

Chapter 2

The Impact of Urbanization on Land Use and the Changing Role of Forests in Vientiane

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Abstract This paper investigates urbanization in Vientiane, the Laotian capital city, and its vicinity. The intent is to address the relationship between urbanization and land use, especially focusing on the changing role of suburban forest. In the Vientiane suburbs, forests still supply many items to villagers: firewood, charcoal materials, wild vegetables, mushrooms, insects, small animals and others. However, when off-farm work increases and commuting to factories is prevalent among villagers, the time to collect and hunt forestry products declines. Foods except for rice are purchased from stores in cash and firewood and charcoal are replaced by propane gas. In the near future, forests may become unnecessary for villagers from an economic aspect. What meaning do suburban forests have? For one, they have cultural and environmental meanings such as the securing of better landscapes and biodiversity, but their more important role is to act as a barrier to prevent urban sprawl.

Keywords Forest • Land use • Non-farm job • Paddy field reclamation • Urbanization • Vientiane

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2.1 Introduction

A general characteristic of urbanization in Monsoon Asia is numerous old and large cities in existence before modern industrialization. These cities have been supported by rice cultivation with high carrying capacity. Rural areas also have had relatively high population density and have been spreading their populations to urban areas. “Urbanization without industrialization,” based on the transfer of populations forced out of farming villages, has generated urban economies relying on informal sectors and extensive slums. With increasingly accelerated urbanization along with recent progress in industrialization, many megacities with populations greater than ten million are expected to appear in Asia. It has become a challenge to cope with environmental problems caused by these ballooning megacities and large city aggregations, such as lack of water and energy, waste and air pollution.

Another characteristic of urbanization in Monsoon Asia is areas that appear to be neither urban nor rural. Such peri-urban areas spread widely around Asian cities and environmental problems there, such as soil and water contamination caused by invasion of polluting firms and accumulated waste, have recently become serious. How to curb urban sprawl and secure green space and quality farm land in city fringes has become a major challenge.

Laos is an exception in that it is less densely populated, despite its location in Monsoon Asia. Together with Bhutan, Laos ranks as the lowest population density country there. This is because Laos is mountainous, and the majority of its territory is covered by forests. Plains are limited to small-scale lowlands along the Mekong River. This paper addresses urbanization in Vientiane, the capital city, and considers how urbanization affects the forest.

2.2 Urbanization in Laos

Before the Second World War, Laos was a French colony. During the colonial era, French Indochina had been an important economic interest for France and the French government invested in Vietnam and Cambodia, establishing commercial ports in both countries. Because Laos was a landlocked country, it lacked importance in this respect and received little investment in terms of traffic infrastructure, remaining unsuited to land transport until recently. Following the Second World War, the United States of America (US) invested heavily in Laos to prevent it from falling under the influence of communist countries. However, their efforts were limited to Vientiane, and Vientiane became isolated from other regions of Laos. Close to Vientiane and even in suburban areas, Laotian people continued to live traditional rural lives (Askew et al. 2007). After the end of the Vietnam War in 1975, the US evacuated Laos, and the population of Vientiane remained small because of a controlled urban economy, and migration under a socialist regime. In about 1980, Vientiane had a population of less than 200,000, though it was the most

populated city in Laos. The urban population in Laos had not increased significantly because of the scarce population in rural and mountainous regions, and there was minimal migration to the cities. Laos did not experience huge population flows to cities as a result of the “push factor” of migration, which was commonly seen in other Asian developing countries. Thus the urbanization of Laos was different from that in other countries in Monsoon Asia, because of these geographical, historical and political factors.

The situation in Laos drastically changed after a market economy was introduced in 1986 by the central government advocating “Chintanakan Mai” (New Thinking). Since the turn of the century, commercial and urban development has progressed, brought about by improvements in traffic infrastructure and an inflow of foreign capital. This has resulted in Laos beginning to share similar urbanization characteristics to those in other regions in Monsoon Asia. Migration from rural areas to Vientiane has soared, mainly among young generations motivated by an increasing demand for cash income, the growing demand for factory workers in Vientiane, and expansion of the urban economy into rural areas. Therefore, the population of Vientiane, which topped half a million in the 1990s, is expected to reach one million in the 2010s (United Nations Department of Economic and Social Affairs, Population Division 2010). In addition, conversion of forest and farmland to factory and residential land has increased, along with extensive development of urban areas.

