Spatial Diversity of Urban Village Development in Shenzhen

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Abstract: Dynamic urbanization in China during the reform period has led to the emergence and proliferation of so-called urban villages in many cities. The development of urban villages, based on a self-help approach of indigenous villagers, has been satisfying great demand for migrant housing and space for other activities. Consequently, urban villages are characterized by rapid growth of housing units and the mix of various land uses including residential, industrial, commercial, and public amenities. This paper uses GIS applications and Municipal building surveys as instruments to analyze the physical development of urban villages in the period 1999-2009 and their land use diversity in 2009 in Shenzhen, one of the most dynamic cities in China. Using measurements drawn from different disciplines, analyses reveal significant variation of urban village development across the city. The development of housing units and other functions in an urban village is found to be linked to its location in the urban fabric. This suggests that the development of urban villages is likely to be driven by the overall planning and urban development, which can provide informative guidance for local policy making associated with urban village (re)development.

Keywords: urban village, informal development, diversity, spatial analysis, Shenzhen

1. INTRODUCTION

Economic growth in China has resulted in two direct consequences: the migration of rural population into cities and the expansion of urban land. While the former has caused great housing demand in cities, the latter contributes to the proliferation of so-called urban villages, which accommodate millions of rural migrants and help to prevent potential housing crisis. Urban villages are created when agricultural land is expropriated for urban expansion but the residential component of the rural village remains untouched in order to avoid costly compensation and relocation programs. The village settlement then forms a very distinctive spatial and social space as it is encompassed by formally planned and developed urban areas (figure 1). In the face of great housing demand generated by rural migrants who are excluded from the formal housing market, the indigenous residents of such urban villages develop additional housing units for rent based on a self-help approach and in an unauthorized style. Consequently, urban villages become popular migrant enclaves as they provide affordable and accessible urban housing (Zhang et al., 2003). In the meantime, the entrepreneurship of the indigenous villagers and their committees leads to investment in the development of other facilities on their collective land. Numerous industries, commercial facilities and various public amenities are developed, transforming the urban villages into multi-functional neighborhoods.

Figure 1 Dafen Urban Village in Shenzhen (Author’s Photograph)

Since little empirical research has examined the physical development of urban villages, the heterogeneity of the development across different villages has not been recognized nor explained. It is clearly though an issue with multiple perspectives and both positive and negative connotations for the residents and for the city. For instance, although urban villages are in fact the only feasible living place for the huge amount of rural migrants, the general policy rejects those urban villages, leading to large-scale demolition-redevelopment programs currently underway in many cities (Chung, 2009, Hao et al., 2011). The implementation of these programs would deprive many migrants' access to affordable housing as well as their niche places where migrants and indigenous villagers alike, work, consume and obtain amenities and services. Moreover, these programs hardly differentiate between urban villages. As a result, it is necessary to have a better picture of how urban villages develop and function in order to attune the policy to the specific characteristics of each of the urban villages. More importantly, planning strategies should be broadened to avoid mass demolition and relocation (Hao et al., 2011, Zhang, 2005, Song et al., 2008). To this end, this paper uses GIS applications and Municipal building survey data to examine the development of urban villages in Shenzhen, one of the most dynamic and populous cities in China. Several measurements are adopted to examine the development patterns of urban villages at both city and village scales. The results exhibit great variation in urban village development depending on the location of urban village in the urban fabric.

Shenzhen was set up as a city in 1979 for establishing an export-oriented economy owing to the proximity to Hong Kong. In 1980, the Shenzhen Special Economic Zone (SEZ) was established as an experiment to attract foreign capital, technology and management skills, making it the first city in socialist China to experience the operation of a market economy. Thereafter, the astonishing development of the city has led to its population growth from about 310,000 to 14 million in just three decades. Spatial expansion of urban development has been swallowing its rural hinterland, leading to the creation of 320 urban villages (figure 2). These urban villages are distributed throughout the city, existing as an interwoven component of the formal urban landscape and economy (Hao et al., 2011). In Shenzhen, urban villages are thought to provide shelter for approximately seven million people, which is half of the total population (Zacharias and Tang, 2010).

