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TITLE: A vulnerability index: mapping household vulnerability in Calakmul, Mexico.

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ABSTRACT

Los estudios de vulnerabilidad comparten el interés de analizar cómo los individuos, y la sociedad en su conjunto, son capaces de vivir una buena vida. Este estudio se enmarca dentro de la idea de vulnerabilidad social incorporada por W. Neil Adger (1999) dónde se pretende poner de manifiesto la importancia de la dimensión social y política en el estudio de los componentes y estructura de la vulnerabilidad. Dichos componentes son: 1) la exposición de esa población a las perturbaciones; 2) la sensibilidad de esa población a sufrir daños por esas perturbaciones; y 3) la capacidad de adaptación de esa población para hacer frente y adaptarse a las nuevas condiciones del entorno. El estudio realizado en dos comunidades rurales del municipio del Calakmul, Campeche (México) pretende arrojar luz sobre la heterogeneidad de los patrones de vulnerabilidad a nivel de hogar frente a múltiples perturbaciones detectadas localmente: la variabilidad de los patrones de precipitación, la volatilidad de los precios del chile y las reglas formales de conservación. La información cuantitativa recogida en las 93 encuestas a los jefes de hogar nos permite desarrollar un detallado indicador de vulnerabilidad adaptado a las condiciones locales, y en el que se pueda detectar qué aspectos de la sensibilidad hacia las perturbaciones o de la capacidad de adaptación de los hogares son más relevantes en la investigación.

INTRODUCTION

Vulnerability studies share an interest in analysing how an individual or a collective are able to live a "good life" (Miller et al., 2010). More specifically, this research draws on Adger's definition of social vulnerability as "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 livelihood" (Adger, 1999: 249). Existing research has recognised three dimensions of vulnerability: exposure, sensitivity and adaptive capacity (Adger, 2006). Exposure is "the magnitude, frequency, duration" of each stressor (Adger, 2006: 270). Sensitivity is "the degree to which a system is modified or affected by perturbations" (Adger, 2006: 270). Last, adaptive capacity describes "the preconditions necessary to enable adaptation, including social and physical elements, and the ability to mobilise these elements" (Nelson et al., 2007; p.397). We shed some light on the analysis of these three dimensions by developing a Household-level Vulnerability Index (VI) as a tool that attempts to: 1) evaluate households' vulnerability patterns to multiple stressors (i.e., climate, socio-economic and institutional stressors), and 2) identify the influence of multiple exposures across households. We used data from two rural communities in South-eastern Mexico.

RESEARCH AT LOCAL SCALE: TWO LOCAL EXPERIENCES IN CALAKMUL, MEXICO

The research was carried out in two communities located in the Calakmul municipality, state of Campeche, Mexico. Calakmul municipality was created in 1996, following the 1989 establishment of the biggest Mexican tropical forest protected area that gives the name to this administrative figure and that covers 52% of the municipal territory: the Calakmul Biosphere Reserve (CBR). At present, this municipality has a population of 26.882 inhabitants (CONAPO, 2010); 85.8% of the population in the municipality lives in poverty, 46.1% in extreme poverty (CONEVAL, 2010).

The selected communities, Once de Mayo (hereafter *Once*) and Santo Domingo-El Sacrificio (hereafter *Sacrificio*) are located in the Southeastern part of the municipality. Inhabitants of both communities arrived in the 1980s and 1990s attracted by the opportunity to obtain land through stimuli

established under federal government laws. However, the history of the creation of each of these communities is dramatically different. *Once* is an *ejido* (i.e., Mexican common property regime) established in 1981, and officially recognised in 1994. This community has a population of 350 inhabitants (CONAPO, 2010) divided into 78 households, where only 55 persons in the community are *ejidatarios* (i.e., people who hold usufruct rights over lands of common property). This *ejido* is socio-culturally heterogeneous, gathering three ethnic groups and inhabitants from 10 different states. By contrast, El Sacrificio was a small community without official land rights when, in 1999, four communities¹ were resettled in its current location to create a community of small private properties called Santo Domingo-El Sacrificio (*Sacrificio*). The resettlement was the result of an intervention promoted by the government and the CBR. However, as soon as the land titling process began, the government institutions realised that some land plots were still located inside the CBR and suspended the land titling process, which has yet to be resolved. Lack of land rights in *Sacrificio* has constrained households' access to government funding and development programs. To date, *Sacrificio* has 547 inhabitants (CONAPO, 2010) belonging to 134 households, where only 99 persons are considered as potential landowners (yet still pending formalisation through land titling).

