster response.

**Democracy**

| **Development** | **High** | **Low** |
|---|---|---|
| **High** | Panama (0.001)<br>Brazil (0.001)<br>Philippines (0.009) | Saudi Arabia (0.288) |
| **Low** | Bangladesh (0.009)<br>Madagascar (0.000)<br>Botswana (0.000) | Sudan (0.066)<br>North Korea (0.014) |

hypothesis that democracy increases disaster response and is inconsistent with the hypothesis that development increases disaster response. While a sample of only nine cases does not reveal any general trends, it does show that for some cases democracy provides the potential to explain variance in disaster response when development cannot.

*Conclusion*

While brief in nature, these case studies all tell a similar story: when a regime is democratic, stable, and durable, their citizens are impacted less by natural disaster than when a regime is non-democratic, unstable, and/or young. In other words, they all support the hypotheses presented at the end of chapter. Naturally, one cannot draw general conclusions from a handful of case studies, and the next chapter demonstrate that the results of this chapter are indeed valid and generalizable.

# Chapter 3: A statistical analysis of the political determinants of disaster impact

Magnitude and frequency have little intrinsic meaning in such a context, unless they are tempered with some measure of human invulnerability and risk

Alexander (2000)

When analyzing the political determinants of the impact of a natural disaster, there are a number of non-political factors to consider and control for. While no perfect method exists to control for all of the possible factors that could and do contribute to the impact of natural disasters, this chapter presents a basic methodology for testing the validity and generalizability of the three hypotheses of Chapter 1. From the risk equation, I develop a linear regression equation to model the socio-economic-political-physical determinants of disaster impact.

In this chapter, I first return to the risk equation to develop a statistical model of the relative impact of natural disasters. I then discuss the data and data sources. Finally, I present the results of a regression of disaster impact with standard environmental, physical, social, economic, and political indicators. This regression provides an estimate of the relative importance of these sources of vulnerability. In the next chapter, I consider the reliability, validity, generalizability of the findings in Chapters 2 & 3 along with a brief discussion of policy implications.

*A Model of Disaster, Disaster Response, and Disaster Impact*

Recall that the International Strategy for Disaster Reduction postulates the following relationship between risk (R), hazard (H), vulnerability (V), and capacity (C),

$$R = H \times (V/C) \qquad \text{(i)}$$

and further stipulates that V and C are dependent on a host of physical, social, economic and political factors. In this equation, the variables V and C represent the "human" factors of risk, while H represents the "natural." Using this formulation as a starting point, I develop an analytical relation that can be tested using basic data on disasters, their impact, and the socio-economic-political context of the impacted area.

As a basic research design assumption assume that the quantity V/C can be expressed as a function of physical (Ph), social (S), economic (E), and political (Po) variables. It then follows that R depends on Ph, S, E, and Po :

$$\begin{aligned} R &= H \times V/C \\ &= H \times f(Ph, S, E, Po). \qquad \text{(ii)} \end{aligned}$$

This functional relation for R allows us to develop a statistical model for quantitatively analyzing the relationship between disasters, disaster impact, and the physical-social-political-economic context. However, before delving into this analysis a basic reformulation is necessary to bridge the gap between definitions and data.

Importantly, risk is defined in terms of a probability that a destructive event *will* happen at some point in the future. However, the available data (to be described shortly) provide information only on events that *have* happened in the past. Thus, instead of talking about risk and hazards, we can talk about disasters (D), disaster response[10] (Re),

[10] This variable ranges from 0 to 1, with 0 implying effective response and no actual impact and 1 implying an ineffective response where the actual impact equals the full potential impact.

and disaster impact (I). Similar to the above formulation for risk the impact of a natural disaster depends on the severity of disaster multiplied by a factor that represents the response. Mathematically,

$$I = D \times Re. \tag{iii}$$

One way to think about this relationship is to imagine that a natural disaster can be characterized by its *potential impact*, represented by the variable D, which refers to its total potential to take lives, destroy homes, or damage economies. However, the *actual impact*, represented by I, is only some fraction of the potential impact, where the *response fraction* equals Re. In this sense, the "natural" factors of disaster impact are represented by D, while the "human" factors of disaster impact are represented by Re, and I equals the interaction of the two.

As has been argued throughout this thesis, we expect that political institutions, to a large extent, either facilitate or hinder a country's response to natural disasters. And, as previous scholars have noted, physical, social and economic conditions also influence disaster response. Thus, we have

$$I = D \times Re(Ph, S, E, Po) \tag{iv}$$

which reflects equation (ii) above. While the actual function in equation (iv) is unknown, a simple linear approximation to this equation provides a method for testing the three hypotheses. Using the linear approximation of equation (iv), equation (iv) becomes

$$I = D \times (A + B{*}Po + C1{*}Ph + C1{*}S + C2{*}E) \tag{v}$$

This model equation controls for the ecological (through the variable D), the physical, the social, and the economic sources of vulnerability and provides an indication of the relative importance of political vulnerability in contributing to I.

Importantly, the application of equation (v) that follows rests on an important methodological decision – disasters as the unit-of-analysis. In this study, the population consists of natural disasters, while the sample consists of the events that meet the selection criteria of the EM-DAT database for which all data points are available. In contrast to this approach, typical comparative political science studies utilize the country or country-year as the unit-of-analysis. Typically, these studies are interested in explaining some variable of interest that varies between country or country-years. The present study, however, aims to explain a variable that is observed to vary between events. While a study that employs the country-year as the unit of analysis would possess some benefits (especially in regards to policy analysis), such a study will have to wait until a standardized disaster vulnerability dataset that uses the country-year as the unit of analysis becomes available[11]. In the meantime, this study rests on the implicit assumption that the available data provides an adequate random sample of the population of interest: natural disasters.

*EM-DAT: The International Disasters Database*

The Center for Research in the Epidemiology of Disasters (CRED) in collaboration with US OFDA and the Université catholique de Louvain in Brussels, Belgium provides a standardized, cross-national dataset for assessing disaster severity and impact. According to the CRED website at www.cred.be/emdat, the Emergency

[11] Such an approach with the present data would lead to a serious ambiguity: how to code countries or country-years where disasters that did not happen. In this regard, a big distinction exists between years when disasters did not occur (zero killed and zero affected) and years when disasters did occur but did not take any lives (zero killed but some number affected.) In this regard, the United Nations Development Program, as part of its disaster reduction initiatives, is working on a Global Risk-Vulnerability Index that

Events Database (EM-DAT) "contains essential core data on the occurrence and effects of over 12,800 mass disasters [over 8,000 of which are classified as natural disasters] in the world from 1900 to present. The database is compiled from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies." Included as essential core data are the number of people affected and the number of people killed along with basic information such as type of disaster, country, date, etc. While measurement issues are always a persistent problem in such an ambitious data collection project, this dataset has overcome a number of methodological issues related to cross-national standardization and possesses no clear political or ideological bias. However, there may exist a bias toward more developed countries and more recent years due to better reporting of events.

Using the database, one can construct a set of indicators that measures the impact of disasters and controls for many aspects of the disasters themselves. Conceptually, this data set will rest on the use of the number of people affected as a proxy measure for the disaster potential (viz. the hazard variable of the risk equation.) While the type, strength, and location of the disaster are the three important characteristics that determine the disaster potential, the total number of people affected serves as a good proxy measure of these three characteristics. Clearly, the number of people affected by the disaster will depend on the type, strength, and location of the disaster (see Appendix B for a partial justification of this assumption). In addition, once nature determines the type, strength, and location of a disaster there is little that humans or governments can do to change the number of people that will be affected by the disaster. For example, if a major hurricane

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will provide a quantitative comparison of risk and vulnerability between countries and over time. For more or earthquake is going to strike a major population center, the government can do nothing to change the number of people that lives in the affected area at the time of the disaster[12]. However, through disaster response, the government can influence the fraction of the affected people that are impacted (killed, left homeless, injured.)

In addition to the number of people affected, the EM-DAT database provides a measure of the impact of disasters that are utilized here: the number of people killed. However, unlike the number of people affected, this figure does not simply depend on nature alone. While dependent on the type, strength, and location of the natural disaster, the number of lives lost also depends on the conditions of vulnerability and capability. In other words, while disaster response cannot change the number of people affected, it can influence the number of people impacted.

These measures provide standardized indicators of disaster impact and severity that apply across countries and disaster types. While it is difficult to compare and quantify the impact of a hurricane in Cuba to the response to an epidemic in the Congo or to compare an earthquake in India with a flood in Bangladesh, the assumptions outlined above allows us to include all of these cases into a single dataset that includes quantitative measures of the disaster impact that applies across countries and across disaster types. Naturally, such assumptions are always subject to criticism and skepticism, and, likewise, every research design possesses some limitations. However, these indicators and this methodology do provide a solid foundation for testing the three

information see http://www.undp.org/erd/disred/publications.htm.

[12] Though it is true that governments can exert an indirect influence over this variable through land-use planning and zoning.

hypotheses regarding the political determinants of disaster impact once an adequate set of independent and control indicators has been chosen.

Finally, a few mathematical transformations improve and simplify the analysis. First, relative measures of severity and impact are preferred to absolute measures. Thus, disaster impact is measured as the ratio of people killed to people impacted while severity is measured as the ratio of people affected to the total population of the impacted country. Next, taking the log transforms of these variables provided data that followed normal distributions. Finally, using the identity $\log(x/y) = \log(x) - \log(y)$ to transform equation (v) above to

$$\log(I) = \log(D) + (A + B*Po + C1*Ph + C1*S + C2*E) \qquad \text{(vi)}$$

which given the operationalization of I and D as relative indicators leads to

$$\log(\text{killed}) = \log(\text{affected}^2/\text{population}) + (A + B*Po + C1*Ph + C1*S + C2*E) \qquad \text{(vii).}$$

*Operationalization of the political variables.*

Comparing these indicators of disaster impact to standard measures of level of democracy, regime durability, and political stability provides a test of the three hypotheses. The Polity IV project provides Polity Index, which is a commonly used indicator of democracy, and the Durability Index, which measures durability as the number of years that the current regime has been in power. The polity dataset along with the codebook and other information is on the internet at http://www.cidcm.umd.edu/inscr/polity/

The Banks Cross National Data Archive provides a domestic conflict index that measures political instability as a weighted sum of recorded number of events that indicate political instability. The events used and their weight (in parentheses) in this index are as follows: the number of Assassinations (24), General Strikes (43), Guerrilla Warfare (46), Government Crises (48), Purges (86), Riots (102), Revolutions (148), Anti-Government Demonstrations (200).

Based on the findings in the literature review, we expect that these political variables will influence the effectiveness of a country's response to natural disasters and reduced the observed impact. In particular, the hypotheses predict that a regression with the number killed by the natural disaster as the dependent variable would have a negative coefficient for polity, a negative coefficient for durable, and a positive coefficient for instability.

*Operationalication of the control variables.*

In addition to using indicators of the political institutions of a country, an adequate model of disaster response and impact must control for the physical, social and economic determinants. A number of standard and commonly used indicators exist for these variables. And, while one can write a long list of physical, social and economic indicators that likely correlate with the impact of natural disasters, I preserve the parsimony of the model by utilizing proxy indicators for each dimension of vulnerability. Although this technique glosses over many of the important social, economic, and physical processes that influence disaster response and impact, it helps keep the focus on the political processes that are the subject of this study.

The framework provided by the ISDR provides a set four conceptual variables and a list of potential indicators for each variable. The framework, however, stops short of specifying the relative significance of each indicator. More generally, the selection and weighting of indicators is a common problem in disaster research. The regression below uses radios per capita as the indicator of physical vulnerability, population density as the indicator of social vulnerability, and the national government expenditure per capita as the economic indicator. These indicators were chosen from the Banks Cross-National Data Archive because they have the fewest missing cases. Finally, each indicator was converted to a zero-to-one index where one indicates increased vulnerability.

Table 7: Codebook of indicators and source.

| **Variable** | **Indicator** | **Source (Year of Release)** |
|---|---|---|
| Impact | The log of the number of people killed by natural disaster. | OFDA/CRED (2003) |
| Severity | The log of affected-squared divided by population | OFDA/CRED (2003), Banks (2000) |
| Polity | The combined democracy/ autocracy score (modified version.) | Polity IV Project (2002) |
| Durability | The number of years since the most recent regime change. | Polity IV Project (2002) |
| Stability | A weighted sum of the number of general strikes, guerrilla warfare, crises, purges, riots, revolutions, and anti-government demonstrations. | Banks Cross National Data Archive (2000) |
| Political Index | Average of zero-to-one index of polity, durability, and stability. | Polity IV (2002), Banks (2000) |
| Physical Index | Zero-to-one index of radios per capita. Zero indicates more radios and lowered vulnerability. | Banks Cross National Data Archive (2000) |
| Economical Index | Zero-to-one index of government expenditures per capita. Zero indicates higher spending and lowered vulnerability. | Banks Cross National Data Archive (2000) |
| Social Index | Zero-to-one index of population density. Zero indicates low population density and lowered vulnerability. | Banks Cross National Data Archive (2000) |

*Regression results*

With this operationalization of the variables, the model equation, equation (vii), becomes the following regression equation:

$$\log(\text{killed}) = A + B1*\text{polity} + B2*\text{durability} + B3*\text{stability} + B4*\text{participation} + C1*\log(\text{affected}^2/\text{population}) + C2*\text{physical} + C1*\text{social} + C2*\text{economic} \qquad \text{(viii)}$$

In this regression equation, considering the factors of political vulnerability as individual terms allows us to test the three hypotheses of chapter 1 and while combining them into a single political index estimates the relative importance of political vulnerability. Thus, before analyzing the complete model above, two complementary regressions will demonstrate the importance of political vulnerability.