2.3 Recent Land Use Changes in Vientiane

We studied recent land use changes in Vientiane using satellite images. The study area was the Vientiane prefecture (or Vientiane Capital), which includes core urban districts of Vientiane (Chanthabuly, Sisattanak) and surrounding rural districts (Naxaithong and Xaythany for example) (Fig. 2.1).

Data were selected for detecting land use changes from three time periods: 1995, 2005, and 2011. To control for seasonal effects, we only used the Landsat imagery data acquired during the dry season. Data for 1995 were obtained from Landsat 5 Thematic Mapper (TM). Satellite images for 2005 and 2011 were obtained from Landsat 7 Enhanced Thematic Mapper Plus (ETM+). Gaps in the Landsat 7 images were filled using the NASA gap filling software known as “Frame and Fill”. For each of the time periods, the following three Landsat scenes were used: path 129/row 47; path 128/row 47; and path 128/row 48. A resolution of 30 m was used for all images.

Before beginning the analysis, we undertook two tasks to improve the accuracy of land use change detection. First, we removed atmospheric interference from the selected imagery using the QUAC (Quick Atmospheric Correction) method of the ENVI Atmospheric Correction Module. Second, using the ENVI image-to-map registration method and appropriate topographic maps, the images were aligned to a common UTM coordinate system. Land classification was performed using ENVI’s

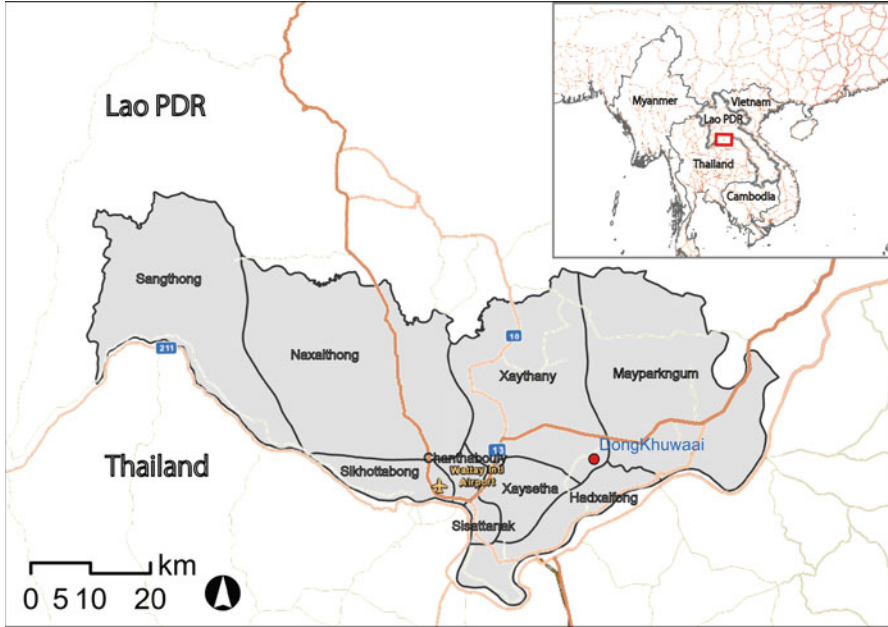


Fig. 2.1 Study area

Maximum Likelihood Supervised Classification method. We classified the images into five categories: forest, water, farmland, barren land, and built-up area.

The results from the classification are illustrated in Fig. 2.2, which shows the patterns of urban expansion in Vientiane. Figure 2.2a shows that until 1995, built-up lands were mainly concentrated around the core urban area. Figure 2.2b shows that between 1995 and 2005, the existing urban areas became denser. This demonstrates that the urban area expanded outside the core urban area, and sprawled into surrounding farmland and forests. Another significant change was the increase in development along the major transport corridors. In particular, new built-up areas were concentrated around National Road 13 North, National Road 10, and National Road 13 South (Fig. 2.1). Urban growth outside the core urban area was characterized by sprawl into land that in the previous period was forest or farmland. Figure 2.2 also shows the increasing area of farmland. Between 2005 and 2011, large areas of forest were changed to farmland.