Both communities have two factors in common that are relevant to understanding household vulnerability patterns. The first factor they share is social and cultural diversity dominated by the *Chol* group. The second factor is diversity of livelihoods systems. Each household engages in two to six productive activities, with agriculture being the principal source of food and income. Wage labour is an essential activity in both communities; people in *Once* work in the community whereas people in *Sacrificio* seek employment outside of the community. Households in both communities receive income support – principally governmental – of between 1,000 and 50,000 Mexican

¹ These four resettled communities were known as San Isidro - Aguas Amargas, Las Delicias, Veintidos de Abril and Aguas Turbias. They were founded in the 1990s decade within the core zone II of the Calakmul Biosphere Reserve and in 1999 the government's Agrarian Reform Secretariat (SRA, in Spanish) and the CBR relocate them.

pesos (1\$=13.284 Mexican pesos, 09/08/2014). Livestock production is increasing in *Once*, but almost inexistent in *Sacrificio*.

MAPPING HOUSEHOLD VULNERABILITY PATTERNS

Vulnerability mapping is a growing field of research that attempts to fill the gap in the analysis and measurement of vulnerability patterns. The mapping of vulnerability enables the identification of (1) factors determining vulnerability patterns across households, groups and communities; and (2) the presence of households affected by a “multiple exposure” condition. Regarding the latter, this research follows O’Brien *et al.* (2004) who determined an approach to identify regions that have been exposed to more than one stressor, referred to as “double exposure”.

In the attempt to map vulnerability, the development of a VI is the more complex task; mapping is the visual tool required to present the results of the study. In order to encapsulate complex realities, a VI faces two main challenges (Adger *et al.*, 2004; O’Brien *et al.*, 2004; Vincent, 2004; Notenbaert *et al.*, 2013): 1) an intrinsic dynamism of vulnerability conditions, as pressures on households and access to and use of natural resources vary in time and space; and 2) processes that shape vulnerability operate at different scales, from global to local levels. Moreover, there is no consensus regarding the development of baselines and/or specific indicators to encapsulate relevant information in a VI. Recent studies include social factors such as social networks (Hahn *et al.*, 2009) or knowledge (Mountjoy *et al.*, 2013), while other studies set vulnerability indicators closer to poverty studies focusing on economic and material aspects.

To map rural vulnerability in the two communities, we developed a household-level VI. Our index considers exposure, sensitivity and adaptive capacity patterns across households. The subsequent steps to build this VI are (O’Brien *et al.*, 2004): 1) selection of the most important stressors as locally perceived; 2) analysis of households' level of exposure to the selected stressors; 3) selection of variables that proxy households' level of sensitivity to each stressor; and 4) selection of variables that proxy households' ability to cope or adapt to those stressor. According to the results of the VI, we then classify households of each community into three categories: low, medium, and high vulnerability.

Step 1: Selection of the locally perceived stressors

In this first step we identified the main past and present stressors perceived in both communities. To elicit the environmental history of the communities and households we used semi-structured interviews (N=30) and timeline focus group (N=5) carried out between September and November 2012. After that, we selected three perceived stressors following these criteria: 1) to select more than one stressor to research on this “multiple exposure” condition; 2) to select stressors that are external to households rather than internal sources of stress; 3) to select different typologies of stressors; and 4) to select stressors that are currently relevant to community members’ livelihoods. All methods were conducted in Spanish and, when required, conversations were translated from the corresponding indigenous language (i.e., *Chol*) with the support of a local translator.

