Chapter 31

On the Vulnerability of the Indigenous and Low-Income Population of Mexico to Natural Hazards. A Case Study: The Guerrero Region

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Chapter Outline

Abstract
This chapter deals with some of the issues behind the vulnerability of that part of the Mexican population who are most exposed to natural hazards due to the site and conditions of their dwellings. In the case of Mexico, as is the case in many other countries, the people most vulnerable to natural hazards, in general, are the ones with the lowest income. This fact, in turn, translates in countries such as Mexico, in a large percentage also being indigenous. The issue of ethnicity plays various roles dealing with ethics when facing measures to issue warnings or carry out contingency procedures. Although it would be intuitive to assume that low-income people are most vulnerable to natural hazards, it is necessary to quantify the degree of vulnerability compared to the rest of the population, so measures can be taken to reduce the unfair difference. In this chapter, we want to draw attention to the different causes for the vulnerability of this segment of the population in Mexico, and some of the reasons why the ways to help them improve their living conditions continue to be neglected. We also address the question of whether

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there is a difference in vulnerability, which corresponds directly to the ethnicity status. We estimate the degree of vulnerability by means of an index derived from figures on demography (Social Vulnerability Index). Overall, we can see a clear coincidence between the level of social marginalization in the indigenous regions with vulnerability, as expected. Our results also show that the vulnerability of the central and coastal regions is lower than that of the Montaña (mountain) region and the recovery time is an important factor to be considered as a source of the difference between the three areas due to the isolation and difficulty of access to the mountain region. We estimate that the fatality rate in the rural population would be 20% larger than in the urban population in case of a hypothetical earthquake with magnitude M8.6 off the coast of Guerrero. We discuss some of the repercussions of a lack of planning strategies to mitigate damage and/or lack of enforcement of planning and regulations in cases where they exist. The recent catastrophic results of the "Manuel" storm of September 2013 are examples of poor preventing strategies and lack of enforcement of hazard mitigation practice.

Keywords: Earthquakes; Emergency warning; Hazards; Low income; Urban planning; Vulnerability.

INTRODUCTION

Recently, important advances have been made in the evaluation of what is now known as social vulnerability, which deals with aspects other than the biophysical or built environment. One of the main reasons why this aspect had been neglected in the past is the difficulty in quantifying socially created vulnerabilities (Cutter, 2003; Schmidtlein et al., 2008). This effort has lead to research, which has provided means for comparing the differences in vulnerability between different localities in a particular region or country, and has even lead to the creation of institutions fully devoted to this type of studies such as the Hazards & Vulnerability Research Institute at the University of South Carolina, USA.

Vulnerability varies over time and space, as Cutter et al. (2003) have pointed out, so it is necessary to have a method that can be used to derive inferences about the differences in vulnerability as they pertain to time and space.

We also agree with Cutter et al. (2003) in that "Social vulnerability is partially the product of social inequalities—those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond. However, it also includes place inequalities—those characteristics of communities and the built environment, such as the level of urbanization, growth rates, and economic vitality that contribute to the social vulnerability of places. To date, there has been little research effort focused on comparing the social vulnerability of one place to another."

Mexico comprises a large population of indigenous people, who in general suffer a lack of social services and infrastructure, as compared to the rest of the population. In many instances, indigenous communities are isolated and far from the emergency services, so response in an emergency phase is usually too slow. However, the condition of income or ethnicity not always bears negatively on the vulnerability of a community to any type of hazard. For example, some indigenous style of dwelling structures are more resistant to the impact of earthquakes due to the natural flexibility of their construction materials (Figure 1), but can offer little protection from storms and hurricanes.

In this work, we present figures on demography for one of the states of Mexico (Guerrero) with the largest proportion of indigenous communities as a particular example of the conditions that render indigenous people highly vulnerable to natural hazards. Then we make use of the Social Vulnerability Index (SOVI) method, proposed by Cutter and colleagues, in order to quantify a measure of the vulnerability of the localities of Guerrero state. We then attempt to correlate the index of vulnerability with the social status (i.e., income and ethnicity) of the localities identified as being most vulnerable to natural hazards. We discuss some of the possibilities of using this method for evaluating a particular characteristic of hazard, such as earthquakes or flooding, and point

FIGURE 1 Typical dwellings of many indigenous communities in Mexico. (a) Example of “palapa” with wood planks walls. (b) Palapa with walls of palm leaves.

out questions, which, from our perspective, should be addressed in order to minimize the risk of communities that are susceptible of suffering serious harm. Finally, we conduct an exercise estimating the casualties that are expected to result from an earthquake with magnitude M8.6 along the coast of Guerrero. This last section compares the relative impact of earthquakes on large and small communities.

