Title: Migratory Responses to Climate Change in Viet Nam
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EXTENDED ABSTRACT

Climate change and associated environmental events have implications for human populations, including mid- and long-range impacts on human settlement patterns. Climatic events may trigger increased population mobility or suppress it by intensifying constraints on resources required for migration (Gray and Mueller 2012; Gray et al. 2014; Hunter, Luna, and Norton 2015; Nawrotzki, Dickinson, and Hunter 2012). Broadly, the existing literature demonstrates that environmental phenomena often increase domestic migration, especially rural to urban movement, and international migration in areas with longer migration histories (Fussell et al. 2017; Gray and Mueller 2012; Hunter, Luna, and Norton 2015; Hunter, Murray, and Riosmena 2013; Nawrotzki and DeWaard 2016). In regions that lack migration histories, changing environmental conditions may reduce migration, reflecting constraints in residents' ability to rely on migration as an adaptive strategy (Gray and Mueller 2012; Hunter, Murray, and Riosmena 2013).

I. Research Question and Hypotheses

In this study, I examine migratory responses to environmental conditions using longitudinal data on provincial and municipal migration rates and monthly weather station rainfall and temperature recordings from the General Statistics Office of Viet Nam (GSO). In particular, I am interested in the question of how exposure to rainfall variation and harsh temperatures is associated with recent changes in migration in Viet Nam.

My goal is to understand to what degree rainfall and temperature changes generate short-term disruptions or longer-term change in migration rates—likely exacerbating urbanization trends as people respond to livelihood disruptions. This project examines the macro-level connections between rainfall and temperature variation and in-migration, out-migration, and net-migration rates at the provincial level.

My overarching hypothesis is that provinces and municipalities experiencing more erratic and extreme precipitation events and temperature patterns will have the greatest changes in migration—primarily through higher rates of out-migration. I also expect that out-migration will more intensely affect the rural, agriculturally-dependent regions in which the majority of the population resides (GFDRR 2017).

II. Research Setting

The Global Facility for Disaster Recovery and Reduction (GFDRR) at the World Bank ranks Viet Nam as one of the five countries most susceptible to climate change and natural disasters (GFDRR 2017). Furthermore, the Ministry of Natural Resources and Environment in Viet Nam highlights that between 1958-2007 the annual average temperature increased about 0.5 degrees Celsius (Ministry of Natural Resources and Environment 2014). The U.S. National Aeronautics and Space Administration estimates that a 0.5 degree rise in temperature will increase heat-wave

duration, rainstorm intensity, and sea-level rise by approximately one-third (Silberg 2016), especially problematic for the 3200 kilometer coastline in Viet Nam where more than 70% of the population resides (GFDRR 2017). Viet Nam is a country with a distinct dry season (winter months) and a heavy rainfall, monsoon season (summer months). Viet Nam is highly dependent on agriculture with 65.76% of its population residing in rural areas (World Bank 2018), and even small changes in rainfall may significantly affect agricultural livelihoods (Cutter and Emrich 2006; Hunter et al. 2014; Huy and Khoi 2011; Nawrotzki et al. 2012). The increased droughts in the winter months and unseasonably heavy rainfall in the summer months are causing significant crop loss and unpredictability for rural populations in particular. To elaborate, over the past 50 years, average rainfall has increased in the southern portion of the country and decreased in the northern portion of the country. The Red River Delta, in northern Viet Nam, has the largest population and highest population density, and approximately 10% of the region's GDP is vulnerable to permanent inundation from sea level rise plus 40% of the GDP is vulnerable to storm surge damage (Neumann et al. 2015). The south-central region has experienced heavy rainfall in both the dry and monsoon seasons—the annual rainfall increased by about 20% since 1958—greatly impacting agricultural production in the Mekong River Delta, where approximately half of the country's rice cultivation occurs (Ministry of Natural Resources and Environment 2014).

In Viet Nam, much of the internal (or interprovincial) migration literature focuses on economic development, such as higher rates of in-migration to provinces with higher monthly income per capita and higher rates of urbanization (Huy and Khoi 2011), with little attention to changes in environmental conditions (Kim Anh et al. 2012). From an environmental perspective, recent research has explored how natural disasters affect household welfare and poverty (Arouri, Nguyen, and Youssef 2015) and impact output growth in Viet Nam (Noy and Vu 2010), with minimal attention to migration. Research in the country focuses on environmental stressors at the individual level (Koubi et al. 2016)—how individual perceptions of different types of environmental stressors induce internal migration, suggesting that the individual perception of long-term environmental events, including droughts, reduces migration while perceptions of sudden-onset environmental events, such as floods or tsunamis, significantly increase the likelihood of migration. Therefore, my addition to the demographic and sociological fields pushes beyond individual perceptions to elucidate the macro-level intersection of interprovincial migration and climate change in Viet Nam by using spatial environmental rainfall and temperature data.

