



Regionalisation of global insights into dryland vulnerability: Better reflecting smallholders' vulnerability in Northeast Brazil[☆]



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ABSTRACT

Global analyses of vulnerability reveal generic insights into the relation between socio-ecological systems and the stress impacting upon them including climate and market variability. They thus provide a valuable basis for better understanding and comparing the evolution of socio-ecological systems from a broad perspective. However, even when reflecting sub-national differences, global assessments necessarily aggregate regional variations in the underlying conditions of vulnerability. Refinements are therefore necessary to better accommodate context-specific processes and hence facilitate vulnerability reduction. This study presents a novel methodology to refining global insights into vulnerability at a regional scale. It is based on a spatially explicit link between broad patterns of vulnerability and modelled regional smallholder development. Its application in order to better represent the drylands of Northeast Brazil reveals specific facets of smallholders' vulnerability at the *município* level, reflecting non-linear dynamics. The results show that smallholders' vulnerability was widely exacerbated in the most vulnerable areas. One key mechanism causing such a vulnerability increase involved intensifying resource degradation and the related potential for impoverishment as modelled at the regional scale. In addition, by subsequently re-orienting their livelihoods towards off-farm activities, smallholders became more sensitive to fluctuations and competition in the labour market. In contrast to these critical trends, living and environmental conditions improved in only some areas, thus indicating a decrease in vulnerability. Altogether, in differentiating the heterogeneity of resource management and smallholders' livelihoods, the regional refinement presented in this study indicates necessary adjustments to generic strategies for vulnerability reduction gained at the global scale.

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1. Introduction

Global vulnerability analyses provide an overview of generic processes that determine the relation between socio-ecological systems and stress (UNDP, 2004; Brooks et al., 2005; Dilley et al., 2005; Sietz et al., 2011a; ADW, 2012). Typical factors such as the scarcity and overuse of natural resources, poverty and social exclusion help to frame the underlying conditions of vulnerability as multi-dimensional and interactive processes. The evaluation of

such generic conditions of vulnerability is valuable in better understanding and comparing the evolution of socio-ecological systems in the face of perturbation. In particular, global vulnerability analyses that reveal similarities among socio-ecological systems may facilitate the transfer of successful intervention options (Sietz et al., 2011a), thus supporting vulnerability reduction efforts substantially. Moreover, a spatially explicit indication of underlying conditions (UNDP, 2004; Dilley et al., 2005; Sietz et al., 2011a) allows an assessment of regions for which empirical evidence is not available.

Due to their worldwide coverage, global assessments of vulnerability inevitably reflect regional conditions only to some extent. Thus, regional facets of specific processes such as the recovery of natural resources, labour allocation, market integration and migration (Eakin, 2005; Sietz et al., 2006; Sallu et al., 2010) are considered in a generalised form only. In addition, global vulnerability assessments are constrained by the availability of high-resolution data for the quantification of underlying processes. Often, available data either cover the systems under

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investigation only partially (e.g., Lepers et al., 2005; Vörösmarty et al., 2010) or they are limited to larger grid elements (e.g., Alcamo et al., 2003) or even the national resolution (e.g., World Bank, 2008; UNDP, 2010).

A better reflection of regional heterogeneity within environmental and socio-economic conditions would, however, be important for designing policies that are well tailored to particular contexts (Campbell et al., 2006; Andersen et al., 2007; Vetter, 2013). This would help differentiate and enrich generic policies for vulnerability reduction with regard to particular social groups or exposure to specific stresses. Overall, working at an intermediate functional scale, that is to say between an all-embracing global and a purely local perspective, provides a suitable basis for a more successful analysis and more targeted strategies for reducing vulnerability (Cash et al., 2006).

Recognising the value of more differentiated insights, this study aims at improving our capacity to globally assess dryland vulnerability by better reflecting regional heterogeneity for the purpose of enhancing vulnerability reduction efforts. It demonstrates an innovative methodology for refining global insights into dryland vulnerability at a regional scale. Taking the drylands of Northeast Brazil as an example, the refinement considers regional processes that shape the vulnerability of smallholders, focusing on key inter-linkages between agricultural land use and environmental as well as socio-economic conditions. Vulnerability is employed as a concept for framing the relation between smallholder systems and recurrent stress. The concept of vulnerability as applied in this study encompasses exposure to climate, market-related and other stresses as well as the sensitivity of a socio-ecological system to these stresses and its capacity to cope and adapt (IPCC, 2007). This concept is suitable for capturing the multi-dimensional character of vulnerability.

