

# Assessment by Land Use Change using SI models in Khon Kaen, Thailand

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**Abstract:** Growing economies of developing Asian countries have spurred rapid urbanization, increasing automobile popularity, and housing development in suburban areas. This causes urban sprawl and destruction of the natural environment, especially in suburban areas. Therefore, it is necessary to design future urban and land-use plans for creating city where humans and nature can coexist. However, in many rural cities of developing countries, land-use databases that should be used for developing these plans have never to be established. Therefore, this research focused on the city of Khon Kaen in Thailand as a typical rural city in a developing country and established fundamental GIS data, and then analyzed the impact of its urbanization on the natural environment including the greenery coverage and habitat area for endangered species (Butterfly lizard: *Leiolepis belliana*) using developed suitability index models.

**Keywords:** Land use, Suitability index model, GIS, Butterfly lizard

## 1. INTRODUCTION

In many local cities of developing countries, many of biodiversity and ecosystem have been disappearing and then the species with the risk of extinction have been also rapidly increasing due to the infrastructure construction with urban sprawl and economic growth. The main causes of this situation include such as that the basic data and information to strategically avoid, minimize and compensate the adverse effects on the ecosystem are not sufficiently developed and that the ecological evaluation method is not established. Therefore, this study aims to develop land use data by GIS (Geographic Information System) through field survey focusing on Khon Kaen city, Thailand, which is a typical local city in developing countries. In addition, suitability index (SI) models of the targeted endangered species were developed to quantitatively analyze the impact on the potential habitat from the perspective of the quality and area, and then compared between 2011 and 2015 accompanied with the road development and urbanization.

## 2. LITERATURE REVIEW

Since the local cities of developing countries where a database of land use has not been developed, there are few studies that quantitatively assessed the effects on the natural environment due to the urban sprawl. Ito et al.(2015a, 2015b) developed a database of detailed land use (50m mesh) of Khon Kaen city, Thailand to quantitatively evaluate the impact on the reduction rate of the ecosystem services due to the rapid urbanization of Khon Kaen city, and then it was shown that amount of ecosystem services is declining. Nakamura et al. (2013) analyzed green coverage rate of come

scenarios in Bangkok, Thailand by using GIS, taking impacts of urban sprawl into consideration.

On the other hand, suitability index (SI) models which were developed in the USA have attracted attention in Japan as one of assessment methods for evaluating the quality of environment based on a few habitat conditions of the targeted species (Tanaka, 2012). The SI score indicates the habitat quality, and is calculated for the range 0 – 1.0 by applying collected data to the SI model. The habitat suitability index (HSI) score that is also shown for the range 0 – 1.0 and indicates synthetic habitat quality score is generally computed by using the geometric average or arithmetical mean of all SI scores. SI models have been utilized in various fields such as to assess Satoyama (Ueno et al. 2011), and construct a biodiversity potential map that shows the suitable habitat areas for individual endangered species (e.g., Aichi Prefecture 2010; Ministry of Environment 2005; Noyori et al. 2012; Nishizawa et al. 2014). Ueno et al. (2011) used the SI model for *Apodemus speciosus* (the large Japanese field mouse), to assess the quality of Satoyama. Previous studies regarding biodiversity potential maps have visualized the potential endangered and threatened species habitat areas, and compared these with the actual distribution of the target species.

In this study, by focusing on the endangered species living in the forest, we analyzed the change of area and quality of forest using the SI models by the urbanization and road development.

### 3. METHODOLOGY

#### 3.1 Study area and targeted species

Khon Kaen city is located approximately 450 kilometers to the northeast of Bangkok and it is one of typical local cities in developing countries. Since the number of endangered species has been increasing in Khon Kaen city due to acceleration of urbanization and progress of motorization, the conservation of biodiversity and ecosystem has been needed extremely. To solve this problem, Butterfly lizard as an endangered species was selected as a representative species among 9 endangered species inhabiting the bright forest through interview survey to Dr. Adcharaporn who is biologist of the Khon Kaen University and developed SI models.