We used a Normalized Difference Vegetation Index (NDVI) analysis to reinforce the knowledge gained from applying the QUAC method to the ENVI. NDVI is a graphical indicator that indicates the amount of green biomass in an area (Conway and Hackworth 2007).

NDVI is calculated using the following equation:

$$NDVI = \frac{NIR - RED}{NIR + RED}, \quad (2.1)$$

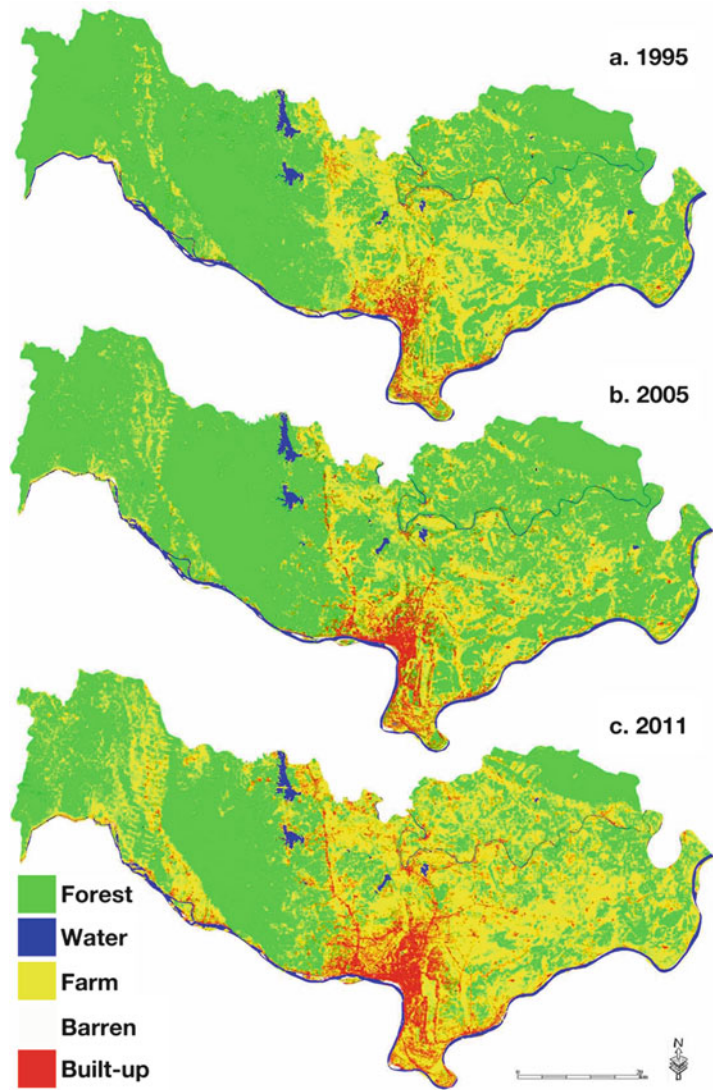


Fig. 2.2 Land use changes in Vientiane from 1995 to 2011 ((a), (b), and (c) respectively show the land cover in 1995, 2005, and 2011) (*Source:* Sharifi A, Chiba Y, Okamoto K, Yokoyama S, Murayama A." Rapid population, land-use and land-cover changes accompanying urbanization in Vientiane, Laos: Can master planning control and regulate urban development?" (Submitted for publication/ Under review))

where NIR and RED are the values for near infrared and visible red, respectively. "Highly vegetated areas have an NDVI value closer to 1, while locations dominated by water, impervious surfaces or bare soil have values closer to -1 " (Conway and Hackworth 2007). All the NDVI analyses were performed using ArcGIS 10 software (ESRI, Inc.).