Researchers are identifying the associations between natural disasters and changes in demographic processes throughout Southeast Asia (Bangalore, Smith, and Veldkamp 2016; Huong, Bo, and Fahad 2018; Huy and Khoi 2011; Koubi et al. 2016), but increasingly researchers and policymakers aim to focus on slower onset changes in rainfall, rising temperatures, and rising sea level over longer periods of time. This paper aims to contribute to the ways in which Vietnamese migration patterns change over time in relation to gradual rainfall and temperature changes in recent years.

III. Methodological Approach

This geographic area is an ideal case to pursue my research question given the severity of environmental changes, the total land area affected, and the complete representation of all rural provinces and urban municipalities in Viet Nam.

To test my hypotheses, I use annual in-migration and out-migration data[1] from the GSO for 58 provinces and 5 centrally controlled municipalities[2] over the period 2005-2015. To explore whether regions are a more appropriate level of analysis, I also investigate regional migration data from the Red River Delta; the northern midlands and mountain areas; the northern central area and central coastal area; the central highlands; the southeast; and the Mekong River Delta. The GSO also provides monthly rainfall and temperature data from 15 weather stations throughout the country, including stations located in the north, central, south, coastal, and highland areas. I use spatial tools based on distance and regional climate to link the provinces and municipalities to the nearest weather stations.[3]

For my outcome, I examine whether net-migration rates increase, decrease, or remain constant. I also explore in-migration and out-migration separately as outcomes. In terms of rainfall variation measures, I generate and test the following: *amount of precipitation* (flat average in millimeters for a given month); *inter-annual rainfall variation* (the average rain per year in millimeters compared with the average rainfall over the entire 11-year period); and *rainfall duration* (the length of the rainy season in a given year for a given province) (Dorélien 2016; He and Earn 2007; Ngongondo et al. 2011; Nguyen, Renwick, and McGregor 2014). By using the *amount of precipitation* and *rainfall duration* measures, I investigate whether a change in migration rates is associated with a threshold effect of experiencing extreme high or low rainfall; whereas, the *inter-annual rainfall variation* measure looks at the relationship between migration and rainfall volatility over the period of study. In Viet Nam, in recent years, rainfall tends to produce more agricultural losses and induce climate migration compared to temperature fluctuations in the region (Bangalore, Smith, and Veldkamp 2016; GFDRR 2017; Nguyen, Renwick, and McGregor 2014). However, I conduct sensitivity analyses using the changes in temperature as well. Similar to my rainfall measurements, I generate and test the following temperature variation measures: *average monthly temperature* (the average temperature in Celsius for a given month); and *inter-annual temperature variation* (the average temperature per year in Celsius compared with the average temperature over the entire 11-year period). My analysis also considers the effects of different time lags between rainfall variables and migration rates (i.e., six months versus one-year versus two-year lags) plus indicators for rural provinces versus urban municipalities.

[1] It is reasonable to assume that migration rates are internal within Viet Nam because internal migration rates far outstrip international migration in the country (Nguyen-Hoang and McPeak 2010; United Nations Department of Economic and Social Affairs 2017).

[2] Municipalities and provinces can be analyzed as the same level of analysis (GSO n.d.).

[3] There are 172 weather stations in Viet Nam, but only 15 of the weather stations have publicly accessible data for monthly rainfall and temperature through the GSO. If I am able to obtain additional data from other weather stations from the GSO or the World Bank, I will incorporate weather data from these additional stations. However, the 15 weather stations with available data already represent a robust mixture of regional and climatic variation.

I use linear regressions to examine how the provincial/municipal migration rates are associated with a set of dummy variables for each month, my appropriate rainfall measure, and the interaction between month and the rainfall measure, with random effects for year and province/ municipality. Additionally, I run the same models substituting rainfall with temperature.

In terms of limitations, populations with tighter resource constraints at baseline may have different responses to rainfall and temperature variations than populations with fewer constraints. I recognize that my current modelling does not include an explicit analysis of socioeconomic conditions and only incorporates an indicator for rural as a measure of agricultural dependence, but instead my primary objectives are to identify to what degree the spatial patterning of rainfall/temperature and migration coincide, and to disentangle the extent to which migration responses to extreme rainfall and temperature fluctuations are temporary or longer lasting.

IV. Discussion

I aim to differentiate the ability of the provinces and municipalities to withstand weather shocks and stresses without significant upheaval, a measure of social resilience (Adger 2000; Adger et al. 2002), by considering the ways in which migratory responses to environmental events systematically vary across different types of municipalities/provinces, whether urban or rural, and different climatic regions.

My research contributes to theory on environment and migration in Southeast Asia by considering the dimensions of and places where population churning through migration is more or less likely to occur. Climate change may exacerbate the recent declining rural population trends through out-migration in rural settings, which may contribute to agricultural livelihood losses and place additional stress on urban centers. Similarly, agricultural losses from changing weather patterns are altering the livelihood strategies needed to survive throughout Viet Nam. From a policy perspective, by considering the ways in which migratory responses to environmental events systematically vary across different types of places in Viet Nam, we can develop more realistic and comprehensive scenarios of how climate change will differentially affect human populations and settlement patterns.

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