#### 3.2 Development of SI models of Butterfly lizard

For developing SI models of Butterfly lizard, we collected a variety of literatures concerning Butterfly lizard and extracted four indispensable habitat conditions such as the temperature, illumination, forest density and the ground temperature of the forest. For the SI models, we set the most suitable environmental conditions to the SI value of 1.0 based on the data of habitat environment described in the literature, and another model was set to the SI value of 0 for the habitat impossible environmental conditions as shown in Fig. 1. For these models, we obtained the SI value based on the data obtained in the field survey to calculate the habitat suitability index (HSI) value representing the overall quality by the arithmetic mean.

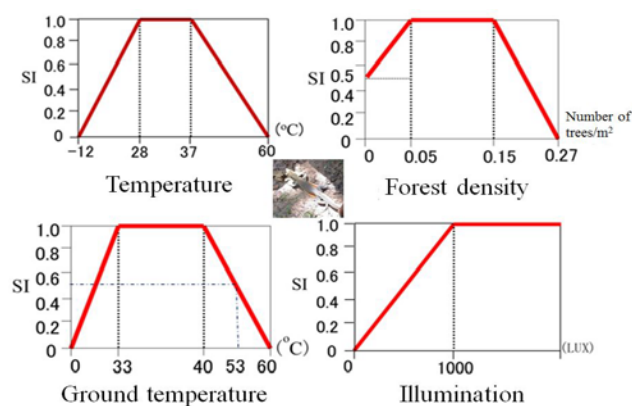


Fig. 1 Developed SI models of Butterfly lizard

### 3.3 Field survey and development of GIS data

We performed the field survey in January 2016 in Khon Kaen city, Thailand. We developed land use data (5m mesh) of the entire city within the ring road in 2016 by GIS through the field survey to grasp the land use and road development status. In addition, we also developed GIS data of 2011 based on satellite photograph of 2011 provided by Google and results of an interview survey with Dr.Thaned, a researcher of urban planning in Khon Kaen University.

Regarding the field survey in forest areas, we set the quadrats of 10 m mesh to obtain the data from 12 forests (more than 50ha) such as the trunk diameters and heights of the trees, the air temperature, illumination and forest density, and the ground temperature in 12 forest areas (Fig.2). We applied these data from the field survey to each SI model of Butterfly lizard and then we evaluated HSI value of each forest area using each SI value by the arithmetic mean.