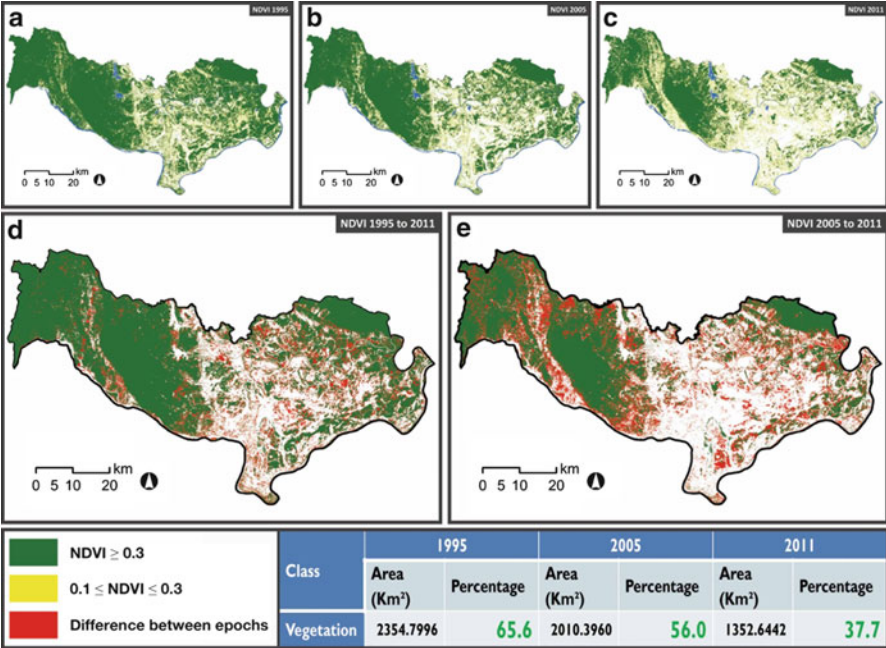


Fig. 2.3 Results of the NDVI analysis ((a), (b), and (c) respectively display the NDVI results for 1995, 2005, and 2011; (d) indicates NDVI difference between 2005 and 1995; (e) indicates NDVI difference between 2011 and 2005) (*Source: Sharifi A, Chiba Y, Okamoto K, Yokoyama S, Murayama A.* "Rapid population, land-use and land-cover changes accompanying urbanization in Vientiane, Laos: Can master planning control and regulate urban development?" (Submitted for publication/ Under review))

The results of NDVI analysis are accurate, because it is designed for analyzing changes in vegetation. The main findings of the NDVI analysis are summarized in Fig. 2.3. The dark green color represents those areas for which the value of the NDVI index was ≥ 0.3 . These are the areas where the density of forests was high. The yellow color shows the forests with low density ($0.1 \leq \text{NDVI} < 0.3$). Figure 2.3a–c show that the area covered by forests has decreased over time. The NDVI differences between any two epochs are illustrated in Fig. 2.3d, e. For instance, Fig. 2.3d shows the NDVI difference between 1995 and 2005.

As a whole, deforestation in Vientiane can be characterized as having taken place in two phases. First, forests were replaced by farmlands and pastures. Later, some of these areas were then replaced by built-up areas. There is an obvious resemblance between the results of the land use change analysis using the maximum likelihood supervised classification, and those from the NDVI analysis. The results clearly show that, over time, the forests inside and adjacent to the core urban area almost disappeared.

2.4 Land Use Changes in Suburban Farming Villages

We considered the current situation and future development using a suburban farming village of Vientiane as an example. Multidisciplinary research has been conducted from the perspectives of geography, history, agronomy, forestry, and city planning in the village of Dong Khuai, Xaithany District (Fig. 2.1), since 2004 (Nonaka 2008). Similar to other farming villages on flat land in Laos, Dong Khuai depends on rice cultivation in rain-fed paddy fields. In addition to rice cultivation, villagers also engage in fishing, collection of wild vegetables in forests, hunting of small animals, and production of salt.

