Urban Sprawl and Land Use Characteristics in the Urban Fringe of Metro Manila, Philippines

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Abstract

Census data and GIS were used to examine population growth rate patterns, changes in land use and the characteristics of mixed land use in Metro Manila, Philippines, one of the most rapidly growing cities in Southeast Asia. Small-scale analysis of land use change in the urban fringe of Metro Manila was carried out to understand past and ongoing land use changes. A highly complex mixture of urbanized and agricultural land was observed to spread like a belt around the center of the city. This area was found to be absorbing rapid population growth in Metro Manila. In the fringe of Metro Manila, rapid urban growth was absorbed by two types of residential areas: squatter residential areas that expanded along the main street, and a subdivision development on backmarsh land that had formerly been used as paddy fields. The study found the latter development caused many environmental problems, and that a strategy to avoid such developments and to control urban and rural land use is needed.

Keywords: Asian urbanization; population growth; land use conversion; join-count analysis; uncontrolled development

1. Introduction

Asian mega-cities have undergone rapid population growth compared with that experienced in Western countries, and this growth is continuing. The explosive population growth has brought drastic changes to the urban landscape, causing serious environmental problems, including the widespread presence of unsanitary conditions, uncontrolled development of urban regions, and expansion of squatters’ settlements. Asian environmental planning systems should not be based solely on experience drawn from highly developed countries, as the characteristic urbanization patterns, the process by which urbanization causes environmental problems, and the substance of environmental problems in these areas differ from those experienced during the growth of cities in Western countries (McGee, 1991; Yokohari et al., 2000). Consequently, an understanding of the characteristics of Asian urbanization and the environmental problems it causes will be indispensable for the establishment of a sound planning system that meets unique local needs; such an understanding should be developed through case studies.

The characteristics of Asian urbanization have been addressed extensively in the literature. McGee (1991) stated that Asian urbanization led to the emergence of a new complex landscape in urban fringe areas. These fringe areas are characterized by an intense mixture of agricultural and non-agricultural activities, and are widely known as “desakota” (an Indonesian term that expresses the mixture of country (desa) and city (kota), which is described in the McGee-Ginsburg model). Many succeeding studies referred to the McGee-Ginsburg model in order to capture the socio-demographic dimensions of Asian urbanization. Recently, some studies of Asian urbanization have begun to pay attention to the spatial features of these regions (Kelly, 1998; Sui and Zeng, 2001; Yokohari et al., 2000), but they discuss spatial features only on the scale of entire mega-city areas. A detailed study is needed to understand past and ongoing problems associated with urbanization, and to understand why problems have occurred in specific locations.

This study describes landscape changes in the urban fringe of Metro Manila in the 1980s and 1990s, and examines the environmental impacts of these changes through geographic information system (GIS) analysis and field surveys. The paper is divided into two sections. An overview of trends in population growth and the pattern of spatial expansion in Metro Manila from 1918 to 1995 is presented using GIS software and census data. The degree to which agricultural and non-agricultural land uses in and around Metro Manila are mixed is assessed and compared with the spatial distribution of population growth in order to examine the geographical specifics of population growth. Based on the results of this overview, a target site in the urban fringe of Metro Manila that is currently undergoing urbanization was chosen, and a small-scale examination was undertaken using GIS analysis and field surveys. The results of this small-scale study are used to describe landscape changes and the environmental problems caused by urbanization.
2. Study Areas and Data Used

Metro Manila is the capital of the Philippines and consists of eight cities and nine other municipalities, which together, cover an area of approximately 638 km² (0.20% of the total national land area). Metro Manila is located in the lowlands of southwestern Luzon Island and is situated on the east coast of Manila Bay at the mouth of the Pasig River.

Population data for 1918, 1939, 1960, 1980, and 1995 for each constituent city of Metro Manila were obtained from the National Statistical Coordination Board of the Philippines. The administrative boundaries defined by the National Mapping and Resource Information Authority of the Philippines (NAMRIA) were digitized and used in the GIS. A land-use map (1:10 000 scale) published in 1986, and aerial photos taken in 1982 and 1997, were obtained from the same agency. The land-use map was created based on the 1982 aerial photos, and therefore shows land use as of 1982. GIS data on land use were prepared by the Metro Manila Urban Transport Integration Study (MMUTIS) based on the land-use maps (published in 1986). The 1961 land-use map published by the Authority of the Board of Technical Surveys and Maps was also prepared and used in the GIS. Land-condition maps published by the Japan International Cooperation Agency (JICA) and NAMRIA in 1986 were digitized and used to help understand the land classification types within Metro Manila.

