Developing a Schema for Calculating Social Vulnerability to Climate Change

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SCRiM — an NSF-sponsored research network for Sustainable Climate Risk Management

Abstract

Vulnerability is defined as the extent to which a natural or social system is susceptible to sustaining damage from climate change (Watson et al. 1997). Ethical factors contributing to vulnerability are endogenous in society and often regionally based. However, spatial complexities underlying the relationship between humans and the environment have long been recognized on a scientific level, rather than from an ethical standpoint. Developing a social vulnerability analysis that exceeds those solely built upon the scientific level could prove to be useful in the implementation of adaptation measures and policy formation. This report reviews how available models have calculated social vulnerability to climate change, and documents further ethical factors not currently addressed in said models.

Introduction

Vulnerability is a function of both the physical system's sensitivity to changes in climate and the ability of the societal system to adapt to said changes. Recently, international coalitions have been formed to combat climate change. These organizations have produced assessments that define regional vulnerabilities to environmental issues for the sake of informing adaptation policies. However, such assessments neglect to take the complexity of regional dynamics underlying diverse societal systems into account. Therefore, the purpose of this study is to present a comprehensive assessment of population characteristics that affect vulnerability to climate change.

Research Question

What are the current factors to calculate social vulnerability to climate change and how can they be altered to be more comprehensive?

Methods

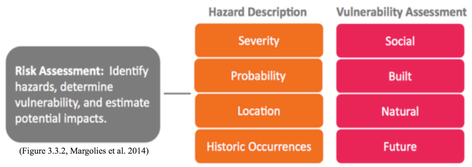
There are a number of ways in which to create a well-researched representation of the term "social vulnerability". It was essential to establish the history detailing the relationship between environmental issues and ethics. This was done by compiling and analyzing various literatures that depicted such a relationship. The texts were chosen based on their holistic summary of the information associated with risk to climate change. In an effort to report current representations of social vulnerability, reports of plans were collected from sources ranging from New York City's Comprehensive Waterfront Plan to the Social Vulnerability Index that will soon be used by FEMA's Hazus-MH. Furthermore, a risk insurance firm was studied for the sake of understanding risk from an insurers perspective. A more comprehensive social vulnerability analysis was then created that incorporated extensive factors, proving to be an invaluable tool for policy makers and practitioners. This tool was then compared to how inclusive past reports and firms have been both scientifically and ethically.

Results of Prior Models

Vision 2020: NYC Comprehensive Waterfront Plan

- Vulnerability Assessment:
- 1. Social Environment: the hazard's effect on the general public, including public health impacts and potential fatalities, with an emphasis on vulnerable and special needs populations
- 2. Build Environment: structural vulnerabilities of the city's building stock and infrastructure. For flooding, coastal storms, and earthquakes, this section also includes a quantitative calculation of loss estimates
- 3. Natural Environment: the hazard's impact on the natural resources, ecosystems, and recreational areas
- 4. Future Environment: how trends such as climate change, population growth, aging infrastructure, and new technology may change the risk and/or impacts of hazards in the future

Risk Assessment Diagram



(Figure 3.3.2, Margolies et al. 2014)

Boston, Massachusetts Climate Change Adaptation Report

- Vulnerable populations are broadly defined as those who are more susceptible to the effects of climate change, and for whom adaptive change will be more difficult. Whether by virtue of economic status, social capacity and resources, health, age, or geography
- In order to determine vulnerability assessments, thorough risk and vulnerability assessments are needed for the following:
  - Existing critical infrastructure
  - Economic sectors
  - Vulnerable groups or populations, including economically disadvantaged communities; densely-populated areas; the elderly, infirmed, and young; and non-English speaking or English-as-second language groups
  - Natural habitats and ecosystems
  - Community-specific analyses, including local hazards and threats; critical local facilities; local public and private water supplies; businesses; homes and the built environment; cultural and historical sites; and crucial local natural resources

University of South Carolina's Social Vulnerability Index of the United States

- Social vulnerability is represented as the social, economic, demographic, and housing characteristics that influence a community's ability to respond to, cope with, recover from, and adapt to environmental hazards.
- This index synthesizes 30 socioeconomic variables, which the research literature suggests contribute to reduction in a community's ability to prepare for, respond to, and recover from hazards. The Social Vulnerability Index data sources include primarily those from the United States Census Bureau.

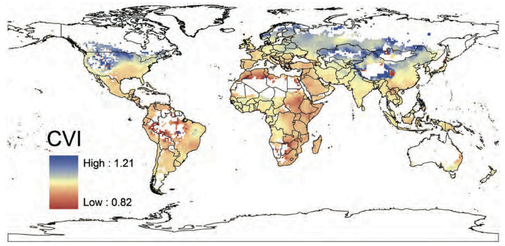
Social Vulnerability Index Variables from 2006-2010 (Table 1, Hazards and Vulnerability Research Institute, 2013)

