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Research Paper

Urbanization, economic development, environmental and social changes in transitional economies: Vietnam after Doimoi

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ABSTRACT

We used the experiences of Vietnam following the economic reform, known as *Doimoi*, to study urbanization, economic development, and environmental and social changes in transitional economies at multi-scales. The country underwent rapid urban land expansion, as indicated by the increase in the mean value of nighttime light data from −1.4 in 1992 to 4.4 in 2012. The urban population grew at a faster annual rate following *Doimoi* (1986–2015) compared to the pre-*Doimoi* period (1960–1985). At the inter-city level, cities with populations more than 1 million experienced more rapid growth of built-up land intensity and population size compared to the national average. At the intra-city level, conversion from farmland contributed significantly to built-up land in Hanoi and Ho Chi Minh City from 1990 to 2010. As indicated by $PM_{2.5}$ and NO_2 concentrations, urban environments in large cities deteriorated; yet poverty was alleviated, as measured by populations falling under the poverty line and the proportion of the urban population living in slums. Coupled dynamics of urbanization, economic development, and environmental and social changes were modeled and the main findings are: (1) economic development strongly influenced urbanization and (2) urbanization and economic development contributed to environmental deterioration while promoting the social conditions. How urban land expansion was facilitated by local institutional interventions such as frequent changes of administrative boundaries, master plans, and policies is also discussed. Our study highlighted a multi-scale and multi-dimensional perspective, the independent and coupled relationships between economic development, urbanization, and environmental/social changes, and a hybrid approach of examining the influences of the institutional intervention and the market mechanism on urbanization in transitional economies.

1. Introduction

Transitional economies refer to economies undergoing the change from a centrally planned economy to a free market (Feige, 1994). Because both the state and the market have exerted their influences in urban land use changes, urbanization in transitional economies is distinctively different from that of industrialized countries, non-transitional economies in the developing world, or their socialist pasts (e.g., Fan et al., 2016; Wu, Xu, & Yeh, 2006). A plethora of literature appears to have examined the patterns, driving forces, and consequences of urbanization in transitional economies, particularly in China since the economic reform (e.g., Cheng & Masser, 2003; Fan et al., 2017; Kontgis et al., 2014; Park, Fan, John, & Chen, 2017; Wu et al., 2006). Despite growing interest, three major knowledge gaps can be identified from the existing literature, especially for non-Chinese cities in transitional economies. First, there is a lack of analyses on the spatiotemporal changes of urbanization at multiple scales linked with multiple dimensions, such as land, population, environment, and poverty. For example, in Vietnam, existing studies on urbanization changes tend to focus mostly on the spatiotemporal changes of urban land with population growth at a particular scale (Kontgis et al., 2014; Pham, Yamaguchi, & Bui, 2011; Smith & Scarpaci, 2000).

Second, in the context of transitional countries integrated in the global economy, there is an urgent need to incorporate different levels

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of institutional factors and global influences (e.g., Cohen, 2006; Fan et al., 2017; Sassen, 1991) as drivers. Institutions "are the humanly devised constraints that structure political, economic and social interaction" that "consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, and property rights)" (North, 1991, pp. 97). While some have recognized these needs (e.g., Fan et al., 2016; Wu et al., 2006), few researchers have incorporated these aspects in their analyses of other transitional economies, despite the fact that state policies and interventions often control resources and guide market forces for urban development. Globalization is the process of international integration of economic, cultural, and political aspects (IMF, 2000). Only a few recent studies have started to look at how globalization has affected urbanization in transitional economies through quantitative analyses (e.g., Fan et al., 2017).

Third, urbanization has not been closely analyzed by considering linkages with two other dimensions of sustainability: environmental conditions and social equity for most studies (e.g., Park et al., 2017; Wolch, Byrne, & Newell, 2014). Rapid urbanization in transitional economies and the developing world has resulted in severe environmental degradation through the expansion of impervious surfaces, decreased green space in cities, elevated pollutants in the air, water, and soil, and increased vulnerability to urban flooding, climatic extremes, and other physical disturbances (Chen, Zhu, Fan, Tian, & Lafortezza, 2016; De Sherbini, Schiller, & Pulsipher, 2007; Economy, 2011). Urbanization and economic developments have also shaken the egalitarian foundation of socialism, widening social disparities between rich and poor and residents and migrants (Cohen, 2006). While previous researchers have examined the changing environment in cities and regions (Chen et al., 2016; Economy, 2011) and the transforming social structures (Friedmann, 2005; Drakakis-Smith & Dixon, 1997; Wu et al., 2006), few have integrated analyses connecting urbanization with socioeconomic changes, or assessed the consequences for the environment and society. For sustainable urban development, it is necessary to provide insights on the inter-linkages between urbanization and the three dimensions of sustainability.

Using Vietnam as an example, we explored the economic, environmental and social changes that occur during urbanization, within the context of transitional economies in an integrated global economy, with the following three specific questions:

(1) What spatiotemporal changes had occurred for Vietnamese cities after the economic reform? What were the main patterns at the national, regional, and city levels?
(2) What were the major driving forces of urbanization in Vietnam? In particular, how did institutional factors and globalization, in addition to economic development, contribute to the process of urbanization?
(3) What are the coupled dynamics between environmental/social conditions, urbanization, and economic development?

Like many transitional economies in Southeast Asia, economic reform in Vietnam has produced profound impacts on urbanization, as its urban built-up area increased by a factor of 8.8 times from 1992 to 2010; whereas this figure is 6.0 and 3.6 times for Laos and Cambodia, respectively (Ouyang, Fan, & Chen, 2016). Previous studies on land use changes in Vietnam have focused on non-urban areas, such as agricultural land changes in rural areas in connection with urban transitions (Leisz & Rasmussen, 2012; Van den Berg, Van Wijk, & Van Hoi, 2003), forest land transition in connection with globalization (Lambin & Meyfroidt, 2010; Munroe & Müller, 2007), and rural-urban migration and rural landscape changes (Adger, Kelly, Winkels, Huy, & Locke, 2002; Nguyen, Raabe, & Grote, 2015). A few studies have focused on urbanization and the planning of individual cities such as Hanoi (Pham et al., 2011; Turley, 1975), Ho Chi Minh City (HCMC) (Kontgis et al., 2014), or the broad-scale urbanization of Vietnam (Drakakis-Smith & Dixon, 1997; Smith & Scarpaci, 2000).

Our study made a unique contribution to the general study of urbanization in the following three ways. First, we used a multi-scale and multi-dimensional perspective to examine the changes in urbanization and the environment. We developed a method and framework that can be adapted for use in other similar studies. Second, we analyzed the independent and coupled relationships between economic development, urbanization, and environmental/social changes through applying structural equation modeling (SEM), a method from which other researchers can learn how to construct useful SEM models to investigate the possible causes and consequences of urbanization. Third, our study revealed that researchers should incorporate analyses on both the market mechanism and institutional interventions to examine urbanization in transitional economies.