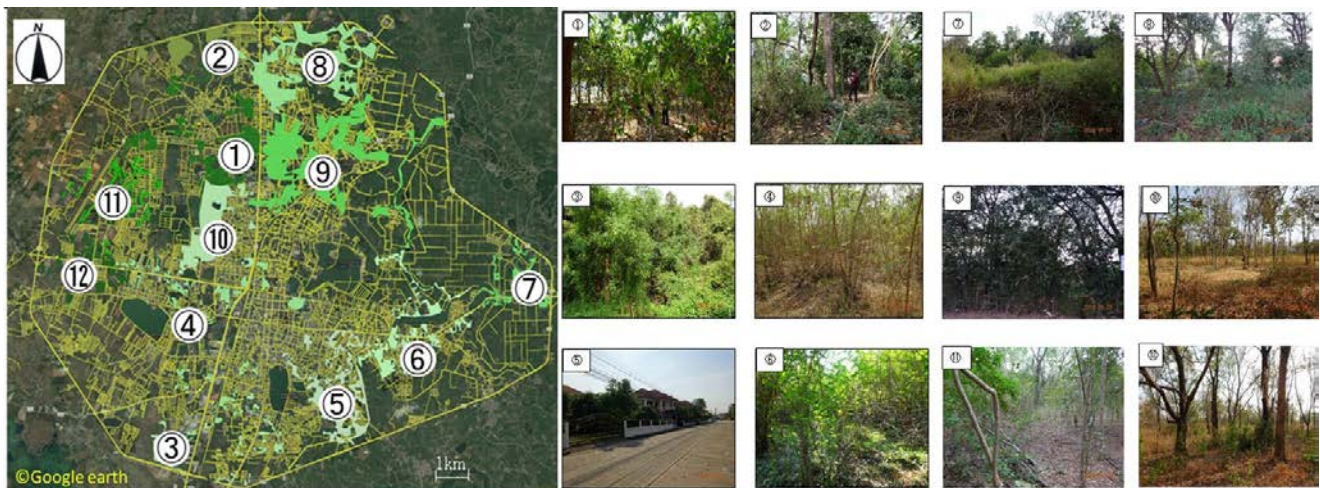


Fig. 2 12 forest areas surveyed in Khon Kaen

## 4. RESULTS

The actual measured value, SI value and HSI value obtained in the field survey of each forest are shown in Table 1. As a result, average SI values of temperature, ground temperature, illumination and forest density were respectively 1.0, 0.89, 0.61 and 0.75. The SI value of illumination varied widely in particular. HSI values of each forest were generally high results with the exception of the No.3 and No.6.

Fig. 2 shows the green coverage rate, area of forest, area of road, area of residential area, and the estimated result of the total habitat units (THU) that multiplied each HSI value and area of forest including peripheral forest. Regarding all HSI values in 2011, we assumed the quality of all forest has never changed and we used same values as 2015. In addition, the green coverage rate to be defined in this study strictly targeted only the forests as a green coverage rate.

As a result, when compared between 2011 and 2015, it is shown that the green coverage rate has decreased by 11%, and the forest area has decreased even by 41%. The residential land area within the ring road has increased by approximately 10%, with road extension areas increased by 27% and new housing development around new roads. In addition, forest area in the center of the city has disappeared in particular between 2011 and 2015.

When compared with the THU calculated by multiplying the HSI value with the forest area, it is shown that the THU of 2015 has reduced even about 40% compared with 2011. Thus, the potential habitat environment of Butterfly lizard has markedly reduced accompanied with the urbanization and it is necessary to implement conservation measures.

Table. 1 Results of area of forest, field survey, SI value and HSI value in 2015

No.	Area of forest in 2011 (m <sup>2</sup> )	Area of forest in 2015 (m <sup>2</sup> )	Result	Temperature (°C)	Ground temperature (°C)	Illumination (Lux)	Forest density (trees/m <sup>2</sup> )
1	494.5	230.3	Actual measurement value	28.0	28.3	370	0.12
			SI value	1.00	0.86	0.37	1.00
			HSI value			0.81	
2	360.5	109.7	Actual measurement value	29.2	29.3	1000	0.14
			SI value	1.00	0.89	1.00	1.00
			HSI value			0.97	
3	128.2	100.9	Actual measurement value	30.4	29.3	720	0.27
			SI value	1.00	0.89	0.72	0.00
			HSI value			0.65	
4	266.9	132.9	Actual measurement value	33.1	31.3	1000	0.02
			SI value	1.00	0.95	1.00	0.70
			HSI value			0.91	
5	298.4	201.8	Actual measurement value	31.0	28.7	690	0.10
			SI value	1.00	0.87	0.68	1.00
			HSI value			0.89	
6	324.8	165.9	Actual measurement value	31.7	28.7	360	0.25
			SI value	1.00	0.87	0.36	0.17
			HSI value			0.60	
7	95.3	61.1	Actual measurement value	31.0	30.3	306	0.19
			SI value	1.00	0.92	0.31	0.67
			HSI value			0.72	
8	534.7	346.9	Actual measurement value	30.5	28.0	450	0.16
			SI value	1.00	0.85	0.45	0.92
			HSI value			0.80	
9	91.5	61.1	Actual measurement value	29.6	28.0	80	0.15
			SI value	1.00	0.85	0.08	1.00
			HSI value			0.73	
10	141.5	283.7	Actual measurement value	30.0	30.3	1500	0.15
			SI value	1.00	0.92	1.00	1.00
			HSI value			0.98	
11	183.9	109.6	Actual measurement value	31.5	29.0	400	0.20
			SI value	1.00	0.88	0.40	0.58
			HSI value			0.72	
12	339.8	130.7	Actual measurement value	31.5	31.3	1400	0.08
			SI value	1.00	0.95	1.00	1.00
			HSI value			0.99	
Total	3260.0	1934.6	Average SI value	1.00	0.89	0.61	0.75
			Average HSI value			0.81	

