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Social vulnerability to climate-induced natural disasters: Cross-provincial evidence from Vietnam

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Abstract: *This paper conducts an analysis of the socioeconomic determinants of Vietnam's cross-provincial variations in natural disaster vulnerability. The purpose is twofold: (i) to capture disaggregated vulnerability variations normally obscured by national statistics, thereby providing more nuanced insights into Vietnam's vulnerability to natural disasters; and (ii) to take advantage of the fact that the overall political system and key institutional structures to a large extent are constant across Vietnam's provinces, which makes the analysis a novel addition to the many disaster studies based on cross-national variations. The paper's analysis indicates that much of Vietnam's cross-provincial variations in natural disaster fatalities and economic costs can be explained by differences in key socioeconomic factors. High provincial rates of inequality, poverty and infant mortality, for instance, appear to drive up natural disaster fatalities. Local adaptation efforts should focus as much on these broader socioeconomic dimensions as they focus on the geophysical susceptibility to natural hazards of individual areas.*

Keywords: *climate change, natural disasters, poverty, provinces, Vietnam, vulnerability*

Introduction

The research interest in the determinants of climate-induced natural disasters should not need much elaboration: already today, climate-induced natural disasters (triggered by meteorological and climatological occurrences) are disrupting millions of people's livelihoods, and there are strong indications that most poor countries will experience increased vulnerability (*ceteris paribus*) in the decades to come due to climate change (Stern, 2006; IPCC, 2007a).

There is a general consensus that natural disasters have increased worldwide during recent decades, whether measured in frequency, numbers of people affected or economic damage (UNDP, 2004, 2008; Red Cross/Red Crescent, 2007; UNEP, 2007; World Bank, 2009). According to the cross-national database on natural disasters, the Emergency Events Database (EM-DAT, 2012), compiled by the WHO Collaborating Centre for Research on the Epidemiology of Disasters, this rise in natural disasters has been caused almost exclusively by a doubling of hydro-meteorological hazards – often referred to as climate-induced hazards.[1] Globally, these disasters (mainly floods, droughts and storms) increased from approximately 200 in 1990 to 440 in 2010 (EM-DAT, 2012). The number of people affected worldwide by such disasters increased from 52 million annually in the 1970s to 232 million annually during the 2000s (EM-DAT, 2012).

The social determinants of natural disaster vulnerability have previously been investigated quantitatively by testing the link between various socioeconomic factors and a proxy for disaster vulnerability expressed in fatalities, people affected or economic losses per capita (UNDP, 2004; Brooks *et al.*, 2005; Kahn, 2005; Roberts and Parks, 2007; Toya and Skidmore, 2007; Noy, 2009; Rubin and Rossing, 2012). Some of these studies have focused mostly on the economic impacts of natural disasters (Toya and Skidmore, 2007; Noy, 2009) while others have focused mostly on the social implications (UNDP, 2004; Brooks *et al.*, 2005; Rubin and Rossing, 2012). What they all have in common,

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however, is that the studies are based on cross-national data. The analysis in this article, on the contrary, will apply a disaggregated approach by examining Vietnam's cross-provincial vulnerability to natural disasters. The opportunity for drawing on provincial variations in the vulnerability to natural disasters within a particular country carries with it two important advantages.

First, the study will be able to capture the disaggregated variations that are normally obscured by national statistics. Such variations are particularly important with respect to natural disasters that often primarily have local consequences (Brooks *et al.*, 2005; Heltberg *et al.*, 2009). Vietnam's climate-induced disasters are also relatively limited in scale and scope; the biggest single disaster in Vietnam's newer history was the storm in 2000, which claimed the lives of 460 people (EM-DAT, 2012). Thus, a quantitative study based on provincial statistics allows for more nuanced insights into Vietnam's vulnerability to natural disasters.

Second, the article will provide further insights into the socioeconomic determinants of vulnerability to climate-induced natural disasters by examining intra-national variations – thereby keeping constant a host of institutional and political variables – of disaster fatalities and economic damages. The cross-provincial study of Vietnam can take advantage of the fact that the overall political system and many key institutional structures to a large extent can be kept constant. Cross-national comparisons often struggle to take these effects into account to minimise bias of the estimates. One can obtain more robust results, for instance, if the bureaucratic structures, the political system, the liberal rights, the policy strategy papers and the rule of law can be kept constant when estimating the effect of socioeconomic variations on natural disaster vulnerability outcomes. The analysis, therefore, constitutes an important contribution to the natural disaster literature dominated by studies based on cross-national variations in disaster vulnerability.

Vietnam possesses some characteristics that makes it an interesting case for analysing the social determinants for natural disaster vulnerability; the most significant being a high share of climate-induced disasters as well as modest (although increasing) economic inequality (Asian Development Bank, 2009; World Bank, 2009). In that sense, Vietnam constitutes what Flyvbjerg (2006) refers to as a critical case with strategic importance: if income disparities play a role in disaster vulnerability in this comparatively equal country, then it is likely to play an even greater role in the many low-income and middle-income countries with much greater inequality. Further, the country's high share of climate-induced disaster can provide hints of the type of disasters that might become more prominent in the future due to climate change.