2. Study area, data, and methods

2.1. Study area

Vietnam is located on the eastern side of the Indochina Peninsula, bordering China to the north, Laos and Cambodia to the west, and Thailand, Indonesia, the Philippines, and Malaysia to the southwest, southeast, and east, respectively (Fig. 1), with a long coastline of 3444 km and a land area of 331,123 km^2. North Vietnam is characterized by mountains, hills, and the Red River Delta, whereas South Vietnam features coastal lowlands, the Mekong River Delta, the Annamite (Truong Son) Range mountains, and tropical forests. With a population of 92.7 million in 2016, Vietnam is the 14th most populous country. Together with China, Cuba, North Korea, and Laos PDR, Vietnam is one of the few one-party socialist countries still espousing the communist regime. The country embarked on its journey as a transitional economy in the 1980s, when the Vietnam Communist Party launched its economic reform, i.e., *Doimoi*. In 1986 the government formally abolished the central management system and shifted to a market-driven economy. Subsequent reforms included a freer environment for domestic trading, permission and encouragement of private companies for commodity production, greater autonomy and independence of state enterprises, and the recognition of private land use rights. Acceptance by the World Trade Organization (WTO) in 2007 signified Vietnam's integration into the global economy. *Doimoi* has placed Vietnam amongst the list of countries with the world's highest economic growth rates, with a gross domestic product (GDP) growth rate of 7–8% in the 1990s and 2000s. It encouraged the growth of small private enterprises, increased the zeal of work for many farmers and some workers, and improved agricultural productivity and industrialization, which consequently enhanced urbanization (Beresford, 2008; Boothroyd & Pham, 2000; Kirk & Tuan, 2009). However, new challenges also emerged, such as increased inequality between rural and urban areas and between different regions, the dominance of foreign and private companies, the misuse of local elites' power in land allocation, and endangered "commons" through land privatization (Beresford, 2008; Kirk & Tuan, 2009).

We additionally selected six large cities that had over one million population in 2015 to examine the changes in urban land, population, and environmental conditions. These cities are growth poles of the national economy and the political and cultural hubs. With a population of 8.1 million people, HCMC, formerly Saigon, is the country's largest city and economic center, contributing over 8.8% of the population and 24% of the GDP of Vietnam in 2015. With a population of 7.2 million people in 2015, Hanoi is the nation's capital and the second largest city in Vietnam. Hai Phong, Da Nang, and Can Tho are located in the northern, central, and southern parts of the country, respectively, with Hai Phong and Da Nang serving as maritime port cities and Can Tho serving as a freshwater port city in the Mekong Delta. Bien Hoa, a city in the Dong Nai Province located 30 km east of HCMC, has enjoyed remarkable urban growth with a population exploding from only 0.3

Fig. 1. Vietnam and its six large cities with populations over one million: Ho Chi Minh City, Hanoi, Hai Phong, Da Nang, Can Tho, and Bien Hoa.

million in 1999 to 1.1 million in 2015.

2.2. Data and methods

2.2.1. Urban land data and processing

We examined the spatiotemporal patterns of urbanization in Vietnam through the analysis of DMSP/OLS nighttime light (NTL) data. NTL brightness is strongly correlated with urban land/impervious area (Elvidge et al., 2010; Lu & Weng, 2007), thus implying the density of built-up land. To reduce the variations and differences among sensors, an inter-calibration of NTL data was first performed following Elvidge et al. (2009). When there were multiple annual DMSP/OLS NTL composites for a year, we chose the one with the largest number of cloud-free observations. To convert NTL to actual urban land area, a proper threshold of NTL is needed for different periods and regions. Because we were more interested in the trend of urban expansion, we used the average NTL brightness of the six cities and the whole country to compare their changes from 1992 to 2012. A larger value indicated a higher percentage of, or more intensive, urbanized land.

To offer an intra-city perspective, we derived land use data of the urban district of Hanoi and HCMC for three periods centered around 1990, 2000, and 2010 and developed land use conversion matrixes for 1990–2000 and 2000–2010. Landsat images of TM and ETM+ were downloaded from the official website of the United States Geological Survey (USGS). For each period, we collected a cloud-free scene of the Landsat image of the year that is closest to each period. We adopted an object-oriented classification (Ouyang et al., 2016) using eCognition Developers and classed the land objects into four classes: built-up land, farmland, green land, water, and bare land. Briefly, threshold-based rule sets based on proper water and vegetation indices were applied to classify water, green land, and bare land. Supervised classification using the Nearest Neighbor Classifier was then employed to differentiate built-up land and farmland. Lastly, manual corrections were applied to further improve the classifications through comparisons with Google Earth high resolution images, including revising image objects around the urban-rural fringes, searching for missed low reflectance built-up areas, and excluding bare soil. To check the quality of land use classification data, we validated the 2010 classification for both Hanoi and HCMC using 300 randomly sampled 30 × 30 square sites from Google Earth. The overall accuracies of the two cities were 87.1% and 89.5%, respectively.

2.2.2. Environmental data and processing

We extracted spatial mean values of surface air pollution data of fine particulate matter less than 2.5 μm in size ($PM_{2.5}$) from 1999 through 2013, and NO_2 from 1998 to 2011 for the six cities as well the whole country from the Atmospheric Composition Analysis Group (2017). The surface $PM_{2.5}$ at 0.01 × 0.01 degrees resolution were estimated by combining aerosol optical depth retrievals from the NASA MODIS, MISR, and SeaWIFS instruments with the GEOS-Chem chemical transport model and subsequently calibrated to global ground-based observations of $PM_{2.5}$ using geographically weighted regression (Van Donkelaar et al., 2016). The surface NO_2 mixing ratio at 0.1 × 0.1 degrees resolution was inferred from the GOME, SCIAMACHY, and GOME-2 satellite instruments (Lamsal et al., 2008).

2.2.3. Socioeconomic and population data and processing

We collected data on demography and economic development, including population, GDP, GDP per capita (GDPpc), percentages of primary, secondary, and tertiary industry's value added GDP, foreign direct investment (FDI), international trade, etc. We collected data on environmental and social conditions, including emissions of green house gases, % of poverty population, number of doctors per one thousand people, and life expectancy at birth. Major data sources were

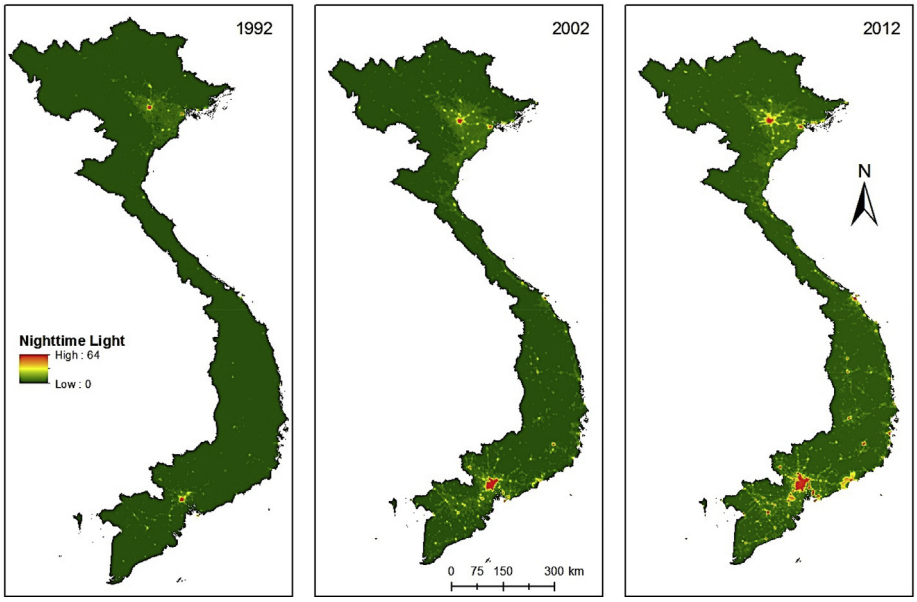

Fig. 2. The spatial distribution of nighttime light (NTL) in original DN Values in Vietnam in 1992, 2002, and 2012. The higher the value of NTL, the higher the density of urban land. The figure shows the emergence of three main urban clusters in Vietnam over the years.

