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Short Paper
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Development and Validation of a Sub-national Multi-hazard Risk Index for the Philippines

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Abstract

Disasters in relation to natural hazards continue to have a heavy toll on humans, ecosystems and economies. They therefore undermine efforts for sustainable development, particularly in transitional countries. The Philippines is amongst the most disaster-prone countries on the globe, due to its high exposure to natural hazards and considerable societal vulnerabilities. While a number of global risk assessments have helped to identify risk hotspots at the level of individual countries, sub-national and local risk assessments for informing disaster risk management on the ground are often lacking. To address this gap, we provide a down-scaled risk assessment, at the municipality level, for the Philippines. In the interests of coherency and scale hierarchy, we draw on the modular approach used in the World Risk Index, considering hazard exposure, susceptibility, lack of short-term coping capacity, and lack of long-term adaptive capacity. The paper aims not only to present the results but also to debate key methodological questions behind the development of sub-national multi-hazard risk indices. The outlook looks at the applicability, from the end-user's perspective, of this level of risk assessment for decision-making at local and national levels.

Keywords:

disaster risk, vulnerability, multi-hazard, usability, The Philippines

1 Introduction

Risks emerging from the combined consequences of climate change and natural hazards, growing exposure due to expansion and development in hazard-prone areas, and prevailing vulnerabilities are now widely acknowledged (IPCC, 2012, 2014). Globally, Asia-Pacific is amongst the most disaster-prone regions. Island states and coastal areas in Southeast Asia are at particular risk, given that much of the current and future urbanization and development are in low-elevation coastal zones exposed to multiple natural hazards (UN-DESA, 2015; IPCC, 2014; Garschagen & Romero-Lankao, 2015). Despite major achievements in tsunami and cyclone early warning following the Indian Ocean tsunami in December 2004 and the subsequent adoption of the Hyogo Framework for Action (HFA) 2005–2015, available risk information in the region is often hazard-specific, inaccurate and/or highly localized

(UNESCAP, 2011). Therefore, major gaps persist in terms of coherent and available information on geographical patterns of disaster risk with a comprehensive view of exposure to multiple hazards as well as of societal factors of vulnerability.

While a range of global multi-hazard risk assessments exist at country level, such as the World Risk Index (BEH & UNU-EHS, 2015; Welle & Birkmann, 2015), the INFORM Index (INFORM, 2016), the Climate Risk Index (Kreft et al., 2016) and the Disaster Risk Index (Peduzzi et al., 2009), these indices cannot account for the spatial variability in exposure and vulnerability patterns within countries. In contrast, local risk assessments mostly focus on selective case studies and very fine spatial resolutions, e.g. at the level of individual communities. The middle ground in terms of spatial resolution is therefore typically underemphasized, or even lacking, in existing risk assessments. This is striking given that it is one of the most relevant scales for national and regional policy-making and practical action in disaster risk management.

This paper therefore presents the development of a composite index that represents multi-hazard risk and its two components, exposure and vulnerability, at a sub-national scale for one of the countries with the highest disaster risk – the Philippines (rank 3 out of 171 in the 2015 World Risk Report). The conceptualization of risk and the index-based approach for its assessment are closely linked to the annual World Risk Report (BEH & UNU-EHS, 2015). As well as down-scaling the global World Risk Index to the municipality level, another objective is to examine the utility of such a sub-national index for disaster risk reduction and management through expert-based validation.

2 Methods

Study area

The Philippines is an archipelago in South-East Asia of approximately 300,000 km2, composed of 7,101 islands. The lower- to middle-income country is divided into three main island groups, 18 regions, 81 provinces, 144 cities, 1,490 municipalities and 42,029 barangays (PSA, 2015). Due to rapid urbanization between 1950 and 1990, almost half of the Philippine population of 92 million currently lives in settlements classified as urban (UN-DESA, 2015). Despite ongoing urbanization, the steady population growth is expected to lead simultaneously to an increase in the rural population, keeping the split between urban and rural populations the same (roughly 50% urban, 50% rural) until 2050 (UN-DESA, 2015). The densely populated islands are located directly on the Pacific Ring of Fire and the Typhoon Belt and are therefore exposed to a multitude of natural hazards, with event numbers and impacts increasing (IPCC, 2012, 2014). According to the International Disaster Database (EM-DAT, 2016), storms, floods, landslides and earthquakes were the most frequently occurring hazards between 1990 and 2014, with storms causing most fatalities and the highest economic losses.