SOME BASIC DEMOGRAPHICS OF THE STATE OF GUERRERO, MEXICO

The states of Mexico hardest hit by large earthquakes (mostly related to the subduction process of the Cocos and Caribbean plates under the North-American plate taking place along the Pacific Margin) and climate phenomena are the regions with the largest proportion of indigenous inhabitants, namely the coastal sates of Guerrero, Oaxaca, and Chiapas. Among these, the state of Guerrero has the lowest Human Development Index (HDI) in the country. This index was developed by the United Nations Development Programme to have an objective means to quantify poverty. The HDI combines indicators of life expectancy, educational attainment, and income into a composite index. The HDI sets a minimum and a maximum for each dimension, called goalposts, and then shows where each country stands in relation to these goalposts, expressed as a value between 0 and 1. Guerrero has an HDI of 0.6151 compared to the highest value of 0.7683 for Jalisco, considering indigenous population only (Informe PNUD, 2010).

Guerrero has 3,388,768 inhabitants who live in 81 municipalities distributed as 58% in urban communities and 42% in rural communities (following the classification of the National Institute of Statistics and Geography, a rural community is that which comprises less than 2500 people, with the opposite being an urban community). The state is known for its ethnic diversity and its large indigenous population, with an estimated half million people who speak a vernacular or indigenous language and live in one of the 76 municipalities of this state.

THE SOVI FROM ETHNIC FACTORS

The method for constructing the SOVI for the regions of Guerrero based on ethnicity, is based on the steps proposed by Cutter et al. (2000). In general, the SOVI is constructed by the normalization of each variable with respect to its maximum and minimum value for each municipality, also considering whether its contribution is positive or negative.

In our case, we selected four variables from available data, which we think represent the specific vulnerability of indigenous communities (after data from the National Committee for the Development of Indigenous Communities Report, CDI, 2008). The variables selected represent the levels of population dispersal and the economic and social characteristics of the regions for the indigenous population. They also provide dimensions to some educational and cultural issues. The selected variables are percentage of indigenous population, illiteracy percentage, distribution of the population in households with indigenous population by urban area, and percentage of population with high levels of social marginalization. These criteria have been considered due to the characteristics of the region and the data available.

DISCUSSION

The pattern of regional vulnerability as shown by the SOVI results (Figure 2(a)) closely follows that of the regional distribution of indigenous population (Figure 2(b)). We emphasize that the variables employed in the SOVI calculations have been normalized with respect to the total population, but in order to show that the total population is not related to the vulnerability, we also show the total population regional distribution in the histogram of Figure 2(b). Thus, this can be seen as an indication of how indigenous people are shaping the distribution of vulnerability in the state of Guerrero due to the conditions under which they live.

The above findings are also evident when considering the distribution of the social marginalization index (hereafter SMI) for all the population of the regions (after data from the Comisión Nacional de Pueblos Indígenas, 2008). The SMI is based on the following variables: illiterate population of 15 years of age or more; population with 15 years of age and over, who did not completed primary education; occupants in dwellings without drainage or toilet; occupants in dwellings without electricity; occupants in households without tap water; homes with some level of overcrowding; occupancy in houses with dirt floor; population in towns with less than 5000 inhabitants; people employed with income of up to two minimum wages. As illustrated in Figure 2(c), this index also matches the most vulnerable region as identified by their SOVI. The Montaña region, shown as the most vulnerable area in our results, is the region with the largest indigenous percentage of the population and with the highest SMI and poverty. The region with the lowest SMI (i.e., the Norte region), on the other hand, also matches the region with the lowest SOVI and has the lowest indigenous percentage except for the regions marked as "other," which basically have no significant indigenous population (and therefore was excluded from the SOVI calculation for indigenous regions). The indexes of the two intermediate regions do not match as closely, possibly due to the limitations in the variables employed for the analysis.