World Development Indicators (World Bank, 2017), the statistical yearbooks of Vietnam and its provinces and cities. We also collected reports, documents, and news related to land regulation and urban development/planning policies. We conducted field surveys from 2015 to 2016 in HCMC, Hanoi, and Can Tho and interviewed 3–10 local experts in each city, consisting of experienced urban planning professionals, academic researchers or government officials on economic development, social development, or environmental protection of the respective cities, with at least 10 years of professional experience. Each interview lasted 1.5–2.0 h. Our findings were also sent back to some of the interviewees for validation.

2.2.4. Urbanization: causes and consequences

We used partial least squares structural equation modeling (PLS-SEM) to understand the complex relationships among economic development, urbanization, and environmental/social conditions. Structural equation modeling (SEM) has been widely used to quantify the complicated relationships among multiple factors (Fan, Chen, & John, 2016; Hair, Hult, Ringle, & Sarstedt, 2013). With small and non-normally distributed data, PLS-SEM can be used to do exploratory research (Hair et al., 2013). We hypothesized that economic development affects urbanization and social conditions positively, but affects environmental conditions negatively. Economic development can be reflected by economic growth, industrialization, and economic globalization (Borensztein, De Gregorio, & Lee, 1998; Sassen, 1991) and is an important driving force for urbanization (Davis, 1965). The level of economic development is directly linked with environmental quality or degradation (Dinda, 2004; Stern, Common, & Barbier, 1996). While the connection between economic development and social conditions has long been questioned, we based our model on the finding from Ranis, Stewart, and Ramirez (2000) and Deaton (2008) that economic development may foster social conditions in regard to education and health, in order to substantiate the hypothesized linkage between economic growth and social conditions. Urbanization, however, has different impacts on environmental and social conditions. While developing countries have experienced environmental stress due to drastic population growth (Brennan, 1999) resulting in worsened natural environments in cities, cities in industrialized countries generally experience improved urban environmental conditions, and the subsequently altered lifestyle, nutrition, and healthcare services may be the leading factors in the improved life expectancies of urban dwellers (Popkin, 1999).

We could not develop a complex model to incorporate all of our hypothesized relationships due to limited data. Instead, we developed two separate models that share the same structure to handle environmental and social conditions separately. For the environmental model, the PLS-SEM had the following structure: economic development is a potential driver on urbanization and environmental conditions. Economic development (*Econ*) was modeled as a latent variable based on three variables that represent economic growth, industrialization, and economic globalization, i.e., *GDPpc*, the percentage of the manufacturing value added in GDP (*Mfg*), and the percentage of foreign direct investment in GDP (*FDI*). *Urbanization* was directly modeled by an observable variable, the ratio of urban population to the total population. Environmental condition (*Envir*) is a latent variable modeled by three variables related to green house gas emissions, i.e., CO_2 emission per capita (CO_2), CH_4 emission per capita (CH_4), and NO emission per capita (*NO*). For the social model, the PLS-SEM had the same structure, except that the latent variable of environmental condition was replaced by social condition (*Social*), which was modeled as a latent variable *Social* by the number of doctors per thousand people (*#_Doc*) and life expectancy at birth (*LE*). To confirm the model's stability, we conducted a bootstrapping analysis (i.e., 1000 iterations) – a statistical method to test the statistical significances of the estimated path coefficients from randomly generated sub-samples based on the original dataset.

3. Results

3.1. Urbanization in Vietnam

3.1.1. National dynamics and the six large cities

Vietnam underwent rapid urban land expansion, as indicated by the increase in the mean value of nighttime light from −1.4 in 1992 to 4.4 in 2012 (Figs. 2 and 3). Furthermore, three major urban clusters became distinct: (1) HCMC-Bien Hoa-Can Tho in Mekong River Delta of South Vietnam, (2) Da Nang in the central coast, and (3) Hanoi-Hai Phong in North Vietnam. All six cities had higher relative values of nighttime light than the national average value, with Bien Hoa (56) and HCMC (33) having the highest relative values in 2012, indicating higher built-up land densities in these two cities than in the others. All

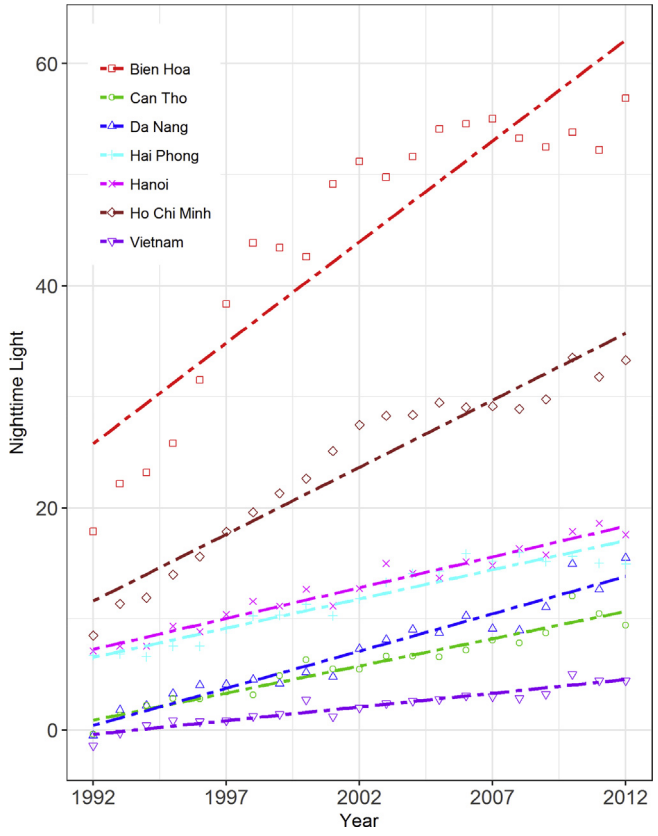

Fig. 3. Annual change of mean nighttime light (relative value from 1 to 64) in the six selected cities as compared to the entire country. All six cities have higher relative values and a steeper slope than the national average value of Vietnam.

