An exploratory spatial study of urbanization, urban in-migration, and dengue in Indonesia 1980 to 2010

Beatrice Abiero (Penn State)

[Draft submission for PAA 2014 - Please do not cite or quote]

Introduction

Migration and urbanization have important implications for health, particularly in the developing world context [1]–[3]. Indonesia is a relevant study subject as it is the fourth most populous country with a substantial proportion of the population residing in urban areas [4]. As a middle income country, Indonesia faces challenges in addressing an uneven distribution of social capital and rural poverty. These challenges are coupled with burgeoning globalization and increased foreign investment due to a more recently established industrialized economy [5], [6]. Furthermore, Indonesia has experienced tremendous and rapid population growth within the past 40 years [4], [7]. In regard to health, Indonesia faces high non-communicable and communicable disease burdens [8]–[10]. Notably, the risk of dengue occurrence is particularly high in Southeast Asia, with some of the highest risk occurring in Indonesia [11]. The purpose of this study is to explore from a spatial lens how urban in-migration is related to urban growth and whether instances of dengue are more likely to occur in these urban areas. Additionally, this study discusses whether proximity to low elevation coastal zones (LECZ) and flooding areas correlate with dengue occurrence and urban growth. This study offers a nuanced approach in examining how urbanization and climate change may influence health by analyzing these factors both spatially and temporally.

Background

In Indonesia and elsewhere, a demographic shift has led to urban growth surpassing rural growth [7]. The main factors that distinguish the rapid urbanization in Indonesia compared to more developed regions include: socioeconomic/political factors, decentralization, and internal migration concentrated in urban areas [4,7]. Historically, urbanization in Indonesia resulted from transmigration programs that promoted development of outer islands of Indonesia by relocating individuals. The most notable areas that have experienced rapid urbanization and development are: Jakarta Metropolitan Area, Surabaya, Bandung, Medan, Palembang, and Semarang [4], [10]. The hypothesis guiding this study is that urban growth results from urban in-migration. Urbanization in Indonesia marks an important demographic factor in influencing disease transmission and intervention. Since migration is a primary cause of urbanization, migration must also be considered in determining health issues.

Research supports population factors such as density and lower altitude as major contributors to emerging infectious disease [12]. For dengue, urban areas offer ample settings for the replication and transmission of the dengue virus [13]. Climate change, along with urbanization, also impacts health. Urban areas tend to contain more heat because of land use change introduced by increasing infrastructure and environmental factors such as less vegetation cover [13]. Furthermore, increases in temperature and rising sea levels can implicate health and the "ecology of infectious disease" [13]**.** In Southeast Asia, research has found support for statistically significant correlation between increased climate change and dengue [14]. These factors further warrant the exploration of the interplay among urbanization, climate change factors, and health.

Methods

Data: This study uses Indonesia decennial census data from the International Integrated Public Use Microdata Series for 1980 to 2010 (IPUMS). Indonesia census surveys are administered nationally and are weighted by population. The data contain individual level data; however, these measures are aggregated. The data are standardized for each of the 27 provinces.

Measures: Measures include: 5-year urban in-migration rates by province, percent urban population by province, 5-year previous residence rates by province, 10-year population growth rates by province, and

10-year urban population growth rates by province. Climate change spatial data, including population distribution, urban extents, low elevation coastal zones (LECZ) were overlaid on migration rates and urban population [15], and dengue occurrence [11] using geographic software ArcMap 10. Dengue occurrences were derived from secondary sources and are geo-located areas of confirmed dengue infection.

Urban classification is primarily designated by a census enumerator. Generally, the Indonesia census surveys preceding the 2000 census defined urban areas as having a population density of 5,000 or more people per square kilometer, having 25% or less of households employed in the agricultural sector, and having eight or more kinds of urban facilities [4].

Analytic Approach: This study describes 1) the migration rates over the 40-year period and which areas received the most migrants, 2) where migrants came from, 3) areas where dengue fever occurred, and 4) proximity to climate change factors both for urban areas and instances of dengue.