Multi-hazard risk assessment using an index-based approach

The Intergovernmental Panel on Climate Change (IPCC) defines risk as the likelihood of severe alterations in the functioning of a society or community resulting from the interaction of natural hazards with the vulnerability of exposed population groups (IPCC, 2014). In line with the IPCC framing of risk, the global World Risk Index (BEH & UNU-EHS, 2015; Welle & Birkmann, 2015) is designed as a composite index comprising indicators for both exposure and vulnerability, in which vulnerability is viewed as a product of susceptibility, and the short-term coping and long-term adaptive capacities of a society. In the interests of coherency and scale hierarchy, the approach presented here follows the conceptual framing of the World Risk Index and aims at a down-scaling from the national to the sub-national level at the resolution of municipalities.

In the initial step, a hazard profile of the Philippines was developed on the basis of a review of the literature as well as through the analysis of hazard events in the Philippines provided by different hazard databanks (e.g. the EM-DAT database). The analysis revealed that storms, floods, landslides, earthquakes and tsunamis are among the most relevant hazards for the country. Data for these hazards was obtained from the UNEP Preview Grid platform (http://preview.grid.unep.ch) and combined with gridded high-resolution population data obtained from WorldPop (http://www.worldpop.org.uk) into spatially explicit exposure layers. In the next step, relevant vulnerability indicators, including indicators of susceptibility, and (lack of) short-term coping and long-term adaptive capacity, were identified by drawing on the indicators used in the World Risk Report (BEH & UNU-EHS, 2015) and a systematic review of the literature using predefined search terms in the Web of ScienceTM and Scopus databases. Next, after intensive data-mining using both national and global data repositories, 13 susceptibility indicators, 9 indicators for lack of coping capacity and 4 for lack of adaptive capacity were populated with data (Table 1 and Figure 1). Socio-economic data for the vulnerability indicators was obtained from the 2010 Census of Population and Housing (https://psa.gov.ph) and the USAID-funded 2008 Demographic and Health Survey (NSO & ICO, 2009). Information on stunting in children was accessed from the Food and Agriculture Organization of the United Nations (FAO), while data on infrastructure (location of roads, hospitals, police stations, fire stations and schools) was acquired from OpenStreetMap (http://www.openstreetmap.org/) and the national Department of Education (DepEd). Data on the location of violent conflicts and aid projects was downloaded from the Uppsala Conflict Data Program (http://www.ucdp.uu.se/ged/data.php) and the AidData initiative (http://aiddata.org/) respectively. The National Statistical Coordination Board (NSCB) of the Philippines provided data on governance. Information on protected areas and changes in forest cover was obtained from the UNEP Protected Planet initiative (http://www.protectedplanet.net) and Hansen et al. (2014).

Table 1: Indicators and datasets

Indicator name	Sign	Data source (year)
Exposure		
Population exposed to earthquakes (%)	+	UNEP Preview (1973–2007)