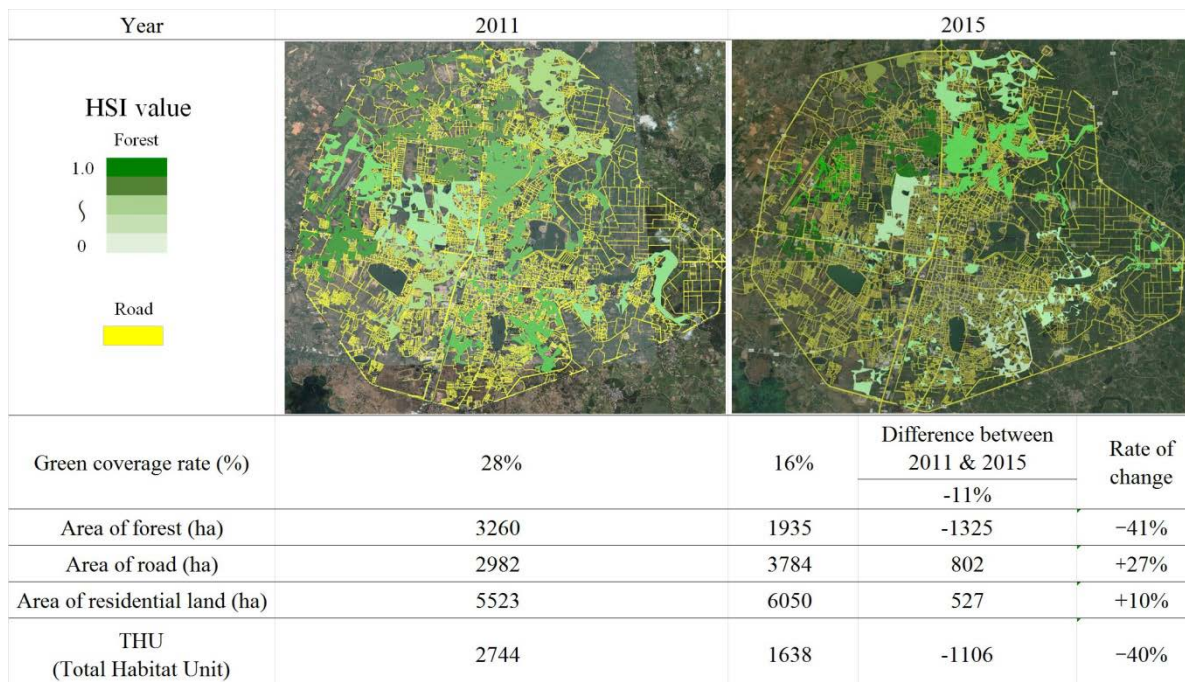


Fig. 3 Comparison result between 2011 and 2015



## 5. CONCLUSION

In this study, it was concluded that the area of forest and green coverage rate (including farmland, field and forest) have been decreasing and the habitat area for endangered species also have been remarkably reducing by urbanization and housing development by estimating the habitat unit that takes into account the quality and area of the forests using SI models.

For further study, we need to develop the SI models of other endangered species to assess the quality of habitat from the perspective of biodiversity. Moreover, since the city master plan has never been updated in recent years, and appropriate land use regulation has never been introduced in Khon Kaen, it is an urgent need to consider how to solve these problems in the future.

## Acknowledgment

Dr. Adcharaporn and Dr. Thaned of Khon Kaen University cooperated us to provide many valuable materials and information with interview surveys. We would like to express our gratitude for the cooperation. In addition, this research was supported by Grant-in-Aid for Young Scientists (B), and also carried out as part of the joint research program of the EcoTopia Science Institute, Nagoya University,

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