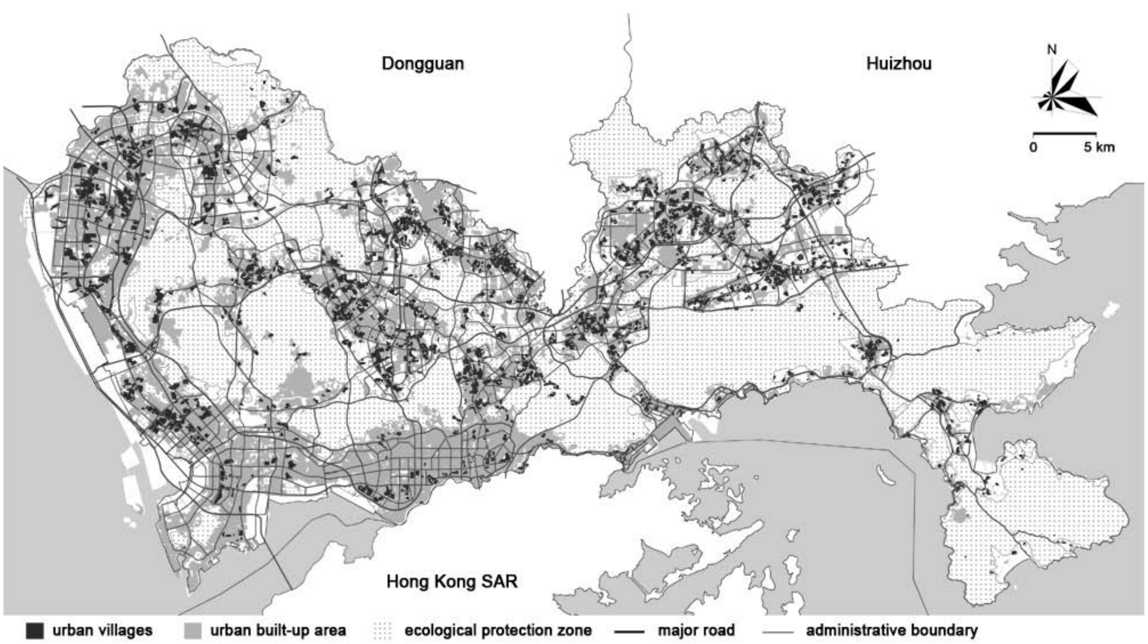

Figure 2 The Distribution of Urban Villages in Shenzhen (Source: Shenzhen Urban Planning Bureau)

The following content is organized in five sections. It begins with a discussion of urban village development in Chinese cities. This is followed by an introduction of the data and methods of analyses. Empirical analyses are then undertaken to reveal the development pattern of housing (section 4) and the spatial diversity of land use (section 5). The final section concludes with main findings and recommends future research topics.

2. LAND USE DEVELOPMENT IN URBAN VILLAGES

The possibility for urban villages to provide a large quantity of inexpensive housing has its roots in China's dichotomous land ownership (Zhang et al., 2003). While the state owns urban land whose use rights can be leased to users in exchange for payment, rural land is allocated to rural communities free of charge (Tian, 2008). The collective ownership of village land does not allow villagers to alienate their lands other than to transfer ownership to the government. However, the specific occupancy of a house plot turned each village family into a *de facto* landlord with unrestricted tenure (Zhang et al., 2003). As a result, the indigenous urban village residents can take advantage of their land's prime location and exploit it via highly profitable room rental to migrants. As urban planning or regulations do not scrutinize development projects in urban villages, indigenous villagers are able to provide sub-standard housing and services. This not only substantially reduces the construction and management costs thus enabling low rents, but it also enables quick and massive constructions that provide large quantities of housing units to satisfy the increasing demand (Hao et al., 2010).

Village land is further classified into two types: individual-family-controlled land for housing, referred to as *zhaijidi*; and collectively owned and managed land for streets, public facilities, village offices, and premises used for businesses. When agricultural land was expropriated by the city government for formal development, besides compensation, the government left some spare land to villages to serve two main purposes: to enable proper infrastructure and solve the unemployment problem created by the loss of agricultural land (Wang et al., 2009). This additional land added to the existing collective land in villages and it can be used for the benefits of the village collective. As a result, for urban villages more land can be used for buildings besides dwelling houses. Driven by market forces, developments of other facilities such as shops, markets, school and factories are carried out at massive scale, catering to the demand for space for these activities. Buildings with different functions have been built for rent, leading to dramatically increased land use mix in urban villages. As rural land development is not scrutinized by formal urban planning and building codes, such land use developments are not well controlled nor inspected by urban planning authorities. It is the developments of various facilities on the collective-controlled land leading to the land use mix in urban villages.

As the existence and distribution of urban villages are pre-determined, the rural landscape of the villages – low-density residential settlements surrounded by farmland – determines the initial settings of the urban village development. These include their original size, layout and natural and man-made landscape. In the early stages of urban village development, encroachment on adjacent agricultural land was easy and more important within the constraints implied by financial considerations and technology. New houses were built on the vacant land around the village, causing the village to expand. The encroachment becomes increasingly difficult over time as the expansion of both the village and the urban development has converted the limited agricultural land. However, inside the village there is still potential for more houses, as the built-up density is still low. Consequently houses are built within the village, yards are occupied, open spaces are developed, roads are narrowed, all of which increase the villages' density. As the developable land inside the village becomes scarce development pressure gives rise to increased building heights. By replacing traditional low-rise houses with concrete high-rise apartment buildings, the growth of floor space can be further sustained. Eventually, by maximizing the usage of available land and maximizing the height of buildings possibly to their limits, an urban village can be extremely over-developed.

Consequently the development path of urban villages involves three phases, namely expansion (more land), densification (higher built-up density through infilling) and intensification (increasing floor space per plot). Facing increasing natural and institutional constraints, this development path is a logical response for the indigenous villagers to exploit the economic potentials of their properties.

At the citywide spatial scale, given that urban development can be diverse, the effects of overall urban development on urban village development are also likely to be diverse. For instance, an urban village in a prime location is an attractive proposition to become a popular housing neighborhood and thus is likely to experience dramatic growth of housing units. These urban villages are also likely to vary in functional structure due to different preferences for different land use types. It is expected that both the development of village housing and land use patterns will exhibit variance across different urban sections. Detailed knowledge and insight in these variances is of great importance to help design proper policy measures concerning the future of urban villages. The remainder of this paper will demonstrate how spatial diversity of urban village development is uncovered by analyzing data of urban villages in Shenzhen.