Population exposed to storms/cyclones (%)	+	UNEP Preview (1970–2009)
Population exposed to storm surges (%)	+	UNEP Preview (1975–2007)
Population exposed to floods (%)	+	UNEP Preview (1999–2007)
Population exposed to landslides due to earthquakes (%)	+	UNEP Preview (2010)
Population exposed to landslides due to precipitation (%)	+	UNEP Preview (2010)
Population exposed to tsunamis (%)	+	UNEP Preview (2010)
Vulnerability (susceptibility)		
Population density (per km2)	+	Census (2010)
Population without access to sanitation (%)	+	Census (2010)
Population without access to safe drinking water (%)	+	Census (2010)
Population without access to electricity (%)	+	Census (2010)
Population living in informal settlements (%)	+	Census (2010)
Population living in poorly-constructed houses (%)	+	DHS (2008)
Stunting in children under 5 (per km2)	+	FAO (2007)
Dependency ratio (%)	+	Census (2010)
Dependency on agriculture (%)	+	Census (2010)
Unemployment (%)	+	Census (2010)
Poverty as measured by the Wealth Index (%)	+	DHS (2008)
GDP per capita (US$)	-	UNEP Preview (2010)
Conflict density (km2)	+	UCDP (2015)
Vulnerability (lack of coping capacity)		
Good governance index (%)	-	NSCB (2008)
Road density: primary, secondary, tertiary roads (per km2)	-	OpenStreetMap (2015)
Population without a car/motorcycle (%)	+	Census (2010)
Population without a boat (%)	+	Census (2010)
Shelter density: primary/secondary schools (per km2)	-	Government, DepEd (2015)
Density of emergency services (per km2)	-	OpenStreetMap (2015)
Households without a mobile phone (%)	+	Census (2010)
Households without access to the internet (%)	+	Census (2010)
Households without access to media (radio/TV) (%)	+	Census (2010)
Vulnerability (lack of adaptive capacity)		
Illiteracy (%)	+	Census (2012)
Protected areas (%)	-	UNEP WCMC (2015)
Forest cover change (%)	+	Hansen et al. 2013 (2000–2014)
Density of aid projects (per km2)	-	AidData (2010–2014)

Following data acquisition, the data were aggregated to municipal level where necessary. For four indicators (stunting in children, poverty, poor housing and good governance) where data was missing for a small proportion of the 1,634 municipalities/cities (< 10%), data was imputed using the average provincial scores (good governance, stunting in children) and Inverse Distance Weighted (IDW) interpolation (poverty, poor housing). After testing for multicollinearity, the indicator "population living in poorly-constructed houses (%)" was removed due to high collinearity with "poverty (%)",resulting in a final set of 31 indicators that were used to construct the index. To render the data comparable, linear max normalization was used. During this step, several indicators (e.g. GDP per capita, good governance, road density, shelter density, density of emergency services, protected areas, and density of aid projects) were adjusted according to their sign (see Table 1) to ensure that high indicator scores always contributed to an increase in vulnerability and risk. Using the normalized indicators as an input, a weighted linear additive aggregation (summation) method was used to combine the exposure indicators into a multi-hazard exposure, and the vulnerability indicators into a vulnerability index. The exposure and vulnerability indices were then combined in a multi-hazard risk index by means of multiplicative aggregation. Indicators and components of vulnerability and risk were weighted equally. Figure 1 shows the overall concept of the index and its components (adapted from Welle & Birkmann, 2015), as well as its actual calculation.

