Typologies of socio-ecological conditions

Identifying relevant and valid patterns to support resilience building

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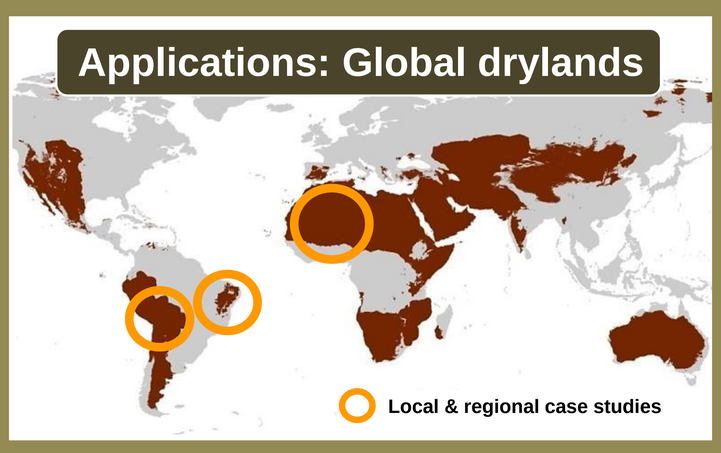
Background: Within the multitude of conditions determining the relation between socio-ecological systems and stress impacting upon them, distinct processes recur in various regions inspiring research on typologies. The categorisation of a limited number of typical patterns presents an efficient approach to improving our understanding of vulnerability and related decision-making. However, the question arises as to how do we identify typical patterns in the socio-ecological properties in order to enhance our understanding of a systems' behaviour in the face of stress?

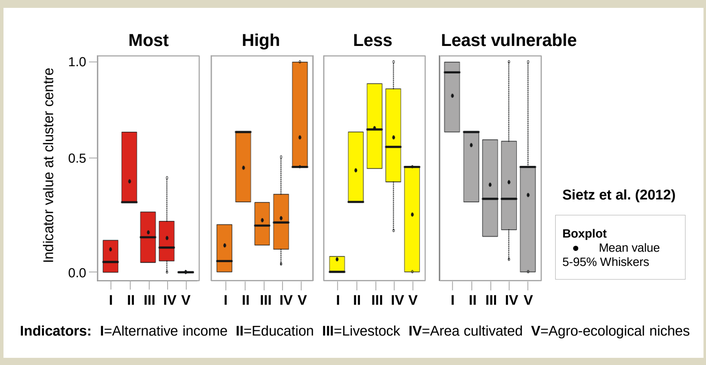
Aim: The aim of this study is to reveal the conditions necessary to identify relevant and valid vulnerability patterns. Focusing on an applicable methodology and practicable insights, these conditions may facilitate the application of pattern recognition in future vulnerability analyses.

Methodology: This study employs cluster-based pattern recognition relying on well-defined and formalised mechanisms that generate vulnerability. Cluster analysis is based on a sequence of hclust and k-means algorithms using routines from the statistics package R. It is stochastically initialised and performed in a pairwise way to identify the number of elements (e.g., grid cells or households) with an identical cluster allocation in both cluster partitions. The five methodological steps necessary to identify typical vulnerability patterns are outlined below.

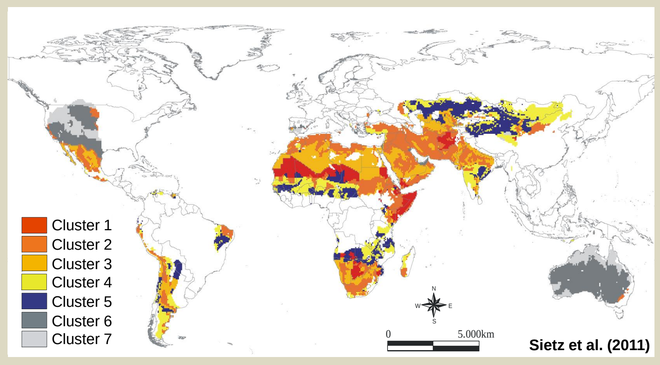
Applications: Global drylands



Farmer households in Peru (Andes)



Global drylands



Patterns of vulnerability

Step 1: Mechanism hypotheses

- Using **grounded theory**, information on vulnerability is elicited from case studies and expert knowledge. The formulation of mechanism hypotheses follows **heuristic principles** by sampling cases that broaden the scope of knowledge. Specific meanings and the relation between findings are explored in local contexts.
- The hypotheses are adequate when **patterns** identified are **interpretable** in the light of the mechanisms elicited.

Step 2: Quantitative indication

- Based on the hypotheses formulated in Step 1, **quantitative data** are chosen to indicate vulnerability. Data used for indication need to be **well-resolved both spatially and temporally** reflecting congruent spatial resolution and temporal intervals. It is outlined explicitly how the selected indicators describe the respective vulnerability dimension.
- Indicators that contribute significantly to the **variance** of the data space and are **least correlated** are most suitable for clustering.

Step 3: Cluster analysis and robustness

- The cluster algorithms tend to yield similar results in **stochastically initialised runs** if the cluster number fits the structure of the data space. Therefore, the **reproducibility** of cluster partitions is calculated in pairwise comparisons (200x) for a given cluster number to indicate cluster robustness.
- Further, the ratio of the **between-cluster and inner-cluster variance** supports the choice of cluster partitions. The higher the variance ratio, the more dissimilar and compact the clusters identified.

Step 4: Validation

- **Patterns** are empirically valid if they **correspond to** independently reported **outcomes of vulnerability** and if the pertinent **mechanisms** are **consistent and plausible** (Step 1). A clear correlation reveals that the similarities given by the clusters hold true for reported outcomes.
- Application validity is proven if the **transferability of strategies** to reduce vulnerability can be confirmed within a given cluster.

Step 5: Ranking

- **Vulnerability outcomes** and **the distribution of indicators** are used to rank the patterns identified. For example, a higher damage (vulnerability outcome) indicates more severe vulnerability.
- If methodologically consistent information about stress exposure and outcomes cannot be obtained (e.g., at global scale), the **indicators** at cluster centres may be **summed up** for an initial approximation to rank the patterns.

Methodological refinements and further research: The five methodological steps reflect **scale-dependent opportunities** such as an elaborate outcome-oriented validation at local level using independently acquired information (Sietz et al. 2012). Moreover, a novel methodology was developed to **refining global insights into vulnerability at a regional scale** (Sietz 2014). It is based on a spatially explicit link between broad patterns of vulnerability and modelled regional smallholder development in Northeast Brazil. Feeding back to case study research, regionalised mechanisms such as those identified by Sietz (2014) may stimulate investigations to further elaborate our knowledge. Finally extending the methodology outlined in this study, **dynamics in vulnerability patterns** and the **linkages between vulnerability patterns and violent conflicts** have been assessed in drylands worldwide (Lüdeke et al. 2014, Sterzel et al. 2014).

References:

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