3. DATA AND METHODS

This study uses Municipal building surveys as a primary data source to explore the development of urban villages. Urban villages are recognized by their collective land ownership and administrative boundaries. The study area is the whole city of Shenzhen including a 410 km^2 Special Economic Zone (SEZ) comprising four districts of Luohu, Futian, Yantian and Nanshan, and a much larger non-SEZ area comprising Baoan and Longgang districts covering 714 km^2 and 845 km^2 respectively (figure 3).

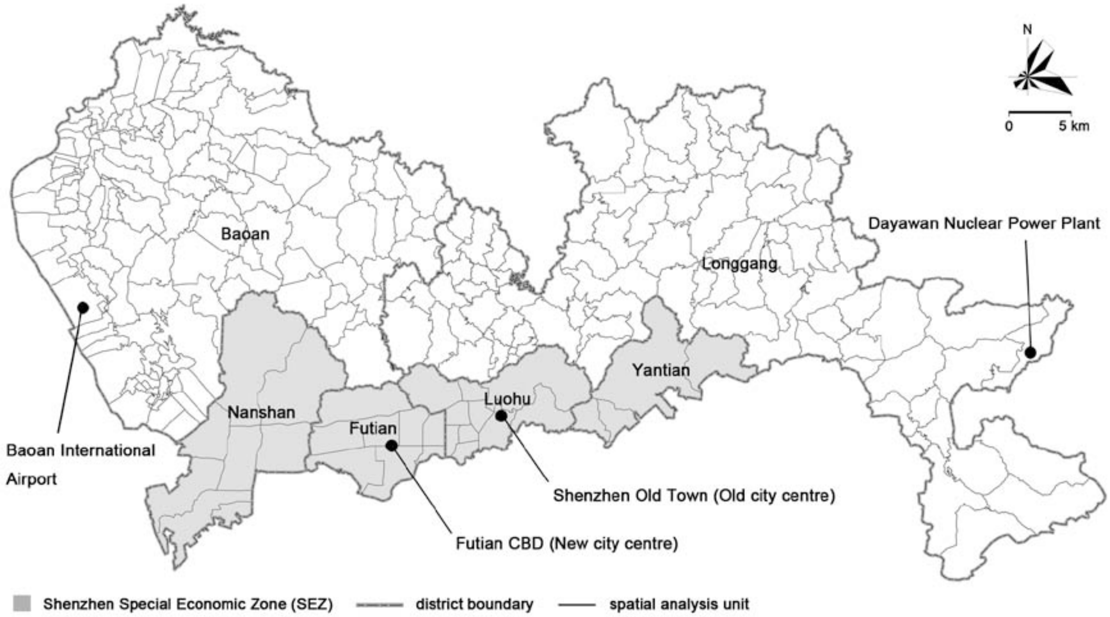

Figure 3 Administrative Divisions of Shenzhen and Analysis Unit Boundaries

Data, which were collected by the Shenzhen Urban Planning and Design Institute, contain physical status of all urban villages in Shenzhen in 1999 and 2004 respectively. Attributes at administrative village level include gross land area, the number of buildings, total built-up area and total floor space. Shenzhen Urban Planning Bureau commissioned a more detailed survey in 2009, which provides data at building level including plot area, house footprint area, the number of stories, and floor space of every building. These are aggregated at the administrative village level for comparison with the data of 1999 and 2004.

Although urban village statistics for the period from 1999 to 2009 were available at the unit of administrative villages across the entire area, the relevant spatial boundaries were only available outside of the SEZ. In the non-SEZ districts these boundaries are not only stable over time but they are also used for urban village survey. They thus provide a standard to integrate data. Within the SEZ area, as a result of intensive urban development, the administrative village boundaries are no longer used. Instead, the *jiedao*, an administrative division similar to ward in western cities, is used for the SEZ districts. The *jiedao* boundary is basically an aggregation of former administrative village areas so the statistics for the 91 former administrative urban villages inside the SEZ districts were aggregated to 30 *jiedao* areas prior to the analyses being made. The final result is that the city is divided into 261 analysis units, 30 *jiedao* in the SEZ and 231 administrative villages outside the SEZ. The city's 320 urban villages are found in 255 of the 261 analysis units.

The initial focus of this study is on the temporal and spatial changes of urban villages' residential components in terms of the three forms of growth – expansion, densification, and intensification. This is carried out via an analysis of three variables: gross land area (the land coverage of the urban village's residential components), built-up area (the sum of the areas of footprints of all dwelling houses) and total floor space (the sum of the floor areas of all dwelling houses). The expansion is measured by the change of gross land area. The densification can be measured by the change of built-up density (built-up area / gross land area) and the intensification can be measured by the change of floor area ratio (total floor space / built-up area). Consequently, the amounts of urban villages' expansion, densification and intensification can be mapped and compared.

As the growth of urban villages is driven by the housing demand of rural migrants, the growth pattern of urban villages can imply the distribution of migrant population growth, which is of great importance for local planning and policy making. Specifically, it is crucial to understand to what extent the growth is concentrated as well as the locations of the concentrations. For these purposes, however, the statistical analysis of urban village development cannot detect or identify the spatial concentration or clustering of urban village development, while the choropleth mapping is highly dependent on the way that data are organized, which could lead to biased interpretations (Messner et al., 1999). Spatial autocorrelation analysis is therefore used to examine if the urban village development is spatially concentrated and to identify the development clusters independent from classification schemes used in choropleth mapping.