The residents and officers of the city planning office of the cities of Metro Manila were interviewed to gain a better understanding of land use change in Metro Manila. Reference was also made to documents stored at the local governments’ assessor’s office.

3. Overview of Urbanization Trends

3-1. Population growth

In order to understand the patterns of population change in the four periods under review, we calculated average yearly population growth rates using city- and municipality-level population data. The results are summarized in Fig. 1, and show the process of expansion and urbanization of Metro Manila.

During the first period (1918-1939) the Philippines were governed by an American colonial regime that lasted from 1898-1946. The areas with high population growth rates during this first period were limited to the cities and municipalities around Manila City, which form the central part of Metro Manila. The size of the capital city was still small. During the period of colonization, the American government promoted the construction of arterial roads and highways. The infrastructure constructed during this time helped urbanize the area to spread in later periods.

During the second period (1939-1960) population growth rates increased in the areas surrounding Epifanio De Los Santos Avenue (EDSA), including Paranaque,..
Valenzuela, Kalookan City, and Quezon City. This indicates that urbanization was extending outward from EDSA during this period. The northern region (particularly Quezon City) recorded particularly remarkable population growth, possibly resulting from the transfer of the capital city to Quezon City (a process that occurred between 1949 and 1976), and subsequent development in Makati. This period recorded the highest average population growth for Metro Manila as a whole, indicating that this is when full-scale urbanization of Metro Manila began.

Population growth in the surrounding areas, such as Las Pinas, Tagig and City of Muntinulupa, progressed most rapidly during the period 1960-1980. The growth rate was particularly high in the southern region, through which the main highway leading to the southern part of the country passes. The growth rates in the central part of Metro Manila decreased to low levels.

The overall population growth rate became moderate in the period 1980-1995. Although the population grew little, or even decreased in some areas of the central part of Metro Manila, population growth rates remained high in the surrounding areas (especially in the southern parts of Metro Manila).

The preceding analysis indicates that although rapid population growth was at first concentrated in the central part of Metro Manila, since 1939 the fastest-growing regions have been located at an increasing distance from the center; population growth has thus been chiefly absorbed by the surrounding regions.

In addition, the high population growth rates of 1980-1995 occurred in regions with relatively low population densities. This suggests that the rapidly growing regions have not yet become fully urbanized, and that the process of urbanization is proceeding through the conversion of land to urban uses.

3-2. Land Use Mixture

In order to compare the distribution of population growth and the land use characteristics that result from rapid urbanization, we analyzed the degree to which land use was mixed by using the “join-counts” method. This method serves to reveal the presence of any significant spatial patterns in categorical data (Fortin, 1999; Upton and Fingleton, 1985). The join-counts method was developed by geographers to detect significant spatial patterns associated with diseases or social behaviors (Cliff and Ord, 1981), and it has been broadly used to measure the degree of complexity of other spatial patterns. The method counts the “joins” between contiguous grid cells (i.e., the contacts along contiguous edges). In the example in Fig. 2, black cells and white cells represent two different categories, and the diagram shows the method of calculating joins as BB joins (joins between two black cells), WW joins (joins between two white cells), or BW joins (joins between a black cell and a white cell) in a 4x4 matrix. (Joins are counted only along contiguous edges, not at the vertices of each cell in the matrix.) The join-counts method for the evaluation of the complexity uses the number of BW joins as its value, since this represents the frequency of contiguity between black and white (i.e., between cells in different categories). In the present study, we analyzed join-counts between urban and agricultural land use. Thus, the value of join-counts indicates the frequency of contiguity between urbanized and agricultural land use (in other words, the degree to which urban and rural land-
uses are mixed).

We calculated the land use join-counts by using GIS-based datasets for Metro Manila. The original GIS land use data that showed land use as of 1982 were vector data, and the entire Metro Manila area was classified into 18 land-use classes. We converted the vector data to raster data, and constructed a new dataset with 20-m resolution. We also integrated the 18 original classes into three land-use types: urbanized land use (including residential areas, business areas and other built-up areas), agricultural land use (including agricultural, forest and grass lands), and “other”. In this study, the “forest” and “grassland” categories (which were included among the 18 original classes) were reclassified as agricultural land because natural forest or grassland, in the strict sense, did not exist; such areas are usually utilized for some agricultural activities in Asian regions.

The resulting values are plotted in Figure 3. A high value indicates that urban and agricultural land uses are highly mixed; to indicate that the land use is complex around that pixel, it is denoted as a black area on the map. A low value indicates that land use complexity in that location is low; to indicate that the land use is homogeneous around that pixel, it is denoted as a white area.