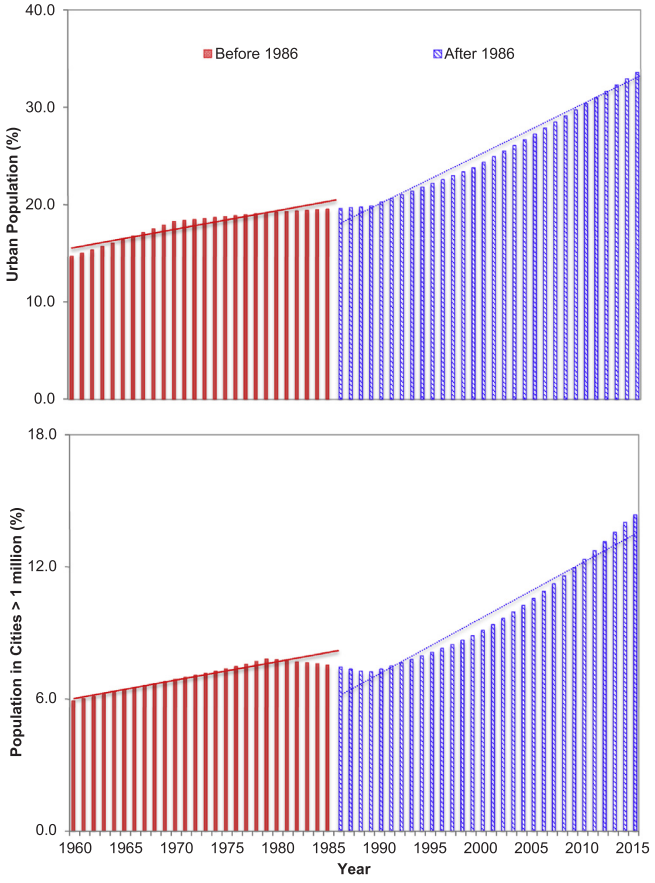

Fig. 4. Urban population dynamics of Vietnam (1960–2015). The urban population grew faster in 1986–2015 than in 1960–85. Cities with > 1 million population grew even faster than the urban population.

six cities showed a more rapid change in annual mean nighttime light, illustrated by their steeper slope of lines than that of the national average (Fig. 3), indicating a faster increase of built-up land density of the six cities than that of Vietnam as a whole.

The urban population in Vietnam grew faster after *Doimoi* than before Doimoi, as the annual growth rate increased slightly from 3.18% for 1960–1985 to 3.24% for 1986–2015 (Fig. 4). Cities with populations greater than 1 million grew even faster after *Doimoi*. Their average annual growth rate was 3.0% for 1960–1985, but increased to 3.6% for 1986–2015, leading to 14.4% of the total national population residing in these cities in 2015.

3.1.2. Hanoi and HCMC

Urban built-up land in the inner cities of HCMC and Hanoi more than doubled from 1990 to 2010 (Fig. 5a). Urban built-up land of both cities expanded at an even faster pace than their urban population. While the urban population in Hanoi increased by 2.6 times, from 1.06 million in 1990 to 2.80 million 2010, urban built-up land increased by about 2.7 times during the same period. The urban population of HCMC increased by a factor of 2, from 3.03 million in 1990 to 6.11 million in 2010, whereas its urban built-up land increased by a factor of 2.9 (Fig. 5b).

3.1.3. Land cover change in Hanoi and HCMC

For Hanoi, urban built-up land increased from 50.5 km^2 to 138.4 km^2, whereas farmland declined from 260.2 km^2 to 171.3 km^2 during 1990–2010 (Table 1). Farmland contributed to 65% and 46% of built-up land for the two decades, respectively. For HCMC, urban built-up land increased from 100.3 km^2 to 293.8 km^2, whereas both green land and farmland of HCMC declined significantly, from 213.1 km^2 to 83.6 km^2 for green land and from 134.6 km^2 to 77.3 km^2 for farmland (Table 1). While 33% and 21% of the increased built-up land were converted from farmland for 1990–2000 and 2000–2010, respectively, 26% and 4% of the increased built-up land were converted from green land during these two periods. Although water bodies constituted a small portion of the land area, a significant percentage of the water bodies in both cities were converted to other types of land, particularly farmland and built-up land: specifically, 28% and 32% for Hanoi, 19% and 26% for HCMC for the two decades, respectively. It should be noted that HCMC underwent a much larger increase of urban built up area (+193.5 km^2) than Hanoi (+87.9 km^2) from 1990 to 2010. Furthermore, while most of the increase of built-up area in Hanoi was from the loss of farmland, both farmland and green land contributed to urban built-up land of HCMC by 140.3 km^2 and 72.4 km^2, respectively. In addition, a large area of green land (106 km^2) was converted to farmland (93.5 km^2 for 1990–2000, 12.5 km^2 for 2000–2010) for HCMC, and the conversion in 1990–2000 probably facilitated some of farmland-urban built up land conversion for 2000–2010. Whether or not green land was a significant source for urban built-up and farmland of these two cities may be due to different levels of green land in 1990; while Hanoi had only 3.3 km^2 of green land in 1990 in its study area, HCMC had a vast area of green land (213.1 km^2).

Local experts have also identified three major characteristics of urban development in Vietnam after 1986: (1) conversion of a significant amount of farmland to other types of infrastructure, such as roads and bridges, and residential areas; (2) development of housing complexes and commercial/business facilities on land converted from water surfaces, such as wetlands, lakes, and ponds, and (3) densification of existing residential areas by construction of multistory buildings. Due to the low land compensation costs, development of land converted

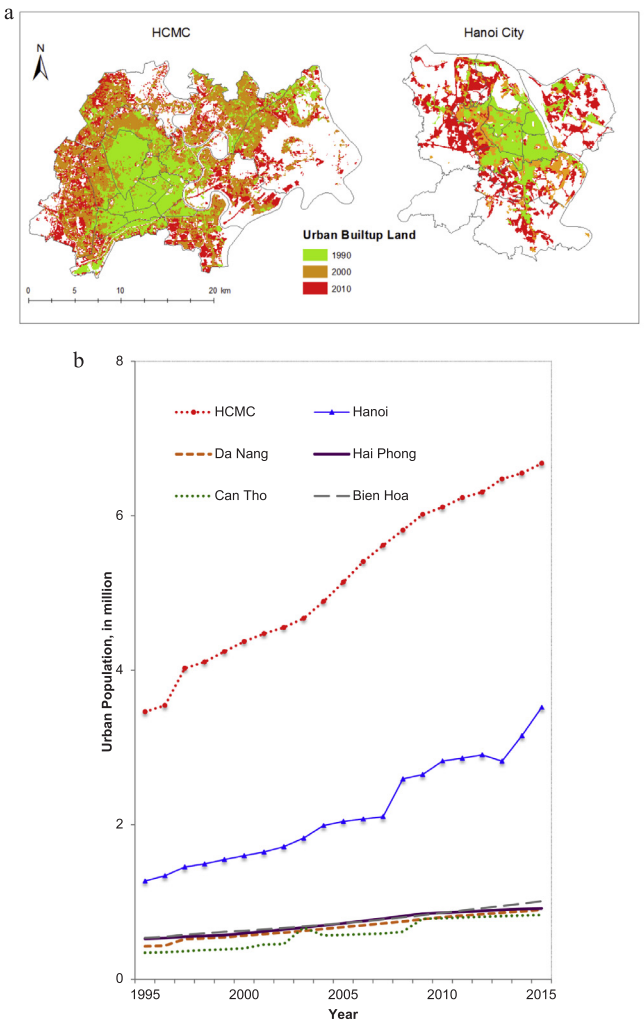

Fig. 5. Urbanization of HCMC and Hanoi, (a) Urban land expansion, (b) Urban population in comparison with four other large cities in Vietnam. Note: We defined the inner city of Hanoi as the twelve urban districts of Ba Dinh, Hoan Kiem, Dong Da, Hai Ba Trung, Thanh Xuan, Cau Giay, Tay Ho, Hoang Mai, Ha Dong, Long Bien, Nam Tu Liem, and Bac Tu Liem. Similarly, we defined the inner city of HCMC as 19 urban districts of District #1–#12, plus the districts of Go Vap, Tan Binh, Tan Phu, Binh Thanh, Phu Nhuan, Thu Duc, and Binh Tan.

from water surfaces was a dominant development type for a long time up until the exhaustion of this type of land.

