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A Short Historical Overview of the Concepts of Resilience, Vulnerability, and Adaptation

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Reviewing the literature used as “seed” documents in the visualization mapping exercise outlined in “Scholarly Networks on Resilience, Vulnerability and Adaptation within the Human Dimensions of Global Environmental Change”, a compilation of definitions for the three concepts was recorded. This paper seeks to identify trends in the definitions of the three concepts – resilience, vulnerability, and adaptation – found in the seminal literature over the past 30 years. . The attempt here is to build upon the IHDP-sponsored research of the past year and identify interesting developments in the literature. A challenge of this inquiry has been in fixing the conceptual boundaries of the study and retaining only usage of the terms within the human dimensions of global environmental change. The Appendix to this paper provides the specific definitions used.

Each of the three terms has colloquial usage as well as historical meaning across a variety of scholastic literatures ranging from psychological studies to purely ecological analyses to business publications. We have rigorously maintained a focus only on the human dimensions of global change regardless of source. Even so, many of the key records cite literature far beyond these boundaries, and some of the most interesting findings relate to the evolution of use of these terms from fields outside of the study of human dimensions of global change.

Several remarkable findings emerged from this review. First, resilience scholars have the most singular definition, based almost exclusively on the work of C.S. Holling. Second, literature on vulnerability emerges from three distinct fields and appears to becoming more concise over time. Third, adaptation literature, as it relates specifically to the human dimensions of global environmental change comes forward as a newer concept more constrained by definition than by practice. Finally, as emerges in the citation analyses conducted in the “Scholarly Networks” paper, recent literature within each concept has begun to cross-reference the other concepts.

Resilience

Of the three terms, the concept of resilience has the most fundamental base. Nearly all of the literature refers in one manner or another to various works by C.S. Holling. His single most important work, as cited by the resilience literature, is his 1973 article “Resilience and Stability of Ecological Systems”, where the author defines resilience as “a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables” (p. 14). In 1986, Holling refines this definition and defines resilience as “the ability of a system to maintain its structure and patterns of behavior in the face of disturbance” (Holling, 1986: p. 296). Holling offers up a third definition in *Barriers and Bridges to the Renewal of Ecosystems and Institutions*, which builds on the first two, stating that resilience is the buffer capacity or the ability of a system to absorb perturbations, or the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables and processes that control behavior (Holling et al., 1995 cited in Adger, 2000).

Stuart Pimm’s 1984 article on the stability of ecosystems offers the only other moderately cited definition without strong affiliation to the work of C.S. Holling. He defines resilience as the measure of the speed of a system’s return to equilibrium following a perturbation. Holling, himself, acknowledges this measure of stability as “engineering resilience” and contrasts that with his preferred definition of resilience (those shown above) as a measure of absorptive capacity, which he denotes as “ecological resilience”.

Other definitions not explicitly citing Holling tend to come from members of the Resilience Alliance, a research network with which Holling has long been affiliated. Most of these definitions use a common mathematical foundation with formulaic representations of resilience. The language used specifically refers to domains of attractors, stability domains, state variables, the amplitudes and magnitudes of stressors, and equilibrium conditions. This shared mathematical background is quickly apparent in the literature, with mathematical proofs and theoretical illustrations used to describe the resilience of systems.

Scanning the literature for definitions of resilience, it is interesting to see the number of definitions that cite one of Holling’s original definitions and then chart the changes made to the definition. Most discuss some type of system (ecological, social, socio-ecological, or other)

being exposed to a stress, disturbance, change undergone, perturbation, or other type of outside influence. Resilience is then “measured” as the system’s ability to rebound, return, or recover its original state, structure, equilibrium, or state of nature or to persist, maintain, retain, or remain in its original state. Resilience is equated with absorbing stress, absorptive power, recuperative power, perseverance, and stability. A few definitions offer particularly relevant extensions of resilience, linking it to the concept of adaptation. Walker et al., (1981; p. 495) note that “resilience is the ability to adapt to change by exploiting instabilities” and that it is *not* simply “the ability to absorb disturbance by returning to a steady state after being disturbed”. Adger (2003: p. 1) concisely states that resilience “is the ability to persist *and* the ability to adapt [emphasis added].