The second focus of this study is on the land use diversity of urban villages. This part of analysis focuses on 2009 because the information of non-residential buildings is only available in the 2009 building survey. According to the survey data, the main function of every building in urban villages is identified. There are in total 333,576 buildings, which can be classified into four categories according to their main function: dwelling house (314,709), industry (6683), commercial facility (5154), and public amenity (7030) such as schools, clinics, ancestor temples and village offices. Together with the floor space of these buildings, the total floor space for each function can be calculated. Then, the functional diversity of an urban village can be measured and the variation in such diversity across different urban villages can be examined.

Five empirical indices and their measurements are listed in table 1, which is followed by explanations.

Table 1: Measurements of Urban Village Development and Functional Diversity

Scale	Measurement	Input variable
Development of residential houses		
City	(1) Moran's *I* $I = \frac{N \sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\left[\sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} W_{ij}\right] \sum_{i=1}^{N} (x_i - \bar{x})^2}$ $\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N}$	• Increase/decrease of total land area • Increase/decrease of built-up density • Increase/decrease of floor area ratio
Village	(2) LISA $I_i = z_i \sum_j W_{ij} z_i$ $= \frac{x_i - \bar{x}}{\frac{\sum_{j=1, j\neq i}^{N} {x_j}^2}{N-1} - \bar{x}^2} \sum_{J=1}^{N} W_{ij}(x_j - \bar{x})$	• Increase/decrease of total land area • Increase/decrease of built-up density • Increase/decrease of floor area ratio

Functional diversity		
City	(3) Index of Dissimilarity (ID) $\mathrm{ID} = 0.5\sum_{k=1}^{n}\left\|\frac{b'}{B} - \frac{w'}{W}\right\|$	• total floor space for each minority function per village • total floor space for each minority function of all villages • total floor space for the majority function per village • total floor space for the majority function of all villages
Village	(4) Shannon entropy $H = -\sum p_i \ln p_i$	• percentage of total floor space for each function in total floor space for all functions
Village	(5) Location Quotients (LQ) $LQ_i = \frac{F_{ij}/F_i}{\sum F_{ij}/\sum F_i}$	• total floor space for each function per village • total floor space for each function of all villages • total floor space for all functions per village • total floor space for all function of all villages

1) The spatial autocorrelation of urban villages' expansion, densification and intensification are measured respectively. This aims to examine whether it is the case that locational similarity of urban villages is matched by value similarity of urban village development. The global Moran's ***I*** is used to identify the occurrence and degree of spatial autocorrelation at the city scale in terms of expansion, densification and intensification respectively.

The Moran's ***I*** index is calculated by equation 1 in table 1. Where, x_i is the value of variable in the unit i and the $W(i,j)$ is a spatial weight matrix where $W(i,j) = 1$, if the unites i and units j are contiguous, and $W(i,j) = 0$ otherwise. A positive Moran's ***I*** means that adjacent urban villages have similar change in terms of specific development form, while negative spatial autocorrelation can be interpreted as spatial dispersion in terms of specific development form.

2) At the local level, the Local Indicators of Spatial Association (LISA) (Anselin, 1995) is used to detect the spatial development concentrations. It allows for the identification of both local clusters reflecting positive or negative spatial autocorrelation. In the LISA calculation (table 1, equation 2), a local Moran index for a unit *i* is defined, where z_i is the standardized form of x_i, and the $W(i,j)$ is the same as that in the global Moran index. The sum of all the local Moran's indices is equal to the global Moran's index. The significance level is set as 5 percent and 999 permutations are used to test the significance of local Moran's ***I*** against a null hypothesis of no spatial autocorrelation.

According to the identification of significant LISA, LISA cluster maps are plotted, in which the analysis units are grouped with significant LISA into four categories. High-high units refer to high-development units showing significant positive spatial autocorrelations with their neighboring high-development units; Low-low units refer to low-development units showing significant positive spatial autocorrelations with their neighboring low-development units; Low-high units refer to low-development units showing significant negative spatial autocorrelations with their neighboring high-development units; and high-low units refer to high-development units showing significant negative spatial autocorrelations with their neighboring low-development units.

3) To evaluate the diversity of urban villages' land use structure, we first examine whether different functions are distributed differently across urban villages (i.e. the occurrence of functional segregation). The land use of urban villages is measured by recording the function and quantity of floor space of every building in urban villages. By summing up the floor areas of buildings of each function, the total amount of floor space for each function can be calculated. The Index of Dissimilarity (ID) is adopted to evaluate if different functions of urban villages are spatially segregated at the city scale. Urban village level data are relied upon to build estimates of the degree and extent of segregation or integration for the whole city of Shenzhen.

The ID is calculated by equation 3 in table 1, where b' is the floor space of the minority function (industrial, commercial or amenity) concerned in the analysis unit, and w' is the floor space of the majority function (residential) in the analysis unit; B is the total floor space of the minority function in the city, W is the total floor space of the majority function, n is the number of analysis unit. Possible ID values range from 0 (no segregation) to 1 (complete segregation).

4) At urban village level, the combination of different functions in the land use mix reflects the distribution pattern of the multiple functions if the distribution is more even or more uneven. To measure the degree of land use diversity and to make comparisons between urban villages, we take into account both the richness of functions and the evenness of different functions, which is a universal concept used for developing biodiversity indices (Magurran, 1988). The Shannon index (H), derived from entropy maximization, is used to quantify the diversity of functions based on two components: the number of functions and the proportional distribution of these functions.