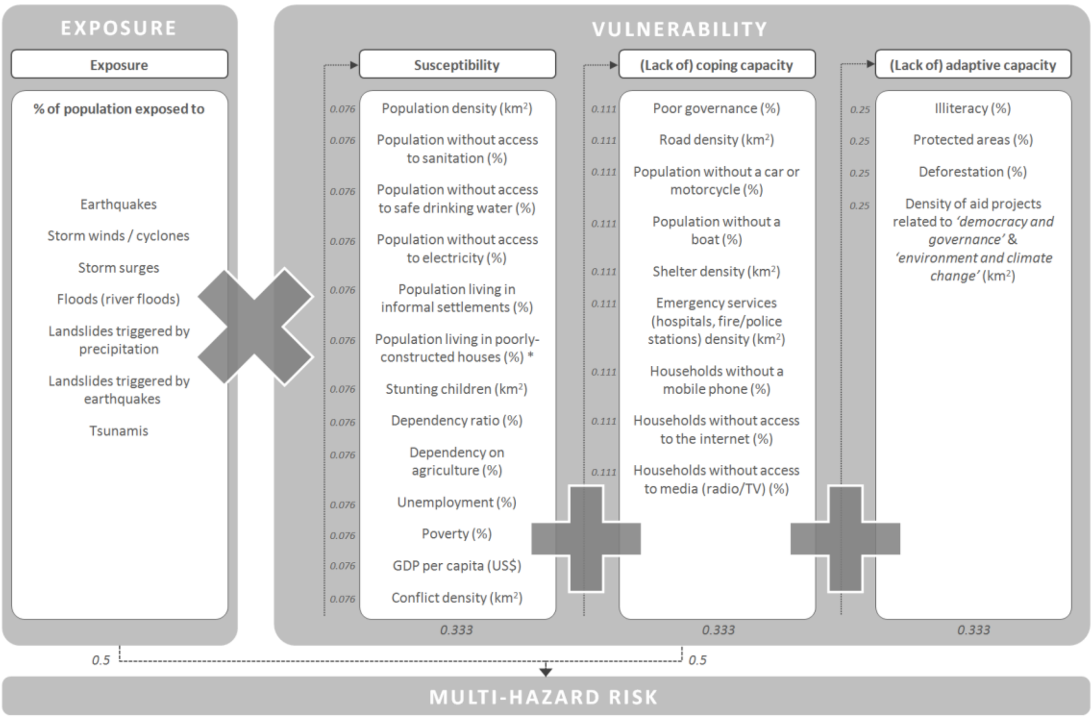

Figure 1: The components of the multi-hazard risk index and the indicators used for the Philippines (adapted in part from BEH & UNU-EHS, 2015 and Welle & Birkmann, 2015). *This indicator was removed due to very high correlation with poverty.

3 Preliminary results and outlook

Multi-hazard risk in the Philippines

Figure 2 shows the multi-hazard risk index at municipality level. In addition to the overall risk (panel 1), the figure also shows the two components of risk, i.e. exposure (panel 2) and vulnerability (panel 3). Comparing panels 2 and 3, it becomes evident that the two components of risk are heterogeneous across the country. Exposure to natural hazards is particularly high in the northern and central parts of the country (primarily due to a combination of typhoons, landslides and earthquakes), and high levels of vulnerability prevail in the south. These combinations of factors lead to an overall high level of multi-hazard risk in almost all parts of the country, except for the western and some of the southern parts of the country.