Standard Model

The model of risk presented by the ISDR, what I term the Standard Model, posits that disaster risk depends on ecological, physical, economic, and social sources of vulnerability. This model is operationalized in the following reduced form of the full regression equation above

$$\log(\text{killed}) = A + C1*\log(\text{affected}^2/\text{population}) + C2*\text{physical} + C1*\text{social} + C2*\text{economic}. \qquad \text{(ix)}$$

The results of this regression support the Standard Model, except that the economical index is not significant and overall R-squared is not very high. Econometrically, this model suffers from heteroskedasticiy and omitted variable bias. To compensate for these shortcomings, robust standard errors are presented.

Table 8: The Standard Model of Disaster Vulnerability.

| n = 1525, F(4, 1520) = 94.24, $R^2$ = 0.18 | | | | | | |
|---|---|---|---|---|---|---|
| **Independent Variable** | **Coefficient** | **Robust Standard Error** | **t** | **p > \|t\|** | **95% Confidence Interval** | **Standardized Beta Coefficient** |
| Severity | .1128721 | .0078542 | 14.37 | 0.000 | (0.0974659, 0.1282784) | 0.323099 |
| Physical | 5.620112 | 1.322239 | 4.25 | 0.000 | (3.026505, 8.213719) | 0.1436598 |
| Economic | 1.185378 | .7616191 | 1.56 | 0.120 | (-0.3085578, 2.679313) | 0.0604141 |
| Social | .843245 | .2668087 | 3.16 | 0.002 | (0.3198928, 1.366597) | 0.073491 |
| vif =1.50, hettest = 10.58, ovtest = 15.17 | | | | | | |

Note: vif, hettest, and ovtest refer to stata regression diagnostic commands for collinearity, heteroskedasticity, and omitted variable bias. Generally speaking a value above 2.00 indicates that the sample fails to adequately follow the respective OLS assumption.

The Standard+Political Model

To assess the relative importance of political vulnerability, a composite political index was calculated as the average of a zero-to-one index calculated from each of the three political variables. With the addition of the political index, the R-squared of the model is higher, an indication that this model offers a more complete explanation of the variance in the dependent variable. The coefficient for the political vulnerability index is significant, and greater than the coefficients for social and economic vulnerability. However, like the above case this regression suffers from heteroskedasticity and omitted variable bias, though heteroskedasticity is lower than in the previous regression.

Table 9: The Standard+Political model.

| N = 1515, F(5, 1509) = 88.78, $R^2$ = .19 | | | | | | |
|---|---|---|---|---|---|---|
| **Independent Variable** | **Coefficient** | **Robust Standard Error** | **T** | **p > \|t\|** | **95% Confidence Interval** | **Standardized Beta Coefficient** |
| Severity | 0.1145906 | .0077953 | 14.70 | 0.000 | (0.0992998, 0.1298814) | 0.3291471 |
| Physical | 5.585847 | 1.310963 | 4.26 | 0.000 | (3.014344, 8.157349) | 0.1435755 |
| Economic | 0.9925324 | .7716113 | 1.29 | 0.199 | (-0.5210119, 2.506077) | 0.0508974 |
| Social | 0.5910399 | .2703823 | 2.19 | 0.029 | (0.0606749, 1.121405) | 0.0517378 |
| Political | 3.861908 | .6471755 | 5.97 | 0.000 | (2.592449, 5.131367) | 0.1272318 |
| vif = 1.41, hettest = 3.80, ovtest = 15.74 | | | | | | |

Table 10: Regression with polity, durability, and instability.

| N = 1493, F(7, 1485) = 69.87, $R^2$ = .21, vif = 1.82, hettest = 4.63, ovtest = 9.49 | | | | | | |
|---|---|---|---|---|---|---|
| **Independent Variable** | **Coefficient** | **Robust Standard Error** | **t** | **p>\|t\|** | **95% Confidence Interval** | **Standardized Beta Coefficient** |
| Severity | .1206591 | .0077342 | 15.60 | 0.000 | (0.1054879, 0.1358302) | 0.3474491 |
| Physical | 6.858652 | 1.718271 | 3.99 | 0.000 | (3.488155, 10.22915) | 0.1774148 |
| Economic | .9577765 | .7956066 | 1.20 | 0.229 | (-0.6028557, 2.518409) | 0.048793 |
| Social | .7648393 | .2725263 | 2.81 | 0.005 | (.230262, 1.299417) | 0.0672458 |
| Polity | -.0177468 | .0069738 | -2.54 | 0.011 | (-0.0314264, -0.0040672) | -0.066906 |
| Durability | .0056841 | .0023083 | 2.46 | 0.014 | (.0011563, .0102119) | 0.0868271 |
| Instability | .0000212 | .00000386 | 5.49 | 0.000 | (.0000136, .0000287) | 0.1231585 |
| vif = 1.82, hettest = 4.63, ovtest = 9.49 | | | | | | |

*Testing the Three Hypothesis*

In the complete regression equation (viii) the coefficients for polity, durability, and stability are all significant. However, while polity and stability have the expected sign, the observed sign for durability is opposite from the expected. This result indicates that the data support H1 and H3, but reject H2. Again, the regression results are limited by heteroskedisticity and omitted variable bias.

*Statistical Simulation of Results*

This section complements the presentation of regression results in the previous section by simulating the expected relationship between the number of people killed and each of the political indicators. The simulations were done using the Clarify software package (Tomz, et al 2003, King et al 2000) that simulates standard regression results and calculates expected values of the dependent variable given values of each of the independent variables. The tables below present simulated values of the number of people killed when all but one political variable is set to its mean value and the remaining political variable varies between its min and max. The largest change is observed with instability; as the weighted conflict index varies between its max and min values, the number of killed varies between 5236 and 167. In contrast, the predicted range of people killed with the polity variable is small and insignificant.

Figure 16: Expected value of people killed versus polity.

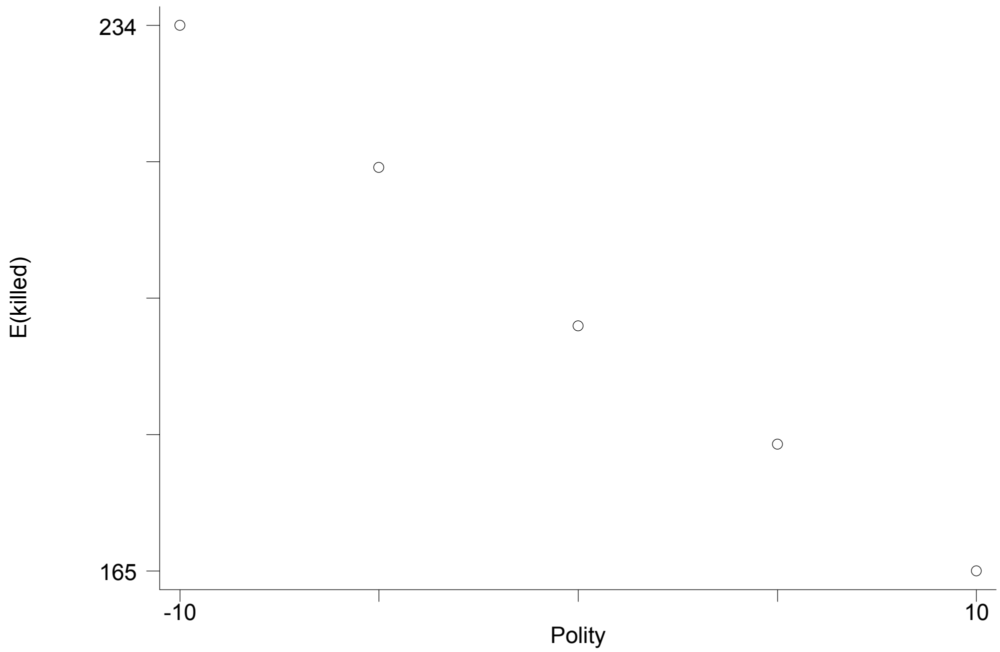



Figure 17: Expected value of people killed versus instability.

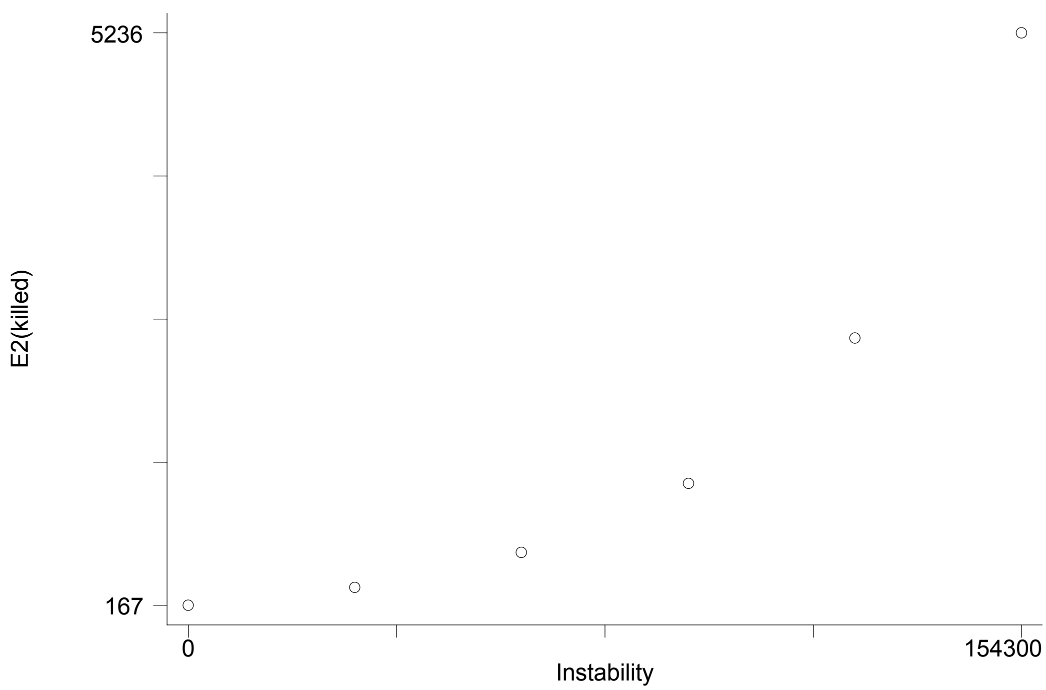
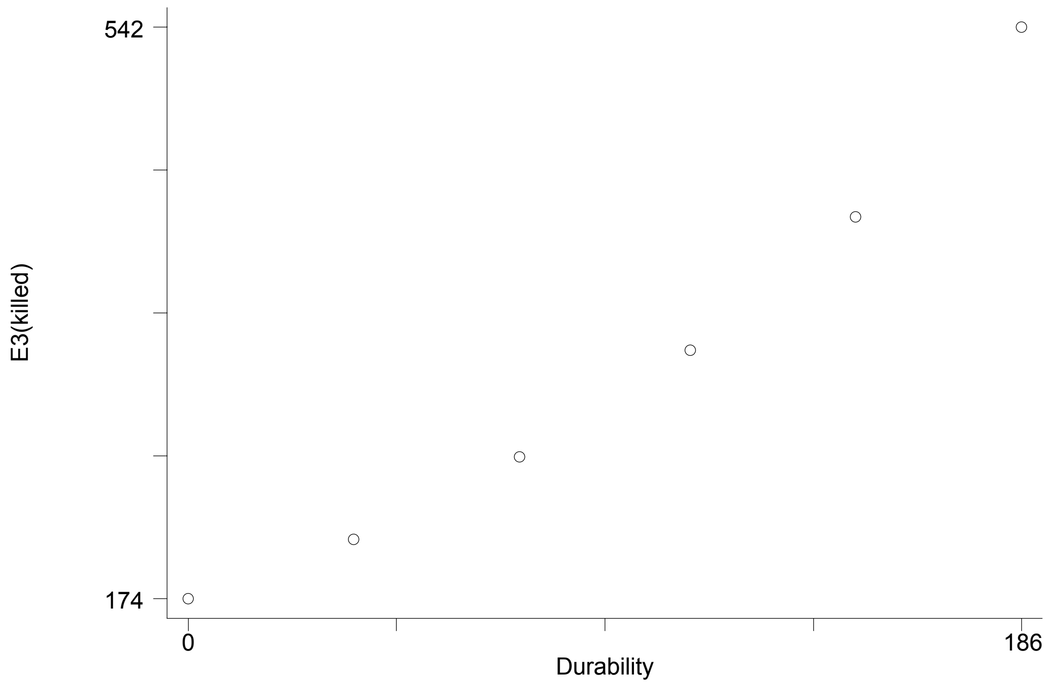


Figure 18: Expected value of people killed versus durable.




*Conclusion*

The first two regressions demonstrate that political vulnerability does matter, and indicates that is it is as important as physical vulnerability. Comparing the R-squared of these two regressions shows that the model that includes a term for political vulnerability explains more of the variance in disaster impact than the model that excludes this term. Further, the coefficients of the four types of vulnerability in regression 2 suggest that physical and political vulnerability is more important than social and economic vulnerability.