VARIABLE	DESCRIPTION
QBLACK	Percent Black
QNATAM	Percent Native American
QASIAN	Percent Asian
QHISP	Percent Hispanic
QAGEDEP †	Percent of Population Under 5 years Old or 65 and Over
QFAM †	Percent of Children Living in Married Couple Families
MEDAGE	Median age
QSSBEN	Percent of Households Receiving Social Security
QPOVTY	Percent Poverty
QRICH200K	Percent of Households Earning > $200,000 Annually
PERCAP	Per Capita Income
QESL †	Percent Speaking English as a Second Language with Limited English Proficiency
QFEMALE	Percent Female
QFHH	Percent Female Headed Households
QNRRES	Percent of Population Living in Nursing and Skilled-nursing Facilities
HOSPTPC	Hospitals Per Capita (County, Tract Levels ONLY)
QNOHLTH †	Percent of Population Without Health Insurance
QED12LES	Percent with Less Than 12th Grade Education
QCVLUN	Percent Civilian Unemployment
QURBAN	Percent Urban Population (County, Tract Levels ONLY)
POPDENS	Population per Square Mile (Block Group Level ONLY)
PPUNIT	People Per Unit
QRENTER	Percent Renters
MDHSEVAL †	Median House Value
MDGRRENT †	Median Gross Rent
QMOHO	Percent Mobile Homes
QEXTRCT	Percent Employment in Extractive Industries
QSERV	Percent Employment in Service Industries
QFEMLBR	Percent Female Participation in Labor Force
QNOAUTO †	Percent of Housing Units with No Car

† Denotes new variables included in the SoVI 2006-2010

Jason Samson: Geographic Disparities and Moral Hazards in the Predicted Impacts of Climate Change on Human Populations

- Incorporates three variables into climate exposure/vulnerability:
- 1. Regional relationships between populations and climate (which looks at the four most prominent climate variables with a relationship to human population density (annual mean temperature, mean temperature diurnal range, total annual precipitation, and precipitation seasonality)
- 2. The direction and magnitude of regional climate change
- 3. Current and predicted demographic trends

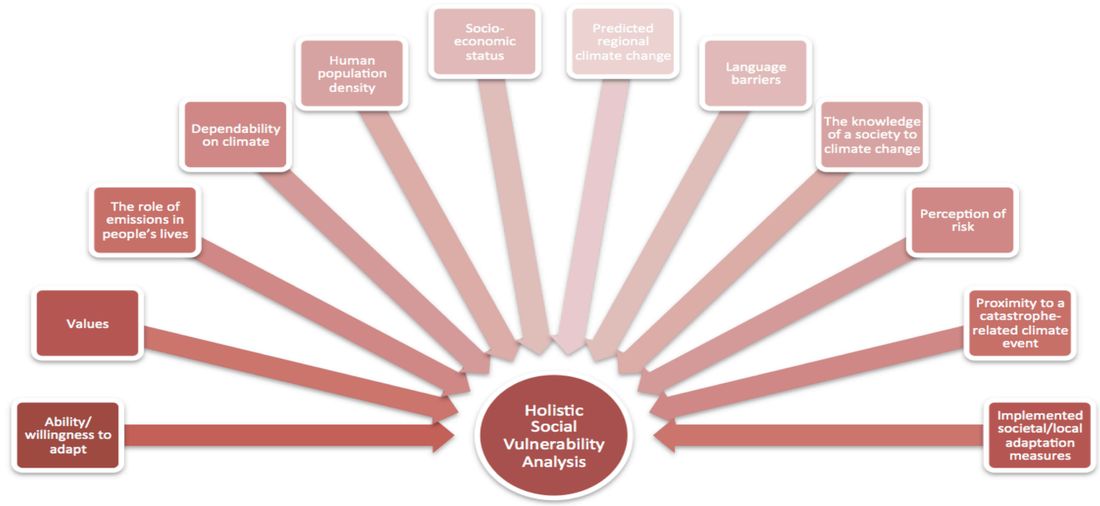


" Climate vulnerabilities index (CVI) expressed as climate-consistent annual growth rate (λ_i; see equation 4) based on current human density–climate relationships (Fig. 3) and a 2050 climate forecast (Fig. S3a). Climate-consistent annual growth rates of less than one, indicated in red, represent negative growth and high vulnerabilities, while changes in annual growth rates of greater than one, indicated in blue, represent positive growth and low vulnerabilities. White regions correspond to human density values of zero in the global gridded population database. " (Figure 4, Samson et al. 2014).

Global Risk Consultants: A risk insurance firm

- As an independent, full-service loss control firm, GRC specializes in risk analysis and property loss control. They offer a wide array of services that allows them to understand risk under various contexts: Fire Protection Engineering, Fire Inspections, Boiler and Machinery Engineering, Boiler Inspections, Boiler and Pressure Vessel Inspections, Jurisdictional Boiler and Pressure Vessel Inspections, Infrared Thermography, Ultrasonic Testing and Natural Hazards Analysis
- Probability is a significant factor in risk management decisions and directly correlates to vulnerability. In general, standard property loss control industry practices appear to ignore probabilities in preparing loss estimates. However, there are implied probabilities in loss estimate definitions like Anticipated Probable Loss, Probable Maximum Loss, and Maximum Foreseeable Loss