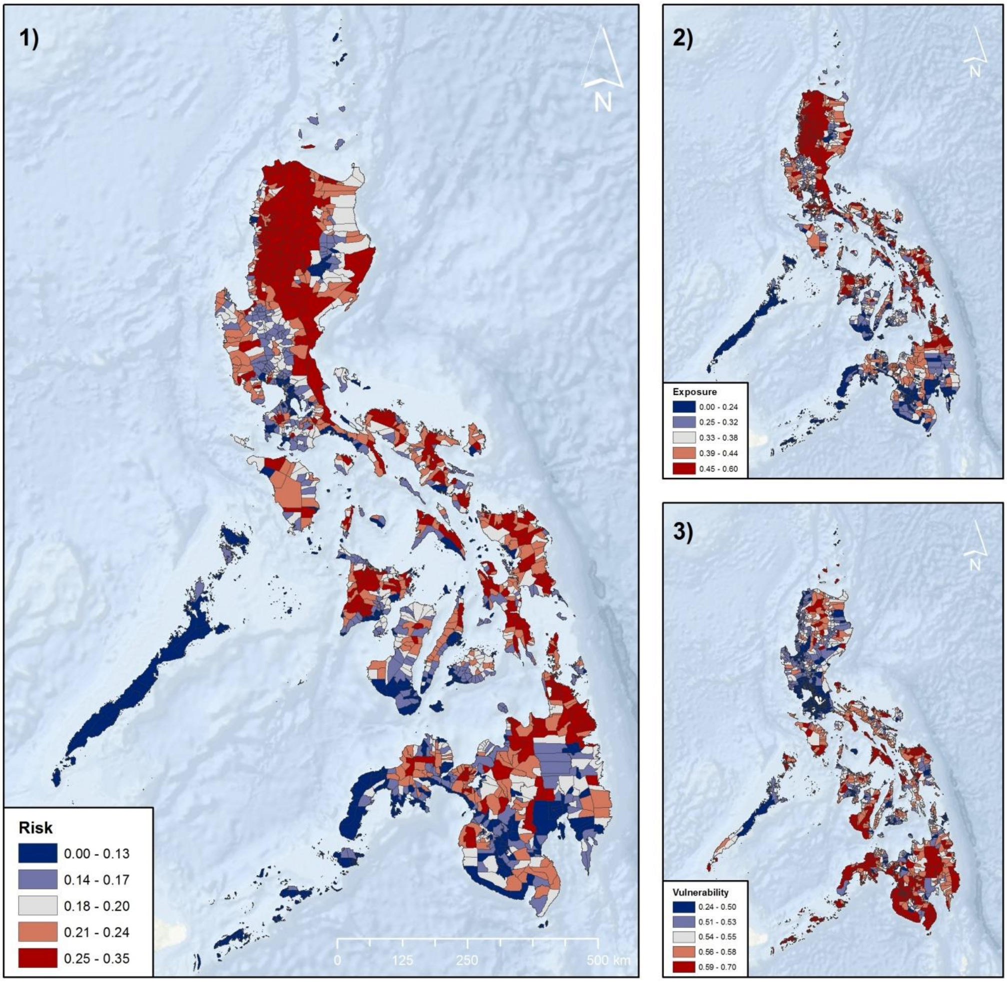

Figure 2: Multi-hazard risk (panel 1), exposure (panel 2) and vulnerability (panel 3) in the Philippines.

Analysing the patterns of the two components of risk provides valuable information regarding the composition and spatial distribution of the overall multi-hazard risk and can potentially be of use for spatially-informed risk management policies. However, the usefulness and applicability of the index for targeted disaster risk reduction (DRR) and climate change adaptation (CCA) still has to be validated by experts. Furthermore, the approach presented has several limitations. To date, only quantitative indicators have been considered in the construction of the index, while qualitative information, such as the presence of end-to-end early warning systems, risk awareness, preparedness training, social capital, existing adaptation strategies, etc. was not included. Hence, although the indicators included here are ones that are often used in multi-hazard risk assessments, the index cannot provide a comprehensive picture of disaster risk; rather, it provides an initial estimation of the spatial distribution of multi-hazard exposure, vulnerability and risk in the Philippines. In addition to the validation of its usability and applicability for DRR and CCA, future work will address the issue of indicator weights, analyse the sensitivity of the index to changes in the input parameters, and evaluate possible scale effects by comparing the findings with the results of the World Risk Index at the national level.

Utility for decision-making

Besides the development and calculation of an index, the validity of index-based approaches (and the resulting maps) for decision-making and planning purposes is a crucial aspect of every risk-mapping exercise. This is currently examined through interviews with relevant state and non-state experts in the fields of DRR and CCA in the Philippines. Relevant actors in national disaster risk policy-making were identified on the basis of a literature review, expert consultation, and snowball sampling. Between May and June 2016, the actors identified will be interviewed on the current state of affairs concerning: risk identification in the Philippines for policy development; their perceptions of the strengths and weaknesses of index-based approaches in general, and of the presented index in particular to support decision-making processes; how risk information should be provided in order to be useful for their work. The opportunity will also be used to discuss the validity (and possibly weighting) of the indicators selected.

4 Conclusions

By calculating a sub-national risk index, we were able to generate location-based risk information at municipal level, including information on multi-hazard exposure and prevailing societal vulnerability. The approach therefore helps to fill the current gap between global risk assessments with national resolution on the one hand, and very local risk assessment at village or city level on the other. Measurements at this resolution are supposedly of high relevance for informing disaster risk management policy within countries. However, the usefulness and applicability of the index for the design and implementation of real DRR and CCA measures still needs be put to the test and evaluated empirically.

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