Finally, in the third regression, we find evidence for hypothesis H1 and H2, and evidence against H3. This regression shows that democracy, durability, and stability all matter, but that the effect of durability is opposite of what was expected. While H3 posits that the impact of natural disasters decreases as the government exists longer, the regression results indicate that the more durable the government, the higher the impact.

Simulations computed with the Clarify software show that political instability can have a very substantial impact of the number of people killed.

## Chapter 4: Conclusion

The conventional wisdom holds that in addition to physical and environmental vulnerability, both economic and social vulnerability increase the threat and impact of natural hazards. However, in developing this understanding of natural disasters, scholars failed to give sufficient attention to political vulnerability. Previous studies, though informative, did not consider regime characteristics as potential determinants of the impact of natural hazards, and, as the results presented here indicate, missed an important dimension of human vulnerability to natural disasters.

In addition to a number of case studies on this topic, one previously published large-N statistical study reported that politics does matter. In fact, the study by Morris and Seitz indicates that for most disaster types, government instability matters more than the amount of available resources. Their model does not include a term to control for the severity of the disaster. In the present study, this result is strengthened by the inclusion of a term for the relative strength of the disaster. Likewise, the generalizability of previous studies is extended through both the case studies and the large sample used in the statistical analysis.

### *Summary of Findings*

Utilizing and extending the framework of analysis presented by International Strategy for Disaster Reduction, this thesis finds strong support for the notion that political vulnerability, like physical, economic, and social vulnerability, increases the risk and the associated impact of natural hazards. The first, third, and fourth case studies all support H1, which relates the level of democracy to the impact of natural disasters. Likewise, the regression results indicate that this hypothesis is valid for a large number of disasters. Regarding H2, the hypothesis that political instability increases the impact of natural disasters, the second case study provides limited support while the statistical analysis finds strong support. Finally, regarding H3, which posits that natural disaster impact decreases as a regime becomes more durable, the statistical analysis rejects this hypothesis and finds that the impact of natural disasters actually increases with the durability of the regime.

*Assessment of Results*

In order to confidently infer a cause-effect relationship between two variables that are observed to be significantly associated, Hennekens and Buring suggest the following criteria for assessing a hypothesis (Hennekens and Buring 1987, p. 39):

a) Strength of the association

b) Theoretical credibility[13]

c) Consistency with other investigations

d) Time sequence

e) Observed policy implications[14]

In this regard the regression results indicate a strong association between political regime characteristics and disaster impact. However, this result is subject to many types

[13] While the authors of this text on Epidemiology use the term “Biologic Credibility” the term “Theoretical Credibility” is taken to imply the same idea but applicable to the present context.

of bias. Seitz and Morris note that the over-identification of disasters in the developed world and the under-identification of disasters in the undeveloped world biases disaster data (Davis and Seitz 1982, p. 552.) In addition, they write "disasters that may have occurred under close-mouthed regimes … go underreported." (Davis and Seitz 1982, p. 554.) Likewise, the indicators of social, economic, and physical vulnerability can be improved by including different aspects of these factors of vulnerability. Finally, from an econometric standpoint, the regression diagnostics indicate that the model is not specified completely leading to the possibility of biased and inconsistent coefficients. Thus, an important next direction for research in this area is the identification and inclusion of the omitted variable(s) (see the end of Appendix C.) However, even this model does no completely cover the large number of actors involved in disaster response.

The theoretical credibility of such a cause-effect relationship is established in both the previous research and the present work. While previous studies, for example *Living with Risk*, are consistent with the notion of political vulnerability to natural disasters, the inclusion of political will and state capability as intervening variables provides a solid conceptual link between political institutions and the impact of natural disasters. However, the theory presented thus far suffers from an endogeneity problem. In particular, just as we expect the underlying social-political-economic conditions to influence the impact of a natural disaster, we should also expect the impact of a natural disaster to influence the underlying social-political-economic conditions of the affected area. Thus, building on Chart 4, Chart 6 offers a more complete model that includes the impact of natural disasters on the underlying human and environmental conditions.

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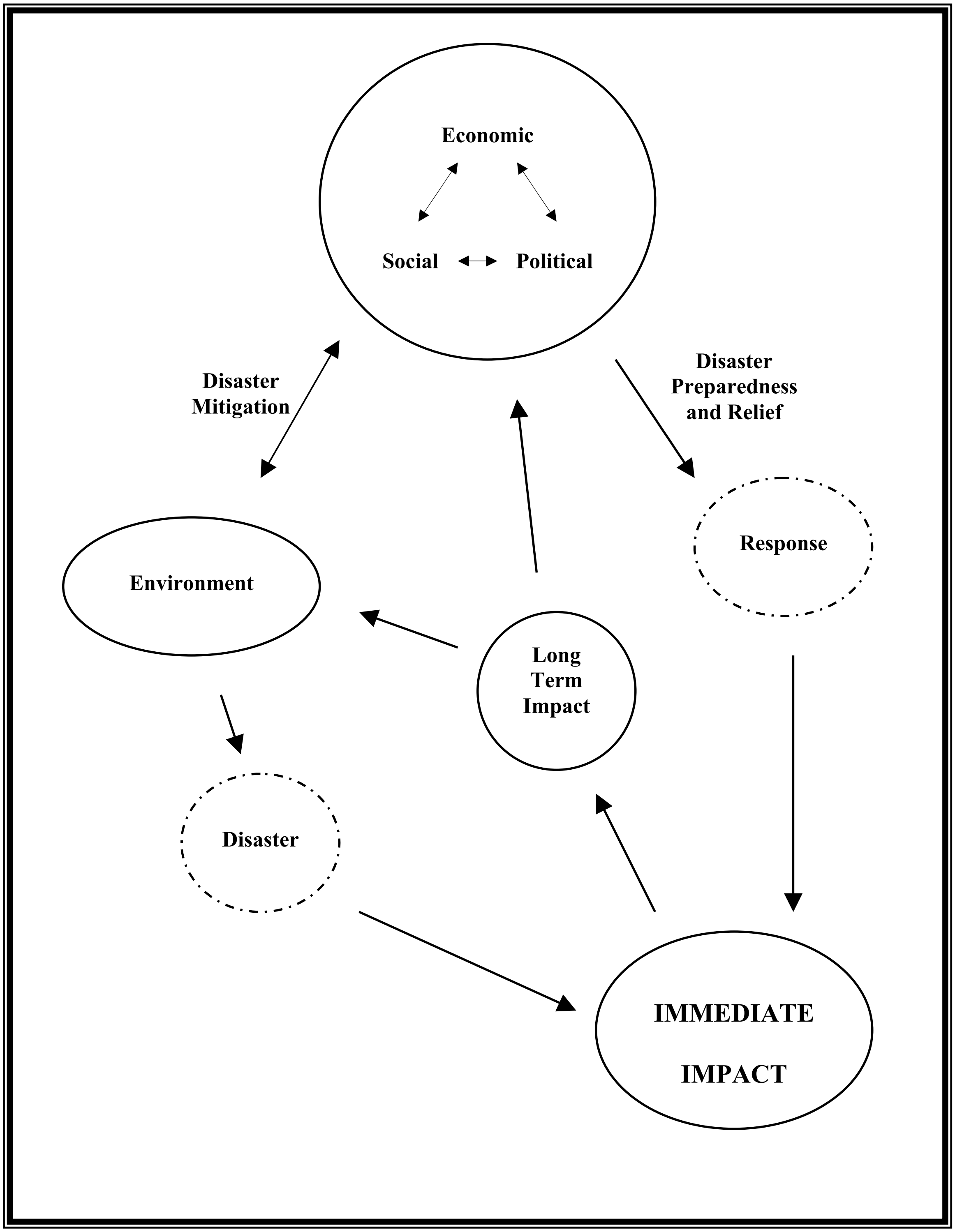
[14] This term is used in substitution for the term "Dose-response relationship" found in the text.

Figure 19: A more complete model of natural disasters.



In addition to a great deal of consistency between the case studies and regression analysis, the results presented here are consistent with previously reported findings, including the study by Seitz and Morris. Likewise, the observation by Wisner and Rocha & Christoplos that El Salvador and Nicaragua did not learn from Hurricane Mitch agrees with the findings regarding H2, the institutional learning hypothesis. Further, the theoretical argument for associating disaster impact with political institutions is consistent with both the political-economy of Lake & Baum and the risk framework by the ISDR.

This thesis, however, does not present a rigorous time-series analysis that associates *change* in disaster impact with *change* in political institutions. The third case study, which does examine change of these variables in Nicaragua and Honduras, is only an initial step in this direction. Using the risk equation to develop a model of change in vulnerability and risk and verifying such a model with times-series analysis is an important next step in research on disasters and their social-economic-political context.

Likewise, as the present focus is limited to the overall political context of natural disasters, it does not examine the implications of specific policy changes at the local, national or international level. Complementary to a large-N time series analysis, case studies that link changes in policy (and more importantly, the policymaking environment) with disaster impact is another important area of research that should be pursued.

*Implications*

While the findings of this study do possess some limitations, it is not likely that these shortcomings will change the overall conclusion that political vulnerability is an important source of risk and has a real influence on the impact of disasters. Clearly, for disaster victims around the world, level of democracy, regime durability, and political stability all affect the chances of survival. The implications of this finding are both theoretical and practical.

From a theoretical standpoint, scholars who look beyond the normative and ideological aspects of domestic political-economy have examined the observed impact of political institutions on many aspects of daily life. For example, Lake & Baum have assessed the impact of democracy on economic growth, public health, and education and found that this regime characteristic impacts each of these quality-of-life issues. In a similar manner, the results here show that regime characteristics matter in another important quality-of-life issue: the impact of natural disasters.

Viewing the state as a rational, self-interested actor that varies only in its domestic policy making environment, it was predicted that democratic, stable, and durable regimes would provide better protection to their citizens during a natural disaster. While the results show that each of these variables matters, only democracy and stability were observed to matter in the predicted direction. Two possible reasons may explain the discrepant finding. First, as they exist longer and become more established, regimes may grow less concerned with legitimacy and become lazy when it comes to protecting citizens. Or, secondly, the rational, self-interested state may over time learn that disaster response does not provide as good of an investment return as other public service provisions, like public health or education, and may hence spend more on these services at the expense of disaster response.

From a policy perspective, two points are important. First, relief workers and planners need to take the political vulnerability of a country into consideration when assessing vulnerability and planning for disasters. Unfortunately, when a country is non-democratic and politically unstable more people go unprotected. Secondly, this raises the question of political reform as a viable disaster reduction strategy. Should organizations such as CARE, International and The International Federation of the Red Cross adopt an active policy of encouraging democracy as a means of reducing the impact of natural disasters? Naturally, more research is required before such a policy option is considered feasible. However, this research does suggest international assistance geared toward developing democratic and stable political regimes will decrease a country's vulnerability toward natural disasters.

## Appendix A: The EM-DAT dataset and some basic stats on disasters

A reported disaster is included in the EM-DAT dataset if a) ten or more people die as a result of the disaster, b) 100 or more people are affected/injured/homeless, or c) the impacted country declares a state of emergency or appeals for international aid. The dataset is updated regularly (every three months) as new data become available. This thesis uses the May 2003 release of the dataset that includes data on over 8,800 natural disasters that have occurred between 1900-2002. The tables below provide a broad summary of the disaster recorded in the EM-DAT dataset.

Table 11: Number of recorded events by disaster type

| **Disaster Type** | **Number of Occurrences** | **Percent of Total** |
|---|---|---|
| Drought | 782 | 8.87 |
| Earthquake | 900 | 10.21 |
| Epidemic | 854 | 9.69 |
| Extreme temperature | 263 | 2.98 |
| Famine | 77 | 0.87 |
| Flood | 2390 | 27.11 |
| Insect infestation | 672 | 0.82 |
| Slide | 449 | 5.09 |
| Volcano | 169 | 1.92 |
| Wave/surge | 41 | 0.47 |
| Wild fire | 270 | 3.06 |
| Wind storm | 2548 | 28.91 |

Table 12: Recorded disasters by continent.

| **Continent** | **Number of Occurrences** | **Percent of Total** |
|---|---|---|
| Africa | 1650 | 18.72 |
| Americas | 2258 | 25.62 |
| Asia | 3286 | 37.29 |
| Europe | 1185 | 13.45 |
| Oceania | 433 | 4.91 |

Table 13: Summary of disaster impact variables.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Killed | 7610 | 8153.451 | 253150.9 | 0 | 2.00e+07 |
| Injured | 3372 | 1102.756 | 13952.1 | 0 | 600000 |
| Homeless | 3131 | 62822.23 | 836215.8 | 0 | 2.80e+07 |
| Affected | 4841 | 1094744 | 1.01e+07 | 0 | 3.00e+08 |
| Damage ($1,000's) | 2548 | 393320.6 | 2998802 | 0 | 1.32e+08 |
| Killed/Affected | 3944 | .054117 | .4431987 | 0 | 16 |
| Damage/Affected | 1496 | 48.73114 | 439.6103 | 6.75e-6 | 10000 |

## Appendix B: Validity of research design assumption

This appendix focuses on the relationship between the disaster impact and the magnitude of the disaster. In addition to the disaster impact indicators the CRED database contains the following measures of disaster type and magnitude: disaster type, disaster subset, disaster scale, and disaster scale value. For a given type of disaster, the disaster scale value gives the relative magnitude of each disaster while the disaster scale variable gives the units for that disaster type. For example, the disaster scale for earthquakes is the Richter and the disaster scale value ranges from 3.5 to 10.0.