3.2. Environmental and social changes

3.2.1. Urban environment and poverty

Concentration levels of $PM_{2.5}$ and NO_2 increased for all six cities and Vietnam as a whole (Fig. 6). $PM_{2.5}$ concentration levels of three cities in the Mekong Delta Region, i.e., Can Tho, HCMC, and Bien Hoa, were always lower than the national average, while that of Da Nang closely followed the national average, and that of Hanoi and Hai Phong was above the national average. $PM_{2.5}$ was kept above 37 $\mu g/m^3$ for Hanoi, falling into the unhealthy range for sensitive groups according to the air quality standards published by the U.S. Environmental Protection Agency (33.5–55.4 $\mu g/m^3$). Concentration levels of NO_2 for Da Nang and Can Tho were always below the national average, whereas those of the other four cities were far above the national average, particularly in Hai Phong.

Since the 1990s, Vietnam's poverty at the national level, measured by the percentage of the national population falling below the poverty line, i.e. $3.10 a day (2011 Purchasing Power Parity), decreased

Table 1
Land use conversion matrices for the Inner City of Hanoi (top) and HCMC (bottom) in 1990–2000 and 2000–2010 (km^2).

	HANOI					
	Areas in 1990					
Areas in 2000	Farmland	Green Land	Built-up Land	Water	Bare land	Total
Farmland	198.1	0.1	28.3	9.7	0.5	236.6
Green Land	2.4	0.4	1.4	0.8	0.0	5.0
Built-up Land	47.5	2.4	19.7	2.6	0.3	72.6
Water	11.8	0.4	1.1	24.2	1.0	38.5
Bare Land	0.5	0.0	0.0	0.8	0.0	1.3
Total	260.3	3.3	50.5	38.1	1.9	354.0
	Area in 2000					
Area in 2010	Farmland	Green Land	Built-up Land	Water	Bare Land	Total
Farmland	160.8	0.7	2.3	6.9	0.7	171.3
Green Land	4.8	0.6	1.2	0.6	0.03	7.2
Built-up Land	63.8	2.8	67.8	4.0	0.02	138.4
Water	6.9	0.9	0.9	26.4	0.4	35.4
Bare Land	0.4	0.00	0.4	0.5	0.1	1.5
Total	236.6	5.00	72.6	38.5	1.25	354.0
	HCMC					
	Area in 1990					
Areas in 2000	Farmland	Green Land	Built-up Land	Water	Bare Land	Total
Farmland	46.4	93.5	5.6	7.0	0.0	152.5
Green Land	5.9	50.6	1.1	1.2	0.0	58.7
Built-up Land	78.1	60.3	92.8	4.7	0.0	235.8
Water	4.3	8.7	1.3	32.9	0.0	47.2
Bare Land	0.0	0.0	0.0	0.0	0.0	0.0
Total	134.6	213.1	100.8	45.8	0.0	494.6
	Area in 2000					
Area in 2010	Farmland	Green Land	Built-up Land	Water	Bare Land	Total
Farmland	52.6	12.5	8.7	3.6	0.00	77.3
Green Land	35.2	32.5	12.4	3.5	0.00	83.6
Built-up Land	62.2	12.1	214.2	5.3	0.00	293.8
Water	2.5	1.0	0.6	34.8	0.00	38.9
Bare Land	0.2	0.7	0.01	0.1	0.00	0.9
Total	152.6	58.7	236.0	47.3	0.02	494.6

Note: The number in a cell refers to how much land of type A (column heading) was converted to type B (row heading) from a previous year to another year. For instance, 47.5 km^2 was converted from farmland to developed land from 1990 to 2000 for Hanoi.

continuously from 77% in 1992 to 12% in 2014 (Fig. 7). Poverty in cities, measured by the percentage of the population falling below the poverty line in cities, was usually less than one third that of the national level, whereas that of rural areas was 25% higher than that of the national level, indicating that urban areas had significantly less poverty as compared to rural areas in Vietnam. Furthermore, the proportion of urban poor also dropped steadily (Fig. 7), from 61% in 1990 to 27% in 2014. Here the proportion of urban poor refers to those living in slums, i.e., the proportion of the urban residents lacking one or more of the following: (1) durable housing of a permanent nature that protects against extreme climate conditions, (2) sufficient living area (not more than three people sharing the same room), (3) easy access to clean water in sufficient amounts at an affordable price, (4) access to improved sanitation in the form of a private or public toilet shared by a reasonable number of people, and (5) security of tenure that prevents forced evictions (UN Habitat, 2007; World Bank, 2017).

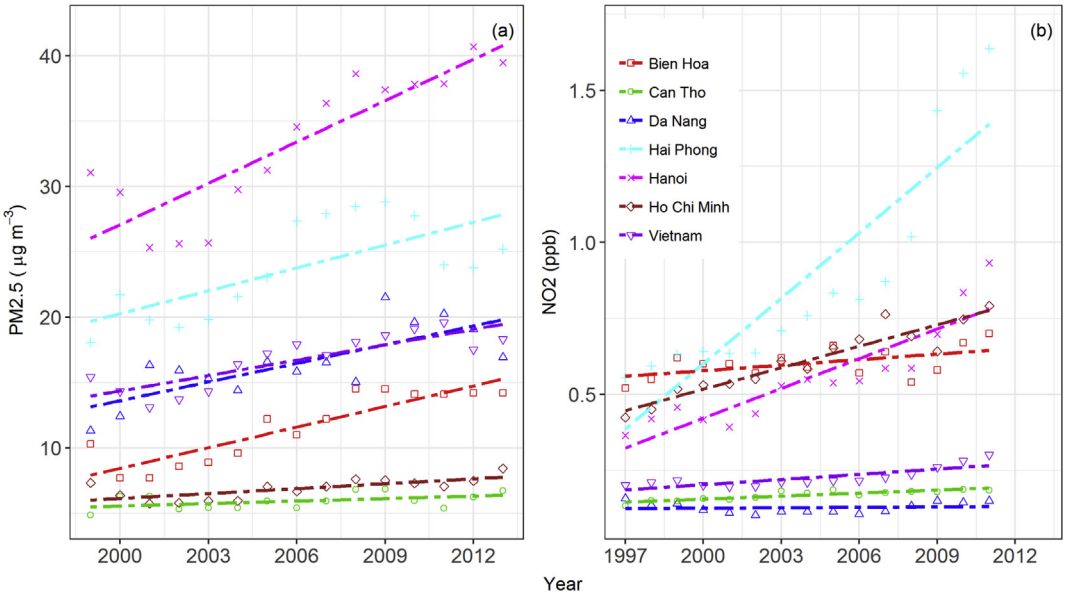

Fig. 6. The annual mean level of air pollutants in the six selected cities as compared to the whole country. Both the $PM_{2.5}$ and NO_2 have increased since 2001 for all six cities as well as for Vietnam.