Natural disasters in Vietnam

A natural disaster can be defined as a temporary event, triggered by a natural hazard that overwhelms local response capacity and seriously affects social and economic development (Hodell *et al.*, 1995). Thus, a natural hazard is a necessary but not a sufficient condition for a natural disaster to materialise, as the extent to which natural hazards turn into disasters depends crucially on the socioeconomic context. Based on EM-DAT data in the period 2000–2010, Vietnam experienced a total of 89 natural disasters, with an average mortality per disaster of 42 fatalities. That is equivalent to an annual disaster mortality rate of 0.41 per 10 000 people. As previously noted, what is particularly interesting in Vietnam is that nearly all the country's natural disasters are climate related (triggered by meteorological and climatological factors): around 95% of Vietnam's contemporary natural disasters incidents are categorised as floods or storms. Floods account for more than half the natural disaster mortality in Vietnam, closely followed by storms accounting for nearly 40% of the mortality rates. The strong impact of flooding becomes even more evident when one looks at the number of households affected. Here, flooding accounts for close to 75% of all the households affected by a natural disaster, with typhoons a distant second. With regard to economic damage, storms account for 58% of the damage while floods account for 37% (EM-DAT, 2012).

With such a high share of climate-induced disasters (as opposed to geophysical disasters), Vietnam risks becoming more vulnerable in the future if socioeconomic development fails

to mitigate the effects of accelerated climate change and variability. The World Bank, the EU commission and the Asian Development Bank expect that Vietnam will suffer considerable adverse consequences because of climate change (Viner and Bouwer, 2006; Asian Development Bank, 2009; World Bank, 2009). The World Bank study on the impact of sea-level rise on developing countries consistently ranks Vietnam as the first or second most vulnerable country across various dimensions (including land area impacted, population affected and economic loss) to sea-level rise (Dasgupta *et al*., 2007). The Asian Development Bank reports that Vietnam's average temperature rose by 0.14°C per decade during 1951–2000, in particular due to hotter summers in recent years, with average monthly temperatures increasing up to 0.3°C per decade (Asian Development Bank, 2009: 23). Vietnam's long coastline and multitude of river basins certainly could make it more vulnerable to climate-induced hazards such as storms and floods (Cuong *et al*., 2009; Quy, 2011). The impacts of climate change will be further compounded by Vietnam's environmental degradations; the destruction of mangrove forest, for instance, has left many areas more exposed to storm surges (Viner and Bouwer, 2006). Hydro-power plants, in particular in central Vietnam, have been blamed for causing or exacerbating flooding in recent years (Bruun, 2012).

Natural disaster vulnerability in Vietnam

Increased vulnerability to natural hazards, however, will not necessarily translate into more or more severe natural disasters. Disasters do not occur out of context, but are embedded in the political structures, economic systems and social orders of the societies in which they take place (Bankoff, 2004: 35). In their extensive monograph on disaster vulnerability, *At Risk*, Wisner *et al*. (2004: 11) conceptualise natural disaster vulnerability as 'the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard'. The same basic understanding is reflected in IPCC's (2007b) definition of climate change (incl. natural hazards) where – slightly reformulated – the vulnerability of a country (or region) to natural disasters can be understood as the degree to which the country is susceptible to, or unable to cope with, adverse effects of natural hazards. The way in which individuals and groups within a society interact with each other, through mechanisms such as risk sharing, mutual assistance and collective action, influences their vulnerability and resilience to natural disasters (Adger, 2003; Pelling, 2011). Social vulnerability, understood as an inadequate capacity of individuals or groups to cope with and recover from the impact of hazards is, therefore, a characteristic of society and its underlying social, economic and political conditions. Understanding social vulnerability as a function of various socioeconomic factors is not to deny the importance of physical vulnerability. Much existing literature indicates that some of the variation in natural disaster vulnerability can be explained by variations in natural hazards and hence physical vulnerability (UNDP, 2004; Roberts and Parks, 2007; Rubin and Rossing, 2012). The point is more that political and socioeconomic processes of marginalisation and differentiation are also crucial for understanding and assessing vulnerability (O'Brien *et al*., 2004).

Unpacking the many different context-dependent dynamics and processes of natural disaster vulnerability is not feasible in this type of cross-provincial study. Instead, vulnerability is operationalised by tracing the direct social consequences of society's inability to cope with the natural hazards. In other word, the focus of this large-n study is on the outcomes of vulnerability rather than the dynamics which are better addressed through case studies. The study is thus aligned with the many existing large-n studies on natural disasters impacts (UNDP, 2004; Brooks *et al*., 2005; Kahn, 2005; Roberts and Parks, 2007; Toya and Skidmore, 2007; Noy, 2009; Rubin and Rossing, 2012).