Table 14: Summary of disaster scale value by type.

| **Disaster Type** | **Disaster Scale** | **Number of Observations** | **Mean** | **Standard Deviation** | **Minimum** | **Maximum** |
|---|---|---|---|---|---|---|
| Drought | $km^2$ | 58 | 52696.6 | 110666.5 | 1 | 560000 |
| Earthquake | Richter | 598 | 6.357274 | .9261336 | 3.5 | 9.5 |
| Epidemic | vaccinated | 18 | 972155.9 | 1854006 | 6000 | 7500000 |
| Flood | $km^2$ | 358 | 56530.16 | 742576.7 | .38 | 1.40e+07 |
| Wildfire | $km^2$ | 148 | 15892.71 | 120007.1 | 1.3 | 1294994 |
| Windstorm | kph | 545 | 620.9431 | 9944.432 | 20 | 232000 |
| Cold Wave | °C | 58 | 18.55172 | 16.37054 | -60 | 7 |
| Heat Wave | °C | 41 | 44.19512 | 6.063537 | 30 | 60 |

A central assumption of the research design is that the number of people affected by the disaster serves as a proxy measure for the severity of the disaster. In otherwords, while a 6.7 on the Richter scale cannot be compared to 190 kph, the number of people affected is a measure of magnitude that is comparable between earthquakes and windstorms. Below I present the results of a bivariate correlation analysis of the different disaster impact parameters with the disaster scale value. For drought, epidemic, and flood there is a strong and significant correlation between the number of people affected and disaster scale value. This finding suggests that the number of people affected does provide a valid measure for the magnitude of the disaster.

Table 15: Correlation between disaster magnitude and disaster impact.

| Disaster Type | Correlation Coefficient between Disaster Scale Value and Affected | Total Affected | Killed | Injured | Homeless | Damage |
|---|---|---|---|---|---|---|
| Drought | **0.7015 (0.000)** | **0.7015 (0.000)** | 0.0896 (0.5538) | | | 0.1961 (0.3370) |
| Earthquake | 0.1384 **(0.0059)** | 0.1079 (0.0107) | 0.2488 (0.0000) | 0.2495 (0.0000) | 0.2107 (0.0001) | 0.0879 (0.1554) |
| Epidemic | **0.5505 (0.0179)** | **0.5505 (0.0179)** | 0.6055 (0.0078) | | | |
| Flood | **0.4290 (0.0000)** | **0.4179 (0.0000)** | 0.0243 (0.6528) | 0.6308 (0.0000) | 0.1034 (0.0955) | 0.3324 (0.0000) |
| Wildfire | -0.0207 (0.8689) | -0.0220 (0.8507) | 0.2868 (0.0024) | -0.0337 (0.8241) | -0.0713 (0.6706) | 0.0336 (0.8458) |
| Windstorm | 0.0276 (0.6008) | 0.0397 (0.4174) | 0.0566 (0.1992) | 0.0667 (0.2361) | 0.0899 (0.1291) | 0.0818 (0.1931) |
| Cold Wave | -0.4037 (0.0695) | -0.3713 (0.0811) | 0.2237 (0.1040) | 0.2986 (0.2444) | | -0.9926 (0.0074) |
| Heat Wave | 0.0302 (0.9220) | 0.0428 (0.8748) | 0.2666 (0.1107) | -0.0609 (0.8292) | | -0.8023 (0.4073) |

Regarding windstorms two comments are in order. This disaster type includes both tornadoes and hurricanes and they should be considered separately. Further, other researchers have found a correlation between El-Nino activity (particularly increased number of windstorms) and the number of people affected by natural disasters (Bourma 1997, p. 1435.)

## Appendix C: The regression analysis

This appendix presents the complete regression analysis that lead to the regression presented in the text. To a large extent, this appendix fills in the gaps left by the theory. For example, the accepted theory tells us that social and economic vulnerability is important, it does not tell how to operationalize these variables. More generally, the issue of indicator selection and weighting remains unresolved.

The goal of this appendix is to find a regression result that includes a large number of cases, produces results that are robust, and passes the important econometric diagnostics. The constraint is data availability. Finally, the method is inductive in nature.

All statistical calculations presented below were made using the STATA software package.

### First determine best indicator of severity

From a numerical standpoint, numerous combinations of affected and population provide a measure of the severity of disaster. I use the data to distinguish between the possibilities. In particular, I consider bivariate regressions with log(killed) as the dependent variable and the possible measures of severity as the independent variables. Below I list the indicator of severity along with the r-squared of the corresponding regression:

| | |
|---|---|
| Log(affected/population) | 0.10 |
| Log(affected^2/population) | 0.15 |
| Log(affected/population^2) | 0.03 |
| Log(affected^2/population^2) | 0.10 |

Since log(affected^2/population) explains the largest portion of the dependent variable, it is the best indicator of disaster severity.

### Selecting Indicators through Data Availability

The most basic method of indicator selection is to follow the data. While the Banks Data Archive includes many variables and many country-years, it also includes many missing values. In the following set of regressions, I calculate the social, economic, and physical indexes based on the chosen by the number of available data points. I start with a single indicator for each index, then I add a second indicator to each index, and then a third.

The following disasters were identified as outliers (high residuals following regression) causing extreme heteroskedasticity and removed from the sample (listed in order of residual-squared with highest first):

```
Note that:
       kil_aff = killed/affected
       aff_pop = affected/population


          countryyear            distype         killed       affected    kil_aff    aff_pop
6948.    Soviet Union1921        Drought        1200000        5000000        .24   .0362745
2411.    Ethiopia1984            Drought         300000        7750000   .0387097   .1837843
3265.    India1965               Drought         500000      100000000       .005   .2054865
4001.    Iran, Islam Rep1990     Earthquake       40000         500000        .08    .009175
```

| | | | | | | |
|---|---|---|---|---|---|---|
| 1949. | Colombia1985 | Volcano | 22800 | 50000 | .456 | .001696 |
| 2398. | Ethiopia1973 | Drought | 100000 | 3000000 | .0333333 | .1150307 |
| 640. | Bangladesh1991 | Wind storm | 138866 | 15000000 | .0092577 | .1345835 |
| 6025. | Peru1970 | Earthquake | 66794 | 3072909 | .0217364 | .226182 |

Comparing these figures to the summary statistics of the entire sample shows that most of these cases are extreme cases in terms of these key disaster variables:

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| killed | 7610 | 8153.451 | 253150.9 | 0 | 2.00e+07 |
| affected | 4841 | 1094744 | 1.01e+07 | 0 | 3.00e+08 |
| kil_aff | 3944 | .054117 | .4431987 | 0 | 16 |
| aff_pop | 3403 | .0246749 | .095489 | 0 | 1.229508 |

Regression #1: Single Indicators

Social: population density
Economic: national government expenditure per capita
Physical: radios per capita

Here is the regression along with the diagnostics:

```
. regress log_kil log_aff2pop phy eco soc

      Source |       SS       df       MS              Number of obs =    1525
-------------+------------------------------           F(  4,  1520) =   81.68
       Model |  1063.90233     4  265.975582           Prob > F      =  0.0000
    Residual |  4949.34105  1520  3.25614543           R-squared     =  0.1769
-------------+------------------------------           Adj R-squared =  0.1748
       Total |  6013.24338  1524  3.94569776           Root MSE      =  1.8045

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1128721   .0083175    13.57   0.000     .0965572    .1291871
         phy |   5.620112   1.280532     4.39   0.000     3.108316    8.131908
         eco |   1.185378   .6377769     1.86   0.063     -.065638    2.436394
         soc |    .843245   .2692437     3.13   0.002     .3151164    1.371373
       _cons |  -4.078444   .9152186    -4.46   0.000    -5.873669   -2.283219
------------------------------------------------------------------------------
```

Regression #2: Two Indicators

In this regression, each of the vulnerability indexes are calculated as an average of two indicators. The composite indexes now represent the follow:

Social: population density, daily newspaper circulation per capita (soc)
Economic: national government expenditure per capita, gross national product (eco)
Physical: radios per capita, highway vehicles per capita (phy)

In this regression, collinearity is present:

```
. regress log_kil log_aff2pop phy eco soc

      Source |       SS       df       MS              Number of obs =    1268
-------------+------------------------------           F(  4,  1263) =   62.66
```

```
       Model |  836.664377     4  209.166094           Prob > F      =  0.0000
    Residual |  4216.19496  1263  3.33823829           R-squared     =  0.1656
-------------+------------------------------           Adj R-squared =  0.1629
       Total |  5052.85934  1267  3.98804999           Root MSE      =  1.8271

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1103175   .0093379    11.81   0.000     .0919979    .1286371
         phy |   3.052072   .9504118     3.21   0.001     1.187513    4.916632
         eco |  -.0650987   1.161948    -0.06   0.955    -2.344659    2.214461
         soc |   .4968848   .5316912     0.93   0.350    -.5462104     1.53998
       _cons |  -.4028557   .5544457    -0.73   0.468    -1.490592    .6848803
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
         phy |      5.04    0.198401
         eco |      4.41    0.226690
         soc |      1.49    0.671313
 log_aff2pop |      1.06    0.946573
-------------+----------------------
    Mean VIF |      3.00

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =    14.14
         Prob > chi2  =     0.0002

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                F(3, 1260) =     16.13
                  Prob > F =      0.0000
```

Regression #3: Three Indicators

Finally, a third indicator was included in each index to make them composite indexes of the following:

Social: population density, daily newspaper circulation per capita, primary school enrollment (socb)
Economic: national government expenditure per capita, gnp per capita, gnp per capita (ecob)
Physical: radios per capita, highway vehicles per capita, size of military (phyb)

While the diagnostics of this regression are relatively good, the sample is limited to only 518 cases from years before 1982 and heavily concentrated in a brief timespan:

```
. regress log_kil log_aff2pop phyb ecob socb

      Source |       SS       df       MS              Number of obs =     518
-------------+------------------------------           F(  4,   513) =   33.19
       Model |   452.90861     4  113.227152           Prob > F      =  0.0000
    Residual |  1750.14076   513  3.41158043           R-squared     =  0.2056
-------------+------------------------------           Adj R-squared =  0.1994
       Total |  2203.04937   517  4.26121735           Root MSE      =   1.847

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1501588   .0145833    10.30   0.000     .1215084    .1788092
        phyb |  -1.274825    1.61385    -0.79   0.430    -4.445392    1.895743
        ecob |   2.300495   2.398026     0.96   0.338    -2.410664    7.011655
        socb |   3.598323   1.261277     2.85   0.005     1.120419    6.076227
```

```
       _cons |  -.5371562   1.479648    -0.36   0.717    -3.444072    2.369759
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF  
-------------+----------------------
        ecob |      2.57    0.388782
        phyb |      2.42    0.413316
        socb |      1.33    0.749684
 log_aff2pop |      1.05    0.953488
-------------+----------------------
    Mean VIF |      1.84

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =    10.39
         Prob > chi2  =     0.0013

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 510) =      4.09
                  Prob > F =      0.0069

. tab year if yhat ~= .

       year |      Freq.     Percent
------------+-----------------------------------
       1949 |          2        0.27
       1950 |          2        0.27
       1952 |          2        0.27
       1953 |          6        0.82
       1954 |          2        0.27
       1956 |          1        0.14
       1957 |          4        0.54
       1958 |          2        0.27
       1959 |          2        0.27
       1960 |          2        0.27
       1961 |          1        0.14
       1962 |          2        0.27
       1963 |          7        0.95
       1964 |         32        4.36
       1965 |         28        3.81
       1966 |         38        5.18
       1967 |         42        5.72
       1968 |         42        5.72
       1969 |         33        4.50
       1970 |         38        5.18
       1971 |         31        4.22
       1972 |         26        3.54
       1973 |         26        3.54
       1974 |         27        3.68
       1975 |         16        2.18
       1976 |         35        4.77
       1977 |         77       10.49
       1978 |         76       10.35
       1979 |         63        8.58
       1980 |         65        8.86
       1981 |          3        0.41
       1982 |          1        0.14
------------+-----------------------------------
      Total |        734      100.00
```

Regression #4: Hybrid

To eliminate the colinearity of the regression #2, the following regression includes two-indicator composite index for social and physical vulnerability, but only one indicator for economic vulnerability:

Social: population density, daily newspaper circulation per capita (soc)
Economic: national government expenditure per capita (eco1)
Physical: radios per capita, highway vehicles per capita (phy)

This sample includes over 1300 cases, but suffers from heteroskedasticity and omitted variable bias:

```
. regress log_kil log_aff2pop phy eco1 soc

      Source |       SS       df       MS              Number of obs =    1356
-------------+------------------------------           F(  4,  1351) =   67.71
       Model |  903.226796     4  225.806699           Prob > F      =  0.0000
    Residual |    4505.635  1351  3.33503701           R-squared     =  0.1670
-------------+------------------------------           Adj R-squared =  0.1645
       Total |   5408.8618  1355  3.99177993           Root MSE      =  1.8262

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1108477   .0090712    12.22   0.000     .0930526    .1286429
         phy |   2.636099   .6474382     4.07   0.000     1.366006    3.906192
        eco1 |   .5094643   .9021742     0.56   0.572     -1.26035    2.279279
         soc |   .6942378   .4985932     1.39   0.164    -.2838631    1.672339
       _cons |  -.7093045   .6096939    -1.16   0.245    -1.905354    .4867451
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
         phy |      2.65    0.377290
        eco1 |      2.13    0.469432
         soc |      1.48    0.676711
 log_aff2pop |      1.05    0.949850
-------------+----------------------
    Mean VIF |      1.83

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =    14.30
         Prob > chi2  =     0.0002

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                F(3, 1348) =     17.09
                  Prob > F =      0.0000
```

Upon comparison, regression #1 possesses the most statistical strength. While heteroskedasticity and omitted variable bias is a problem with each of these regressions, it appears least severe in this regression. Further, this regression includes the most cases and has the highest adjusted r-squared.