These results are reflected in the recent experiences of the vulnerable regions following the disasters triggered by climate phenomena. A total of 1.2 million people were affected when Hurricane Manuel made landfall on September 15, 2013 on Mexico's southwestern coastline, mostly in the state of Guerrero. The Subsecretary of Civil Protection of Guerrero reported (Periodical 24 hours, 2013) that in the Centro region, there were 1000 houses affected, 981 houses were

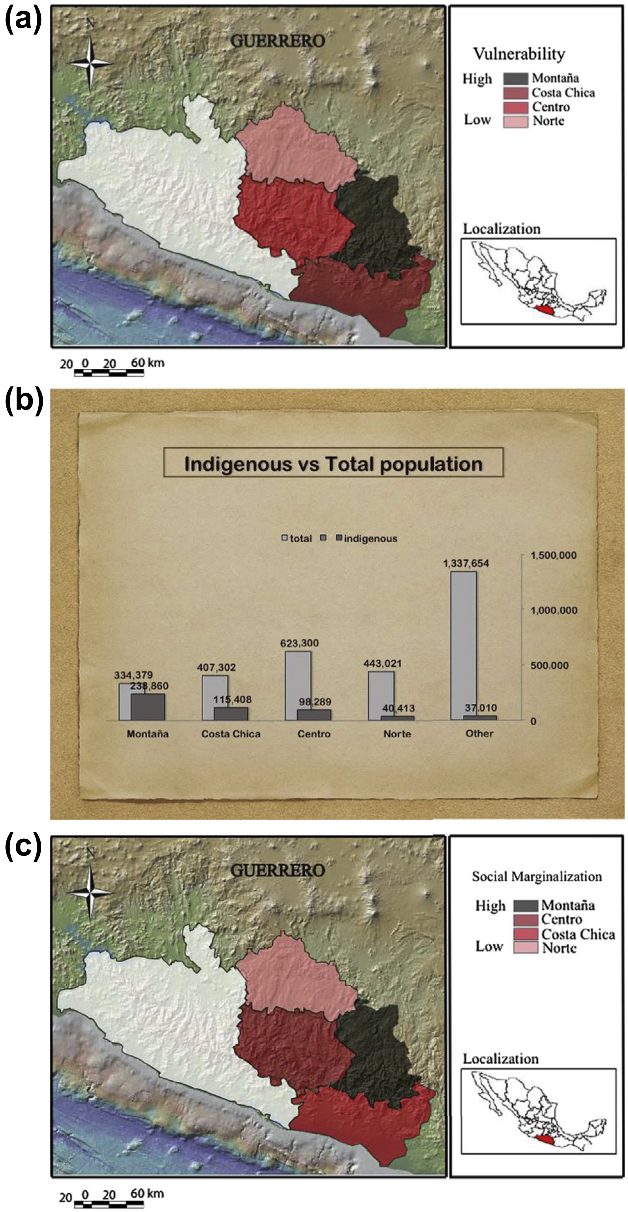

FIGURE 2 (a) Map of the vulnerability index (SOVI) based on ethnic factors at the regional level (see text). (b) Regional distribution of indigenous versus total population in Guerrero for 2010 (indigenous population data from National Institute of Statistics and Geography and total data from Sistema Estatal de Información Estadística y Geográfica (INEGI, 2010). Note that the index of vulnerability (Figure 2(a)) correlates well with the indigenous population but not so with total population. (c) Map of the social marginalization index (SMI) at the regional level. The regions with the highest and lowest SMIs coincide with the highest and lowest indexes of vulnerability (Figure 2(a)). The regions Centro and Costa Chica are not coincident, although this could be due to both having small variations in the indigenous population (Figure 2(b)).

damaged in the Costa Chica region, 2000 houses in the Costa Grande region, and 1400 houses in the Montaña region. However the emergency situation in the Montaña region was exacerbated by the late arrival of government assistance and the slow recovery time due to the isolation of the communities in that region.

