

## Commentary: the challenge of quantifying susceptibility to drought-related crisis

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**Abstract** This paper is a response to a recent special issue of *Regional Environmental Change*, “Quantifying vulnerability to drought from different disciplinary perspectives” (vol. 8, number 4, 2008). In this paper, we examine some of the challenges facing efforts to understand vulnerability to drought through quantification as they are manifest in some of the articles in this special issue.

**Keywords** Vulnerability · Drought · Modeling

### Introduction

Drought-related crises threaten both individual livelihoods and global sustainability. This is especially true in the context of climatic change, which is likely to induce shifts in temperature and precipitation regimes (Postel and Vickers 2004; Safriel et al. 2005; Solomon et al. 2007). There is therefore an urgent need to develop methods that evaluate the vulnerability of people and places to such crises and to identify where actions may be taken to reduce that vulnerability. These efforts require careful framing of research questions, transparent methodologies and rigorous validation of results (Schroter et al. 2005).

In a recent special issue of this journal, entitled “Quantifying vulnerability to drought from different disciplinary perspectives” (vol. 8, number 4, 2008), three articles addressed various disciplinary approaches for estimating vulnerability to drought (Acosta-Michlik et al.

2008; Krömker et al. 2008; Taenzler et al. 2008) as they might be implemented through an approach that combines inference modeling and fuzzy logic (Alcamo et al. 2005; Eierdanz et al. 2008). This article is framed around two of these articles (Acosta-Michlik et al. 2008; Taenzler et al. 2008), because they illustrate two major challenges that lie in the way of the implementation of this approach: the development of meaningful inference statements and the selection of appropriate indicators to populate those statements.

Our goal in this article is not to revisit comprehensively the limitations and challenges of modeling vulnerability, which are already well documented (Adger 2006; Bankoff et al. 2004; Eakin and Luers 2006; O’Brien et al. 2004; Paracchini et al. 2008; Patt et al. 2005; Patt et al. 2008). Instead, we evaluate these two articles to illustrate the significance of these two challenges to the quantification of vulnerability via the proposed inference modeling/fuzzy set approach and our understanding of different disciplinary perspectives on vulnerability, two stated goals of the special issue to which they belong (Alcamo 2008).

### Susceptibility to drought-related crisis

The articles in the special issue are framed around the efforts of Alcamo et al. (2005) and Eierdanz et al. (2008) to develop a new method for assessing society’s vulnerability to drought. Generally speaking, this approach begins with an inference model, which translates qualitative, expert knowledge on the connection between drought and drought-related crises into summary statements, usually framed as assertions. For example, one might draw upon the literature to make the assertion “If educational levels are high and public infrastructural investment is high,

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vulnerability to drought is low.” Indicators are then chosen for each element of the statement. In the hypothetical case above, we would need to identify indicators for both educational levels (such as the percentage of children enrolled in primary school) and infrastructural investment (such as the percentage of the urban population with access to improved sanitation facilities). Fuzzy set theory is then used to convert qualitative statements about susceptibility (high, medium, and low) into numeric values. Finally, these inference models are populated by data from the indicators, and it becomes possible to compute a quantitative value for vulnerability.

Those seeking to use this approach face two critical challenges. First, one must take qualitative, expert knowledge and build summary statements that meaningfully represent that knowledge. This requires extensive familiarity with the qualitative literature on drought, vulnerability, livelihoods and food security. Second, one must identify appropriate indicator variables to populate the elements of each summary statement.

#### Building summary statements

Taenzler et al. (2008) seek to identify characteristics of the state that influence the probability of drought-related crisis from a political science perspective. The conceptual framing of the piece is straightforward and clear. The authors focus on processes and variables at the scale of the state, presumably assuming that these are the variables over which the state has the greatest control, and therefore represent the state characteristics that most significantly affect drought outcomes. They divide these characteristics into capacity, polity and conflict. The intersection of these characteristics in specific places creates state susceptibilities to drought, which then will be manifest in the form of different drought-related crises.