For the purpose of regionalisation, this study links global insights into dryland vulnerability in a spatially explicit way with regional processes relevant to the smallholder systems of Northeast Brazil. It focuses particularly on vulnerability dynamics, that is to say the smallholders' changing ability to assimilate stresses or manage their outcomes. Overall, vulnerability insights are resolved for a significant social group and specific refinements are supported by empirical evidence. Here, the refinement of broad vulnerability patterns to the *municipio* level facilitates decision-making which takes such small administrative units into account. Reflecting the regional heterogeneity of natural resources, their management and the smallholders' livelihoods, the results provide insights that are supportive for locally-adjusted development interventions. Thus, this regional refinement helps to establish more targeted strategies for vulnerability reduction.

2. Background

2.1. Global insights into dryland vulnerability and their refinement

Drylands display a close human-nature interdependence based on their particularly marginal natural resources. Water scarcity and related constraints on primary production and nutrient flows are typical characteristics of dryland regions (Safriel et al., 2005). Drylands cover 41% of the Earth's surface and are inhabited by 36% of the world population, including an estimated one billion poor people in rural areas (Dobie, 2001; Safriel et al., 2005). In view of the widespread prevalence of resource degradation, food insecurity and migration, the United Nations Convention to Combat Desertification underlines the development of environmental and living conditions in dryland regions as an area in need of advancement (UNCCD, 2007). One important task in addressing this need is the design of interventions to minimise adverse outcomes of stress.

Reflecting the importance of vulnerability reduction efforts, global assessments of drylands provide an overview of key issues pertaining to typical vulnerability mechanisms resulting from the multi-faceted interplay between marginal ecosystems, human societies and environmental as well as socio-economic stress (Dregne, 2002; Geist and Lambin, 2004; Safriel et al., 2005; Jäger et al., 2007; Reynolds et al., 2007; Safriel and Adeel, 2008; Sietz et al., 2011a). Vulnerability mechanisms relate to the scarce and unpredictable precipitation conditions, the degradation of the marginal natural resources, diversification of livelihoods, the importance of policies and institutions and social as well as technological ingenuity as an important stimulus for sustainable dryland development.

Focusing on the most important mechanisms derived from empirical evidence, Sietz et al. (2011a) present the first quantitative assessment of vulnerability in drylands worldwide, based on the best available observational and modelled data with complete coverage of global drylands and sub-national resolution. Data used for indication in the global assessment include measures of the degradation of water and soil resources, poverty, natural agro-constraints and isolation. Here, sub-national indicators express the specific values and distribution of dryland characteristics for countries whose territories include drylands and non-drylands such as Brazil and China. This assessment results in seven typical patterns of vulnerability. Among these, one pattern primarily found in Africa displays most severe vulnerability, indicating the poorest people in the most isolated dryland areas with highly over-used water resources, though only a low level of soil degradation (Sietz et al., 2011a). In contrast, the least vulnerable patterns are found in industrialised regions with lowest poverty but with partially depleted water and soil resources. This pattern analysis presents a meaningful generalisation of heterogeneous vulnerability situations in global drylands, allowing their essence to be grasped beyond individual cases and, thus, at a spatially and functionally aggregate level.

The global study presented in Sietz et al. (2011a) allows an assessment of the global distribution and hotspots of dryland vulnerability, based on a limited number of key indicators. Using the representative indicator combinations at the cluster centres, the study systematically derived and discussed strategies for vulnerability reduction and the transferability of successful interventions. The implications for interventions aimed at vulnerability reduction are, however, necessarily broad, thus requiring local adjustments to address specific implementation needs. In this context, the development of approaches to refining global vulnerability insights to specific regional contexts (Birkmann, 2007; GRIP, 2013) arises as an important research field.

In contrast to global assessments, local to regional investigations deliver valuable knowledge on specific characteristics and outcomes of vulnerability, differentiating for example particular social groups or livelihoods (Sallu et al., 2010; Sietz et al., 2012). While stimulating valuable debate, the diverse approaches used to analyse vulnerability in specific dryland areas and elsewhere may complicate the comparison between different studies. In particular, the question arises: how relevant are the specific mechanisms identified in one location for locations elsewhere? This question is important since major decisions for reducing the vulnerability of larger socio-ecological systems are taken at a higher than local level (Adger et al., 2005). Thus, some degree of standardisation is desirable to compare regions. Here, the global perspective provides a suitable basis for developing a common conceptual framework and for standardising methodologies, data collection and knowledge management. To adequately capture the complexity in dryland vulnerability worldwide, however, a global perspective needs to maintain an appropriate level of regional differentiation.

The regionalisation of global insights into dryland vulnerability presented in this study depicts one important step towards

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