While disaster vulnerability is not easily reduced to a single metric (see Adger, 2006; Lebel *et al*., 2011), vulnerability at the country level is often proxied by collecting data on the adverse consequences of natural disasters with respect to deaths, injuries, people affected or economic damage. Even though vulnerability outcomes surely encompass many other dimensions than these, there appears to be a strong relationship between these indicators and other

more broad-based impacts of vulnerability. Natural disaster fatality per capita, in particular, is commonly used as a proxy for natural disaster vulnerability (Brooks *et al.*, 2005; Kahn, 2005; Rubin and Rossing, 2012), not only because fatalities are relevant in their own right (after all, they signify the most extreme and irrevocable consequences of disasters) but also because they are closely related to broader indicators of vulnerability, such as loss of livestock, house damage and injuries. The exception is overall economic damage which appears to be only weakly correlated with natural disaster mortality. The two proxies are not only weakly correlated but they are also qualitatively different: mortality rates relate to social issues of poverty and extreme deprivation, while economic damage reflects an economic vulnerability that increases (*ceteris paribus*) with a more sophisticated and developed economy. The annual average economic damages from natural disasters in the period 2000–2010 for the group of low-income countries amounted to 2.6 USD per capita; for the group of high-income countries, the economic damage per capita was more than 20 times higher at 53.6 USD per capita (EM-DAT, 2012). Thus, developed countries report greater financial damage from natural disasters, not only because citizens and businesses have more financial and physical capital to lose but also because their loss is better accounted for and integrated into the formal economy (Sharma, 2010). It is therefore to be expected that socioeconomic variables explaining variations in natural disaster fatalities are not likely to also explain differences in provincial economic losses. Hence, both fatalities and damage are used as a proxy for natural disaster vulnerability outcomes along different dimensions.

Natural disaster vulnerability outcomes across provinces

In order to analyse the variation in natural disaster vulnerability outcomes within Vietnam, the article relies on a dataset drawn from the Disaster Management Information System (DMIS, 2011) to proxy for the dependent variables. The database is compiled and maintained by the Central Committee for Flood and Storm Control (CCFSC) under the Ministry of Agriculture and Rural Development (MARD). The DMIS dataset allows us to disaggregate the natural disaster mortality down to provincial level. The database contains statistic on the 59 (incl. Hà Tây that became part of Hà Nội in 2008) provinces and the five centrally governed cities. The statistics will be averaged over a ten years period, which produces even more robust aggregates as opposed to data points in individual years. Disasters are by their very nature idiosyncratic events which make it difficult to juxtapose countries in individual years, as there will be many observations with negligible disaster impacts, and then a few extreme observations with considerable disaster impacts. Averaging over a 10 year period (2000–2009) reduces the bias caused by the extreme year-to-year fluctuations provided the length of the period is sufficient to smooth out some of the extreme observations. At the same time, the period should provide an accurate picture of *contemporary* vulnerability outcomes, and stretching the period back to the 1970s and 80s would conflict with this objective.

The map below (Figure 1) has been constructed based on DMIS data, and illustrates the spatial distribution of natural disaster fatalities per 10,000 in the period 2000–2009 (the latest yearly data available at the provincial level). What is particularly striking is the apparent lack of a clear pattern in the spatial distribution of climate-induced disaster vulnerability. Hotspots of natural disaster vulnerability can be found in Southern, Central and Northern Vietnam; they can be found in coastal provinces as well as mountainous in-land provinces; and they can be found in provinces with great rivers basins. The six most vulnerable provinces that are highlighted in dark (Quảng Ngãi, ên Bái, Quảng Nam, Lao Cai, Phú Yên and Đồng Tháp) account for 37 percent of all the natural disaster fatalities in Vietnam (in the period 2000–2009), although they only account for 8 percentage of the population. The population in these six provinces is more than seven times as vulnerable to natural disasters as the rest of Vietnam (2.9 deaths per 10,000 compared to 0.4). If the mortality rate of the six most vulnerable provinces had been brought down to the Vietnamese average for the other provinces more than 1.500 lives could have been saved in the period 2000–2010.

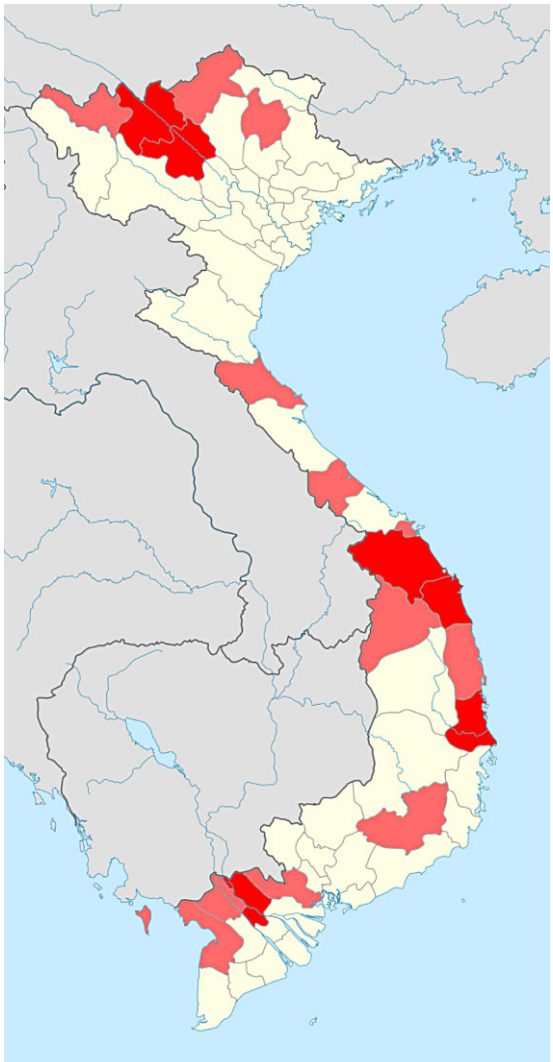

Figure 1. Provincial distribution of contemporary natural disaster fatalities
Source: DMIS (2011). Caption: Dark Red: more than 2 deaths per 10 000 in the period 2000–2009. Red: more than 1 death per 10 000 in the period 2000–2009. White: less than 1 death per 10 000 in the period 2000–2009.