The Political Model

Regression #5: Inclusion of the composite political index.

```
. regress log_kil log_aff2pop phy eco soc pol

      Source |       SS       df       MS              Number of obs =    1515
-------------+------------------------------           F(  5,  1509) =   72.03
       Model |  1143.49442     5  228.698885           Prob > F      =  0.0000
    Residual |  4791.27813  1509  3.17513461           R-squared     =  0.1927
-------------+------------------------------           Adj R-squared =  0.1900
       Total |  5934.77255  1514  3.91992903           Root MSE      =  1.7819

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1145906   .0082511    13.89   0.000     .0984057    .1307754
         phy |   5.585847   1.265533     4.41   0.000     3.103456    8.068237
         eco |   .9925324   .6310214     1.57   0.116    -.2452395    2.230304
         soc |   .5910399   .2702578     2.19   0.029      .060919    1.121161
         pol |   3.861908   .7144891     5.41   0.000     2.460411    5.263405
       _cons |  -4.002774   .9046295    -4.42   0.000    -5.777238    -2.22831
------------------------------------------------------------------------------
```

Regression #6: Testing democracy, durability, and stability

```
. regress log_kil log_aff2pop phy eco soc polity2 durable weighted

      Source |       SS       df       MS              Number of obs =    1493
-------------+------------------------------           F(  7,  1485) =   55.33
       Model |  1201.61117     7  171.658738           Prob > F      =  0.0000
    Residual |  4607.40481  1485   3.1026295           R-squared     =  0.2069
-------------+------------------------------           Adj R-squared =  0.2031
       Total |  5809.01597  1492  3.89344234           Root MSE      =  1.7614

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1206591   .0082485    14.63   0.000     .1044792     .136839
         phy |   6.858652   1.745602     3.93   0.000     3.434544    10.28276
         eco |   .9577765   .6414705     1.49   0.136    -.3005081    2.216061
         soc |   .7648393   .2724744     2.81   0.005     .2303637    1.299315
     polity2 |  -.0177468   .0068689    -2.58   0.010    -.0312206   -.0042729
     durable |   .0056841   .0023644     2.40   0.016     .0010462     .010322
weightedco~x |   .0000212   4.11e-06     5.15   0.000     .0000131    .0000292
       _cons |  -5.356668   1.483022    -3.61   0.000    -8.265708   -2.447629
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
         phy |      3.82    0.261960
     durable |      2.44    0.409443
         eco |      2.00    0.500136
     polity2 |      1.26    0.796449
         soc |      1.07    0.930649
weightedco~x |      1.07    0.933871
 log_aff2pop |      1.06    0.946709
-------------+----------------------
    Mean VIF |      1.82

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
```

```
     Ho: Constant variance
         chi2(1)      =      4.63
         Prob > chi2  =      0.0314

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                F(3, 1482) =      9.49
                  Prob > F =      0.0000
```

In Both heteroskedasticiy and omitted variable bias are present in these regressions (for brevities sake I present the diagnostics of just the last one) and may impact the estimate of the standard errors:

However, when using robust standard errors the results do not change:

```
. regress log_kil log_aff2pop phy eco soc, robust

Regression with robust standard errors                 Number of obs =    1525
                                                       F(  4,  1520) =   94.24
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1769
                                                       Root MSE      =  1.8045

------------------------------------------------------------------------------
             |               Robust
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1128721   .0078542    14.37   0.000     .0974659    .1282784
         phy |   5.620112   1.322239     4.25   0.000     3.026505    8.213719
         eco |   1.185378   .7616191     1.56   0.120    -.3085578    2.679313
         soc |    .843245   .2668087     3.16   0.002     .3198928    1.366597
       _cons |  -4.078444   .8792989    -4.64   0.000    -5.803211   -2.353676
------------------------------------------------------------------------------


. regress log_kil log_aff2pop phy eco soc pol, robust

Regression with robust standard errors                 Number of obs =    1515
                                                       F(  5,  1509) =   88.78
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1927
                                                       Root MSE      =  1.7819

------------------------------------------------------------------------------
             |               Robust
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1145906   .0077953    14.70   0.000     .0992998    .1298814
         phy |   5.585847   1.310963     4.26   0.000     3.014344    8.157349
         eco |   .9925324   .7716113     1.29   0.199    -.5210119    2.506077
         soc |   .5910399   .2703823     2.19   0.029     .0606749    1.121405
         pol |   3.861908   .6471755     5.97   0.000     2.592449    5.131367
       _cons |  -4.002774   .8658775    -4.62   0.000    -5.701225   -2.304323
------------------------------------------------------------------------------


. regress log_kil log_aff2pop phy eco soc polity2 durable weighted, robust

Regression with robust standard errors                 Number of obs =    1493
                                                       F(  7,  1485) =   69.87
                                                       Prob > F      =  0.0000
```

```
                                                       R-squared     =  0.2069
                                                       Root MSE      =  1.7614

------------------------------------------------------------------------------
             |               Robust
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1206591   .0077342    15.60   0.000     .1054879    .1358302
         phy |   6.858652   1.718271     3.99   0.000     3.488155    10.22915
         eco |   .9577765   .7956066     1.20   0.229    -.6028557    2.518409
         soc |   .7648393   .2725263     2.81   0.005      .230262    1.299417
     polity2 |  -.0177468   .0069738    -2.54   0.011    -.0314264   -.0040672
     durable |   .0056841   .0023083     2.46   0.014     .0011563    .0102119
weightedco~x |   .0000212   3.86e-06     5.49   0.000     .0000136    .0000287
       _cons |  -5.356668   1.402128    -3.82   0.000     -8.10703   -2.606307
------------------------------------------------------------------------------
```

Finally, to facilitate better substantive interpretation of these results, I regress using beta coefficients instead of regular coefficients. As opposed to the regular coefficient, which is interpreted as the impact of a one-unit change in the independent variable, the beta coefficients are interpreted as the impact of a one-standard deviation change in the independent variable. Beta coefficients are easy to compare and aid in assessing the relative impact of the different variables.

```
. regress log_kil log_aff2pop phy eco soc, beta

      Source |       SS       df       MS              Number of obs =    1525
-------------+------------------------------           F(  4,  1520) =   81.68
       Model |  1063.90229     4  265.975571           Prob > F      =  0.0000
    Residual |  4949.34109  1520  3.25614546           R-squared     =  0.1769
-------------+------------------------------           Adj R-squared =  0.1748
       Total |  6013.24338  1524  3.94569776           Root MSE      =  1.8045

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1128721   .0083175    13.57   0.000                  .323099
         phy |   5.620112   1.280532     4.39   0.000                 .1436598
         eco |   1.185378   .6377769     1.86   0.063                 .0604141
         soc |   .8432449   .2692437     3.13   0.002                  .073491
       _cons |  -4.078444   .9152186    -4.46   0.000                        .
------------------------------------------------------------------------------


. regress log_kil log_aff2pop phy eco soc pol, beta

      Source |       SS       df       MS              Number of obs =    1515
-------------+------------------------------           F(  5,  1509) =   72.03
       Model |  1143.49437     5  228.698874           Prob > F      =  0.0000
    Residual |  4791.27818  1509  3.17513465           R-squared     =  0.1927
-------------+------------------------------           Adj R-squared =  0.1900
       Total |  5934.77255  1514  3.91992903           Root MSE      =  1.7819

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1145906   .0082511    13.89   0.000                 .3291471
         phy |   5.585847   1.265533     4.41   0.000                 .1435755
         eco |   .9925325   .6310214     1.57   0.116                 .0508974
         soc |   .5910398   .2702578     2.19   0.029                 .0517378
         pol |   3.861908   .7144892     5.41   0.000                 .1272318
       _cons |  -4.002774   .9046295    -4.42   0.000                        .
------------------------------------------------------------------------------
```

```
. regress log_kil log_aff2pop phy eco soc polity2 weighted durable, beta

      Source |       SS       df       MS              Number of obs =    1493
-------------+------------------------------           F(  7,  1485) =   55.33
       Model |  1201.61112     7  171.658732           Prob > F      =  0.0000
    Residual |  4607.40485  1485  3.10262953           R-squared     =  0.2069
-------------+------------------------------           Adj R-squared =  0.2031
       Total |  5809.01597  1492  3.89344234           Root MSE      =  1.7614

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1206591   .0082485    14.63   0.000                 .3474491
         phy |   6.858652   1.745602     3.93   0.000                 .1774148
         eco |   .9577765   .6414705     1.49   0.136                  .048793
         soc |   .7648392   .2724744     2.81   0.005                 .0672458
     polity2 |  -.0177468   .0068689    -2.58   0.010                 -.066906
weightedco~x |   .0000212   4.11e-06     5.15   0.000                 .1231585
     durable |   .0056841   .0023644     2.40   0.016                 .0868271
       _cons |  -5.356668   1.483022    -3.61   0.000                        .
------------------------------------------------------------------------------
```

<u>The Regression Sample</u>

The following figures describe the sample that was used in this regression:

```
       distype |      Freq.     Percent
-------------------+---------------------------
           Drought |         13        0.87
        Earthquake |        199       13.33
          Epidemic |        166       11.12
      Extreme temp |          7        0.47
            Famine |          4        0.27
             Flood |        584       39.12
             Slide |         50        3.35
           Volcano |         28        1.88
        Wave/surge |          1        0.07
         Wild fire |         10        0.67
        Wind storm |        431       28.87
-------------------+---------------------------
             Total |      1,493      100.00
```

```
  continent |      Freq.     Percent
 -----------+---------------------------
     Africa |        181       12.12
   Americas |        358       23.98
       Asia |        800       53.58
     Europe |        110        7.37
    Oceania |         44        2.95
------------+---------------------------
      Total |      1,493      100.00
```

The regression sample covers the year 1949-95. However, the later years are over represented:

```
       year |      Freq.     Percent        Cum.
------------+-----------------------------------
       1949 |          1        0.07        0.07
       1950 |          1        0.07        0.13
       1951 |          1        0.07        0.20
```

| | | | |
|---|---|---|---|
| 1953 | 6 | 0.40 | 0.60 |
| 1954 | 2 | 0.13 | 0.74 |
| 1957 | 4 | 0.27 | 1.00 |
| 1958 | 1 | 0.07 | 1.07 |
| 1959 | 2 | 0.13 | 1.21 |
| 1960 | 4 | 0.27 | 1.47 |
| 1961 | 1 | 0.07 | 1.54 |
| 1962 | 1 | 0.07 | 1.61 |
| 1963 | 4 | 0.27 | 1.88 |
| 1964 | 18 | 1.21 | 3.08 |
| 1965 | 21 | 1.41 | 4.49 |
| 1966 | 32 | 2.14 | 6.63 |
| 1967 | 32 | 2.14 | 8.77 |
| 1968 | 32 | 2.14 | 10.92 |
| 1969 | 27 | 1.81 | 12.73 |
| 1970 | 30 | 2.01 | 14.74 |
| 1971 | 12 | 0.80 | 15.54 |
| 1972 | 20 | 1.34 | 16.88 |
| 1973 | 17 | 1.14 | 18.02 |
| 1974 | 23 | 1.54 | 19.56 |
| 1975 | 15 | 1.00 | 20.56 |
| 1976 | 30 | 2.01 | 22.57 |
| 1977 | 51 | 3.42 | 25.99 |
| 1978 | 53 | 3.55 | 29.54 |
| 1979 | 46 | 3.08 | 32.62 |
| 1980 | 45 | 3.01 | 35.63 |
| 1981 | 43 | 2.88 | 38.51 |
| 1982 | 48 | 3.22 | 41.73 |
| 1983 | 53 | 3.55 | 45.28 |
| 1984 | 43 | 2.88 | 48.16 |
| 1985 | 57 | 3.82 | 51.98 |
| 1986 | 64 | 4.29 | 56.26 |
| 1987 | 70 | 4.69 | 60.95 |
| 1988 | 72 | 4.82 | 65.77 |
| 1989 | 51 | 3.42 | 69.19 |
| 1990 | 47 | 3.15 | 72.34 |
| 1991 | 87 | 5.83 | 78.16 |
| 1992 | 50 | 3.35 | 81.51 |
| 1993 | 92 | 6.16 | 87.68 |
| 1994 | 87 | 5.83 | 93.50 |
| 1995 | 97 | 6.50 | 100.00 |
| Total | 1493 | 100.00 | |

Regression Sub-Samples

Calculating the regression coefficients for different sub-samples provides an indication of the different domains where the model best applies, and can provide some insight on the missing variables of the model. In particular, the regression can be broken into sub-samples based on disaster type, continent, and time period. To a large extent, the regression results do not change in a significant manner for the samples. However, looking at the restricted domain of disasters in Asia between 1970 and 1990 produced regression results that passed the three important diagnostic tests.