The Shannon index is calculated by equation 4 in table 1, where p_i is the proportion of an urban village's floor space found in function ***i***. The maximum value of the Shannon index is reached when all functions have the same proportion of total floor space. According to the Shannon entropy value of each spatial analysis unit, the functional diversity map of urban villages is produced, which allows for the comparison across different city sections and the identification of the places that accommodate urban villages with dramatically high or low diversity.

5) In addition to the measurement of the overall diversity level of an urban village, we are also interested in the specialty of the urban village as well as the variation in such specialty across different villages. To this end, Location Quotients (LQ) (Isserman, 1977) is adopted to compare an urban village's share of a particular type of function with the reference urban village's share of the same type of function. It helps to identify the locations, which experienced significantly higher or lower development of certain function than the average level for the city.

The LQs of urban village are calculated by equation 5 in table 1, where F_{ij} is the floor space of function *i* in analysis unit *j*, and F_i is the floor space of function *i* in all analysis units. According to the LQ of each analysis unit per function, LQ maps are produced for the four main functions. These maps indicate the distribution pattern of certain land use function, from which the specialty of each place can be implied.

4. DEVELOPMENT PATTERNS OF URBAN VILLAGE HOUSING

Table 2 lists the Moran statistics of urban villages' expansion, densification and intensification respectively. The Moran's ***I*** coefficient of the expansion of urban villages for the period 1999-2004 is 0.36 (significant at 0.1% level), indicating a significant positive spatial autocorrelation. This implies that urban villages with a similar geographic location tend to expand at more or less same scales and thus the expansion is spatially clustered. For the period 2004-2009, the Moran's ***I*** coefficient is 0.08 (significant at 5% level), indicating an almost random distribution of expansion. As the expansion of urban villages significantly slowed down in the second period due to diminishing land availability, the concentration pattern of the expansion also diminished in the second period.

Table 2: Spatial Autocorrelation Measured by Global Moran's ***I*** Index

	Expansion		Densification		Intensification	
Period	99-04	04-09	99-04	04-09	99-04	04-09
Moran's ***I***	0.362	0.081	0.159	0.145	0.427	0.343
P-value	0.001	0.037	0.001	0.004	0.001	0.001

In terms of densification, urban villages' growth exhibits small positive spatial autocorrelation for both periods (1999-2004 period: Moran's ***I*** = 0.16, significant at 0.1% level; 2004-2009 period: Moran's ***I*** = 0.15, significant at 0.5% level). The pattern and trend are different from the ones observed for land expansion. The clustering of densification was not prominent. This can be explained by the fact that land expansion is confined by different level of land inadequacy in different locations. However, constructing more houses through infilling provides relatively more equal change for different villages. Consequently, the pattern and trend of a mild clustering sustained throughout the two periods.

As for intensification of urban villages, the statistics reveal significant positive spatial autocorrelation for both time periods. The Moran's ***I*** coefficient is respectively 0.43 and 0.34 (both are significant at 0.1% level). This implies that the production of floor space by increasing building heights is highly concentrated in certain locations, which are likely to be more attractive for rural migrants.

These results demonstrate that in general urban village development tends to cluster in space, probably because certain urban villages, such as those are close to job locations, are more popular for rural migrants. In facing housing demand, expansion, densification and intensification are used as means to provide more housing units. However, expansion is the least sustainable form due to diminishing land availability in the surroundings of urban villages. Over time, as expansion becomes gradually more difficult, the clustering pattern of expansion also diminishes. Similarly the densification process is also facing increasing difficulties due to diminishing land availability inside urban villages. However, for the intensification process, the lack of land entails much less constraints. By increasing the height of buildings, the production of housing units maintained. Consequently, the highly clustered distribution of intensification sustained in the two periods (Hao et al., 2011).

At local level (figure 4), the spatial clustering of urban village development exhibits distinct patterns between different development modes and time periods. For land expansion, in the first period the high-high units were clustered in two groups. One was in Baoan district, adjacent to the city center. The other cluster, which was in Longgang district, was relatively further away but it still has good access to the city center. The low-low units were clustered in the SEZ where vacant land can barely be found. However, in the second period, land expansion was much more confined. Therefore the clusters of high-high units were much smaller. The low-low units are found in Dapeng Peninsular at the remote east end of the city.