In the Central and Costa Chica region, urban development for touristic purposes has taken an important role in the vulnerability issue because even though the levels of marginalization are often lower due to access to better infrastructure, low-income people favor the election of unsafe but cheap places to live on unstable ground or on the slope of rivers. Thus, in these regions there is a trade-off in vulnerabilities because of the context in which populations are developed although poverty is still the main factor that drives these communities as the most vulnerable. As for the region of Tierra Caliente and Costa Grande, the demographic data indicate no indigenous communities that inhabit the area. The results, which show these regions as least vulnerable, come as no surprise since they include the most developed towns due to the recent tourism boom in this area. The Tierra Caliente region comprises the state's municipalities with the largest population. Therefore, some of them have high rates of vulnerability, which would be necessary to analyze as a particular case.

ESTIMATING THE RELATIVE IMPACT OF EARTHQUAKES ON LARGE AND SMALL COMMUNITIES

While sophisticated models are constructed for large cities to estimate losses in future earthquakes, this is not so for equally large urban populations. Data on vulnerability, such as those compiled in this work, are currently not being used in estimating future earthquake losses and in designing strategies to protect the population. The difference in impact of earthquake disaster between large and small communities has not been quantitatively estimated, as far as we know. In this section, we will theoretically estimate the casualties that would result from an earthquake with magnitude M8.6 in Guerrero.

The hypothetical earthquake model assumes a rupture of L = 440 km along the Pacific subduction zone section off Guerrero. This length equals that of the 1787 San Sixto earthquake, which ruptured the plate boundary to the east of Guerrero.

Our results are only order-of-magnitude estimates. It is the sort of first-order review of a problem that is called "back of the envelope calculation." We submit that our estimate has the essential quality of the back-of-the-envelope approach. Although approximate, it cuts straight to the heart of the problem.

The computer program QLARM (Trendafiloski et al., 2009) has been used for 11 years to estimate damage, fatalities, and injured in real time after earthquakes worldwide (Wyss and Wu, 2014) and for scenario calculations like the one here (Wyss, 2005, 2006). The population data for Mexico are based on the 2010 census, in which small and large settlements are considered. The data on building stock come from the Web site of the World Housing Encyclopedia (www.world-housing.net). The distribution of dwellings in QLARM is modeled separately in three size classes of settlements: population smaller than 2000, between 2000 and 20,000, and larger than 20,000 because villages do not have skyscrapers. The aforementioned limits have been proposed by Satterthwaite (2006) for developing countries. They may not be the best choice for Mexico, but we will use them in the absence of specific classification for the area studied.

Before venturing to estimate losses in hypothetical future earthquakes in Mexico, we have verified that QLARM correctly calculates intensity of shaking for 10 large earthquakes during the last decades, and that fatalities are also estimated correctly within the margins of error of about a factor of two (Wyss, personal comm.). The mean damage calculated in the case of a hypothetical M8.6 earthquake offshore Guerrero is mapped in Figure 3. The mean damage grade in each settlement is color coded on a scale from 0 to 5 (total destruction). Major damage is expected in the settlements shown by red dots along the coast. Based on the damage caused by the strong ground shaking, the percentages of fatalities and injured are calculated, resulting in casualty counts for each settlement. We have had good success in estimating the sum total of casualties in large earthquakes worldwide (Wyss and Wu, 2014), but the numbers for single settlements can be off substantially, depending on the circumstances (Wyss et al., 2011).