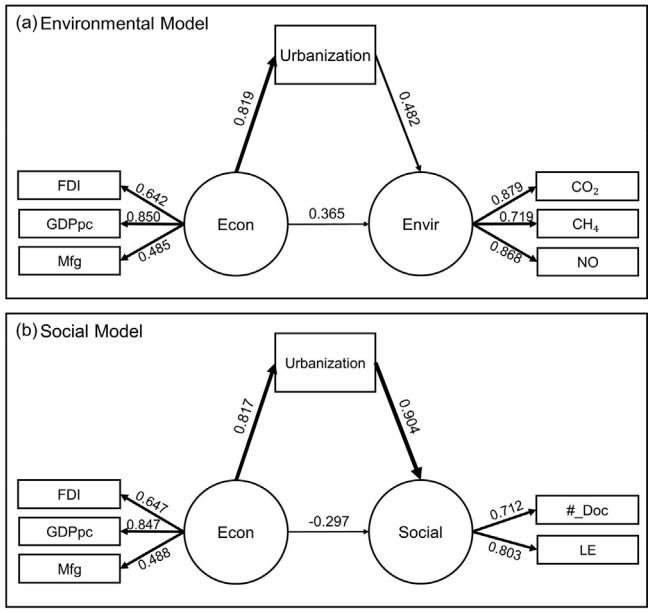

Fig. 7. Partial least squared structural equation modeling (PLS-SEM) of economic development (Econ), urbanization, environmental (Envir), and social conditions in Vietnam (1980–2015). Circles indicate the latent variables and the squares refer to measured variables. The path coefficients describe the relationships between variables and are located on the path. The measured variables are GDPpc, the percentage of the manufacturing value added in GDP (Mfg), the percentage of foreign direct investment in GDP (FDI), CO2 emissions per capita (CO2), CH4 emissions per capita (CH4), and NO emissions per capita (NO), number of doctors per capita (#_Doc), and life expectancy (LE).

3.2.2. Coupled dynamics

Economic development (*Econ*) strongly influenced urbanization in both models, with high path coefficient values of 0.819 for the environmental model (Fig. 7a) and 0.817 for the social model (Fig. 7b). All three variables, *GDPpc, FDI,* and *Mfg*, in decreasing order, affected *Econ*. In the environmental model, *Econ* affected *Envir* directly (0.365) and indirectly through *urbanization* (0.395), implying that urbanization and economic development had a positive effect on environmental degradation. In the social model, while *urbanization* seemed to enhance *Social* (0.904), *Econ* seemed to have a direct negative influence (−0.297), but the indirect impact of *Econ* on *Social* was higher (0.817 × 0.904 = 0.739), outweighing the negative direct impact. We therefore may conclude that economic development and urbanization promote the social conditions measured by the two variables (*#_Doc* and *LE*) in Vietnam. The latent variables in two PLS-SEM models (Fig. 7) appeared to have high variance inflation factors (VIF > 0.2) and high convergent validity (average variance extracted (AVE) > 0.5), suggesting the statistical robustness of these models. The bootstrapping analysis with 1000 iterations also verified the stability of estimated parameters. The estimated path coefficients are statistically significant within the environmental model: *Econ* and *Urbanization* ($p < 0.01$), *Urbanization* and *Envir* ($p < 0.01$), and *Econ* and *Envir* ($p < 0.1$), as well as the social model: *Econ* and *Urbanization* ($p < 0.01$), *Urbanization* and *Social* ($p < 0.01$), and *Econ* and *Social* ($p < 0.01$).

3.3. Institutional factors

Local governments have played an important role in urbanization in large cities such as Hanoi. First, Hanoi's government frequently changed its administrative boundary (Fig. 8), which was adjusted four times after the Anti-French Resistance War ended in 1954, with dramatic changes in the area's size and population, especially after *Domoi*. These frequent changes substantially increased the availability of Hanoi's non-urban land to be converted to urban built-up land at each stage of enlargement. After the expansion of the administrative boundary, a significant amount of urban land conversion occurred in the areas within the new administrative boundary but not outside the old administrative boundary. When combined with ambitious planning, administrative expansion facilitated the development of city infrastructure (e.g., bridges) and made better use of the existing infrastructure (e.g., national roads). This encouraged the development of satellite towns, as the compensation cost for land converted from agricultural land to developed land in the newly acquired area was much smaller than the central city area.

Second, Hanoi government used urban planning such as the Master Plan to 2030 (The Prime Minister, 2011) to initiate major infrastructure work on airports, major roads, and bridges that greatly facilitated urban land expansion and urban spatial restructuring. In the late 1980s, there were only three bridges across the Red River: Long Bien, built in 1902,

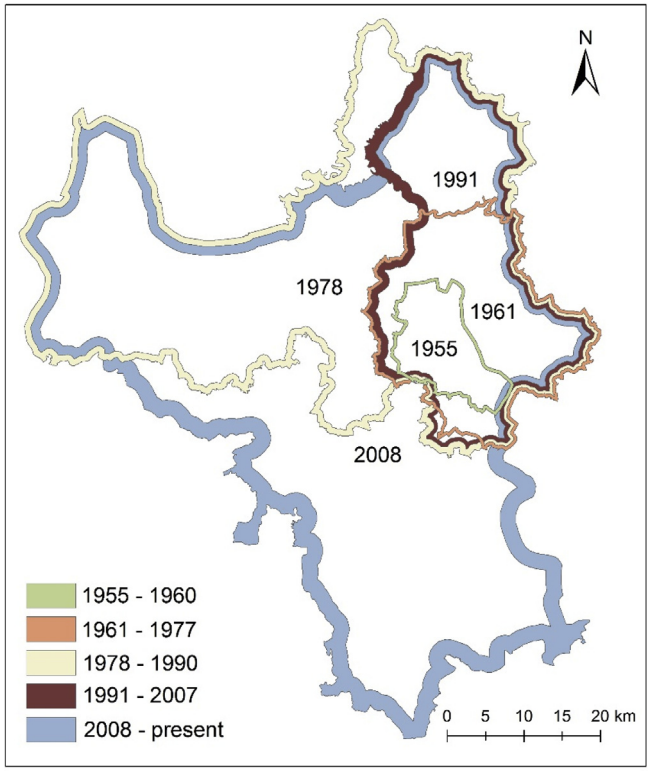

Fig. 8. Changes in the administrative boundaries of Hanoi during 1955–2015. Hanoi had a total area of 152.2 km^2 and 0.53 million population in 1954. Its total area changed to 586.2 km^2, 2130.5 km^2, 922.8 km^2, and 33485 km^2, with populations of 0.92, 2.45, 2.13, and 6.45 million in 1960, 1976, 1991, and 2008, respectively.