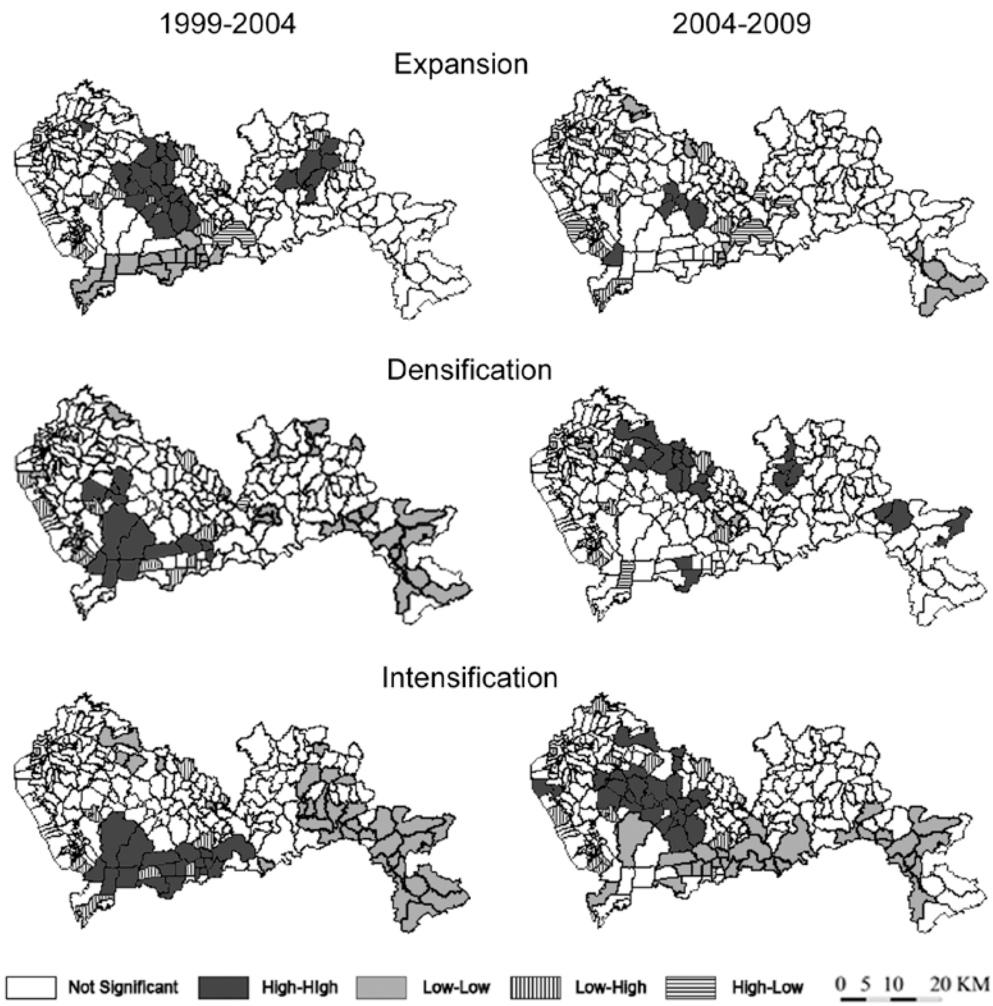

Figure 4 LISA Cluster Maps of Urban Village Development in Terms of Expansion, Densification and Intensification Respectively

For densification, in the first period the high-high units were clustered in the locations that are very close to the city center. The low-low units are mostly found in the eastern part of Longgang. In the second period, the high-high units were clustered in more peripheral locations than in the first period. And there were no obvious low-low clusters.

And for intensification, in the first period, the high-high units were clustered inside the SEZ. Almost all low-low units were in the eastern part of the city, distant from the city center. In the second period, the clusters of high-high units shifted from the SEZ to Baoan district, and the city center turned to be clustered with low-low units. This implies that urban villages in the SEZ had gone through a dramatic intensification process thus lack potentials to further do so. However, urban villages in outer districts followed the same development trend to produce more housing units. The patterns trends of urban village development over time, from a spatial point of view, confirm that urban villages would seek more housing units through first expansion and densification and later intensification.

As the identification of spatial clusters with LISA is based on statistical methods, in which a random generator is applied, the LISA cluster map will be slightly different when the random generator is run for another time. This is not a problem for the high-high or low-low clusters because only the boundaries of the clusters will slightly change (at the boundaries of the clusters, some significant units would turn to be not significant while some not significant units would turn to be significant) but the locations and the sizes of the clusters do not significantly vary. However, as for the high-low and low-high clusters, which usually comprise few units, their locations are not stable. Interpreting the results for these clusters is therefore precarious.

The analysis results have shown great variation in the physical development of urban village housing across Shenzhen. The development speed and scale of an urban village is determined by its location in the urban fabric, making the development phases of different urban villages vary. At the city scale, the development of urban villages tends to be clustered and village development in terms of each development phase (expansion, densification and intensification respectively) manifests itself as a spillover effect from the inner districts to the outer ones. This implies the possible diffusion of migrant employment out of the Special Economic Zone into two outer districts. In terms of phases, the urban villages in the outer districts generally lagging behind those in the inner districts but following the same general development trajectory.

5 LAND USE DIVERSITY OF URBAN VILLAGES

Overall, all urban villages in Shenzhen are expectably dominant by residential function (table 3). The proportions of the residential floor space in total floor space range from 64.9% to 99.9% across all urban villages. The remaining proportion of total floor space is shared by other three main functions: industrial, commercial and public amenities. The proportions of industrial and commercial functions show larger variance across villages. This can be explained by the fact that industrial and commercial activities are involved with a broader labor and consumer market from not only inside the urban villages. However, the variance of the proportions of public amenities is smaller, which is because that sufficient amount of amenity provision is necessary for every urban village to serve local village population.

Table 3: Descriptive Statistics of the Proportions of Major Land Use Types in Urban Villages in Shenzhen (N=255)

Function	Min	Max	Mean	S.D.
Residential	64.9%	99.9%	92.8%	0.056
Industrial	0%	25.2%	3.4%	0.041
Commercial	0%	31.7%	2.3%	0.031
Amenity	0%	12.5%	1.5%	0.015
Entropy	0.012	0.953	0.292	0.163

Table 3 also shows the statistics of the Shannon entropy values of all urban villages. The entropy values range from 0.012 to 0.953. The entropy values of urban villages show a large variance across urban villages, indicating that the functional compositions differ across urban villages. The entropy values of urban villages are mapped in figure 5, in which “low diversity” indicates an entropy value 50% lower than the mean value, and “high diversity” indicates an entropy value 50% higher than the mean value. From the map, the low diversity villages are found in both the most developed new city center (Futian district) and the least developed area in Dapeng Peninsular. Urban villages having high diversity values are found outside the SEZ and none of these are located in sub-city centers.