Areas with high complexity (based on the join value) spread like a belt around the central part of Metro Manila, and this can be discerned in Figure 3. This belt area coincides with the regions in which high population growth rates were observed after 1960, as discussed above. The area of homogeneous land use inside the belt represents a highly urbanized area. This area coincides with the region around Manila City, the former capital city. This analysis indicates that the rapid population growth that occurred after 1960 resulted in an increase in mixed land use, a situation that continues to the present.

4. Small-scale Study of Urban Sprawl and Land-use Conversion
4-1. Changes in the land-use pattern

In order to analyze the processes responsible for the increase in mixed land use and to describe the accompanying environmental changes, we further examined a part of Pateros, a municipality located on the fringe of Metro Manila. Pateros is the smallest municipality in Metro Manila and is situated in the middle of the belt area, where mixed land use was observed (Fig. 3). Pateros occupies 183 ha about 13 km southeast of Manila City, adjacent to Makati City, which is in the central commercial district of Metro Manila. Many brooks and creeks run in and around Pateros; flood damage during the rainy season is one of the municipality’s most serious environmental problems. The population of Pateros was 57,407 in 2000.

In the Philippines, the administrative units that make up a city or municipality are called barangays. Pateros consists of 10 barangays. The largest of its 10 barangays is Barangay Sta. Ana, which had an area of 67 ha and a population of 23,565 in 2000.

We assessed land-use distribution in Barangay Sta. Ana during 1982 and 1997 using aerial photos taken in those years. We classified land uses into four categories: urbanized areas (including all built-up areas), agricultural land (paddy fields), vacant land, and “other”. Although a land-use map was available (published in 1986 but based on aerial photos from 1982), we undertook the classification ourselves in order to ensure that consistent land use criteria were used. We created a vector GIS dataset for land use, calculated the ratio of areas in each land-use category in 1982 and 1997, and compared the results. Interviews with local inhabitants suggested that vacant lands were formerly paddy fields, and thus any vacant land was classified as agricultural in the next step. We then converted the vector data to raster data, and created 20-m-resolution raster dataset.

We once again performed a join count analysis, and compared the ratio of joins between former agricultural land and built-up areas with the sum of the joins for the area of Sta. Ana. Finally, we compared the land-use maps for 1982 and 1997, the map for 1961, and the land-condition map to reveal changes in land use, and to determine where these changes occurred.

The amount of agricultural land (paddy fields) decreased from 1982 to 1997 (Table 1), while the amount of vacant land increased. This indicates that many paddy fields were abandoned during this 15-year period. In addition, the ratio of joins between agricultural areas and built-up areas against the sum of the joins increased, while the sum of agricultural land and vacant land decreased, indicating that agricultural lands became fragmented between 1982 and 1997.

The land-condition map (Fig. 5) indicates that the central portion of Sta. Ana consists of filled-in backmarshes, with a natural levee area girdling the backmarsh area. The 1961 map indicates that paddy fields dominated the former backmarsh areas, and that P. Rosales street, which runs through a residential area, was situated on the natural levee. The residential area is believed to have been constructed on the natural levee to avoid flooding. This landscape can be considered to be a typical land-use pattern formed in response to the features of the landform. In 1982, a new residential area was constructed. It takes the form of a subdivision, with discrete blocks of land. The subdivision divided the paddy field into eastern and western parts. During the

Table 1. Land-use Profile in Barangay Sta. Ana

|                | 1982 | 1997 |
|----------------|------|------|
| Paddy field    | 23.1 | 16.5 |
| Vacant land    | 8.0  | 11.8 |
| Former agricultural land | 31.1 | 28.2 |
| Built-up area  | 31.2 | 36.2 |
| Ratio of the join-counts between former agricultural land and built-up area (%) | 22.3 | 25.3 |
same period, the residential area along P. Rosales Street expanded and encroached upon the central backmarsh area, where it appears to be in danger of being inundated during floods. The 1997 map shows that residential development continued along the western part of the divided paddy field. This development accounts for the increased number of join-counts between agricultural land and built-up areas from 1982 to 1997. Many former paddy fields were abandoned and became vacant land.

The above observations suggest that population growth was absorbed by two types of residential areas:

4-2. Environmental Impacts of Land Use Conversion

We used aerial photos (taken in 1982 and 1997) to examine the quality of life for the inhabitants of the residential areas. We defined a 300 x 300-m quadrate, running from P. Rosales street to the southeast, and digitized the roof outline of every building on the aerial photos. We then calculated the roof area, which varies with building size. We used the average roof size as an index to evaluate the quality of life for inhabitants of residential area. In digitizing the outlines, we also referred to the cadastral map at the Pateros assessor’s office. We then plotted the average roof area at 30-m intervals from P. Rosales Street (Fig. 6).