Below I present regression results for the sub-samples that exist with $n > 30$. Thus, for example, a sub-sample of all recorded droughts for which data on all the variables exist ($n = 13$) is omitted.

Disaster type

The model explains windstorms (R^2 = .29) and epidemics (R^2 = .40) best. For epidemics, polity and the conflict index are significant and in the expected direction. None of the other vulnerability variables are significant. For windstorms, the physical and social indexes are significant and in the expected direction. Slides produced the worst goodness-of-fit. No significant difference is observed for any of the sub-samples based on disaster type.

**Earthquakes**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if distype
=="Earthquake", beta

      Source |       SS       df       MS              Number of obs =     199
-------------+------------------------------           F(  7,   191) =   11.23
       Model |  388.554189     7  55.5077412           Prob > F      =  0.0000
    Residual |  943.724041   191  4.94096356           R-squared     =  0.2916
-------------+------------------------------           Adj R-squared =  0.2657
       Total |  1332.27823   198  6.72867793           Root MSE      =  2.2228

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .2584375    .033879     7.63   0.000                  .490592
         phy |   13.18317   7.546656     1.75   0.082                 .2052182
         eco |  -1.849253   1.869376    -0.99   0.324                -.0864994
         soc |   -.311121    2.01175    -0.15   0.877                -.0106908
     polity2 |  -.0187913   .0235595    -0.80   0.426                 -.054949
weightedco~x |   .0000363   .0000142     2.55   0.012                  .161423
     durable |   .0082781   .0093686     0.88   0.378                 .0785381
       _cons |  -9.897326   6.502693    -1.52   0.130                        .
------------------------------------------------------------------------------
```

**Epidemics**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if distype
=="Epidemic", beta

      Source |       SS       df       MS              Number of obs =     166
-------------+------------------------------           F(  7,   158) =   17.04
       Model |  275.548969     7  39.3641384           Prob > F      =  0.0000
    Residual |  365.022727   158  2.31027043           R-squared     =  0.4302
-------------+------------------------------           Adj R-squared =  0.4049
       Total |  640.571696   165   3.8822527           Root MSE      =    1.52

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .2422504   .0244992     9.89   0.000                  .622364
         phy |  -4.959192   6.521027    -0.76   0.448                -.1016828
         eco |   6.605481   4.738991     1.39   0.165                  .195848
         soc |    .727275   .6131045     1.19   0.237                 .0758833
     polity2 |  -.0858428   .0224189    -3.83   0.000                -.3059969
weightedco~x |   .0000396   .0000148     2.67   0.008                 .1940033
     durable |   .0072615   .0089644     0.81   0.419                 .0946248
       _cons |     .95644   5.456389     0.18   0.861                        .
------------------------------------------------------------------------------
```

**Floods**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if distype =="Flood",
beta

      Source |       SS       df       MS              Number of obs =     584
-------------+------------------------------           F(  7,   576) =   29.66
```

```
       Model |  486.484636     7  69.4978052           Prob > F      =  0.0000
    Residual |  1349.61571   576  2.34308283           R-squared     =  0.2650
-------------+------------------------------           Adj R-squared =  0.2560
       Total |  1836.10034   583  3.14940025           Root MSE      =  1.5307

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1450382   .0130416    11.12   0.000                 .4201336
         phy |  -.8893481   2.389367    -0.37   0.710                -.0243595
         eco |   2.358729   .9031395     2.61   0.009                 .1251968
         soc |   .6233287   .3614666     1.72   0.085                 .0646681
     polity2 |  -.0140054   .0097363    -1.44   0.151                -.0575445
weightedco~x |   .0000309   6.72e-06     4.60   0.000                  .173707
     durable |   .0012749   .0032583     0.39   0.696                 .0209013
       _cons |   .2819307   2.062688     0.14   0.891                        .
------------------------------------------------------------------------------
```

**Slides**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if distype =="Slide",
beta

      Source |       SS       df       MS              Number of obs =      50
-------------+------------------------------           F(  7,    42) =    1.64
       Model |  18.7754503     7  2.68220719           Prob > F      =  0.1518
    Residual |  68.8447862    42  1.63916158           R-squared     =  0.2143
-------------+------------------------------           Adj R-squared =  0.0833
       Total |  87.6202366    49  1.78816809           Root MSE      =  1.2803

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .0920644    .040689     2.26   0.029                 .3632211
         phy |   22.95916   12.44879     1.84   0.072                  .437523
         eco |  -3.117946   4.255373    -0.73   0.468                 -.136311
         soc |  -.7218026   1.881194    -0.38   0.703                -.0611231
     polity2 |   .0362179   .0253718     1.43   0.161                 .2084462
weightedco~x |  -2.64e-06   .0000201    -0.13   0.896                -.0205049
     durable |   .0076336   .0093532     0.82   0.419                  .151946
       _cons |  -15.93401   10.29382    -1.55   0.129                        .
------------------------------------------------------------------------------
```

**Wind Storms**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if distype =="Wind
storm", beta

      Source |       SS       df       MS              Number of obs =     431
-------------+------------------------------           F(  7,   423) =   26.55
       Model |  437.026216     7  62.4323165           Prob > F      =  0.0000
    Residual |  994.544834   423  2.35116982           R-squared     =  0.3053
-------------+------------------------------           Adj R-squared =  0.2938
       Total |  1431.57105   430    3.329235           Root MSE      =  1.5334

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1305089   .0142241     9.18   0.000                 .3943103
         phy |   9.819031   2.567942     3.82   0.000                  .336791
         eco |  -.4103971   1.054932    -0.39   0.697                -.0241313
         soc |   2.097846   .4443406     4.72   0.000                 .2003833
     polity2 |  -.0111672   .0109158    -1.02   0.307                -.0460566
weightedco~x |   .0000221   5.41e-06     4.08   0.000                 .1700231
     durable |   .0108757   .0035999     3.02   0.003                 .2141004
       _cons |  -7.632459   2.158746    -3.54   0.000                        .
------------------------------------------------------------------------------
```

Continent

Disasters that occurred in Asian countries provided the best combination of F-score and R-squared. For this sample, the physical and stability indicators are significant and in the expected direction. The regression is not biased by collinearity of heteroskedastic. However, omitted variable bias is present. The sample of African nations produced the worst goodness of fit.

**Africa**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if cont =="Africa",
beta

      Source |       SS       df       MS              Number of obs =     181
-------------+------------------------------           F(  7,   173) =    3.09
       Model |  81.7980469     7  11.6854353           Prob > F      =  0.0043
    Residual |  653.510772   173  3.77751891           R-squared     =  0.1112
-------------+------------------------------           Adj R-squared =  0.0753
       Total |  735.308819   180  4.08504899           Root MSE      =  1.9436

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .0729899   .0268622     2.72   0.007                 .1996029
         phy |  -22.61857   13.99765    -1.62   0.108                -.1387252
         eco |   12.83455   13.08416     0.98   0.328                 .0888882
         soc |  -5.301008   1.759295    -3.01   0.003                -.2637218
     polity2 |  -.0222889   .0398271    -0.56   0.576                -.0543903
weightedco~x |  -.0000335   .0000352    -0.95   0.343                -.0799709
     durable |   .0103441   .0103951     1.00   0.321                 .0844766
       _cons |   12.90554   16.33177     0.79   0.430                        .
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
     polity2 |      1.84    0.543893
         eco |      1.60    0.625630
         soc |      1.49    0.670632
         phy |      1.43    0.697022
     durable |      1.40    0.712837
weightedco~x |      1.38    0.726790
 log_aff2pop |      1.05    0.952019
-------------+----------------------
    Mean VIF |      1.46

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =     2.99
         Prob > chi2  =     0.0840

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 170) =      2.61
                  Prob > F =      0.0534
```

**Americas**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if cont =="Americas",
beta

      Source |       SS       df       MS              Number of obs =     358
-------------+------------------------------           F(  7,   350) =   14.41
       Model |  272.984514     7  38.9977877           Prob > F      =  0.0000
```

```
    Residual |  946.915686   350  2.70547339           R-squared     =  0.2238
-------------+------------------------------           Adj R-squared =  0.2083
       Total |   1219.9002   357  3.41708739           Root MSE      =  1.6448

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1556483   .0181324     8.58   0.000                 .4316255
         phy |   1.366236   3.393092     0.40   0.687                 .0576657
         eco |   .0577975   2.344017     0.02   0.980                 .0028922
         soc |  -2.720471   1.467669    -1.85   0.065                -.0884155
     polity2 |  -.0235047   .0149478    -1.57   0.117                 -.084169
weightedco~x |   .0000108   8.67e-06     1.25   0.213                 .0605929
     durable |    .000765   .0045054     0.17   0.865                 .0205335
       _cons |   .6092553   2.801426     0.22   0.828                        .
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
         phy |      9.25    0.108129
     durable |      6.59    0.151662
         eco |      6.20    0.161193
     polity2 |      1.29    0.774054
 log_aff2pop |      1.14    0.877164
weightedco~x |      1.06    0.939245
         soc |      1.03    0.974751
-------------+----------------------
    Mean VIF |      3.80

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =    14.61
         Prob > chi2  =     0.0001

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 347) =      1.08
                  Prob > F =      0.3562
```

**Asia**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if cont =="Asia",
beta

      Source |       SS       df       MS              Number of obs =     800
-------------+------------------------------           F(  7,   792) =   32.29
       Model |  653.354116     7  93.3363023           Prob > F      =  0.0000
    Residual |  2289.29414   792   2.8905229           R-squared     =  0.2220
-------------+------------------------------           Adj R-squared =  0.2152
       Total |  2942.64825   799  3.68291396           Root MSE      =  1.7002

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1341186   .0104557    12.83   0.000                 .4126009
         phy |   9.291852   2.779984     3.34   0.001                  .135144
         eco |  -1.716705   1.205728    -1.42   0.155                -.0563495
         soc |   .6429819   .3292784     1.95   0.051                 .0650655
     polity2 |  -.0019942    .008978    -0.22   0.824                -.0075846
weightedco~x |    .000023   4.87e-06     4.72   0.000                 .1550504
     durable |   .0020294    .004105     0.49   0.621                 .0163284
       _cons |  -5.125004   2.294139    -2.23   0.026                        .
------------------------------------------------------------------------------

. vif
```

```
    Variable |       VIF       1/VIF  
-------------+----------------------
         phy |      1.66    0.600847
         eco |      1.59    0.627121
     polity2 |      1.19    0.842449
         soc |      1.13    0.884724
     durable |      1.11    0.900444
weightedco~x |      1.10    0.909514
 log_aff2pop |      1.05    0.949403
-------------+----------------------
    Mean VIF |      1.26

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =     0.01
         Prob > chi2  =     0.9228

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 789) =      7.35
                  Prob > F =      0.0001
```

**Europe**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if cont =="Europe",
beta

      Source |       SS       df       MS              Number of obs =     110
-------------+------------------------------           F(  7,   102) =    4.41
       Model |   103.47486     7  14.7821229           Prob > F      =  0.0003
    Residual |  341.671895   102  3.34972446           R-squared     =  0.2325
-------------+------------------------------           Adj R-squared =  0.1798
       Total |  445.146755   109  4.08391518           Root MSE      =  1.8302

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1073617   .0359489     2.99   0.004                 .2925556
         phy |   17.68197   9.855514     1.79   0.076                 .3709994
         eco |   1.174608   1.348536     0.87   0.386                  .128594
         soc |   3.243222   2.968532     1.09   0.277                 .1293429
     polity2 |   .0430836   .0350904     1.23   0.222                 .1218879
weightedco~x |   .0000163   .0000241     0.68   0.499                 .0610499
     durable |    .013556   .0096015     1.41   0.161                 .1723402
       _cons |  -16.30611   8.734548    -1.87   0.065                        .
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF  
-------------+----------------------
         phy |      5.68    0.175979
         eco |      2.90    0.345243
     durable |      1.98    0.505031
         soc |      1.86    0.536896
     polity2 |      1.31    0.763542
 log_aff2pop |      1.28    0.784182
weightedco~x |      1.08    0.928436
-------------+----------------------
    Mean VIF |      2.30

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =     7.62
         Prob > chi2  =     0.0058
```

```
. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                  F(3, 99) =      2.31
                  Prob > F =      0.0814
```

**Oceania**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if cont =="Oceania",
beta

      Source |       SS       df       MS              Number of obs =      44
-------------+------------------------------           F(  7,    36) =    4.22
       Model |  42.4069719     7  6.05813885           Prob > F      =  0.0017
    Residual |  51.6866629    36  1.43574064           R-squared     =  0.4507
-------------+------------------------------           Adj R-squared =  0.3439
       Total |  94.0936348    43  2.18822407           Root MSE      =  1.1982

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .0328782   .0418487     0.79   0.437                 .1177744
         phy |  -16.81395   7.992016    -2.10   0.042                -.7117428
         eco |   10.32481    2.90583     3.55   0.001                 1.067455
         soc |   -22.7231   19.61556    -1.16   0.254                -.2623685
     polity2 |   .3452976   .1471061     2.35   0.025                 .5087383
weightedco~x |   .0002733   .0001492     1.83   0.075                 .3323711
     durable |  -.0108622   .0121732    -0.89   0.378                -.3019758
       _cons |   5.177203   6.175877     0.84   0.407                        .
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
     durable |      7.51    0.133229
         phy |      7.50    0.133320
         eco |      5.92    0.169060
         soc |      3.36    0.297458
     polity2 |      3.08    0.324827
weightedco~x |      2.16    0.463429
 log_aff2pop |      1.47    0.678994
-------------+----------------------
    Mean VIF |      4.43

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                  F(3, 33) =      0.64
                  Prob > F =      0.5939

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =      0.64
         Prob > chi2  =      0.4250
```

Time Period

The model fits best the decades 1970-80 and 1980-90. In both samples, the conflict index is significant and in the expected direction. While the polity index is significant and in the predicted direction for the most recent decade, the durability index is significant and in the expected direction for the latter decade. Interestingly, the most recent disasters are not well explained by the model.