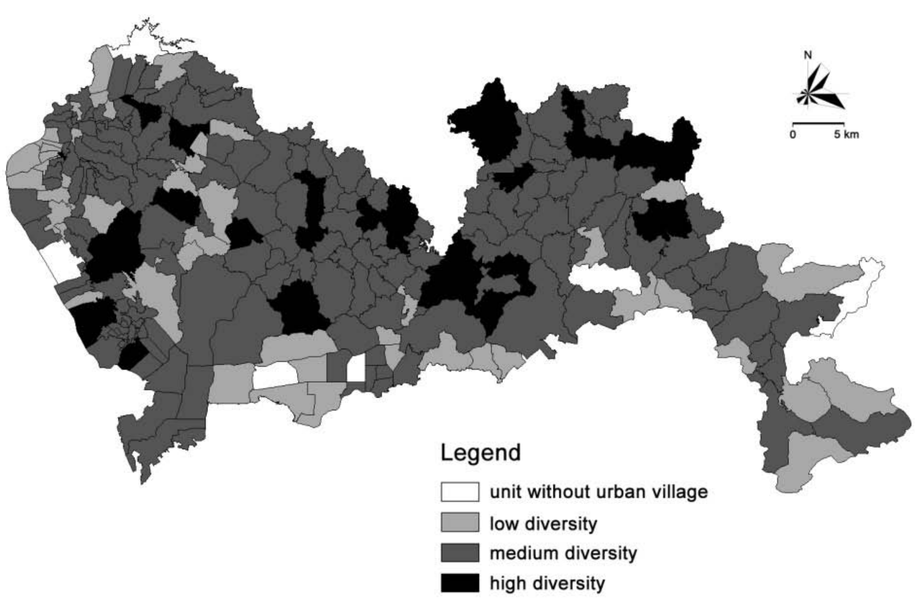

Figure 5 Entropy Map of Functional Diversity of Urban Villages in Shenzhen

Table 4 shows the ID of industrial, commercial and public amenity respectively as minority function against residential as majority function. First, segregation between public amenity and residential function is 0.254, indicating that there is no severe segregation of public amenities from residential houses. This is natural because as discussed earlier amenities provide basic services for the urban village residents and these are in need everywhere. Nevertheless, segregation between industrial function and residential function is much higher, 0.392. This suggests that industrial activities are highly segregated from residential houses at the citywide spatial scale. It further implies that certain locations in the urban fabric are more preferable for industrial development, while such locational preferences are less relevant for urban villages to develop commercial facilities and even less for amenity development.

Table 4. The Index of Dissimilarity for Major Functions in Urban Villages

Variable	Minority	Majority	Index
Function	industrial	residential	0.392
	commercial	residential	0.307
	amenity	residential	0.254

Figure 6 demonstrates the LQs of the four main functions respectively. For the residential function, the LQs show very small variance across urban villages (indicated by the LQ values). As the dominant function, the residential function is more or less evenly distributed over the city, however, the highest concentration of the residential function is found in places including the most developed urban areas in the SEZ and the least developed urban areas in Dapeng Peninsular. Many urban villages in the transition zone between the city center and peripheries exhibit lower LQs. The overall pattern is characterized by a homogeneous city center and peripheries divided by a heterogeneous middle zone.