When it comes to natural disaster damages per capita, other provinces report higher losses than do the six provinces. As expected, the city-provinces of Da Nang and Ha Noi, in particular, report high losses (8 and 9 million VND per capita, respectively). Still, the six provinces carry losses that are three times as high compared to the rest of Vietnam. The following section will address the socio-economic causes underlying the observed unequal distribution of natural disaster vulnerability outcomes.

Socioeconomic determinants of natural disaster fatalities/damage

The analysis is not the first to exploit the richness of Vietnam's provincial data on natural disasters. Noy and Vu (2010) have conducted a quantitative analysis relying on provincial data to determine the impact of natural disasters on the country's macro-economy. The authors show that more costly disasters appear to boost output growth in the subsequent period (thus rendering some support for the hypothesis of creative destruction, popularised by Schumpeter in his 1942 work *Capitalism, Socialism and Democracy*, where the destruction of the existing modes of production spurs renewed creativity and economic innovation) while the number of people killed and affected does not have a significant effect on output growth. Their study has a clear economic angle, and it does not aim to identify determinants of broader natural disaster vulnerability. This analysis is concerned with social vulnerability outcomes, and the dependent variable is thus primarily fatalities of natural disasters.

Based on the existing literature on natural disaster vulnerability, the article will introduce a model where the number of people (per capita) killed by natural disasters is dependent on various socioeconomic indicators. The average level of household income is hypothesised to be negatively correlated with natural disaster mortality across province (while provincial poverty prevalence rates are expected to be positively correlated). The poor are normally considered to be more vulnerable to natural disasters. UNDP reports that the brunt of hydro-meteorological disasters is being borne by the developing world, and, within the developing world, by the poorest of the poor (UNDP, 2008). The vulnerability of the poor has been established by several empirical studies (Adger, 2006; Simms and Reid, 2006; Satterthwaite *et al.*, 2007; Rossing *et al.*, 2010).

The poor generally settle in more disaster-prone areas, in simple and fragile housing structures, and financially their resilience is further eroded due to a lack of access to funds, credit and insurance. The majority of low-income settlements in urban and rural areas tend to be located in inhospitable areas prone to flooding and landslides (Satterthwaite *et al.*, 2007).

Poverty might force people to live in hazard-prone but affordable and unregulated areas as their only option, or the risk of natural hazard could simply be outweighed by the benefits of living by fertile volcanic slopes or near lush riverbanks (Rossing *et al*., 2010). Poverty in itself could also exacerbate the risk of localised natural hazards if it leads to extensive depletion of the surrounding natural resources. Such deterioration of natural capital could increase the incidents and impacts of floods and storms. Faced with a lack of credit and insurance, poor households might also be forced to dispose of their few productive assets during disasters. In Honduras after Hurricane Mitch in 1998, for instance, the poorest households were forced into long-term poverty traps, as they had to dispose of valuable assets needed for recovery (De la Fuente, 2007). The IPCC (2007a) notes how poor communities tend to have more limited adaptive capacities, and are more dependent on climate-sensitive resources such as local water and food supplies. Their dependence on natural capital, as a source of food and income, coupled with a lack of physical and financial adaptive capacity, means that they are at increased risk of impact from natural disasters (Rossing *et al*., 2010).

Specifically with respect to Vietnam, this journal published an illuminating article by Fortier on climate change adaptation (CCA) in Vietnam where he finds that poorer Vietnamese households are often the most exposed and sensitive to climate change (Fortier, 2010: 231). One of the main sources of vulnerability identified by Fortier (2010) is the difficulties of adapting to alternative livelihoods after an exogenous shock due to a limited asset-base among the poor. Few and Tran (2010: 534) conducted field studies in the Mekong Delta and in the Central Provinces, and concluded that 'economic factors were as central as might be expected in shaping risk of health impacts from floods and typhoons'. One of the main channels through which poverty exacerbated vulnerability, according to the study, was through the physical location of the household in flood and storm-prone areas (Few and Tran, 2010). Based on highly disaggregated data for Vietnam, Minot and Baulch (2005) also find that households living in semi-permanent houses without access to water and sanitation have much lower per capita expenditure than households in permanent housing. Regardless of whether households live in urban or rural areas, the living area of houses was found to be a useful predictor of household well-being (Minot and Baulch, 2005: 468). The poor also appear to suffer from a lack of access to and knowledge of formal institutions in times of crisis. With the purpose of improving local CCA, East Meets West conducted a field survey in 2009 based on 125 households in 25 local communities representing the most vulnerable regions in the province of Quang Nam. The results reveal that communities were often unaware of national policies and procedures related to disaster preparedness and planning: 49% of the respondents were unaware of national policies and procedures and 72% of interviewees did not know about disaster plans that were made at the community or commune level (East Meets West, 2009: 24). Even a series of recent training sessions on disaster preparedness held by the local authorities at the commune level appears not to have had great public penetration: only 37% of the respondents were aware of training sessions when queried (East Meets West, 2009). In his analysis of social vulnerability to climate change in the Xuan Thuy district in Vietnam's Nam Dinh province, Adger (1999: 259) emphasises an institutional discrimination where the poor are inherently more vulnerable to natural disasters because they have less access to state resources in natural disaster situations for recovery and reconstruction. In the subsequent analysis, therefore, a strong correlation between provincial vulnerability to climate-induced natural disasters and poverty rates across provinces is to be expected.