In a straight line, the village is only about 20 km from the central Vientiane. However, until the access road to the village was slightly improved in 2010, it took more than an hour to reach the village by car. During the rainy season, it required even more time to travel to the village because some parts of the road would be flooded. Without any means of transport, it was impossible for residents to commute to Vientiane; therefore, the villagers have to work away from home to obtain cash.

When numerous foreign-capitalized factories progressed in and around Vientiane in the 2000, they provided commuting bus service from factories to secure workers. This integrated Dong Khuai into the commuting area. However, most commuters are currently young women working in factories; few men are so engaged.

Table 2.1 shows changes in land use in Dong Khuai during the past 50 years (Adachi et al. 2010). The area of rain-fed paddy fields has constantly increased, whereas that of forested land has decreased. This paddy field reclamation involves cutting down forests to convert the land into rain-fed paddy fields. However, the speed of paddy field reclamation has recently decreased. Even though the area of built-up land is increasing, it is still only a small part of the total area of the village. Land used for horticulture and commercial farming activities is only a small area in 2006. Village residents have made a living from transporting agricultural products collected in forests

Table 2.1 Land-use changes in Dong Khuai (Source: Adachi et al. 2010)

	Year1952		Year1982		Year1997		Year 2006	
	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)
Rain-fed paddy field	172.4	6.7	423.6	16.4	663.0	25.7	749.4	29.1
Floating rice field	0.0	0.0	23.9	0.9	139.5	5.4	100.4	3.9
Irrigated rice field	0.0	0.0	0.0	0.0	53.4	2.1	55.6	2.2
Forest	1,539.3	59.7	1,362.8	52.9	1,182.0	45.9	1,085.1	42.1
Riparian forest	265.6	10.3	291.9	11.3	237.4	9.2	253.9	9.8
Grass field	493.3	19.1	366.6	14.2	187.1	7.2	197.9	7.7
Build-up area	2.5	0.1	4.2	0.2	9.8	0.4	16.0	0.6
Water area	104.8	4.1	104.9	4.1	105.6	4.1	111.1	4.3
Commercial farm	0.0	0.0	0.0	0.0	0.0	0.0	8.3	8.3

and paddies, such as mushrooms and bamboo shoots, to market. In 2005, only three out of 261 households cultivated vegetables. Furthermore, even though grazing of cows and buffaloes has become more prominent, it has been undertaken in forested land or meadows in the rainy season and in dried-up rain-fed paddy fields in the dry season.

Thus, Dong Khuai has still not reached the urbanization stage in terms of employment and land use. However, there are signs that urbanization will accelerate in the near future. The village of Don Daeng, located in the northeastern part of Thailand, is a good example for reference. With continuous involvement of Japanese research teams since the 1960s, the transformation of that village has been clarified (Fukui 1988; Funahashi 2006). Even though the village was dependent on rain-fed paddy fields until approximately 1980, irrigation in the village area has subsequently increased. Furthermore, with increased numbers of commuters to factories in surrounding areas of the neighboring city of Khon Kaen, the ratio of household workers having regular employment reached 40 % in 2002; in most households the level of income including that from self-owned businesses and daily employment has now surpassed that from farming. Few households are involved exclusively in fishing or vegetable cultivation, and in most households cash income from paid work has increased, with rice cultivation undertaken for only household consumption. Today, irrigated paddy land is the most common land use type, while the area of forested land is small. The roads within the village are paved, propane gas is provided, and several factories are located near the village.

2.5 Forests and Urbanization

Based on the examples of Dong Khuai and Don Daeng, and drawing on similar examples from Japan, land use transition in suburban farming villages in Monsoon Asia can be modeled, as shown in Table 2.2. The area of forested land significantly decreased during all three of the periods shown in Table 2.2. Dong Khuai is currently in transition from the paddy field reclamation period to the first stage of the part-time farming period, while Don Daeng is at the beginning of the second stage of the part-time farming period. Further economic development of Khon Kaen, the regional center for Don Daeng, will bring more urban land use changes to Don Daeng, resulting in a land use pattern similar to that in suburban farming villages in Japan.