Findings

Table 1 shows the average distribution of migration, population, and urban measures. On average, 4-8% of the population reported urban in-migration. Urban growth rate from 1980-1990 was 5.82%, while for 1990-2000, the rate was 4.48%, from 2000-2010, the rate was 3.21%. The population growth rate ranged between 1.42% and 2.26%, with the highest growth rate occurring from 1980-1990. Additionally, dengue occurrences typically occurred in more urban areas that were also in LECZ areas. We expect that after conducting raster analysis using zonal statistics, findings may support dengue occurrences in areas of high migration and high urban population.

Table 1. Average distribution of migration, population, and urban measures

National Weighted Measures	Census Year						
	1980		**1990**		**2000**		**2010**
% Average In-migration to Urban	8.0		7.0		5.0		4.0
%Average Urban	20.35		27.8		36.96		41.9
Urban growth by decade (per annum)		5.82		4.48		3.21	
Population	125,445,850		156,857,551		180,580,260		213,362,610
Population growth by decade (per annum)		2.26		1.42		1.68	

Discussion

The intersection of migration, urbanization, climate change, and health offers a unique research opportunity in regard to understanding how these factors are related and how they may shape disease patterns and inform policy and health interventions. Urban growth rates decreased across the time frame, and this decrease may have resulted from the Indonesia population being heavily concentrated in Central Java. However, these trends most likely mask sub national variation. Additionally, the findings suggest that migration is an exchange among more densely populated areas; migration more likely occurs in urban rather than rural provinces. Dengue occurrences typically occurred in more populated areas that were also in LECZ areas. This study has some limitations. First, aggregate estimates that look at changes over time may mask year-to-year changes. Despite this limitation, the main strength of this study is its examination of migration and urbanization changes over time and place. Second, the distinctions between urban and rural areas are subjective as they are determined by census enumerators. Furthermore, finer geographic census information is ideal yet unavailable, thus this study focuses on the province level. However by overlaying the GRUMP extent, we minimize the subjectivity of the urban/rural classification. This study takes a step toward understanding the interplay of migration, urbanization, and climate factors both spatially and temporally.