As a first step in the analysis, Figure 2 illustrates the significant positive relationship between provincial poverty rates and natural disaster deaths (logged). High poverty rates appear to increase vulnerability to natural disasters irrespectively of provincial vulnerability to natural hazards.

While climate-induced disaster deaths could surely impact poverty levels for the affected households, the causality at the provincial level is more likely to run from poverty levels to higher natural disaster fatalities. After all, the cross-provincial death rate of 0.6 people per 10 000 in the period 2000–2009 is not likely to

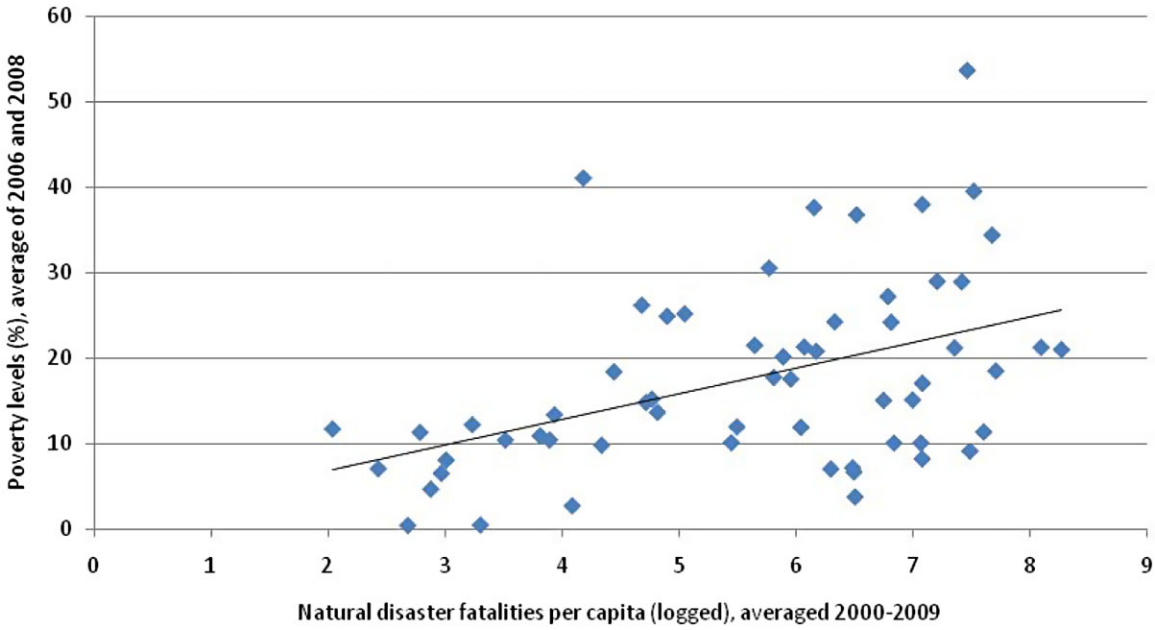

Figure 2. Relationship between provincial poverty levels (%) and natural disaster fatalities (logged)
Source: DMIS (2011) and General Statistics Office of Vietnam (2009a,b).

have a major effect on overall provincial poverty rates. Even the highest provincial fatality rate of 4.2 per 10 000 people (in the province of Quảng Ngãi) is not likely to have a substantial direct impact on economic growth or poverty in the province. However, to the extent that natural disaster deaths proxy for broader adverse consequences of natural disasters (such as injuries or loss of natural, physical and financial capital), then at least part of the causality could very well run from natural disasters to poverty levels. Such reverse causality is still likely to be limited; not least keeping in mind that Noy and Vu (2010) found no significant effect of provincial natural disaster fatalities on economic growth rates in the provinces.

This indicative relationship is supported by this article's more rigorous quantitative analysis. In the first multivariable linear regression (Table 1, column 1), provincial natural disaster mortality between 2000 and 2009 (logged) has been modelled as the dependent variable based on the following exogenous variables: (i) the number of houses damaged (logged); (ii) income per capita (logged); and (iii) the income-ratio between the bottom 20% and the top 20% to proxy for inequality. The socioeconomic exogenous variables are drawn from Vietnam's Statistical Yearbook 2009; Vietnam's Survey on Household Living Standards 2008; and The 2009 Vietnam Population and Housing Census, all available at the website for the General Statistics Office of Vietnam. A more detailed list of the sources underlying the variables can be found in Appendix I.

The included variable of the number of houses reported damaged functions as a proxy for the degree to which a province is hit by natural disasters. The number of damaged houses is expected to be positively correlated with natural disaster mortality. Further, the model includes a proxy for inequality to test whether high inequality increases natural disaster mortality as is found elsewhere (Roberts and Parks, 2007; Rubin and Rossing, 2012). Adger also concluded that inequality mattered a great deal in terms of social vulnerability from his Vietnam case study of Xuan Thuy district, not because inequality is necessarily associated with poverty but because the concentration of wealth and capital restricts access to resources for buffering the impact of external shocks (Adger, 1999: 264). The results of this first regression are as follows.

