Correlation Analysis of Factors Influencing Changes in Land Use in the Lower Songkhram River Basin, the Northeast of Thailand

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Abstract: The goal of this research is to analyze land-use change and to study the relationship between physical and socio-economic factors which affect the land use change. The land use change was processed by interpreting the LANDSAT-5 TM and THAICHOTE MS data acquired in 2005 and 2011 respectively and using overlay analysis and dynamic model. The study of the relationship between environmental factors affecting the land use change was analyzed using a statistical tool, which is the Binary Logit Model. The results showed that the land use change from the year 2005 to 2011, the types of land use that had increased, were perennial plants, farm plants, and man-made water sources with the increased area of 2,618.92 (0.86%), 729.51 (0.24%), and 264.85 (0.09%) ha respectively. The type of land use that decreased were deciduous forest, tropical evergreen forest, and natural water sources with the decreased area of 2,391.51 (0.78%), 852.02 (0.28%), and 457.03 (0.15%) hectare respectively. The rate of the area change per year using the dynamic model shows that perennial plants, man-made water sources, and farm plants have the positive rates of change, which are 1.59, 0.71, and 0.54 respectively. On the other hand, natural water sources, deciduous forest, and tropical evergreen forest have slightly negative rates of change, which are 0.82, 0.77, and 0.60 respectively. The type of land use that has no change is salt pan. Based on the Binary Logit Model, the relationship between physical and socio-economic factors affecting the land use change expressed that population (P) and distance from the canal (St) are independent variables which have a negative relationship with the land-use change without 0.05 logistical significance. Height above mean sea level (Sl), numbers of female (F), numbers of male (M), numbers of household (H), distance from road (T), and distance from village (V) are independent variables which have a positive relationship with the land-use change without 0.05 logistical significance.

INTRODUCTION

Land is one of the important natural resources for living. In fact, Thailand is always based on agriculture which uses land as our main source. Not only population but also the need of land use for other economic activities such as urban and industrial development has increased. As a result, we face some issues with land use such as the use of agricultural land for urban expansion, the use of bad land for agriculture, and the forest invasion for agriculture and housing. The use of land without guidelines will result in the destruction of land which affects direct and indirect to farmers, communities, and the country. Land use is not stable, but it is always changed; for example, the decrease of forests, the increase of agricultural land, and the increase of community area. A lot of farmlands which are decreased, is turned into industries, households, golf courses, resorts, or parks (Research facility for Thailand development, 2011). Therefore, it is important to study land-use change and relationship between physical and social-economic factors affecting the land-use change in order to plan, manage, and develop guidelines for future land-use change, best utilize existing natural resources for human most benefits, and better quality of life for agriculturists. Technology has been developed very quickly especially the geographic information system (GIS) which has been improved to be more efficient in area analysis. With great amount of memory storage, ease of use, user-friendly functions for analysis plus the geographic system can be represented in map and logistics, the integration of GIS and current logistical tools then becomes a new way to help us in the research of land-use change and relationship between physical and socio-

economic environmental factors affecting the land use change. The information from the research will be significant and useful for us to plan and to manage land use effectively.

OBJECTIVES

The objectives of this study are to analyze land use change and the relationship between physical and social-economic factors affecting the land use change