Vulnerability

Outlining the different definitions of vulnerability has proven more difficult than for resilience. Vulnerability has been used in a wide variety of contexts and in many different fields. To date, there is no consensus definition of vulnerability as it relates to the human dimensions of global environmental change. Common to all of these sources is that vulnerability generally has a human or society-centered perspective. This contrasts with a great deal of the early resilience literature which focuses more generally on eco-centric analyses. Historically, the most popular definitions have come from two distinct literature sources depending on the academic training of the researcher. Geographers and natural scientists have quite often referred to vulnerability literature from within the study of natural hazards.

A few of the leading definitions from this field include Blaikie et al., (1994: p. 9) which defines vulnerability as “the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural hazard” and Burton et al. (1978), which discusses vulnerability as a result of change placing people at risk. Development and poverty experts and welfare economists use the concept of vulnerability a bit differently. Most draw extensively on the work of Amartya Sen and his work on the fragility of humanity through entitlements and government failures.

The most highly cited definition of vulnerability in this sector comes from a special issue of vulnerability by the IDS Bulletin (1990: Vol 20, Issue 2). In the introductory article Robert Chambers defines vulnerability by stating that “vulnerability is not the same as poverty. It means not lack or want, but defencelessness, insecurity, and exposure to risk, shocks, and

stresses” (p. 2). Of the literature surveyed, roughly 50% draws primarily on natural hazards research and a third comes from the entitlement and poverty literature. Recently, a third branch of literature has emerged from climate change researchers. This work draws heavily on the IPCC reports, and through these reports has relatively strong linkages to adaptation literature. Tol et al. (1998: p. 109) cite one IPCC report as stating that “vulnerability to climate change is a function of both the sensitivity of a system to changes in climate, and the ability to adapt the system to such changes”.

A common theme running through much of the vulnerability literature, regardless of background, is a link to coping and the capacity to handle stress or perturbation. In this way, the literature closely parallels work in the resilience literature and its notions of recuperative power and capacity to handle disturbance. Some authors, including Adger (2000), view resilience and vulnerability as equivalent but opposite concepts. Others do not see the concepts as equivalent, notably Chambers (1990). In his 1981 monograph, Peter Timmerman begins to link the concepts of resilience and vulnerability, but this linkage remained unstudied for the following 20 years and has only recently been picked up by several researchers including Neil Adger (1999 and 2000) and Turner et al. (2003). In the IHDP Update 2 in 2001, van der Leeuw links resilience and vulnerability by defining vulnerability as “instances where neither its robustness nor its resilience enables a system to survive without structural changes”(p. 9). As noted earlier, the climatologists are taking preliminary steps to combine the concepts of vulnerability and adaptation.

Adaptation

The use of the concept of adaptation as it relates to the human dimensions of global environmental change is still somewhat vague. Much of the literature on adaptability stems from climate change research. The IPCC reports, in particular, incorporate the concept into their work on the impacts of climate change. Most of the definitions that we have collected thus far reflect this origin. Smit et al., (2000: p. 225), for example, write that “adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer term climate change”. This literature explicitly links adaptation with vulnerability, and it is unclear whether the two concepts should be viewed separately or in aggregate. Frequently adaptation is contrasted with mitigation, with adaptation being responsive and mitigation being preemptive.

Smithers and Smit (1997: p. 134) address this, stating that “adaptation refers to the unplanned reactive response to an event or condition which has already been experienced, as distinct from what is termed “mitigative” actions which seek to avoid negative impacts through anticipatory actions”. The authors proceed to develop a model which uses both resilience and vulnerability as system characteristics that determine adaptive responses to climate disturbances. Of interest is their view that adaptation is the antithesis of resilience, with the former equated with change and the latter with entrenchment. This approach contrasts with Walker et al. (2004) who use the phrase adaptive capacity to be a means of improving the resilience of a system. Similarly, Olsson et al. (2004) use the concept of adaptive management as a means of managing social-ecological systems for improved resilience. With such disparity in how the three concepts link, it is unclear how these cross-cutting themes should be related.