The locally perceived stressors (Ruiz-Mallén et al., 2015) were as follows:

- 1) Rainfall variability was identified as a one of the biggest concerns for local livelihoods, reflecting the importance of meteorological conditions over agricultural and livestock activities. The dramatic dependence of agriculture on precipitation and the natural low water retention in the soil determine the historical evolution of local livelihoods in the region;
- 2) Price volatility of cash crops, particularly chilli, is considered one of the main stressors in the region. The price of chilli, which is controlled by intermediaries, has changed very little - from 1 to 4.50 Mexican pesos - over the course of the past decade. Since mid-1970s, chilli trade has become in the first cash crop in Calakmul; and
- 3) Conservation rules, including the set of rules regulating both the CBR and the federal programs of Payments for Ecosystem Services (PES) and Environmental Compensation programme (EC). These conservation rules have been influencing, and sometimes constraining, the access to, use of and control over local natural resources by local people. This institutional stressor is differentiated in our selected communities. Household livelihoods in *Once* and *Sacrificio* are influenced by the presence of the CBR. The federal programmes PES and EC have been influencing forest resource management specifically in *Once* since the late 2000s.

Step 2: Analysis of households' level of exposure to the selected stressors

We follow (Adger et al., 2004; Vincent, 2004; Hahn et al., 2009; Notenbaert et al., 2013) and consider households' exposure to a given stressor as evenly distributed across the territory. Rainfall variability is understood as equally distributed among the studied communities because there is meteorological information is not specific to each community. For the chilli trade, both communities have the same intermediary, hence the same price volatility regime. However, given the difficulty of assessing qualitatively the consequences of exposure to conservation rules in the context of both communities, we decided not to use this measure in this VI. (For instance, the Payment for Ecosystem Services programme and other conservation initiatives are only present in *Once*. Whilst the Calakmul Biosphere Reserve has a different influence over households in *Sacrificios* since they were relocated and are still claiming land tenure rights.)

Step 3: Selection of variables that proxy households' level of sensitivity to each stressor

Considering rural households, sensitivity is closely related to the diversification of activities and economic incomes (Eakin and Bojórquez-Tapia, 2008). Moreover, these sensitivity variables are highly specific to the stressor affected. So, variables that explain household's sensitivity to rainfall variability are not the same as variables that reflect household's sensitivity to conservation rules. Therefore, this Household-level VI has three measures of sensitivity corresponding to each stressor.

Sensitivity to rainfall variability: Agriculture and livestock rely on rainfall patterns in the region. Therefore, the assessment of household's sensitivity to rainfall refers the importance of these farm activities in a household's economy, such as the percentage of land dedicated to agricultural activities or the percentage of the household's economic income derived from agricultural and livestock production.

Sensitivity to chilli price volatility: Chilli is the principal cash crop in both communities. Hence, household's sensitivity to chilli price volatility refers the percentage of land dedicated to chilli production in comparison to total land available, or the economic income dependence of household from trade of this cash crop.

Sensitivity to conservation rules: Vulnerability to conservation rules related to the access to and use of forest resources by households. Specifically, we assessed the potential amount of firewood used by households and hunting restrictions.

Step 4: Selection of variables that proxy households' ability to cope or adapt to selected stressors

Based on previous research by Adger *et al.* (2004), household's adaptive capacity is categorised into six sets of indicators, in order to highlight the importance of economic and material factors, as well as the relevance of institutional, human and social factors that determine household's ability to adapt. To select variables that proxy households' ability to cope or adapt to those stressors we look at variables included in the literature (Cutter *et al.*, 2003; Adger *et al.*, 2004; O'Brien *et al.*, 2004; Vincent, 2004; Eakin and Bojórquez-Tapia, 2008; Hahn *et al.*, 2009; Mountjoy *et al.*, 2013; Notenbaert *et al.*, 2013), selecting and adapting these variables to encapsulate the reality of our selected communities.

Economic wellbeing: savings or economic income diversity are variables associated with the potential household investment and the economic power and ability of this household.

Education and knowledge: high levels of education, rich knowledge and the willingness to do new activities are variables associated with more adaptive capacity.

Materials and physical infrastructure: the materials and physical infrastructure of a household are relevant aspects reflecting the ability that this household to do current and new activities.

Land rights, governance and social networks: the relation and status of a household with its local institutions, governance system and social networks are crucial factors determining household's ability to adapt.

Demographic and geographic factors: variables such as the number of adults, age and health status or the distance to the agricultural field are proxies of the amount of natural and economic resources needed, and how easy or hard can be to obtain these resources.



Natural resources: these variables reflect the household capacity to access and use some resources such as water, land, forests, livestock, and in which quality and quantity.

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