My Model



Discussion & How the Models Compare

	Vision 2020: NYC Comprehensive Waterfront Plan	Boston, Massachusetts Climate Change Adaptation Report	University of South Carolina's Social Vulnerability Index of the United States	Jason Samson: Geographic Disparities and Moral Hazards in the Predicted Impacts of Climate Change on Human Populations	Global Risk Consultants: A Risk Insurance Firm
Ability/Willingness to Adapt					
Values					
The Role of Emissions in People's Lives					
Dependability on Climate					
Human Population Density					
Socio-economic Status					
Predicted Regional Climate Change					
Language Barriers					
The Knowledge of a Society to Climate Change					
Perception of Risk					
Proximity to a Catastrophe-Related Climate Event					
Implemented Societal/ Local Adaptation Measures					

Yes
No
Not Applicable

The research indicated that the five models investigated were singular in thought. They neglected to take various ethical ideals into account and instead focused solely on scientific principles. These results suggest that this is one of the few studies that use scientific data in addition to ethical data.

Ethical theory and its relation to climate change has recently attracted growing interest, arguably following the publication of Stephen Gardiner's 2004 article, *Ethics and Global Climate Change*. Albeit the article successfully drew attention to the lack of moral philosophy in climate change, ethics has yet to be seen in the current models depicting social vulnerability to climate change. Hence, in order to successfully determine those populations who are most vulnerable, current social vulnerability models must take ethical factors such as perception of risk and values into account. Such factors will allow for modelists to determine who will have more difficulty adapting to climate change. This will then convey the changes in beliefs necessary of a highly vulnerable population.

Conclusion

Effective models for calculating social vulnerability to climate change can be built through an interdisciplinary nature that takes scientific and economic reasoning into account in addition to ethical reasoning. Ethical elements inherent in any society contribute to restraining the successful adaptive response of society and thus must be considered when developing a social vulnerability index or report outlining such limiting factors. The purpose of this study was to develop a model that improves the current methods for calculating social vulnerability to environmental issues. This was done by incorporating regional ethical standpoints that were a result of the different priorities and values held within society. The role of ethics and its manifestation in the current models for calculating social vulnerability is critical and characterizes the ability of a society to adapt to climate change.

References

Adger, W. Neil, et al. "Are there social limits to adaptation to climate change?." *Climatic change* 93.3-4 2009. 335-354.

Fischhoff, Baruch. "Risk Perception and Communication." *Oxford Textbook of Global Public Health* 2015. 893-906. *Global Risk Consultants*. June 2015. Web. 24 June 2015.

Gardiner, Stephen M. (2004). Ethics and global climate change. *Ethics* 114 (3):555-600.

Jamieson, Dale. "Ethics, Public Policy, and Global Warming." *Morality's Progress: Essays on Humans, Other Animals, and the Rest of Nature*. 2nd ed. Vol. 17. Oxford: Sage Publications, 1992. 139-53. Print.

Samson, Jason, D. Berteaux, B. J. McGill, and M. M. Humphries. *Geographic Disparities and Moral Hazards in the Predicted Impacts of Climate Change on Human Populations. Global Ecology and Biogeography*. Blackwell Publishing Ltd, 2011. Web. 12 July 2015.

Shue, Henry. "Subsistence Emissions and Luxury Emissions." *Climate Justice: Vulnerability and Protection*. 1st ed. Vol. 15. Cambridge: Basil Blackwell, 1993. 39-60. Print.

"SoVI Frequently Asked Questions." *SoVI Frequently Asked Questions*. Hazards and Vulnerability Research Institute, 30 Oct. 2013. Web. 24 July 2015.

United States of America. Adaptation Advisory Committee. Executive Office of Energy and Environmental Affairs. *Massachusetts Climate Change Adaptation Report*. By David Cash. Boston, MA: Commonwealth of Massachusetts, Executive Office of Energy and Environmental Affairs, 2011. Print.

United States of America. Office of Energy Management. *2014 NEW YORK CITY What Is a Hazard Mitigation Plan? A Comprehensive Document That: Profiles Natural and Man-made Hazards. Assesses the City's Vulnerability to These Hazards. Identifies and Analyzes Existing Projects and Proposed Actions to Lessen the Impact from These Hazards. HAZARD MITIGATION PLAN*. By Jane Margolies. New York City: n.p., 2014. Print.

Watson, Robert T., Marufu C. Zinyowera, Richard H. Moss, and David J. Dokken. "IPCC SPECIAL REPORT THE REGIONAL IMPACTS OF CLIMATE CHANGE: AN ASSESSMENT OF VULNERABILITY." *IPCC SPECIAL REPORT* (n.d.): n. pag. Intergovernmental Panel on Climate Change, Nov. 1997. Web. 1 July 2015.

Acknowledgments

I would like to express my sincere gratitude to the supervisors of The Network for Sustainable Climate Risk Management (SCRiM) for the opportunity to participate in the SCRiM 2015 Summer Scholars Program.

I am obliged to Mr. Chris Heaton, President of Global Risk Consultants, for his invaluable contribution to this analysis. This work was supported by the National Science Foundation through the Network for Sustainable Climate Risk Management under NSF cooperative agreement GEO-1240507.