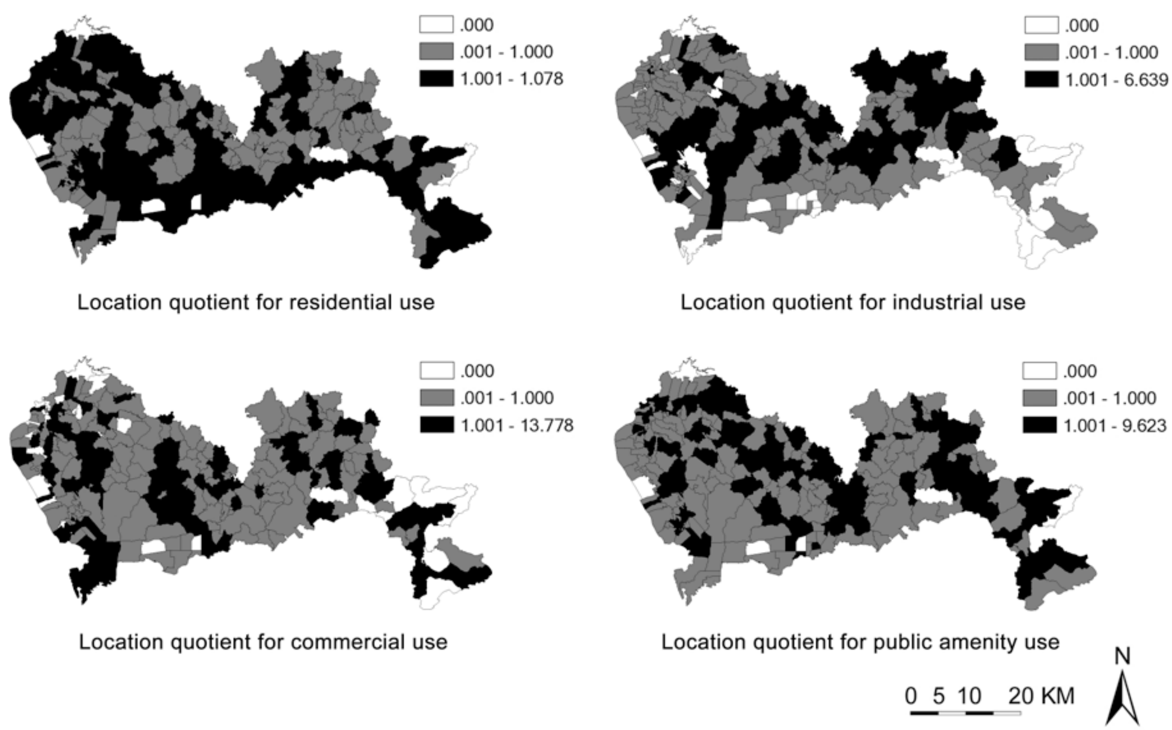

Figure 6 Location Quotients for the Four Major Functions Respectively

The LQs of industrial function show larger variance across urban villages (indicated by LQ values). Urban villages with high industrial development mainly concentrate in the transition zone between the city center and the peripheries. In contrast, both the SEZ (city center) and the peripheral areas (northwest of Baoan and eastern part of Longgang) have few urban villages with high level of industrial development. At city scale, the distribution pattern of the LQs for industries also shows a pattern characterized by a homogeneous city center and peripheries divided by a heterogeneous middle zone. Moreover, it is clear that the concentrations of industrial development are mostly located in the areas where residential function is less pronounced.

Urban villages with high commercial development is much more scattered in distribution comparing to the residential and industrial functions. The urban villages are found in places including more developed areas such as the old city center (Luohu) and Nanshan district in the SEZ as well as less developed areas such as the eastern part of Longgang.

Urban villages with high development of public amenities mostly appear outside the SEZ, in both the areas close to the SEZ and the city peripheries. They are very scattered in distribution. Urban villages, which have high development of public amenities, are seldom located in the city center or district centers, where public amenities are sufficiently developed in the formal urban areas.

Besides the great variation found in the development of urban village housing, land use in urban villages exhibits diversity and the level of diversity vary across urban villages. While all urban villages are dominant by the residential function, among the three other main functions, industrial land use shows the greatest spatial segregation at the city scale while the commercial function shows less and amenity function shows the smallest spatial segregation. For each function, different spatial distribution patterns are detected. While the residential and public amenity functions are more evenly distributed over the city, the industrial and commercial functions are more intensively developed in specific locations. These patterns suggest that the functional structure of an urban village is likely to be related to its location in the urban fabric as well as the land use development in the formal urban areas in its surroundings.

6 CONCLUSIONS

This paper demonstrates the usefulness of GIS applications and several popular spatial and non-spatial indices in analyzing the pattern and trend of urban village development. The urban villages, which were transformed from rural villages on-site, are distributed throughout Shenzhen. This is different from the situation in other contexts where informal settlements often emerge and proliferate in the city center or the outskirts (Harris and Wahra, 2002, Nijman, 2010). However, the development of the urban villages exhibits great variation, in both the development of housing properties and facilities for other uses. The housing development of urban villages tends to be clustered in distribution and the development manifests itself as a spillover effect from the inner districts to the outer ones, implying the possible diffusion of migrant employment out of the Special Economic Zone into two outer districts. Besides, the functional structure of an urban village is likely to be linked to its location in the urban fabric. Given the big variation in the physical development and the land use structure of urban villages across the city, it is clear that the general assumption made about the nature of urban villages (i.e. migrant enclaves composed of crowed buildings) does not hold true for all.

The measurements, mapping and analyses of the development patterns and trends of urban villages can help to suggest possible driving factors of the variations in such patterns and trends, which is essential for the understanding of urban village development. For instance, the growth of urban village housing may be positively influenced by good access to job locations; the land use structure of urban villages may be impacted by the land use development in the formal urban areas in their surroundings. The interrelationship between urban village development and the overall urban growth is important knowledge for making robust policy decisions about how to deal with urban villages in general and with specific ones in particular. To explore the causal relationship between spatial and non-spatial characteristics of urban villages and their development is another challenging research topic, which is the subject of ongoing research that will be reported subsequently.

It is foreseen that China's urban growth will continue to accelerate in years to come (Song and Ding, 2009). As a subsidized housing scheme for rural migrants is still absent in most cities, low-cost housing such as that provided by urban villages is likely to remain in great demand. Officials in Shenzhen and other Chinese cities in which urban villages form a substantial component of the low-income housing market would do well to consider whether and how intervention strategies could be broadened to include responses that might avoid mass demolition and relocation. The lack of standard regulations, professional guidance on development options and enforcement measures for developments in urban villages are reasons for many of the physical problems found in urban villages today, including over-development, infrastructure deficiency and chaotic land use. In the situation that market forces undermine development regulations, enforcing building codes in urban villages is critical to ensure proper construction and the provision of adequate infrastructure. A potentially interesting option could be to investigate whether municipal planners can provide professional guidance on preferred development options for specific villages in order to improve the quality of construction and the environmental quality and livability of the villages.

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