and Thang Long and Chuong Duong (both built in 1985). Few developments were observed along the four national roads (which were in poor condition) that connect Hanoi with the rest of the country: Road # 32 heading west towards Son Tay, Road # 6 heading south-west towards Ha Dong and Hoa Binh, Road # 1 heading south, and Road # 5 heading north then east towards Hai Phong. The construction of new bridges in the 2000s and 2010s, i.e., Vinh Tuy (2009), Thanh Tri (2007) and Nhat Tan (2015), and the rehabilitation of main national roads, led to the development of Hanoi north of the Red River. Hanoi's development burgeoned many new housing complexes, including Viet Hung, Vinhome Riverside, and Vincity, as well as industrial processing zones such as Sai Dong and Phu tin. The development of towns occurred along Road #32, including Phung, Troi, Nhon, as well as housing complexes including Kim Chung Di Trach and XpHome. Along Road #6, Ha Dong was developed with housing complexes such as Van Phu, Xa La, Park City, and Mulbery land. Urbanization was also affected by planning policies that relocated public and industrial facilities such as government offices, universities, training centers, and factories from inner cities to the outskirts and surrounding areas, which led to large areas of land within inner cities being converted from public and industrial land to commercial and residential land.

Third, Hanoi's government used its capital city status and major global/regional events to boost urban development. Through the Law of Capital of Hanoi (The National Assembly of Vietnam, 2012), Hanoi's government obtained a high level of autonomy from the central government, as it can approve policies independently from the central government. Hanoi launched an ambitious urban development plan set out by its master plan. Hanoi's government also capitalized on its unique historical legacy, i.e., celebrating the establishment of Hanoi for 1000 years, promoting the constructions of important infrastructures such as the Thang Long Highway, Vinh Tuy Bridge, the 3rd ring road, Hanoi Museum, and Hoa Binh Park (Hanoi's People Committee, 2009). Hanoi's government actively competed to host regional and global events, such as the Southeast Asia Game in 2003 and APEC Summit in 2006. These mega events left physical imprints in Hanoi's urbanization, with improved public infrastructures and clusters of urban development including grand event venues, newly constructed public spaces, and affiliated residential and commercial developments.

4. Discussion

4.1. Reflections on findings

Our research contributes to the existing understanding of urbanization in transitional economies in three ways. First, it provides insight to the relationships between city size, urban population growth, and economic growth. Current literature on whether large cities grow faster than other cities, or the optimal size for a city, is quite controversial because of many puzzles connected with the growth of city size and the trade-off between economies of scale and congestion, which increase as cities grow (Batty, 2008). While Glaeser (2000) maintained that large cities tend to grow at roughly the same rate as small cities, Xu and Zhu (2009) found that small cities grew more rapidly than large cities in China in the 1990s. We found that large cities with populations more than 1 million seem to grow faster than the national average and the average of all cities, as measured by urban built-up land intensity, implying that for large sized cities within transitional economies, advantages brought on by the concentration of economic resources and social welfare may outweigh the disadvantages, such as increased traffic congestion and higher priced housing and commodities. Furthermore, institutional factors such as urban planning and regulatory changes have boosted the supply of urban land and may be also responsible for the faster growth of large cities.

In discussing city size and economic growth, Frick and Rodríguez-Pose (2016) found that there is no universal positive relationship, but a positive link between average city size and economic growth for high-income countries. This finding does not hold true for developing countries. Glaeser (2014) further pointed out the explosion of impoverished mega-cities over the last thirty years. Our PLS-SEM model demonstrates the strong relationship between economic development and urbanization. This indicates that Vietnam may have followed the classical model of urbanization in which economic development is closely associated with urbanization (Davis, 1965), which may have allowed Vietnam to successfully avoid the trap of growing poverty experienced by many mega-cities in developing countries due to weak governance (Glaeser, 2014).

Second, Our PLS-SEM model shows that urbanization and economic development had a positive effect on environmental degradation as measured by CO_2, CH_4, and NO. Other research on transitional economies has reported mixed results in this respect. Some studies have shown that economic development produced a direct and significant positive influence on the development of urban green space in Shanghai (Fan et al., 2017) and air quality in Hohhot (Fan et al., 2016). It seems that the stage of the economic development and government intervention may have contributed to the different outcomes of environmental quality. As Shanghai moved to the post-industrialization development stage, it started to relocate a large amount of manufacturing enterprises outside of the city, converting some of the former manufacturing areas into green spaces. Hohhot's government actively promoted reforestation of the city, leading to a significant increase in forested land and better air quality (Fan et al., 2016). Vietnamese cities have neither moved to the post-industrialization stage like Shanghai, nor have they placed strict environmental regulations or launched ambitious environmental programs like Hohhot. Thus, Vietnamese cities have followed a path that illustrates that economic growth/industrialization comes along with the cost of a polluted environment.

Third, the PLS-SEM model supports the idea that economic

development and urbanization contributed to the improvement of social conditions as indicated by life expectancy at birth and number of health care professionals. This, however, is in contrast to Mongolia where economic development had a negative influence on the provision of social goods as measured by health care provision and education (Park et al., 2017). Although further investigations are beyond the scope of this study, our research provides a ray of hope that economic development in transitional economies does not have to sacrifice the egalitarian principles of socialist countries.

4.2. Institutional factors at the national level

The most crucial institutional factor for transitional economies is the change in political ideology and the launch of economic reforms (*Doimoi* for Vietnam), which lead to the increased role of the market in the process of economic development and urbanization and other institutional drivers. In addition to the local governments examined in Section 3.3, Vietnam's national government affected urbanization through distinct resource allocation policies and the change of land law and permanent resident registration. These changes and policies, which may occur in different formats in other transitional economies, constitute a significant difference from the non-transitional economies. First, Vietnamese cities received different resources from the central government according to their categories of classes and management control. Cities in Vietnam can be classified into six categories in order of decreasing importance: special, first, second, third, fourth and fifth classes. For the six cities studied in this paper, HCMC and Hanoi are the only two cities in the special class; the rest of the four cities are of first classes. While Bien Hoa is under the management of Dong Nai Province, the other five cities are under the direct management of the central government. Cities of special and first classes under the direct management of central government, particularly Hanoi and HCMC, enjoyed large amounts of investment from the central government for urban development. In contrast, Bien Hoa, a first-class city but a provincial city under the management of Dong Nai Province, has received limited resources from Dong Nai Province. The differences in resource allocation may help explain why cities have distinct growth speeds for urban land or urban population. The central government upholds different policies for different levels of cities, which can also be observed in other transitional economies. For example, Chongqing in China experienced rapid development after it leapt from being a sub-provincial city in the Sichuan Province to being one of the four direct-controlled municipalities in China in 1997, on par with Shanghai, Beijing, and Tianjin.