The Challenge of Operationalizing and Quantifying

A common challenge to each of the literature streams has been in the operationalization and quantification of the concepts. In “From Metaphor to Measurement: Resilience of What to What?” Carpenter et al. (2001) discuss the challenges of the past 30 years in attempting to put resilience into practice. Few studies have successfully responded to this challenge. The same challenge can be leveled at the vulnerability literature. In 2003, Luers et al. provided one example of an attempt to quantify vulnerability. Much work remains to be done in the creation of a concise and agreed upon definition of each the concepts; how the concepts relate to each other; how to operationalize, evaluate, and compare case studies; and how to understand and generate meaningful research cross-cutting the concepts.

Appendix A: Definitions

Resilience:

- “[A] measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables. (p. 14)
 - a. Holling, C.S. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.
- “[T]he amount of disturbance that a system can absorb without changing state.”
 - “[T]he time required for a system to return to an equilibrium or steady-state following a perturbation” – Holling’s engineering resilience.
 - “[T]he magnitude of disturbance that can be absorbed before the system redefines its structure by changing the variables and processes that control behavior.” (p. 426)
 - a. Gunderson, Lance. 2000. Ecological Resilience - In Theory and Application. *Annual Review of Ecology and Systematics* 31:425-39.
 - b. Citing Holling, C.S. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.
- “The capacity of a system to absorb and utilise or even benefit from perturbations and changes that attain it, and so to persist without a qualitative change in the system’s structure.”
 - a. van der Leeuw, Sander E. 2001. 'Vulnerability' and the Integrated Study of Socio-Natural Phenomena. *IHDP Update* 2:8-11.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecosystems. *Annual Review of Ecology and Systematics* 4:1-23.
- The ability of a system to return to the original state after a disturbance (two formats)
 - The time needed to return to equilibrium as an indicator
 - a. Scheffer, Marten, Frances Westley, William A. Brock, and Milena Holmgren. 2002. Dynamic Interactions of Societies and Ecosystems - Linking Theories from Ecology, Economy, and Sociology. In *Panarchy: Understanding Transformations in Human and Natural Systems*, edited by L. Gunderson and C. S. Holling. Washington DC: Island Press.
 - b. Citing Pimm, Stuart L. 1984. The Complexity and Stability of Ecosystems. *Nature* 307 (26):321-326.
 - The maximum amplitude of disturbance that still allows the system to return to the same equilibrium.
 - a. Scheffer, Marten, Frances Westley, William A. Brock, and Milena Holmgren. 2002. Dynamic Interactions of Societies and Ecosystems - Linking Theories from Ecology, Economy, and Sociology. In *Panarchy: Understanding Transformations in Human and Natural Systems*, edited by L. Gunderson and C. S. Holling. Washington DC: Island Press.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.
- The magnitude of disturbance that can be absorbed before a system flips from one state to another

- a. Brock, William A., Karl-Goran Maler, and Charles Perrings. 2002. Resilience and Sustainability: The Economic Analysis of Nonlinear Dynamic Systems. In *Panarchy: Understanding Transformations in Human and Natural Systems*, edited by L. Gunderson and C. S. Holling. Washington DC: Island Press.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.
- The measure of the speed of a systems return to equilibrium following perturbation
 - a. Brock, William A., Karl-Goran Maler, and Charles Perrings. 2002. Resilience and Sustainability: The Economic Analysis of Nonlinear Dynamic Systems. In *Panarchy: Understanding Transformations in Human and Natural Systems*, edited by L. Gunderson and C. S. Holling. Washington DC: Island Press.
 - b. Citing Pimm, Stuart L. 1984. The Complexity and Stability of Ecosystems. *Nature* 307 (26):321-326.
- The amount of disturbance that a system can absorb without changing stability domains.
 - a. Gunderson, Lance, C.S. Holling, and Garry D. Peterson. 2002. Surprises and Sustainability: Cycles of Renewal in the Everglades. In *Panarchy: Understanding Transformations in Human and Natural Systems*, edited by L. H. Gunderson and C. S. Holling. Washington DC: Island Press.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.
- Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state
 - a. Franklin, Stuart, and Tom Downing. 2004. "Resilience and Vulnerability. " GECAFS Project - Poverty and Vulnerability Programme. Stockholm, Sweden: Funding Agencies: Stockholm Environment Institute.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.
- The ability of a system to maintain its structure and patterns of behaviour in the face of disturbance.
 - a. Franklin, Stuart, and Tom Downing. 2004. "Resilience and Vulnerability. " GECAFS Project - Poverty and Vulnerability Programme. Stockholm, Sweden: Funding Agencies: Stockholm Environment Institute.
 - b. Citing Holling, C.S. 1986. The Resilience of Terrestrial Ecosystems: Local Surprise and Global Change. In *Sustainable Development of the Biosphere*, edited by W. C. Clark and R. E. Munn. Cambridge, UK: Cambridge University Press.
- Resilience infers: i) the amount of change the system can undergo and still retain the same controls on function and structure, or still be in the same state within the same domain of attraction; ii) the degree to which the system is capable of self-organization; iii) the ability to build and increase the capacity for learning and adaptation.
 - a. Franklin, Stuart, and Tom Downing. 2004. "Resilience and Vulnerability. " GECAFS Project - Poverty and Vulnerability Programme. Stockholm, Sweden: Funding Agencies: Stockholm Environment Institute.
 - b. Citing Berkes, Fikret, Johan Colding, and Carl Folke, eds. 2003. *Navigating Social-ecological Systems : Building Resilience for Complexity and Change*. New York, NY: Cambridge University Press.