STUDY AREA

The lower Songkhram River basin is located in latitude 103° 29' S to 104° 30' S, and Longitude 17° 28' N to 18° 9' N. The area covers approximately 3,050 km^2 (Figure 1). It lies within the provinces of Sakon Nakhon, Nong Khai, and Nakhon Phanom. Its elevation varies from 136-539 meters above mean sea level. The Songkhram river is the main river which originates from Puparn mountain range in the area of Sakon Nakhon, flow pass Udon Thani , Nong Khai, and ends in Chaiburi, Tha Uthen, Nakhon Phanom with approximately 420 kilometers in length. The different in slope is approximately 3-4 centimeters per one kilometer in length of the river which causes the difference height along the Songkhram river basin is only 8 meter. Consequently, during rainy season, the lower area will be flooded and become a huge lake covering 800-960 km^2. The inundation is for a period of 3-4 months, followed by a slow discharge into the Mekong river. The influence of flood comes from rivers of the north and the Kong River that flows into the Songkhram river and its branches (Thaiban researcher network, the Lower Songkhram River basin, 2005). The majority of land use is flooded forest which is located in wetlands whichwere identified as nationally important in the Wetland Inventory of Thailand. The weather conditions in the area are influent by southwest- and northeast- monsoon winds. This causes rainy season from May to October, winter from November to February, and summer from March to April. There is also an influence, which produces more rain in more area of South China Sea and Pacific Ocean depressions from August to October occasionally.

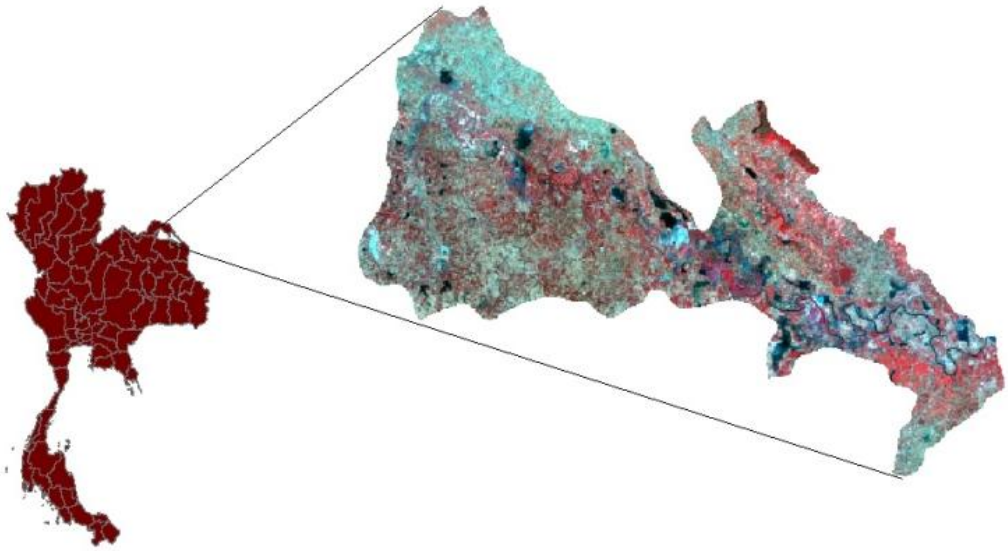

Figure 1: Location of the Lower Songkhram River Basin

METHODS AND DATA

Data: The information of this research was gathered from the satellite images during two periods of time without any cloud over the observed area. These images were captured by LANDSAT-5/TM in 2005 and THAICHOTE in 2011.

Methods: There are six steps during the information analysis(Figure 2). The details are as followed:

Pre-processing: THAICHOTE MS image was geo-referenced using the ground control points obtained from the topographic map at scale of 1:50,000. A nearest neighbour interpolation algorithm was performed. The Landsat TM data was co-registered to the geo-coded THAICHOTE image.

Land use Interpretation: Visual interpretation technique was used to identify type of land use based on the Landsat-5/TM and THAICHOTE MS images acquired in 2005 and 2010 respectively. Recognizing the difference of land use type, the visual elements of tone, shape, size, pattern, texture, shadow, and association were used and land use categories were identified based on the classification system as used by the Land Development Department.

Land use change analysis: A comparison of a pair of land use map between the year 2005 and 2011 was carried out to obtain the land use change map using overlay function of ARCGIS program. The statistics of the changed class were calculated.