**1990-Pres.**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if year > 1990, beta

      Source |       SS       df       MS              Number of obs =     413
-------------+------------------------------           F(  7,   405) =   11.81
       Model |  266.945474     7  38.1350678           Prob > F      =  0.0000
    Residual |  1308.12998   405  3.22995058           R-squared     =  0.1695
-------------+------------------------------           Adj R-squared =  0.1551
       Total |  1575.07546   412  3.82299868           Root MSE      =  1.7972

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .0976335     .01677     5.82   0.000                 .2747925
         phy |   6.191878    3.18819     1.94   0.053                 .2030868
         eco |   .8195003   .7963518     1.03   0.304                 .0700218
         soc |   1.006756   .4581032     2.20   0.029                 .1061671
     polity2 |  -.0097119   .0152416    -0.64   0.524                -.0334285
weightedco~x |   5.86e-06   .0000126     0.47   0.642                  .021786
     durable |   .0051691    .004222     1.22   0.222                 .0996078
       _cons |   -4.49964   2.770019    -1.62   0.105                        .
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF  
-------------+----------------------
         phy |      5.33    0.187537
     durable |      3.23    0.309816
         eco |      2.26    0.442911
     polity2 |      1.34    0.745089
         soc |      1.14    0.878691
 log_aff2pop |      1.09    0.920482
weightedco~x |      1.07    0.936731
-------------+----------------------
    Mean VIF |      2.21

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =     2.71
         Prob > chi2  =     0.0998

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 402) =      2.07
                  Prob > F =      0.1033
```

**1980-90**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if year > 1980 & year
< 1990, beta

      Source |       SS       df       MS              Number of obs =     501
-------------+------------------------------           F(  7,   493) =   22.76
       Model |  426.327737     7  60.9039624           Prob > F      =  0.0000
    Residual |  1319.39577   493  2.67625917           R-squared     =  0.2442
-------------+------------------------------           Adj R-squared =  0.2335
       Total |  1745.72351   500  3.49144702           Root MSE      =  1.6359

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1111908   .0133728     8.31   0.000                 .3406788
         phy |   5.416855     2.9808     1.82   0.070                  .133223
         eco |   2.725426    2.09329     1.30   0.194                 .0901505
         soc |   1.006282   .4304755     2.34   0.020                 .0953298
     polity2 |  -.0332161   .0116067    -2.86   0.004                -.1284194
weightedco~x |   .0000172   5.70e-06     3.02   0.003                 .1271661
```

```
     durable |   .0073035   .0037466     1.95   0.052                  .1063702
       _cons |  -5.680817   2.342041    -2.43   0.016                         .
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF  
-------------+----------------------
         phy |      3.51    0.285248
         eco |      3.13    0.319761
     durable |      1.94    0.514886
     polity2 |      1.31    0.761332
weightedco~x |      1.15    0.867285
 log_aff2pop |      1.10    0.913183
         soc |      1.08    0.921802
-------------+----------------------
    Mean VIF |      1.89

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =     0.29
         Prob > chi2  =     0.5934

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 490) =      3.11
                  Prob > F =      0.0260
```

**1970-80**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if year > 1970 & year
< 1980, beta

      Source |       SS       df       MS              Number of obs =     267
-------------+------------------------------           F(  7,   259) =   12.99
       Model |   305.33711     7  43.6195872           Prob > F      =  0.0000
    Residual |  869.371234   259  3.35664569           R-squared     =  0.2599
-------------+------------------------------           Adj R-squared =  0.2399
       Total |  1174.70834   266  4.41619678           Root MSE      =  1.8321

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
 log_aff2pop |   .1606146   .0201217     7.98   0.000                  .4493783
         phy |   11.54212   5.495526     2.10   0.037                   .251235
         eco |    2.81279   5.272634     0.53   0.594                  .0433882
         soc |   .0932851   .8477804     0.11   0.912                  .0062144
     polity2 |     .00533   .0180138     0.30   0.768                  .0189595
weightedco~x |   .0000427   .0000117     3.66   0.000                  .2048202
     durable |   .0173022   .0078417     2.21   0.028                  .2188581
       _cons |  -12.28579   5.107716    -2.41   0.017                         .
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF  
-------------+----------------------
         phy |      5.01    0.199695
     durable |      3.44    0.290426
         eco |      2.31    0.431968
     polity2 |      1.44    0.695935
         soc |      1.12    0.895860
 log_aff2pop |      1.11    0.901553
weightedco~x |      1.10    0.910139
-------------+----------------------
    Mean VIF |      2.22

. hettest
```

```
Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =    11.54
         Prob > chi2  =    0.0007

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 256) =      3.38
                  Prob > F =      0.0189
```

**Previous to 1970**

```
.  regress log_kil log_aff2pop phy eco soc polity2 weighted durable if year < 1970

      Source |       SS       df       MS              Number of obs =     190
-------------+------------------------------           F(  7,   182) =    6.17
       Model |  153.783274     7  21.9690391           Prob > F      =  0.0000
    Residual |  647.688301   182  3.55872693           R-squared     =  0.1919
-------------+------------------------------           Adj R-squared =  0.1608
       Total |  801.471575   189  4.24059035           Root MSE      =  1.8865

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1289896   .0260282     4.96   0.000     .0776338    .1803454
         phy |  -1.936266   11.38137    -0.17   0.865    -24.39266    20.52013
         eco |    10.7227   36.18578     0.30   0.767    -60.67488    82.12028
         soc |    3.19274     1.5407     2.07   0.040     .1528088    6.232672
     polity2 |  -.0264744   .0217087    -1.22   0.224    -.0693076    .0163588
weightedco~x |   .0000231   .0000113     2.06   0.041     9.33e-07    .0000454
     durable |  -.0111484   .0105761    -1.05   0.293    -.0320159    .0097192
       _cons |  -6.106576   29.27587    -0.21   0.835    -63.87032    51.65717
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
         eco |      4.66    0.214365
         phy |      4.25    0.235514
     durable |      2.56    0.389873
     polity2 |      1.45    0.691788
         soc |      1.36    0.736832
weightedco~x |      1.23    0.810632
 log_aff2pop |      1.10    0.908133
-------------+----------------------
    Mean VIF |      2.37

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 179) =      0.51
                  Prob > F =      0.6793

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =     1.27
         Prob > chi2  =     0.2600
```

<u>Asian during 1970-90 versus 1970-pres: A hint regarding the missing variable</u>

Noteworthy, a sample of Asian disasters between 1970 and 1990 produced results consistent with the large sample but not limited by econometric findings.

Indeed, comparing two samples based on Asian countries indicates a direction for further research to improve the model. While the sample that includes the time period 1970-90 does not possess colinearity, heteroskedasticity, or omitted variable bias, the sample that ranges from 1970 to present does possess omitted variable bias. This finding indicates that a variable(s) that did not matter much before 1990 has changed at that point and matter for the model. Such a variable, once identified, will likely improve the diagnostics for the larger sample.

```
. regress log_kil log_aff2pop phy eco soc polity durable weighted if cont =="Asia" & year
> 1970 & year < 1990

      Source |       SS       df       MS              Number of obs =     444
-------------+------------------------------           F(  7,   436) =   25.02
       Model |  445.448197     7  63.6354568           Prob > F      =  0.0000
    Residual |  1109.03615   436  2.54366089           R-squared     =  0.2866
-------------+------------------------------           Adj R-squared =  0.2751
       Total |  1554.48435   443  3.50899401           Root MSE      =  1.5949

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1424005   .0128238    11.10   0.000     .1171963    .1676047
         phy |   6.328518   4.240908     1.49   0.136    -2.006647    14.66368
         eco |   3.002253   3.644933     0.82   0.411    -4.161571    10.16608
         soc |   .8377212   .4493452     1.86   0.063    -.0454308    1.720873
     polity2 |  -.0026443   .0127338    -0.21   0.836    -.0276715     .022383
     durable |   .0113605   .0057595     1.97   0.049     .0000407    .0226804
weightedco~x |   .0000174   5.55e-06     3.14   0.002     6.49e-06    .0000283
       _cons |  -7.069094   3.197246    -2.21   0.028    -13.35303   -.7851631
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
         phy |      2.06    0.484604
         eco |      2.05    0.487817
     polity2 |      1.36    0.734792
weightedco~x |      1.21    0.823590
     durable |      1.17    0.856125
         soc |      1.13    0.886465
 log_aff2pop |      1.06    0.944559
-------------+----------------------
    Mean VIF |      1.43

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =     0.10
         Prob > chi2  =     0.7512

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 433) =      1.75
                  Prob > F =      0.1560


. regress log_kil log_aff2pop phy eco soc polity durable weighted if cont =="Asia" & year
> 1970

      Source |       SS       df       MS              Number of obs =     702
-------------+------------------------------           F(  7,   694) =   32.77
       Model |  630.732781     7  90.1046829           Prob > F      =  0.0000
    Residual |  1908.07358   694  2.74938556           R-squared     =  0.2484
```

```
-------------+------------------------------           Adj R-squared =  0.2409
       Total |  2538.80636   701  3.62169239           Root MSE      =  1.6581

------------------------------------------------------------------------------
     log_kil |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 log_aff2pop |   .1378325   .0108877    12.66   0.000     .1164557    .1592093
         phy |   9.638273   2.787205     3.46   0.001     4.165909    15.11064
         eco |  -2.014285   1.190855    -1.69   0.091    -4.352395    .3238259
         soc |   .8841544   .3334102     2.65   0.008     .2295409    1.538768
     polity2 |  -.0024627   .0096089    -0.26   0.798    -.0213288    .0164034
     durable |   .0068323   .0041284     1.65   0.098    -.0012733    .0149378
weightedco~x |   .0000239   4.95e-06     4.84   0.000     .0000142    .0000336
       _cons |  -5.462409   2.292306    -2.38   0.017    -9.963096   -.9617219
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF  
-------------+----------------------
         phy |      1.65    0.604893
         eco |      1.62    0.617251
     polity2 |      1.22    0.819047
         soc |      1.15    0.871850
     durable |      1.11    0.897601
weightedco~x |      1.11    0.902193
 log_aff2pop |      1.05    0.947879
-------------+----------------------
    Mean VIF |      1.27

. hettest

Cook-Weisberg test for heteroskedasticity using fitted values of log_kil
     Ho: Constant variance
         chi2(1)      =     0.02
         Prob > chi2  =     0.8934

. ovtest

Ramsey RESET test using powers of the fitted values of log_kil
       Ho:  model has no omitted variables
                 F(3, 691) =      6.24
                  Prob > F =      0.0003
```

## Appendix D: Using the regressions results to predict disaster impact.

Predicting the impact of a natural disaster is one potential application of research on the statistical determinants of natural disasters. The information obtained from these calculations will help disaster relief planners and field workers estimate magnitude of the task before them, and, as such, plan accordingly. Naturally, the utility of this information is limited by precision and accuracy of the data and the analysis. The predictions below are based on preliminary calculations and are presented as examples of possible applications of the regression analysis.

Example 1: Hurricane Isabelle impacts the United States.

During the writing of this thesis, a major hurricane impacted of east coast of the United States. Previous to the landfall of this disaster the news channels reported that an estimated 1 million people will be affected by this natural disaster. Using this estimate of the people affected and the known values of the other indicators, we can estimate the expected number of people killed by the disaster. Note that limitations of the dataset meant that current values of population and each of the indexes was extrapolated from the available data.

Using the Clarify software (described at the end of Chapter 3), the model predicts that between 25 and 74 people were killed during this disaster:

```
. simqi, tfunc(exp) listx

You have set the following values for the explanatory variables:
-------------------------------------------------------
 Variable |          Value              Description
----------+--------------------------------------------
      eco |            .5429622        .5429622
 log~2pop |            15.06874  log(1000000^2/285581
      phy |            .6928783        .6928783
      pol |                .001          0.001
      soc |            .0326193        .0326193
-------------------------------------------------------

Quantities of interest based on those explanatory values:

      Quantity of Interest |      Mean       Std. Err.    [95% Conf. Interval]
---------------------------+---------------------------------------------------
           E[exp(log_kil)] |   43.60254      13.6238     24.55021    73.73593
```

Works Cited

AlertNet, "Same errors recur despite quake lessons learnt." June 2, 2003. Available on the World Wide Web at http://www.reliefweb.int/w/rwb.nsf/6686f45896f15dbc852567ae00530132/3ffdd67aa48f94fec1256d3a003ffbd4?OpenDocument (Accessed July 10, 2003.)

Alexander, David. *Confronting Catastrophe.* New York: Oxford University Press (2000).

Anderson, Mason. "Death Toll Rises in Central Europe's Epic Floods." Disasterrelief.org (Aug. 19, 2002). Available on the World Wide Web at http://www.disasterrelief.org/Disasters/020819europefloods/ (Accessed July 10, 2003.)

Annan, Kofi. *Facing the Humanitarian Challenge: Towards a culture of prevention.* New York: The United Nations (1999).

Banks, Arthur S. *CROSS-NATIONAL TIME SERIES, 1815-1973 [Computer file]*. ICPSR ed. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [producer and distributor], 1976.

Baum, Matthew A. and David A. Lake "The political economy of growth: democracy and human capital." *American Journal of Political Science*. April 2003 v47 i2 p333(15)

Bourma, M., Kouvats, R., Goubet, S., Cox, J., and Haines, A. "Global Assessment of El-Nino's Disaster Burden." *The Lancet*. Vol 350, pp 1435-38 (November 1997.)

Calvi-Parisetti, Piero and Kiniger-Passigli, Donato. "Coordination in Crisis Response and Reconstruction." International Labour Organization (2003). Available on the World Wide Web at www.reliefweb.org (Accessed June 24, 2003.)

CARE USA. "2000 Annual Report." Washington DC: CARE USA (2000).

Clarke, Lee and Short, James F. "Social Organizations and Risk: Some current controversies." *Annual Review of Sociology.* Vol. 19, pp. 375-399 (1993.)

Davis, Morris and Steven T. Seitz. "Disasters and Governments." *Journal of Conflict Resolution*. Vol. 26, Iss. 3, pp. 547-568 (1982.)

Disasterrelief.org. "Mozambique Death Toll in the Thousands." Posted 29 Feb 2000. Available on the World Wide Web at http://www.disasterrelief.org/Disasters/000229mozambique3/ (Accessed on July 10, 2003.)

EM-DAT, 2000. "The OFDA/CRED International Disaster Database." Université catholique de Louvain, Brussels, Belgium. Available on the Web at http://www.cred.be/emdat/natindex.htm

EQE International. "Izmit, Turkey Earthquake of August 17, 1999 (M7.4): An **EQE** Briefing," EQE International (1999.) Available on the World Wide Web at http://www.eqe.com/revamp/izmitreport/index.html (Accessed July 10, 2003.)

EQE International. "The January 17, 1995 Kobe Earthquake: An EQE Summary Report." EQE International (April, 1995). Available on the World Wide Web at http://www.eqe.com/publications/kobe/kobe.htm (Accessed July 10, 2003.)

FreedomHouse. "FH Country Ratings." Available on the web at http://www.freedomhouse.org/ratings/ (Accessed November 13, 2003.)

Freeman, Paul K., Martin, Leslie A., Mechler, Reinhard, and Warner, Koko with Haussman, Peter. *Catastrophe and Development: Integrating Natural Catastrophes into Development Planning.* World Bank Disaster Management Facility, Working Paper Series No. 4. Washington: The World Bank (2002.)

Glantz, Michael, ed. *Once Burned, Twice Shy: Lessons learned from the 1997-98 El Nino.* Japan: United Nations University (2001.)

Hennekens, Charles and Buring, Julie. *Epidemiology in Medicine.* Edited by Sherry Mayrent. Boston: Little, Brown and Company (1987.)

The International Federation for Red Cross and Red Crescent Societies (IFRC.) "Operations – Overview of Trends." http://www.ifrc.org/cgi/pdf_statistic.pl?Opreview.pdf Available on the World Wide Web (Accessed June 25, 2003.)

International Federation of the Red Cross. "Mozambique: Special focus on floods." IFRC (Feb. 16, 2001.) Available on the Web at http://www.ifrc.org/where/country/cn6.asp?iYear=2&xFlag=2&countryid=120&view=1. (Accessed July 10, 2003.)

The International Federation for Red Cross and Red Crescent Societies (IFRC.) "China: Flash Floods." *Operations Update.* Dec. 31, 2002. Available on the World Wide Web at http://www.ifrc.org/cgi/pdf_appeals.pl?02/160205.pdf (Accessed June 25, 2003.)

The International Federation for Red Cross and Red Crescent Societies (IFRC.) "Indonesia: Earthquake." *Operations Update.* Dec. 20, 2002. Available on the World

Wide Web at http://www.ifrc.org/cgi/pdf_appeals.pl?02/300203.pdf (Accessed June 25, 2003.)

The International Federation for Red Cross and Red Crescent Societies (IFRC.) "Uzbekistan: Drought." *Operations Update.* Feb. 11, 2002. Available on the World Wide Web at http://www.ifrc.org/cgi/pdf_appeals.pl?01/270102.pdf (Accessed June 25, 2003.)

The International Federation for Red Cross and Red Crescent Societies (IFRC.) *World Disaster Report, 2002.* Available on the World Wide Web at http://www.ifrc.org/publicat/wdr2002/

Jalali, Rita. "Civil Society and the State: Turkey after the Earthquake." *Disasters*. Vol. 26, Iss. 2, pp. 120-139 (2002.)

King, Gary, Michael Tomz, and Jason Wittenberg. 2000. "Making the Most of Statistical Analyses: Improving Interpretation and Presentation." American Journal of Political Science 44, no. 2 (April): 347-61.

Kinzer, Stephan. "Turkey's Political Earthquake." *Middle East Quarterly*. Vol 8, Iss 4, pp. 41-48 (2001.)

Kreps, G. A. "Sociological Inquiry and Disaster Research." *Annual Review of Sociology.* Vol. 10 (1984), pp. 309-330.

Kreps, Gary A. and Bosworth, Susan. "Disaster, Organizing, and Role Enactment: A structural Approach." *American Journal of Sociology*. Vol. 99, Iss 2 (Sept. 1993), pp. 428-463.

Lake, David A. and Matthew A. Baum. "The Invisible Hand Of Democracy: Political Control and the Provision of Public Services." *Comparative Political Studies*, August 2001 v34 i6 p587

Long, Cynthia. "Search for Survivors Continues in Quake-Ravaged India." Disaster.org (Jan. 27, 2001.) Available on the World Wide Web at http://www.disasterrelief.org/Disasters/010127indiaquake3/ (Accessed July 10, 2003.)

Morris, Davis and Steven T. Seitz. "Disasters and Governments." *The Journal of Conflict Resolution.* Vol. 26, Iss. 3 (Sept 1982), pp. 547-568.

Olson, Mancur. "Dictatorship, Democracy, and Development." *American Political Science Review.* Vol. 87, No. 3 (Sept 1993), pp 567-576.

Rekenthaler, Doug. "Bangladesh Drowning Under a Sea of Flood Waters, Sewage." Disasterrelief.org (24 Sep 1998.) Available on the World Wide Web at http://www.disasterrelief.org/Disasters/980916Bangladesh/ (Accessed July 10, 2003.0

Rocha, Jose L. and Ian Christoplos. "Disaster Mitigation and Preparedness on the Nicaraguan Post-Mitch Agenda." *Disasters*. Vol. 25, Iss. 3, pp. 240-250 (2001.)

Shehabuddin, Elora. "Bangladesh in 1998: democracy on the ground." *Asian Survey*. Vol. 39, Iss. 1, pp. 148-55 (1999.)

The SPHERE Project. *The Humanitarian Charter and Minimum Standards in Disaster Response.* Available on the World Wide Web at http://www.sphereproject.org/handbook_index.htm (Accessed June 25, 2003.

Tomz, Michael; Jason Wittenberg, and Gary King. 2003. "CLARIFY: Software for Interpreting and Presenting Statistical Results. Version 2.1." Stanford University, University of Wisconsin, and Harvard University. January 5. Available at http://gking.harvard.edu/

Quarantelli, E.L. and Dynes, Russell R. "Response to Social Crisis and Disaster." *Annual Review of Sociology.* Vol. 3 (1977), pp. 23-49.

The United Nations Development Program. *Human Development Report 1994: New Dimensions of Human Security.* New York: The United Nations (1994). New York: Oxford University Press (1994). Available on the World Wide Web at http://hdr.undp.org/reports/global/1994/en/ (Accessed June 25, 2003.)

The United Nations Development Program. *From Relief to Recovery: The Gujarat experience."* New York: The United Nations (2001).

The United Nations Inter-Agency Secretariat for the International Strategy for Disaster Reduction. *Living with Risk: A global review of disaster reduction initiatives.* Geneva: The United Nations (2002).

The United Nations International Strategy for Disaster Reduction. "Natural Disasters and Sustainable Development: Understanding the links between development, environment, and natural disasters." Available on the World Wide Web at http://www.who.int/disasters/tg.cfm?doctypeID=60 (Accessed on June 25, 2003.)

The United Nations, Mozambique. "Mozambique Floods 2001: Final report." Untied Nations (May 2001). Available on the Web at http://www.unsystemmoz.org/news/flood/reports2001/default.asp (Accessed July 10, 2003.)

The United Nations Organization for the Coordination of Humanitarian Affairs (UNOCHA). *Symposium on the Best Practices in Humanitarian Information Exchange.* Available on the World Wide Web at http://www.reliefweb.int/symposium/ (Accessed June 25, 2003.)

Wijkman , Anders and Timberlake, Lloyd. *Natural Disasters: Acts of God or Acts of Man.* Washingotn DC: The International Institute for Environment and Development (1984).

Wisner, Ben. "Risk and the Neoliberal State: Why Post-Mitch Lessons Didn't Reduce El Salvador's Earthquake Losses." *Disasters*. Vol. 25, Iss. 3, pp. 251-268 (2001.)

The World Bank. "A Preliminary Assessment of Damage from the Flood and Cyclone Emergency of February-March 2000." The World Bank (March 2000). Available on the Web at http://www.unsystemmoz.org/wb/flood_damage/WB_flood_damages.asp (Accessed on July 10, 2003).

The World Bank. *World Development Report 2000/2001: Attacking poverty.* New York: Oxford University Press, 2001.

Yates, Roger; Alam, Kurshid; Twigg, John; and Hoyois, Debarati Guha-Sipir Phillipe. "Development at Risk." Belgium: CRED (2003.) Available on the World Wide Web at http://www.cred.be/centre/intro.htm

# VITA

A native of New Orleans, LA, Ezra Boyd learned his first lessons about life growing up in the 8th Ward and attending McDonough #15 Elementary School. The celebration of diversity and creativity that he viewed early on guided many of his important decisions later in life. Ezra's mother, Janet, is a Registered Nurse and Registered Holistic Nurse whose other interests include art and nature. She currently resides on 15 acres of forest along Silver Creek outside of Franklinton, LA. Ezra's father, Richard, is reporter for the Times-Picayune and writes poetry in his spare time. His favorite poet is Ezra Pound. Together, his parents taught Ezra to be curious, creative, and patient.

After graduating Mandeville High School, Ezra attended the University of New Orleans. Astronomy 1001 with Prof. C. Gregory Seab was his first class at 8:00 MWF. Inspired by this class, Ezra pursued physics and astronomy with passion. He transferred to the University of Chicago, and received a Bachelor of Arts in Physics with Honors. Prof. Robert Rosner oversaw Ezra's undergraduate thesis on "The Observed Coronal Loop Width Distribution as Observed by TRACE." After earning this degree, Ezra attended the Pennsylvania State University as a graduate student in Astronomy and Astrophysics for two semesters.

During the break between programs, Ezra took a month long backpacking trip around Europe after which he spent a few days in New York City. While in New York, Ezra toured the United Nations building. During this visit, Ezra realized that dedicated researchers and policy makers are successfully using rational thought and the scientific method to overcome many important global problems, including epidemics, famines, conflict, and natural disasters. In the months that followed, Ezra spent much of his free time researching the work of organizations like the International Federation of the Red Cross, the United Nations Development Programs, and CARE, International. During this time, Ezra realized that his new interests demanded a career change.

Following a brief stint at The School of Public Health at Tulane University, Ezra returned to his place of academic origins as a graduate student in the Department of Political Science at the University of New Orleans. While pursuing his Master of Arts degree, Ezra has benefited greatly from his companionship with Profs. Marc Rosenblum and Brandon Prins. These two educators and researchers have endowed Ezra with important skills and knowledge that are applicable in many areas of life.

In October 2000, while filling out graduate school applications in the Mandeville Library, Ezra met his love and companion, Penny Maria Hecker. Currently, Penny is a librarian at the Tulane University Online Louisiana Knowledge Center, and they share a modest home in Slidell, LA.

Ezra remains committed to utilizing science and technology as tools against unnecessary and widespread human loss and tragedy. In his spare time, Ezra enjoys developing disaster response related business plans.

UNIVERSITY OF NEW ORLEANS

# MASTER'S EXAMINATION REPORT
## Thesis

CANDIDATE: Ezra Clay-Kelly Boyd

MAJOR PROGRAM: Political Science

TITLE OF THESIS: The Political Determinants of the Impact of Natural Disasters: A Cross-Country Comparison

APPROVED

| | |
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