- Resilience infers: i) “the amount of change a system can undergo...and still retain the same controls on function and structure (still be in the same configuration—within the same domain of attraction),” ii) “the degree to which the system is capable of self-organization,” and iii) “the degree to which the system expresses capacity for learning and adaptation.” (online p. 5-6)
 - a. Walker, Brian, Steve Carpenter, John Anderies, Nick Abel, Graeme Cumming, Marco A. Janssen, Louis Lebel, Jon Norberg, Garry D. Peterson, and Rusty Pritchard. 2002. Resilience Management in Social-Ecological Systems: A Working Hypothesis for a Participatory Approach. *Conservation Ecology* 6 (1):14.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.
- Resilience is “the potential of a system to remain in a particular configuration and to maintain its feedbacks and functions, and involves the ability of the system to reorganize following disturbance-driven change.” (online p. 6)
 - a. Walker, Brian, Steve Carpenter, John Anderies, Nick Abel, Graeme Cumming, Marco A. Janssen, Louis Lebel, Jon Norberg, Garry D. Peterson, and Rusty Pritchard. 2002. Resilience Management in Social-Ecological Systems: A Working Hypothesis for a Participatory Approach. *Conservation Ecology* 6 (1):14.
- [T]he ability to persist and the ability to adapt. (p. 1)
 - a. Adger, W. Neil. 2003. Building Resilience to Promote Sustainability: An Agenda for Coping with Globalisation and Promoting Justice. *IHDP Update* 2:1-3.
- The resilience of [social-ecological systems] has three defining characteristics: i) the amount of change the system can undergo and still retain essentially the same structure, function, identity, and feedbacks on function and structure, ii) the degree to which the system is capable of self-organisation, and iii) the degree to which the system expresses capacity for learning and adaptation. (p. 4)
 - a. Quinlan, Allyson. 2003. Resilience and Adaptive Capacity: Key Components of Sustainable Social-Ecological Systems. *IHDP Update* 2:4-6.
 - b. Citing www.resalliance.org.
- The ability of systems to absorb perturbation through multiple pathways, whereby new equilibria may be achieved but basic structural relationships remain unaltered.
 - a. Warrick, Richard A., and William E. Riebsame. 1981. Societal Response to CO-2 Induced Climate Change: Opportunities for Research. *Climatic Change* 3:387-428.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.
- “The size of the stability domain around stable time-invariant equilibria (point attractors) or stable oscillations (periodic attractors).”
 - a. Lele, Sharachchandra. 1998. Resilience, Sustainability, and Environmentalism. *Environment and Development Economics* 3 (2):249-254.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.