All variables individually (*t*-test) and combined (*F*-test) significantly (5% level) contribute

Table 1. Summary of multivariable cross-provincial regressions, determinants of disaster vulnerability 2000–2009

Variable	Ln (disaster fatalities/10 000) (N = 60)			Ln (disaster fatalities/10 000) (Reduced form, N = 57)			Ln (economic losses/capita) (Reduced form, N = 60)		
	B	SE B	B	B	SE B	B	B	SE B	B
Ln (house damage/capita)	0.49	0.08	0.59*	0.47	0.07	0.58*	0.47	0.08	0.47*
Inequality ratio	0.35	0.17	0.19**	0.32	0.15	0.19**			
Ln (income/capita)	−2.5	0.49	−0.49*	−2.53	0.84	−0.51*	−5.19	0.82	−0.73*
Infant mortality/capita				0.05	0.03	0.25***			
Urban share				0.03	0.01	0.29**	0.05	0.01	0.37*
Simple house							−0.11	0.02	−0.49*
River dummy							1.47	0.47	0.31*
R^2		0.54			0.64			0.70	

*$P < 0.01$; **$P < 0.05$; ***$P < 0.1$.

to explaining the variation in natural disaster fatalities across provinces. As expected, the number of damaged houses is a strong positive determinant of natural disaster fatalities, while provincial average income has a highly significant negative effect on the number of natural disaster fatalities. Inequality is positively correlated with the number of natural disaster fatalities. When poverty prevalence is replaced with income per capita, however, the parameter for the inequality ratio becomes insignificant, which is to be expected as high inequality combined with low income would produce poverty. The regression only suffers from a few extreme observations, which could be ascribed to the fact that Vietnam has been spared truly catastrophic natural disasters. There do not appear to be any valid theoretical arguments for excluding provinces with extreme statistical values as such outlier observations are to be expected when analysing natural disasters, which are by their very nature idiosyncratic events. In any case, improving the data by trimming the outliers (3 standard deviations from the mean) and replacing missing observations with the mean of the variables did not alter the signs or significance of the parameters.

In Table 1 column 2, the analysis makes use of a methodological approach based on forward stepwise regressions from a larger pool of control variables with the Akaike information criterion (AIC) as the selection criteria.[2] The purpose was to include different health indicators both reflecting the health status of the province population (the percentage of persons suffering from illness or injuries 12 months prior to a 2006 survey; and the infant mortality rate 2009) as well as the provision of health services (number of medical service units per capita 2009). The hypothesis is that a strong health status of the provincial population would lead to fewer fatalities, and that the provision of health services – also proxying for a broader public service delivery – might reduce fatalities. The provincial share of urbanisation was included to account for the effect of natural disasters in urban settings. When controlling for income per capita, we would expect a high degree of urbanisation to increase natural disaster vulnerability as more people are likely to get affected. Although highly correlated, urbanisation proved to be a stronger determinant for natural disaster fatalities than population density. A river dummy was included to account for the exposure to the two major river systems in Vietnam, Mekong and Red River, and we would expect it to be positively correlated with natural disaster fatality.

The results of the reduced model indicate that the parameter estimates for the three key socioeconomic variables from column 1 retain both signs and significance. A high rate of urbanisation, after controlling for income, appears to be positively correlated with natural disaster fatalities. The parameter estimate for infant mortality is significant at the 10% level, and enters the model with the expected positive sign. As with income per capita, the small number of people killed in natural disasters can only have a negligible impact on the infant mortality rate, so reverse causality is not likely to be a major source of bias. However, both urbanisation and

infant mortality are highly correlated with income per capita (correlation of 0.65 and –0.72, respectively), indicating problems with multicollinearity. The other proxy for health status together with the river dummy turned out to be insignificant factors for disaster fatalities.

The fact remains, however, that the analysis suggests socioeconomic indicators matter in explaining variations in provincial natural disaster fatalities per capita. The different models account for between 50 and 70% of natural disaster variability across provinces even without accounting for the exposure to natural hazards. It should be noted that the strong significance of the inequality and income variables runs counter to the results produced by Brooks *et al*.'s (2005) large-n quantitative study of vulnerability based on cross-country data where these two key socioeconomic variables did not retain any significance when included together with a multitude of other indicators. A major reason for the discrepancy between the two studies is that many of the variables that entered significantly in the study by Brooks *et al*. (2005) – political rights and civil liberties among others – are kept constant in this study. Brooks *et al*. (2005: 157) acknowledge that their counterintuitive result could be 'the result of pooling countries with very different socio-economic profiles'. In other words, cross-country 'noise' has been filtered out in this intra-national study, allowing for a more robust analysis of the remaining key socioeconomic variables at the provincial level. This produces results more in accordance with existing context-specific studies of Vietnam (Adger, 1999; Shaw, 2006; East Meets West, 2009; Few and Tran, 2010): income/poverty/inequality do indeed matter in disaster vulnerability.