At a distance of 30 m from P. Rosales Street, roof size averaged 71.1 m² in 1982 and 67.5 m² in 1997. Thus, no significant change was observed at this distance. According to our interviews with residents, the houses on P. Rosales Street have remained unchanged for 40 to 50 years. We believe that this constitutes the early residential area, which was developed atop the natural levee.

At distances between 30 and 120 m from the street, the average roof size decreased rapidly compared with the value at 30 m from the street. In addition, this value decreased from 1982 to 1997. This indicates that the residential area became more congested during the study period. Upon examination, the houses that were added during this period were found to be squatters’ settlements.

No houses were located farther than 150 m from the street in 1982, and only a few houses were found between 120 and 150 m. In 1997, however, development extended well beyond 150 m, and average roof size increased rapidly at distances greater than 150 m from the street. These changes were caused by development of the subdivision.

The subdivision area that extends beyond 150m from the street was formerly backmarsh land and was filled with earth prior to development. The residents in the

Fig.5. Changes in Land Use in Barangay Sta. Ana from 1961 to 1997

Fig.6. Changes in Average Roof Area with Increasing Distance from P. Rosales Street in 1982 and 1997
area 90 to 120 m from P. Rosales Street said that they experienced serious flooding more often after the subdivision was developed. Residents indicated that they believed the land filling associated with the subdivision development increased the vulnerability of the surrounding area to flooding, and worsened living conditions. In addition, as flooding damage became more serious, development of the remaining vacant lands became more difficult. The farmers of the remaining agricultural land said that the frequent flooding and the subdivision’s poor sewage system caused them to stop farming and abandon their farmland.

Urban sprawl in this region proceeded in a vicious manner: subdivision development exacerbated flood damage, resulting in vacant lands remaining undeveloped and causing additional abandonment of agricultural land. This was not a rare case; four other subdivision areas were developed in Pateros during the 1980s and 1990s where paddy fields had formerly existed.

5. Discussion

The overview using census data revealed that over time the fastest growing regions have been located at an increasing distance from the central part of Metro Manila. Through the study of 1982 land-use data, we were able to observe a highly complex mixture of urbanized and agricultural land, which absorbed Metro Manila’s rapid post-1960 population growth. This zone spread like a belt around the center of the city. This indicates that the high population growth that occurred after 1960 caused a mixed land-use condition, one that is considered to be a characteristic feature of Asian urbanization, and which was still the case at the end of the study period.

In a case study of Barangay Sta. Ana, an area included within the mixed land use belt, we observed that the degree to which land use was mixed increased, along with urbanization, after 1982. In Sta. Ana, population growth was found to be absorbed by two types of residential area. One consisted of squatters’ settlements, which expanded along the main street. The other was a subdivision development on backmarsh land that had formerly been used as paddy fields (Fig. 7). The subdivision development caused an increase in the seriousness of flood damage, resulting in existing vacant land remaining undeveloped and causing additional abandonment of agricultural land.

The increase in squatters’ settlements is a common problem in Metro Manila. It is likely that the people living in the Sta. Ana residential area where squatters have settled are suffering, both as a result of congestion and unsanitary conditions. Resolute action by local government to resist further influx by squatters is needed. Action is also needed with respect to subdivision development. Before farmland can be converted into a subdivision, permission must be obtained from the Department of Agriculture (DA) and Department of Agrarian Reform (DAR). Such permission is not difficult to obtain, however; although zoning ordinances existed when the subdivision in Sta. Ana was developed, they proved ineffective. To halt further subdivision development, DA and DAR should not give permission when the possibility to cause environmental problems exists, and local governments should apply zoning ordinances restrictively.

As Kelly (1998) and Yokohari et al. (2000) have indicated, developments along streets that are close to agricultural land (i.e. paddy fields) in suburban areas of Asian mega-cities frequently serve to disturb the development of agricultural land. This may affect agricultural lands that are far from the street, because the residential development blocks access to that land. This can, in turn, lead to further abandonment of agricultural land. The case study of Sta. Ana describes
such a worst case scenario, and is illustrative of the actual conditions of Asian urban sprawl.

Many Asian mega-cities are located on low lying land, a portion of which was once used as paddy fields; the cities are typically still surrounded by paddy fields. When the urban area expands, land conversion from paddy fields to urbanized land use will occur. Therefore, the vicious urbanization process observed in Sta. Ana can be expected on the fringe of other Asian mega-cities as well; an effort to avoid uncontrolled development is strongly needed in these areas.

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