- “Resilience refers to the ‘elasticity’ or recuperative power of a system, its ability to recover or rebound, or the degree of impact that can be experienced without moving the system away from a previous equilibrium.” (137)
 - a. Smithers, John, and Barry Smit. 1997. Human Adaptation to Climatic Variability and Change. *Global Environmental Change* 7 (2):129-146.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.
- [Resilience] “is the buffer capacity or the ability of a system to absorb perturbations, or the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables and processes that control behaviour.” (p. 349)
 - a. Adger, W. Neil. 2000. Social and Ecological Resilience: Are They Related? *Progress in Human Geography* 24 (3):347-364.
 - b. Citing Holling, C.S. 1995. What Barriers? What Bridges? In *Barriers and Bridges to the Renewal of Ecosystems and Institutions*, edited by L. Gunderson, C. S. Holling and S. S. Light. New York: Columbia University Press.
- Resilience is “the speed of recovery from a disturbance.” (p. 349)
 - a. Adger, W. Neil. 2000. Social and Ecological Resilience: Are They Related? *Progress in Human Geography* 24 (3):347-364.
- “[R]esilience is the ability to adapt to change by exploiting instabilities, rather than the ability to absorb disturbance by returning to a steady state after being disturbed.” (p. 495)
 - a. Walker, Brian H., Donald Ludwig, C.S. Holling, and R.M. Peterman. 1981. Stability of Semi-Arid Savanna Grazing Systems. *Journal of Ecology* 69:473-498.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23. (Note: does not use this definition but modifies it)
- Resilience is “the ability of these systems to absorb changes...and still persist.”
 - a. Dow, Kirstin. 1992. Exploring Differences in Our Common Future(s): The Meaning of Vulnerability to Global Environmental Change. *Geoforum* 23 (3):417-436.
 - b. Citing Holling, C.S.. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* 4:1-23.

Vulnerability:

- “[T]he characteristics of persons or groups in terms of their capacity to anticipate, cope with, resist, and recover from the impacts of environmental change.” (online p. 6)
 - a. Bohle, Hans-Georg, and Roger Kasperson. 2001. Vulnerability and Criticality. *IHDP Update* 2:1-8.
 - b. Citing Vogel, Coleen. 1998. Vulnerability and Global Environmental Change. *LUCC Newsletter* 3(March): 15-19 World Commission on Environment and Development. 1987. *Our Common Future*. Oxford: Oxford University Press.
- Instances where neither its robustness nor its resilience enables a system to survive without structural changes.
 - a. van der Leeuw, Sander E. 2001. 'Vulnerability' and the Integrated Study of Socio-Natural Phenomena. *IHDP Update* 2:8-11.

- The exposure to hazard by external activity (e.g. the climatic change) and coping capacity of the people to reduce the risk at a particular point of time.
 - a. Langeweg, Fred, and Edgar E. Gutierrez-Espeleta. 2001. Human Security and Vulnerability in a Scenario Context: Challenges for UNEP's Global Environmental Outlook. *IHDP Update 2*:17-19.
- The degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazard, either a perturbation or stress/stressor.
 - a. Turner, B.L. II, Roger E. Kasperson, Pamela A. Matson, James J. McCarthy, Robert W. Corell, Lindsey Christensen, Noelle Eckley, Jeanne X. Kasperson, Amy Luers, Marybeth L. Martello, Colin Polsky, Alexander Pulsipher, and Andrew Schiller. 2003. A Framework for Vulnerability Analysis in Sustainability Science. *Proceedings from the National Academy of Science* 100 (14):8074-8079.
- “[T]he characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural hazard.” (p. 15)
 - a. Vogel, Coleen. 1998. Vulnerability and Global Environmental Change. *LUCC Newsletter* (3):15-19.
 - b. Citing Blaikie, Piers, Terry Cannon, Ian Davis, and Ben Wisner 1994. *At Risk: Natural Hazards, People’s Vulnerability, and Disasters*. New York, NY: Routledge.
- “[T]he degree to which human and environmental systems are likely to experience harm due to a perturbation or stress.” (p. 255)
 - a. Luers, Amy L., David B. Lobell, Leonard S. Sklar, C. Lee Addams, and Pamela A. Matson. 2003. A Method for Quantifying Vulnerability, Applied to the Agricultral System of the Yaqui Valley, Mexico. *Global Environmental Change* 13:255-267.
 - b. Citing Turner, B.L. II, Roger E. Kasperson, Pamela A. Matson, James J. McCarthy, Robert W. Corell, Lindsey Christensen, Noelle Eckley, Jeanne X. Kasperson, Amy Luers, Marybeth L. Martello, Colin Polsky, Alexander Pulsipher, and Andrew Schiller. 2003. A Framework for Vulnerability Analysis in Sustainability Science. *Proceedings from the National Academy of Science* 100 (14):8074-8079.
 - c. Citing Kasperson et al. 2003, Vulnerability to Global Environmental Change, in *The Human Dimensions of Global Environmental Change*.
- “The potential for loss” with “two sides: an external side of shocks and perturbations to which a system is exposed; and an internal side which represents the ability or lack of ability to adequately respond to and recover from external stresses.” (p. 256)
 - a. Luers, Amy L., David B. Lobell, Leonard S. Sklar, C. Lee Addams, and Pamela A. Matson. 2003. A Method for Quantifying Vulnerability, Applied to the Agricultral System of the Yaqui Valley, Mexico. *Global Environmental Change* 13:255-267.
 - b. Citing Mitchell et al., 1989. A Contextual Model of Natural Hazards. *Geographical Review* 79:391-409.
 - c. AND citing Chamber, R., 1989. Vulnerability, Coping, and Policy.
- “[O]pen to or easily hurt by criticism or attack.” (p. 1)
 - a. Cutter, Susan L. 2003. The Vulnerability of Science and the Science of Vulnerability. *Annals of the Association of American Geographers* 93 (1):1-12.