While income per capita was negatively correlated with natural disaster fatality, wealth is likely to be positively correlated with the other proxy for vulnerability capturing economic damage. Several studies have pointed to the fact that economic damage is higher the wealthier the area hit by the natural disaster (Toya and Skidmore, 2007; Neumayer and Barthel, 2011; Neumayer *et al*., 2012). Although wealthier households and states can afford to implement greater mitigative and precautionary measures, the effect still appears to be unable to cancel out the very robust correlation between wealth and economic vulnerability (Toya and Skidmore, 2007; Neumayer and Barthel, 2011). As households and states accumulate more physical capital, there is simply more that can be damaged or destroyed. Wealthier provinces should therefore suffer from greater natural disaster damage, *ceteris paribus*.

A different proxy for natural disaster vulnerability outcomes, namely the natural disaster losses reported by the provinces, was therefore included in the analysis. Some of the control variables from the previous regression were again included in the regression (houses affected, income per capita, urban share and a river dummy). All these variables are expected to be positively correlated with economic losses. The health variables were excluded and replaced with indicators that would better proxy for economic vulnerability: (i) the percentage of provincial population living in simple housing (the hypothesis being that simple houses will decrease the monetary losses of natural disasters); and (ii) the gross provincial industrial output proxying for the provincial level of industrialisation (the hypothesis being that a higher level of industrialisation leads to greater economic damages).

The analytical results are presented in Table 1 column 3 in reduced form after conducting a series of forward stepwise regressions (using the same AIC as mentioned). The number of houses damaged is positively correlated with economic losses while the share of houses of poor quality is negatively correlated with economic losses. Urbanisation and the river dummy are both positively correlated with natural disaster losses at the provincial level. Income per capita (or industrial output per capita) is negatively correlated with natural disaster losses, which runs counter to what was hypothesised. The counterintuitive result is likely caused by model multicollinearity; another, and purely speculative, explanation is that poor provinces might report higher losses in order to receive more central transfers.

Political implications for Vietnam

The preceding analysis strongly suggests a need for broad-based and disaggregated policies in reducing vulnerability to climate-induced

disasters. This, it will be argued, entails a reprioritisation away from the government's current focus on national-level initiatives of CCA towards greater attention to concrete disaster risk reduction (DRR) policies.

The need for broad-based policies relates back to the importance of socioeconomic factors in explaining climate-induced disaster vulnerability outcomes. Recall that the cross-provincial analysis kept constant the institutional and political responses to natural disasters, and that it was within these overarching political and institutional structures that key socioeconomic development indicators were capable of explaining much of the cross-provincial variation. The concern for future vulnerability to climate-induced disasters should extend beyond increases in natural hazards from climate change (or environmental degradation) to encompass changes in Vietnam's socioeconomic fabric. Vietnam's transformation process towards market-driven forms of production has produced many new opportunities and generated impressive economic growth rates, but at the same time it has also produced new stresses in the form of insufficient land, water and capital, and a range of new inequalities, relating to income, land and labour (Buch-Hansen *et al*., 2013). Policies that address these more deep-rooted development issues such as poverty, inequality, infant mortality and access to quality housing are thus likely to lower vulnerability to climate-induced disasters – irrespectively of the variation (both temporal and spatial) of natural hazards.

The analysis also underscored the need to acknowledge the disaggregated nature of climate change-induced natural disasters; not only due to differences in exposure to climate related hazards, which currently receives the brunt of the attention both from the Vietnamese government and also from many of the Vietnamese researchers (Fortier, 2010; Bruun, 2012), but also because existing differences in key socioeconomic variables across provinces appear to matter greatly even in a comparatively equal society such as the Vietnamese. These differences are bound to be just as pronounced within provinces at the district level (data from the province of Quảng Nam hints at quite substantial variations; Bruun and Casse, 2013), and disaggregating the analysis further could be a fruitful area for future research. The present analysis, however, is sufficient to advocate an increased emphasis on disaggregated adaptation policies because natural hazards impact different parts of Vietnam unequally, surely, but also because differences in the provinces' socioeconomic profile lead to different vulnerability outcomes. The call for such policies echoes previous studies of climate change in Vietnam (Adger, 1999; Shaw, 2006). By relying on a distinct method of systematic cross-provincial variation in Vietnam, however, this study provides further evidence and rationale for disaggregating disaster adaptation policies.

Hence, rather than focusing on national strategies for CCA, an increased attention to broad-based and disaggregated policies for DRR appears warranted. The Vietnamese government appears to follow a general pattern, identified by Birkmann and Teichman (2010), where countries are assigning a peripheral role to DRR in the context of climate change and extreme events. Promoting technical adaptations to climate change in the most vulnerable countries has become a key issue in climate change negotiations (O'Brien *et al*., 2004: 12). Vietnam should rightly be commended for their active stance on CCA Vietnam ratified the United Nations Framework Convention on Climate Change in 1994 and the Kyoto protocol in 2002. Vietnam has compiled a National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (Government of Vietnam, 2007) and is currently adopting the National Target Programme in Response to Climate Change drafted by the Ministry of National Resources and Environment (Government of Vietnam, 2008).