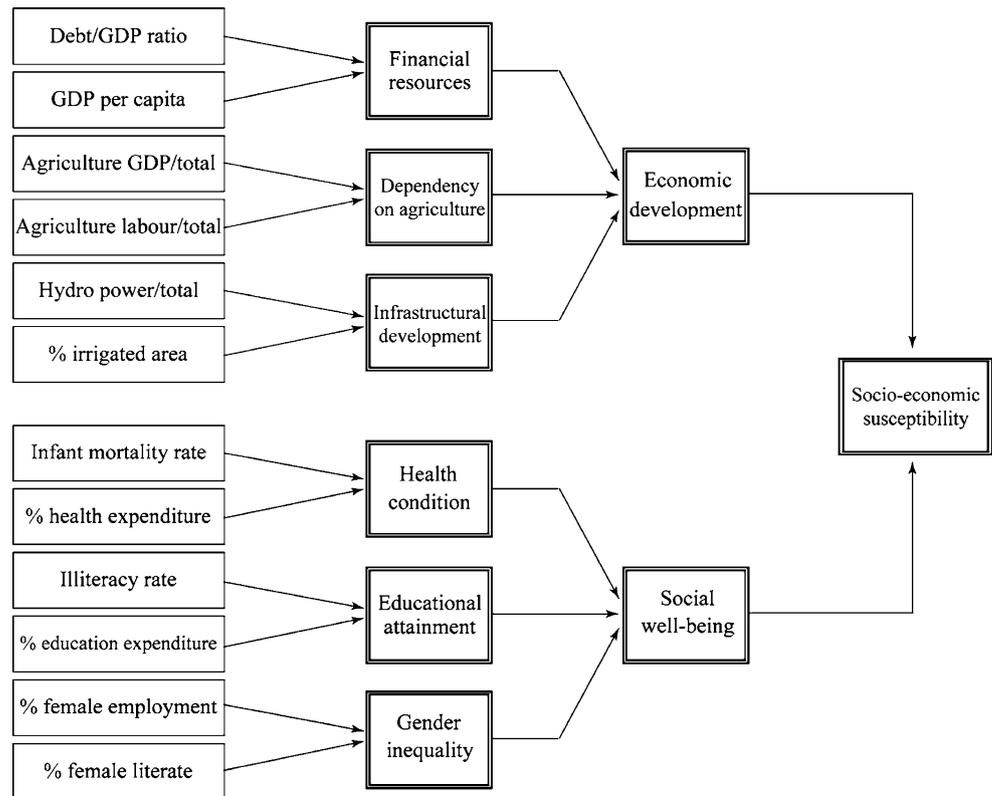
Although the model presented by Taenzler et al. (2008) ostensibly reflects a political science perspective on the causes of drought-related crisis, the selection of the state as the object of analysis runs contrary to extensive literatures (both within political science and beyond) on the connections between nature and society, which see drought-related crisis as an outcome of complex, inextricable, and often multiscalar processes, actors and institutions. For example, the contemporary literature on famine and food insecurity (e.g. Carr 2006; Davis 2004; De Waal 1989; Gladwin et al. 2001; Kotzé 2003; Maxwell 1996; Maxwell and Frankenberg 1992; Maxwell and Smith 1992; Sen 1981; Shriar 2002; Watts 1983) illustrates that the state’s role in famine outcomes is but one of many in a complex political economy spanning global to local processes. On one hand, the pioneering work of Watts (1983), and more recent writing by Davis (2002, 2004), have illustrated that famine cannot

be understood in isolation from climatic processes and a global political economy in which states are bound up but rarely control. In contrast, other authors argue that food insecurity and famine outcomes are greatly shaped by access and entitlements issues, where local social roles shape who has the right to obtain food and where they can obtain the food from (e.g. Carney 1998; Chambers and Conway 1992; Ellis 2000; Scoones 1998). It is important to note that these literatures focus on different aspects of the processes by which food insecurity and famine take shape—they do not contradict each other. Those who work at the local level acknowledge that both access and entitlements can be shaped by events at the level of the state, or at the level of global markets. Conversely, those working at more global scales acknowledge that policies and market fluctuations at the scale of the state do not simply descend upon local populations, but are filtered through various social contexts. Therefore, state action is both enabled and constrained by actors and processes operating at different scales, and in different institutional environments.

By focusing on the state as the object of analysis, the model developed by Taenzler et al. (2008) discounts many of the important processes and actors operating at other scales. For example, they largely set aside the importance of local adaptive capacity, because “coping capacity of communities is likely to erode” in the face of future droughts, and that such capacities “have increasingly been under stress due to the consequences of a globalized market system” (Taenzler et al. 2008). While these claims are true in *some* contexts, it does not *always* follow “that the effectiveness of traditional knowledge for applying coping strategies may be limited” (Taenzler et al. 2008). Although adaptation can change social roles and livelihoods in manners that perpetuate or exacerbate unjust and unequal outcomes within a given community, it may also serve as a robust means of understanding and addressing challenges to human well-being for many communities experiencing significant environmental and/or economic change (e.g. Adger 1999; Carr 2008; Denton 2002; Grothmann and Patt 2005; Smit and Wandel 2006). Therefore, local knowledge and adaptation strategies still play an important role in access and entitlements that shape who will be able to eat, farm, and otherwise make a living, even if they are not able to provide adequate resources to ensure human well-being under particular drought conditions. Thus, they cannot be ignored or diminished in any study of the emergence of drought-related crises.