- b. Citing Webster's Dictionary.
- The characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard.
 - a. Blaikie, Piers, Terry Cannon, Ian Davis, and Ben Wisner 1994. *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. New York, NY: Routledge.
- "Social vulnerability is the exposure of groups or individuals to stress as a result of social and environmental change, where stress refers to unexpected changes and disruption to livelihoods." (p. 249)
 - a. Adger, W. Neil. 1999. Social Vulnerability to Climate Change and Extremes in Coastal Vietnam. *World Development* 27 (2):249-269.
- "Vulnerability...is not the same as poverty. It means not lack or want, but defencelessness, insecurity, and exposure to risk, shocks, and stress." (p. 1)
 - a. Chambers, Robert. 1990. Editorial Introduction: Vulnerability, Coping, and Policy. *IDS Bulletin* 20 (2):1-7.
- "Vulnerability...refers to exposure to contingencies and stress, and difficulty in coping with them." (p. 1)
 - a. Chambers, Robert. 1990. Editorial Introduction: Vulnerability, Coping, and Policy. *IDS Bulletin* 20 (2):1-7.
- "Social vulnerability is the exposure of groups of people or individuals to stress as a result of the impacts of environmental change." (p. 348)
 - a. Adger, W. Neil. 2000. Social and Ecological Resilience: Are They Related? *Progress in Human Geography* 24 (3):347-364.
- "Vulnerability reflects the degree to which a system may react adversely to the occurrence of a calamitous or hazardous event." (p. 45)
 - a. Watts, Michael J., and Hans G. Bohle. 1993. The Space of Vulnerability: The Causal Structure of Hunger and Famine. *Progress in Human Geography* 17 (1):43-67.
 - b. Citing Timmerman, Peter. 1981. Vulnerability, Resilience, and the Collapse of Society. In *Institute of Environmental Studies Research Paper*. Toronto.
- Vulnerability is "the exposure to contingencies and stress, and difficulty coping with them. Vulnerability has thus two sides: an external side of risks, shocks and stress to which an individual or household is subject; and an internal side which is defenselessness, meaning a lack of means to cope without damaging loss." (p. 45)
 - a. Watts, Michael J., and Hans G. Bohle. 1993. The Space of Vulnerability: The Causal Structure of Hunger and Famine. *Progress in Human Geography* 17 (1):43-67.
 - b. Citing Chambers, Robert. 1990. Editorial Introduction: Vulnerability, Coping, and Policy. *IDS Bulletin* 20 (2):1-7.
- "Vulnerability can be defined...as the risks associated with the threat of large-scale entitlement deprivation." (p. 45)
 - a. Watts, Michael J., and Hans G. Bohle. 1993. The Space of Vulnerability: The Causal Structure of Hunger and Famine. *Progress in Human Geography* 17 (1):43-67.
 - b. Citing Sen, Amartya K. 1990. Food, Economics, and Entitlements in *The Political Economy of Hunger*.