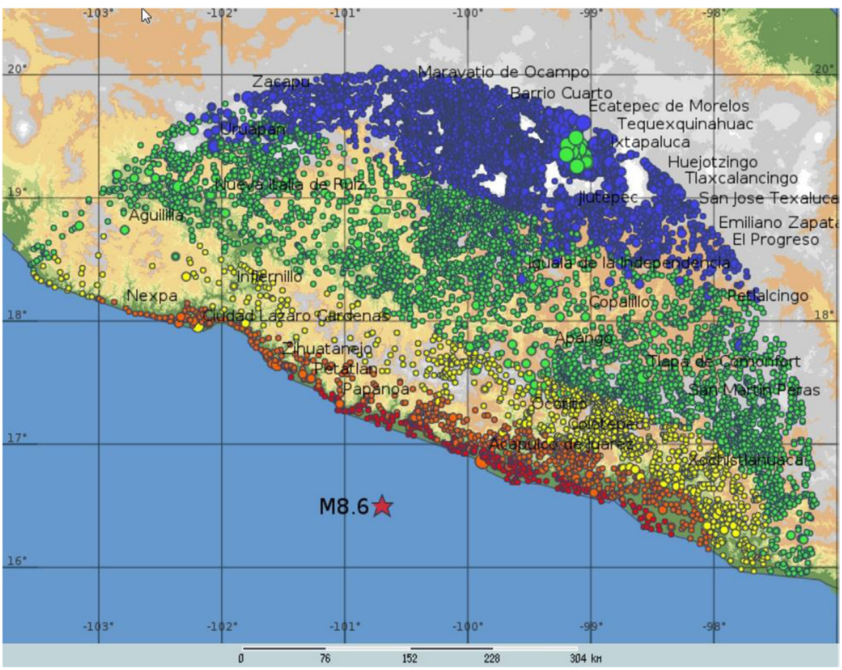

FIGURE 3 Map of mean damage (on a scale of 0–5) by settlement due to a hypothetical earthquake of M8.6, the rupture of which runs along the entire coast of Guerrero. Red is grade 4 (ruinous), blue signifies minor damage such as cracks in walls. The calculation is restricted to a radius of 400 km from the epicenter.

In this thought experiment, we have summed the casualties (fatalities and injured) separately for the affected settlements in each of the three size classes defined above. In these overall sums, we do not consider distance as a parameter, assuming the large and small settlements are mixed approximately equally at all distances. The contrast in losses expected between small and large settlements is quite distinct. The numbers of settlements within 240 km from the epicenter and the population in them are listed for the three size categories in column 1 and 2. The mean numbers of injured and fatalities expected are shown in the columns so labeled. The key column is the one showing the percentage killed (the last column). These results show that there are 20% more people killed in small settlements than in large ones. On the contrary, there are about 40% fewer people expected to be injured in small settlements than in large ones. This is so because in large cities more people survive, but with injuries, due to their more resistant homes.

The estimate of the difference in the suffering of the population in small and large settlements is a function of the model for the building stock in the computer tool we use. Our model is primitive and in its reliability far from what a researcher would wish. Nevertheless, first of all we have tested the performance of QLARM in historic earthquakes, so our estimates are relatively reliable. Secondly, it is a generally observed fact that the built environment in cities is more resistant to strong shaking than in small settlements.

CONCLUSIONS

With respect to estimating the relative impact of earthquakes on large and small communities, we reach two conclusions. (1) The sum of the numbers of fatalities in small settlements equals approximately that of the large cities. This means that the preoccupation of disaster mangers with large cities is partially misplaced. In many earthquake disasters, there are as many suffering people in the countryside as in the cities. Nevertheless, it is true that the largest concentration of victims is found in the cities. (2) The percentage of fatalities is 20% more in small settlements compared to large ones. This is a result that has been shown quantitatively here for the first time, as far as we know.

Regarding the vulnerability of indigenous regions, overall, we can see a clear coincidence between the level of social marginalization in the indigenous regions with vulnerability, as expected, and these results are confirmed after the experience of Hurricane Manuel, and with the damage inflicted by earthquakes that have occurred in the past. Our results also show that the vulnerability of the central and coastal regions is lower than that of the Montaña region and the recovery time is an important factor to be considered as a source of the difference between the three areas due to the isolation and difficulty of access to the mountain region.

When dealing with the vulnerability of indigenous communities, we are faced with several questions such as: Are we really considering the differences in ethnicity that affect vulnerability, should government agencies treat indigenous communities different than the rest of the population, are indigenous and low-income people liable for their living conditions with respect to the hazard of their environment. Even though these are questions that cannot be answered directly by our results, the SOVI method provides an objective way of quantifying differences, which can be used as base for further analysis. These results can also be used toward the planning of strategies for disaster prevention or emergency contingencies. The results of the vulnerability index, quantified by the SOVI, are verified to some extent by the extent and area of the damage inflicted by recent meteorological events, but more detailed analysis is needed so we can establish a firm basis for calculating vulnerability to particular hazards. To date, Mexican municipalities are working toward the generation of a Hazard Atlas, which delineates the principal hazards to which the communities are exposed. However, in the case of Guerrero, only 10% of the municipalities have produced such a document (Urgen a Municipios, 2012), even though it is a requisite to be able to have access to federal disaster prevention funds. The methods used here are an example of how to advance in not only cataloging the current hazards, as is done up to now in the case of Hazard Atlases, but quantifying the vulnerability of the communities.

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