In the second article, Acosta-Michlik et al. (2008), adopting what they call a socio-economic perspective on vulnerability to drought-related crises, view economic development and social well-being as key to understanding susceptibility to drought-related crisis. They narrow development and social well-being to three determinants

**Fig. 1** Diagram of the indicators and determinants of drought-related crisis outcomes (from Acosta-Michlik et al. 2008, p. 154)



each. Each of these determinants is quantified by two indicators (Fig. 1). Results from their inference model suggest that “susceptibility is low in countries with high financial resources and educational attainment, with low agricultural dependency and gender inequality, and with good infrastructure development and health condition” (Acosta-Michlik et al. 2008).

While we generally agree with these conclusions, we are not convinced that their model has captured other important determinants of development and social well-being. The contemporary literature on development contains important debates about the nature of economic development, the goals of such development, and how to best measure development outcomes. Viewpoints in this literature range from neoliberalism-influenced market-led frameworks (De Soto 2000; World Bank 1991) to post-modern and poststructurally influenced calls for a “post-development” era or approach (Escobar 1995; Escobar et al. 2002; Esteva 1992; Esteva and Prakash 1998; Gibson-Graham 2005; McKinnon 2007).<sup>1</sup> Reducing economic development and social well-being to three determinants requires a careful engagement with these debates to ensure that the summary statements framing the model are in line

<sup>1</sup> These two categories of development approaches are very broad, and those we have lumped under each heading often have significant differences with others under the same heading, let alone with those who fit under entirely different approaches to development.

with current expert knowledge. Without such a discussion, it is unclear how this model relates to current understandings of development and human well-being, and therefore improves our understanding of either development or social well-being.

In summary, there are significant discrepancies between the summary statements in these two articles and the expert knowledge that these statements are meant to encapsulate. These discrepancies result in models that oversimplify both political science and economic understandings of the causes of susceptibility to drought to such an extent that any empirical evaluation of these models would speak to the limitations of these summary statements, and not to the disciplinary perspectives from which they were drawn or the more general quantification approach (Alcamo et al. 2005; Eierdanz et al. 2008) on which these particular models are based.

#### Indicator selection

It is difficult to capture the multiple interacting stressors that affect individuals and communities in the context of drought. Susceptibility to harm is a complex process, rather than a static condition, that is difficult to measure directly using indicators (Eierdanz et al. 2008). Therefore, quantifying vulnerability to drought requires the careful selection of indicators and validation of model outputs.

However, indicator selection rarely addresses the subjective, political nature of this process. “Practicality” often seems to preclude such discussions, as indicators are often selected based on the availability of existing data or the low cost production of new data sets. Rather than expend resources building new datasets, we often work with the data that are available and then build models to accommodate the data.

Working with available data, rather than building new datasets, is more than a pragmatic choice. It is a reflection of power relations that determine what is to be measured, where limited resources need to be directed, and consequently what is seen as legitimate and valuable information. Therefore, the selection of indicators, based on data availability, is a value-laden process that reinforces current data gathering foci, which themselves empower or prioritize certain issues. We are concerned that the continued legitimization of variables based on pragmatism will lead to an air of scientific legitimacy surrounding the exclusion of important data-limited indicators, and reinforce current data gathering foci.

Aside from Eierdanz et al.’s (2008) brief mention of indicator selection as a challenge to measuring vulnerability, none of the papers in this special issue addresses the shortcomings of selecting indicators based solely on data availability in their methodological discussions. To be fair, the two articles at hand drew upon an identical set of case study regions for the purpose of making their outputs comparable, and therefore the authors were limited in their choices of data. However, we do not feel that this constraint precluded the authors from discussing the appropriateness of the indicators they chose to the question at hand. Whether a result of the dataset to which these studies were constrained, or a focus on availability as a governing factor in indicator selection, some of the selected indicators do not measure the processes or factors the authors wish to capture in a straightforward way.

For example, Taenzler et al. (2008) use “public health expenditures as a percentage of GDP” as an indicator of state willingness to promote social protection. Although the authors note that gross domestic product (GDP) is commonly used to measure the production and wealth of a country, it appears that they selected GDP primarily on the basis of its availability. The authors note that data availability precludes “the measurement of poverty as a percentage of the population living below the poverty line” and note that “gross national income (GNI) may serve as an alternative measure of wealth, but is unfortunately unavailable for the case studies” (Taenzler et al. 2008). The reliance on GDP is clearly the product of the particular dataset used in this study. The authors’ own claim that “high GNI per capita gives the impression of economic strength, and masks the fact that economic success may be

quite fragile and dependent to a high degree on conditions outside the country’s control” (Taenzler et al. 2008) in fact acknowledges that an approach to drought-related crises bounded at the scale of the state does not capture key processes that make significant contributions to these crises. This tacit acknowledgment, however, does not stand in for a measured discussion of this problem.