- “[V]ulnerability to climate change is a function of both the sensitivity of a system to changes in climate, and the ability to adapt the system to such changes.” (p. 109)
 - a. Tol, Richard S.J., Samuel Fankhauser, and Joel B. Smith. 1998. The Scope for Adaptation to Climate Change: What Can We Learn from the Impact Literature? *Global Environmental Change* 8 (2):109-123.
 - b. Citing Watson, R.T., M.C. Zinyowera, and R.H. Moss. 1998. The Regional Impacts of Climate Change. An Assessment of Vulnerability. In *A Special Report by the Intergovernmental Panel on Climate Change*. Geneva.
- “The most basic definitions take differences in potential exposure to hazard as the measure of vulnerability” (p. 420).
 - a. Dow, Kirstin. 1992. Exploring Differences in Our Common Future(s): The Meaning of Vulnerability to Global Environmental Change. *Geoforum* 23 (3):417-436.
- “Vulnerability is a function of the combination of exposure, resistance, and resilience” (p. 428) where “vulnerability is the degree to which a system, or a part of a system may react adversely to the occurrence of a hazardous event...resilience is the measure of a system’s, or part of a system’s capacity to absorb and recover from the occurrence of a hazardous event.” (p. 422)
 - a. Dow, Kirstin. 1992. Exploring Differences in Our Common Future(s): The Meaning of Vulnerability to Global Environmental Change. *Geoforum* 23 (3):417-436.
 - b. Citing Timmerman, Peter. 1981. Vulnerability, Resilience, and the Collapse of Society. In *Institute of Environmental Studies Research Paper*. Toronto.
- Vulnerability is “the degree to which different classes in society are differentially at risk, both in terms of the probability of occurrence of an extreme physical event and the degree to which the community absorbs the effects of extreme physical events and helps different classes to recover.” (p. 422)
 - a. Dow, Kirstin. 1992. Exploring Differences in Our Common Future(s): The Meaning of Vulnerability to Global Environmental Change. *Geoforum* 23 (3):417-436.
 - b. Citing Susman, P., P. O’Keefe, and B. Wisner. 1983. Global Disaster, a Radical Interpretation. In *Interpretations of Calamity for the Viewpoint of Human Ecology*. Boston, MA.
- Vulnerability is “exposure to contingencies and stress, and difficulty in coping with them. Vulnerability has thus two sides: an external side of risks, shocks, and stresses to which an individual or a household is subject and an internal side which is defenselessness, meaning a lack of ability to cope without damaging loss.” (p. 422)
 - a. Dow, Kirstin. 1992. Exploring Differences in Our Common Future(s): The Meaning of Vulnerability to Global Environmental Change. *Geoforum* 23 (3):417-436.
 - b. Citing Chambers, Robert. 1990. Editorial Introduction: Vulnerability, Coping, and Policy. *IDS Bulletin* 20 (2):1-7.
- Vulnerability is “the exposure to contingencies and stress, and difficulty in coping with them. Vulnerability has thus two sides: an external side of risks, shocks, and stresses to which an individual or a household is subject; and an internal side which is

defenselessness, meaning a lack of ability to cope without damaging loss.” (p. 38 of Bohle et al., citing p. 1 of Chambers)

- a. Bohle, Hans G., Thomas E. Downing, and Michael J. Watts. 1994. Climate Change and Social Vulnerability--Toward a Sociology and Geography of Food Insecurity. *Global Environmental Change* 4 (1):37-48.
- b. Citing Chambers, Robert. 1990. Editorial Introduction: Vulnerability, Coping, and Policy. *IDS Bulletin* 20 (2):1-7.