However, the Vietnamese approach to CCA is still centre driven, with a clear focus on gauging the biophysical impacts of climate change. The recent 1 trillion VND project on raising community awareness and disaster risk management, for instance, builds on clear channels of authority and expertise extending from the central level down to the provinces (Government of Vietnam, 2009). Policies are simply communicated down to the provincial government without clear plans and guidelines necessary to support implementation (Asian Management and Development Institute and The Pressure Group Consultancy, UK, 2011). Bruun (2012)

also identifies clear vertical structures and hierarchies in the Vietnamese climate change research and adaptation policies that confine and standardise initiatives along the more technocratic dimensions of the mainline ministries. Policy making and implementation are being compartmentalised into new climate change organs, each with a narrow accountability towards their respective ministries, policies and donors. The consequence is an insufficient integration of DRR into socioeconomic development plans and climate change programmes (Asian Management and Development Institute and The Pressure Group Consultancy, UK, 2011: 11).

In addition to the centralised perspective of CCA – and as a consequence thereof – the government of Vietnam appears to consider CCA mainly in terms of geophysical problems of increased physical vulnerability. Through a rigorous analysis of Vietnam's climate change strategy, Fortier (2010: 238–240) concludes that climate change is primarily understood by the Vietnamese government as a bio- and geophysical problem that can be grasped by conducting increasingly complex scenario analyses, and that can subsequently be addressed by implementing technical solutions. Climate change is viewed as an external (and unjustly imposed) threat that will result in some concrete natural hazards that can be forecasted and then dealt through dykes, higher bridges, water reservoirs, resilient infrastructure and so on – what is often referred to as 'climate proofing' (UN, 2009). The symbiotic relationship of climate-induced disasters with various environmental as well as socioeconomic dimensions receives less attention. In the 2011 National Strategy on Climate Change (Government of Vietnam, 2011), for instance, most of the focus is clearly on measuring and forecasting weather patterns and sea level rise; DRR is only assigned a few lines, and even here the emphasis is more on the hazards themselves (Government of Vietnam, 2011: 4). O'Brien *et al*. (2004: 12) refer to this as an end-point understanding of climate-induced vulnerability because focus is on limiting impacts and reducing exposure through technological adaptations. However, restricting disaster management to a question of climate change adaptive capacities and the ability to implement technical solutions risks underestimating the multiple socioeconomic processes and stressors involved in disaster vulnerability. One can only hope, but it is doubtful, that the new law on natural disaster prevention, response and mitigation (expected to be approved May 2013) will increase focus on these socioeconomic dimensions of disaster management.

Conclusion

Owing to the fact that Vietnam's vulnerability to natural disasters consists almost exclusively of a large number of minor climate-induced disasters, the country's vulnerability to natural hazards is likely to increase with climate change. Vietnam, with its long coastline and multitude of river basins, is projected to be among those countries most adversely affected by climate change. However, the extent to which natural hazards develop into full-blown natural disasters depends on a range of socioeconomic factors. Acknowledging that Vietnam's natural disasters most often are limited in scope and with local implications, this paper proceeded to analyse the socioeconomic determinants of provincial variations in natural disaster vulnerability (as measured by fatalities and economic damages). It appeared that socioeconomic factors do indeed matter for provincial vulnerability. Income per capita was found to reduce provincial fatality rates, while inequality, poverty, infant mortality and urbanisation were significantly and positively correlated with fatalities. In terms of economic damage, the share of houses of poor quality was negatively correlated, while urbanisation and a dummy for flooding proneness were both positively correlated. The article therefore called for a broader approach to DRR that should take into account socioeconomic – not just geophysical – dimensions of natural disaster vulnerability.

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Notes

1 For a disaster to be entered into the database, at least one of the following criteria must be fulfilled: (i) 10 or

more people reported killed; (ii) at least 100 people should be reported affected; (iii) the government has declared a state of emergency; or (iv) the government has called for international assistance.

2 The stepwise method based on the AIC-metric selects the model with the best goodness of fit relative to the number of variables included. The model with the lowest AIC among all the possible models is considered the best model.

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Appendix I

Table A. List of variables and their sources

Variables	Source
Dependent: Killed per capita of natural disaster (logged)	DMIS 2011
Dependent: Economic damages per capita from natural disasters, million dong (logged)	DMIS 2011
Monthly income per capita average of 2002, 2004, 2006 and 2008, in 1000 dong (logged)	Household Living Standard 2008, Section 5
Poverty rate (% of population), average 2006 and 2008	Household Living Standard 2008, Section 9
Inequality-ratio of poorest quintile to richest, capita average of 2002, 2004, 2006 and 2008	Household Living Standard 2008, Section 5
Infant mortality rate (deaths per 1000 live births)	The 2009 Vietnam Population and Housing census
Urban share (% of population)	The 2009 Vietnam Population and Housing census
Population density (per km^2)	The 2009 Vietnam Population and Housing census
Housing simple (often made of crude materials: mud, leaves, bamboo screen thatch and/or tar paper) (% of households)	The 2009 Vietnam Population and Housing census
Medical service unit per capita, average 2007, 2008 and 2009	Statistical Yearbook 2009, Section 11
Gross output of industry at current prices, billion dong (2000–2008) per capita (logged)	Statistical Yearbook 2009, Section 7
Houses damaged (submerged, swept away, collapsed, roof drifted)	DMIS 2011
Percentage of population that suffered from illness or injuries in the last 12 months, 2008	Household Living Standard 2008, Section 4
River dummy (Provinces where Red and Mekong rivers run through)	Based on map readings

Sources: General Statistics Office of Vietnam (2009a,b); General Statistics Office of Vietnam (2008) and DMIS (2011).