The problem of availability, which may have been out of the authors’ control, is less significant than the fact that neither GDP data nor GNI data capture state willingness to promote social protection. For example, states that underwent structural adjustment were often forced to cut back on investments in public health because the International Monetary Fund (IMF) deemed them “unproductive”. In these states, a low ratio of public health expenditures to GDP or GNI may have more to do with a lack of concern for such issues on the part of the IMF, rather than willingness of the government to commit its resources to helping its people. Therefore, using GDP or GNI to capture the “willingness” of a state to act on the behalf of its people ignores important aspects of history and political economy that contextualize such spending (e.g. Easterly 2006; Gladwin 1991; Williams 1994). Although one might argue that the authors’ framework links low expenditures associated with structural adjustment to key weaknesses of the state that promote the likelihood of a drought-related crisis, it is important to note that this weakness is exogenous to the state.

Acosta-Michlik et al.’s (2008) efforts to populate their model are also principally focused on the availability of data. While the authors are aware of the wide range of potential indicators that might shape both development and social well-being, their selection of indicators is limited to “only those that have good regional time-series data for all the case study regions” (Acosta-Michlik et al. 2008) because they are trying to make cross-country comparisons. While we agree that comparisons must be made with compatible temporal and spatial resolutions, we find it difficult to verify if the indicators used in this model capture the complexity of the socio-economic dynamics that contribute to drought-related crisis. For example, the stance one takes on development and its measurement will greatly condition one’s choice of indicators for this aspect of vulnerability. It is not clear how the authors define development, however, and therefore it is difficult to assess if the indicators they have chosen capture their understanding of this aspect of vulnerability to drought-related crisis.

We are also concerned that a number the indicators used to populate this model could be covariate, making the model outputs less than robust. For example, agricultural GDP/total and agricultural labor/total, while not necessarily completely correlated, should be tested for correlation before being employed as independent variables. The same

could be said of the pairings of infant mortality rate and percent health expenditure, illiteracy rate and percent educational expenditure, and even hydro power/total and percent irrigated area. If these measures are indeed covariate, the selection of variables constrained by availability has led the authors to construct a model that, in many cases, has what amounts to a single measure (reflected in two covariate indicators) supporting a broad determinant of either economic development or social well-being. In short, this populating of the fuzzy-set model strikes us as thin. The risks associated with framing of vulnerability around a potentially tiny set of variables make it unlikely that this model will serve as a rigorous basis for quantifying the complex dynamics that lead to vulnerability and drought-related crisis.

These two articles highlight the need to focus on measuring summary statements through appropriate indicators. Identifying appropriate indicators is more than a technical exercise. Those who seek to quantify and model these processes must engage in a philosophical discussion about the motivations behind such indicator selections, even when they appear pragmatic. For example, while we agree with Eierdanz et al. (2008) that fuzzy set theory can enhance the transparency of model assumptions, it only does so in a technical sense—it forces the modeler to spell out their assumptions. It does not, however, automatically lead to the careful consideration of whether or not these assumptions are founded on meaningful knowledge. What the cases at hand illustrate is the need for a critical approach to knowledge construction. Such approaches are well developed in both qualitative and modeling literatures, and require us to ask questions such as “why is this an appropriate variable?”, “why does everyone use this variable to measure this process?” and “how has certain data come to be viewed as legitimate, while other data has been excluded from models?”

## Conclusion

Quantifying susceptibility to drought offers the potential to inform policy and guide the allocation of limited resources to locations where alleviation efforts are most urgent. It is therefore critical that modeling efforts accurately reflect conditions on the ground. In this article we have focused on the challenges associated with implementing the fuzzy-set model proposed by Alcamo et al. (2005) and Eierdanz et al. (2008). Our review has identified significant issues with two efforts to implement this model (Acosta-Michlik et al. 2008; Taenzler et al. 2008). Some of the issues we have raised were likely beyond the control of the authors, who were constrained to particular datasets. However, all of these issues are

significant such that the likely discrepancies between model outputs and empirically-observed events are great, and therefore the authors’ lack of discussion of these issues is problematic. The questions of disciplinary perspective and quantification remain significant to our understanding of vulnerability, and deserve further careful consideration.

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