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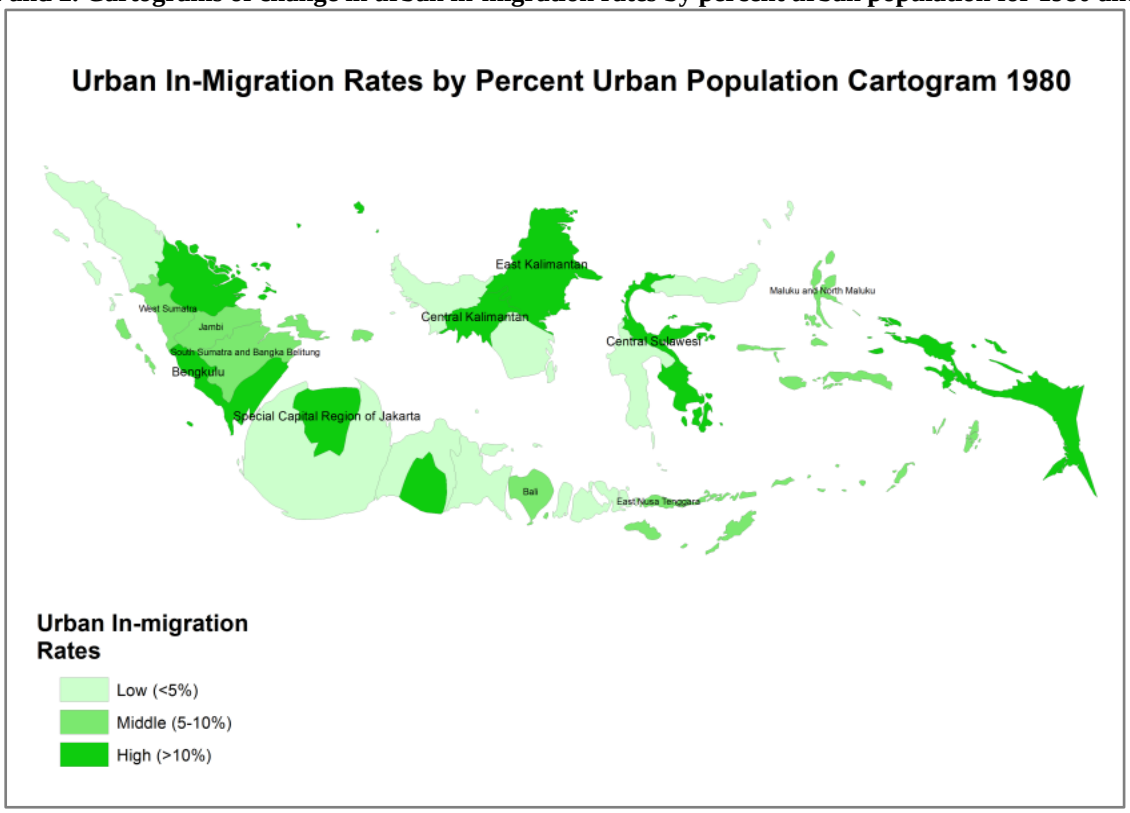
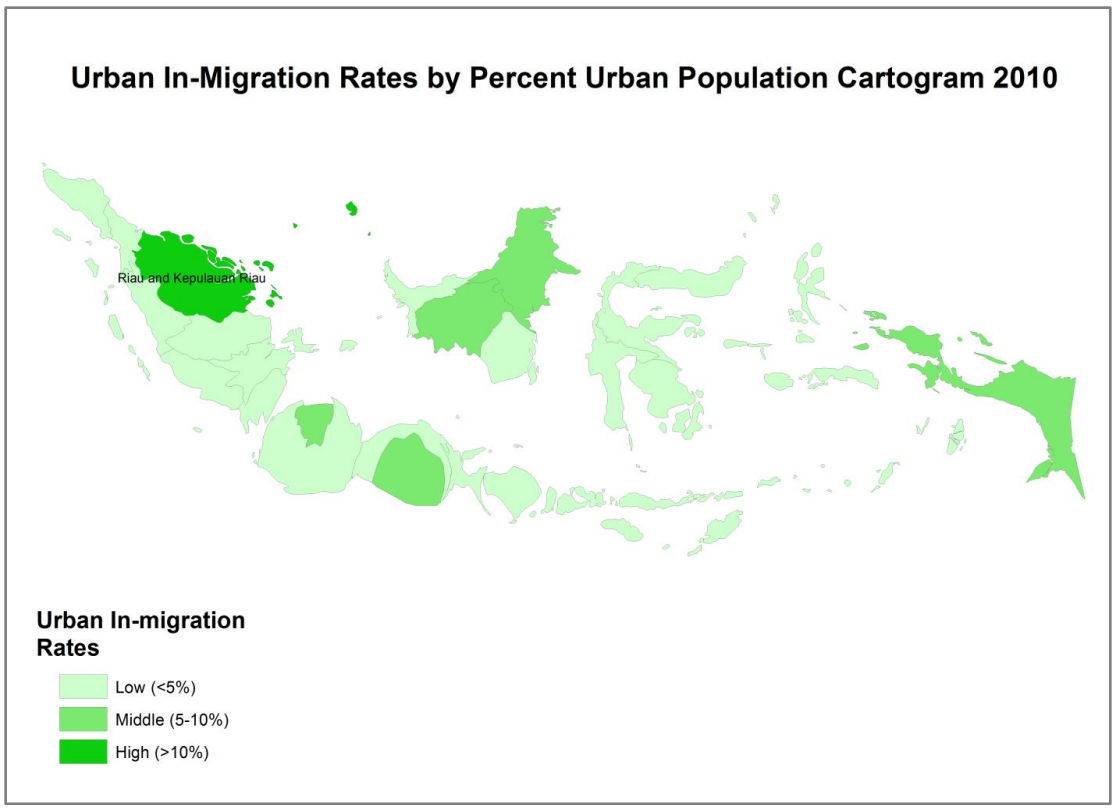
Map 1 and 2. Cartograms of change in urban in-migration rates by percent urban population for 1980 and 2010





Map 3. Occurrence of Dengue