Adaptation:

- “[A]daptation refers to adjustments in ecological-social-economic systems in response to actual or expected climatic stimuli, their effects or impacts.” (p. 225)
 - a. Smit, Barry, Ian Burton, Richard J.T. Klein, and J. Wandel. 2000. An Anatomy of Adaptation to Climate Change and Variability. *Climatic Change* 45:223-251.
- “Adaptation to climate is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides.” (p. 227)
 - a. Smit, Barry, Ian Burton, Richard J.T. Klein, and J. Wandel. 2000. An Anatomy of Adaptation to Climate Change and Variability. *Climatic Change* 45:223-251.
 - b. Citing Burton, Ian. 1992. Adapt and Thrive. In *Canadian Climate Centre*. Downsview, Ontario.
- “Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer term climate change.” (p. 228)
 - a. Smit, Barry, Ian Burton, Richard J.T. Klein, and J. Wandel. 2000. An Anatomy of Adaptation to Climate Change and Variability. *Climatic Change* 45:223-251.
 - b. Citing Smit, Barry. 1993. *Adaptation to Climatic Variability and Change*. Guelph: Environment Canada.
- “[A]daptation means any adjustment, whether passive, reactive, or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change.” (p. 228)
 - a. Smit, Barry, Ian Burton, Richard J.T. Klein, and J. Wandel. 2000. An Anatomy of Adaptation to Climate Change and Variability. *Climatic Change* 45:223-251.
 - b. Citing Stakhiv, E.Z. 1993. Evaluation of IPCC Adaptation Strategies. Fort Bevoir, VA: Institute for Water Resources, US Army Corp of Engineers.
- “Adaptation to climate change includes all adjustments in behaviour or economic structure that reduce the vulnerability of society to changes in the climate system.” (p. 228)
 - a. Smit, Barry, Ian Burton, Richard J.T. Klein, and J. Wandel. 2000. An Anatomy of Adaptation to Climate Change and Variability. *Climatic Change* 45:223-251.
 - b. Citing Smith et al., 1996, “A Process for Evaluating Anticipatory Adaptation Measures for Climate Change”
- “Adaptability refers to the degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of change in conditions.” (p. 228)

- a. Smit, Barry, Ian Burton, Richard J.T. Klein, and J. Wandel. 2000. An Anatomy of Adaptation to Climate Change and Variability. *Climatic Change* 45:223-251.
- b. Citing Watson, R.T., M.C. Zinyowera, and R.H. Moss. 1996. Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analysis. In *Contributions of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.
- “[A]daptation refers to the unplanned reactive response to an event or condition which has already been experienced, as distinct from what is termed ‘mitigative’ actions which seek to avoid negative impacts through anticipatory actions.” (p. 134)
 - a. Smithers, John, and Barry Smit. 1997. Human Adaptation to Climatic Variability and Change. *Global Environmental Change* 7 (2):129-146.
 - b. Citing Glantz, M. 1992. Global Warming and Environmental Change in Sub-Saharan Africa. *Global Environmental Change* 2:183-204.
- Adaptations are distinct from “adjustments according to the persistence of the response, where short term measures are not deemed to be adaptations.” (p. 134)
 - a. Smithers, John, and Barry Smit. 1997. Human Adaptation to Climatic Variability and Change. *Global Environmental Change* 7 (2):129-146.
 - b. Citing Burton, Ian, Robert W. Kates, and Gilbert F. White. 1978. *The Environment as Hazard*. New York: Oxford University Press.
- “Adaptation is the antithesis of resilience.” “[Adaptation] is equated with change and [resilience] with entrenchment.” (p. 134)
 - a. Smithers, John, and Barry Smit. 1997. Human Adaptation to Climatic Variability and Change. *Global Environmental Change* 7 (2):129-146.
 - b. Citing Riebsame, W.E. 1991. Sustainability of the Great Plains in an Uncertain Climate. *Great Plains Research* 1 (1):133-151.
- “Adaptation involves change in a system in response to some force or perturbation.” (p. 135)
 - a. Smithers, John, and Barry Smit. 1997. Human Adaptation to Climatic Variability and Change. *Global Environmental Change* 7 (2):129-146.
- “‘Cultural adaptation’ derives from its evolutionary counterpart and implies long-term, nongenetic adjustment of cultures to their environments.” (p. 269)
 - a. Butzer, Karl W. 1980. Adaptation to Global Environmental Change. *Professional Geographer* 32 (3):269-278.

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