Table 2.2 Stages of land use change in suburban villages in Monsoon Asia

	Paddy field reclamation period	Part-time farming (stage 1)	Part-time farming (stage 2)
Population	++	++	+
Paddy field	++	+	+/-
Forest	-	-	-
Urban land use		+	++

During the paddy field reclamation period, forests supplied firewood and charcoal, house construction materials, and forestry products such as wild vegetables, mushrooms, insects and small animals, as well as grazing lands during the rainy season. However, with the trend toward off-farm work, in future, the time during weekdays that villagers spend in their villages will continue to decrease, depriving them of opportunities to collect forestry products (Nishimura et al. 2010). Except for rice, foods will be purchased from stores using cash obtained from paid work. Raising of livestock will be undertaken on exclusive grazing lands by full-time breeders. Forests will decrease in importance as places for supplying food to villagers. Furthermore, the economic value of forests may decrease for residents in farming villages, if the demand for firewood and charcoal materials is reduced as a result of increasing propane gas use.

So what is the future of suburban forests? Forests provide important cultural and environmental values, and can enhance landscapes and biodiversity; however, a more important role of forests is preventing urban sprawl. As mentioned in the beginning of this chapter, one of the characteristics of urbanization in Monsoon Asia is the presence of regions that are neither urban nor rural areas. This is a result of institutional considerations such as city planning regulations, which are more lax in Monsoon Asia than in Europe, and the dominance of rice cultivation in the region. Because of seasonal variation in labor demand for rice cultivation, labor tends to be diverted to jobs other than rice cultivation during the agricultural off-season. Farmers who live near urban areas tend to have day jobs on construction sites, for example. Such a trend is remarkable in Southeast Asia, with its clearly distinguishable rainy and dry seasons. In addition, in the future, it is likely that the labor demand for rice cultivation will decrease as a result of the introduction of agricultural machines such as tillers and agricultural chemicals. Hence, rice farmers will start having additional non-farming jobs, and the features of urban life will become commonplace in farming villages. Consequently, mixed land use and landscape characterized by agricultural and non-agricultural activities will emerge in peri-urban regions.

Even if controls are implemented to reduce the introduction of urbanized land use into farming villages, such controls will be difficult to implement in regions where only rice paddies remain, after forests have been displaced by paddy field reclamation. This is because with the intention of only producing rice for household consumption, rice cultivation can easily be abandoned, with increasing income from other types of work. Near urban areas, the area of farmland for rice cultivation will be reduced with changes in land use. Urban sprawl will continue to advance when residents in farming villages change to being part-time farmers, or cease agricultural activities altogether. Therefore, it will become increasingly difficult to prevent urban sprawl after deforestation. Conservation of forests without paddy field reclamation is effective to curb this sprawl, so the role of forests in suburban farming villages may critically depend on such conservation.

References

- Adachi Y, Ono E, Miyagawa S (2010) Expansion of lowland paddy field area in the plain region of Laos: case study of farm village in the suburbs of Vientiane. *Geogr Rev Jpn Ser A* 83:493–509 (in Japanese with English Abstract)
- Askew M, Logan WS, Long C (2007) *Vientiane: transformations of a Lao landscape*. Routledge, New York
- Conway T, Hackworth J (2007) Urban pattern and land cover variation in the greater Toronto area. *Canadian Geographer/Geographe Canadien* 51:43–57
- Fukui H (1988) Don Daeng village. Sobunsha, Tokyo (in Japanese)
- Funahashi K (2006) A forty years fixed point observation at the Northeast Thai village: the case study of Don Daeng/Don Charoen villages. In: *Final report of grants-in-aid scientific research* (in Japanese)
- Nishimura Y, Okamoto K, Somkhith B (2010) Time-geographic analysis on natural resources use in a village of the Vientiane plain. *Southeast Asian Stud* 47:426–450
- Nonaka K (ed) (2008) *Life in Vientiane plain*. KoKon-Shoin, Tokyo (in Japanese)
- United Nations Department of Economic and Social Affairs, Population Division (2010) *World urbanization prospects: the 2009 revision*. United Nations, New York

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