Second, similar to China, the Land Law (1988, 1993rev, 2003 rev, 2013rev) had a large impact on urban development in Vietnam as it permits land transactions between non-state sectors and long lease rights of 50 years and reduces the extent of compulsory land requisition by the state (Hansen, 2013). Together with the household permanent registration, i.e., the *Ho Khau* system, it exerted an even greater influence on urban development. *Ho Khau* limits the rights and access to public services of those who lack permanent registration in their place of residence. This system was designed as an instrument of public security, economic planning, and control of migration, and has been an important part of society and life in Vietnam for over 50 years (Vietnam Academy of Science, 2016). *Ho Khau* is important for local residents as it is necessary to "register a car or motorbike, obtain loans from the bank, buy land or build a house, enroll children in public schools, gain legal access to water or electricity, or participate in poverty reduction programs" (Karis, 2013, pp. 261). While in the past a citizen had to have local *Ho Khau* to purchase property (a land-based house or an apartment) in a city, under the current land law, a citizen can buy property in that city without a local *Ho Khau*. After purchasing a property, a citizen then can obtain local *Ho Khau*. As stipulated by the Law on the Capital, to obtain a *Ho Khau*, a citizen should register their temporary residence under the *Ho Khau* of a relative or by owning a land use right certificate of a piece of property for three consecutive years for urban districts and one year for suburban districts (The National Assembly of Vietnam, 2012, Article 19). In fact, the demand for residential housing in large cities such as Hanoi and HCMC has been pushed by migrants who want to secure a local *Ho Khau* through purchasing a property. It should be noted that although the changes of the Land Law and *Ho Khau* system made it possible for migrants to obtain a *Ho Khau*, in realty, it is not affordable for most migrants to own a property, or to have written consent of the lessors or lenders, thus making it very difficult to obtain a *Ho Khau*. We echoed the statement of others (e.g., Karis, 2013) that formal institutional barriers have made it difficult for migrants to integrate into cities, and that residents who do not have local *Ho Khau* are confronted with a challenge of the "right of the city"– a right not only to access urban resources but also to change themselves by changing the cities through exercising a collective power to reshape the urbanization process (Harvey, 2008).

4.3. Globalization, economic development, and urbanization

Our PLS-SEM model indicates that globalization has a positive impact on urbanization through the contribution of economic development to urbanization. At the city level, globalization also affected economic development and urbanization significantly, as reflected by the increasing FDI, trade volume, foreign tourists, international events, etc. For example, GDP generated from FDI in Hanoi increased dramatically from $0.01 billion in 1993 to $4.44 billion in 2014, and FDI as a percentage of GDP started at 3% in 1993 and increased to > 15% after 2000. Several major global events, such as the lift of the US embargo on Vietnam and joining into the Association of the Southeast Asian Nations (ASEAN) in 1995, made the inflow of FDI increase significantly. The Southeast Asia Game in 2003 and the APEC summit in 2006, both held in Hanoi, exerted a positive impact on FDI flow to Hanoi and contributed to urbanization through facilities and infrastructures built for these events.

4.4. Limitations and future research

We did not examine the rural-urban disparity and rural-urban migration because the official statistics only included data on migrants who obtained *Ho Khau*, thus missing many who live and work in cities but lack *Ho Khau*. Our PLS-SEM model has some limitations, as the bi-directional relationships among latent variables cannot be applied in a PLS-SEM model. For instance, while economic development can affect social condition, social conditions in turn may feedback to economic development (Ranis et al., 2000). Similarly, economic development and urbanization may exhibit a circular relationship. When more data become available in the future, a comprehensive SEM equipped with bi-directional paths (e.g., Covariance Based SEM equipped with bi-directional paths) can be used. Additionally, our choices of urban environmental indicators were limited. Future research may consider incorporating other environmental changes due to urbanization, such as urban green space (Fan et al., 2017), water quality (Kontgis et al., 2014; Vo, 2007), flooding risks (De Sherbini et al., 2007), or land degradation that are triggered by urbanization through a "tele-effect", referring to the accelerated flows of forest/agriculture products from remote forests/rural areas to consumers in cities (Vu, Le, Frossard, & Vlek, 2014). Due to rapid urbanization and the increased population, the drainage systems of large Vietnamese cities have lost their self-cleaning abilities and have thus become heavily polluted. The polluted water is usually used in sub-urban areas for agriculture and aquaculture, causing food safety and health concerns. Moreover, as monsoon rains concentrate during certain periods of the year, cities such as Hanoi and HCMC have high urban flooding risks due to natural reservoirs such as lakes, ponds, and wetlands having been filled for urban development. Nevertheless, air quality remains to be one of the most critical environmental variables as it is one of the most severe environmental problems faced by cities and concerned by the urban residents, particularly after Vietnam

became one of the ten countries with the worst air pollution in the world (Phung et al., 2016; VOA News, 2018). Furthermore, air pollution reflected the altered biogeochemical cycles at global, regional, and local scales, which can have both short- and long-term impacts on environmental changes (Grimm et al., 2008). While the increases in motor vehicle usage and industrial emissions have been considered as major sources of air pollution in cities of Vietnam, air quality can also be influenced by many other factors that should be taken into consideration. For instance, forest biomass burning in Northeastern Vietnam and Laos affected the air quality of Hanoi in March and April for 2012–2016 (Lasko, Vadrevu, & Nguyen, 2018). The poor air quality in Hanoi and Hai Phong in North Vietnam may also have resulted from air pollutant diffusion from China (Chifflet et al., 2018; Vietnam Breaking News, 2015). Investigating the driving factors for air pollution in Vietnamese cities, including their external influences, is needed and will have significant policy implications.

5. Conclusions

This research used the experience of Vietnam after the economic reform, *Doimoi*, to study urbanization, economic development, and the environmental and social changes taking place in cities in transitional economies at multiple scales. At the national level, we found that average built-up land intensity increased as the mean value of nighttime light data rose from −1.4 in 1992 to 4.4 in 2012. The urban population grew at a faster annual rate after *Doimoi* (1986–2015) compared to the pre-*Doimoi* period (1960–1985), with a higher annual growth rate than that of national population. At the inter-city level, cities with population sizes more than 1 million experienced more rapid growth of built-up land intensity and population compared to the national average, particularly for the period of 1986–2015. HCMC and Hanoi expanded their urban land by 2.9 and 2.7 times from 1990 to 2010, faster than the urban population growth for the same period (2 and 2.6 times, respectively). At the intra-city level, conversion from farmland contributed to 65% and 46% of built-up land in 2000 and 2010 in Hanoi, respectively, and 33% and 21% of built-up land in 2000 and 2010 in HCMC, respectively. The urban environment in large cities deteriorated, as the $PM_{2.5}$ and NO_2 concentrations increased since 2001 for all six cities and Vietnam as a whole. Poverty was alleviated as the national poverty level decreased continuously, from 77% in 1992 to 12% in 2014, and the proportion of the urban population living in slums dropped steadily from 61% in 1990 to 27% in 2014. Coupled dynamics of urbanization, economic development, environment, and social changes were modeled and the main findings are: (1) economic development strongly influenced urbanization, with high path coefficients over 0.81 for both PLS-SEM models, and (2) urbanization and economic development contributed to environmental deterioration while promoting social conditions. Finally, speedy urban land expansion was pushed by local institutional interventions, such as through frequent changes of administrative boundaries, master plans, and policies to relocate administrative, manufacturing, and higher-education facilities from inner cities to suburbs, and ambitious development due to the autonomy of the city.

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