Analyzing dynamic land use change: The intention of this analysis was to have a better understanding of the complexity of the land use change. The dynamic of the land use change can be calculated using equation 1as follow:

$$K = \frac{(U_b - U_a)}{U_a} \times \frac{1}{T} \times 100\% \qquad (1)$$

When K is the dynamic of a type of land use in a given time. Ua and Ub are scopes of information levels of a land use starting from point a and ending at point b during the research, and T is time from a to b. If T is set to several years, the value of K is then the rate of information levels of land use change, per year, during the research (Zang, X., 2010)

Analyzing environmental factors affecting land use change: To study the relationship between the environmental factors that control the variables of land use change. Furthermore, there is also a test for suitability and accuracy of the approximate model by stratified random sampling from the 300 area studies and analyzing the model with a logistical tool. This tool is Binary Logit Model, and it is the model used to analyze variables that are qualitative data.

Accuracy assessment: The accuracy of the land use interpretation was assessed by surveying the actual sites, and to evaluate the relationship between the environmental factors that control the variables of land use change by using Binary Logit Model.

RESULTS

Land use interpretation: The interpretation of land use in 2005 demonstrates that the most popular types of land use are rice fields, deciduous forest, and perennial plants (rubber and Eucalyptus trees) with the area of 154,498.92 (50.66%), 51,667.03 (16.94%), and 27,410.60 (8.99%) hectare respectively. The most popular types of land use in 2011, similar to the ones in 2005, are rice fields, deciduous forest, and perennial plants with the area of 154,568.86 (50.69%), 49,275.52 (16.16%), and 30,029.52 (9.85%) hectare respectively. The majority of land use is growing rice along rivers while forests are located along the bank and perennial plants are located the most on the west side of the basin (Figure 3 and Table 1).

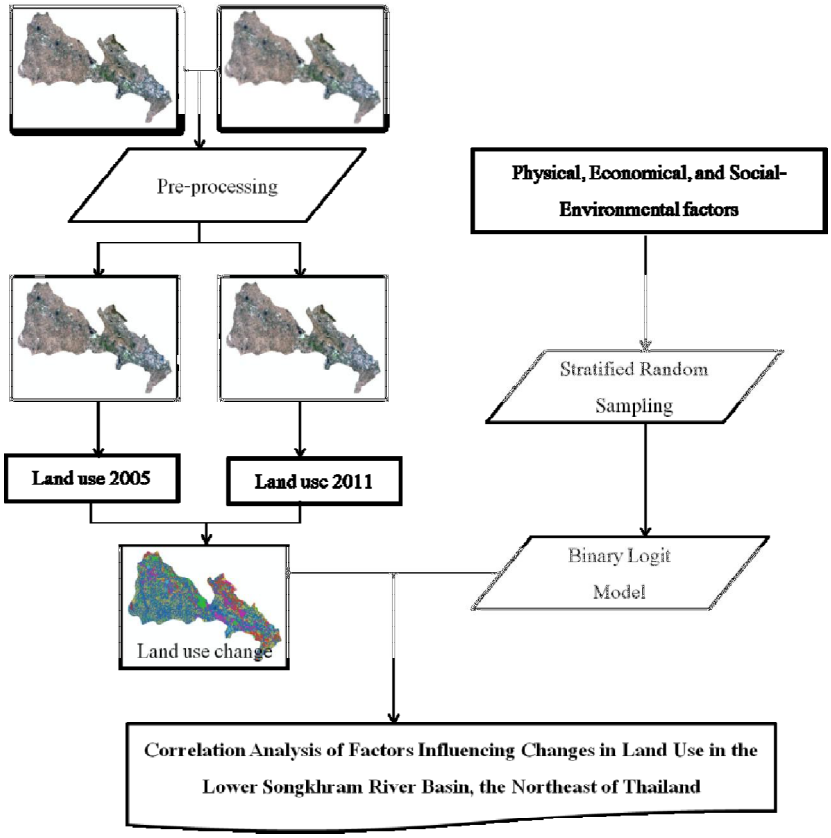

Figure 2. The methodology procedure.

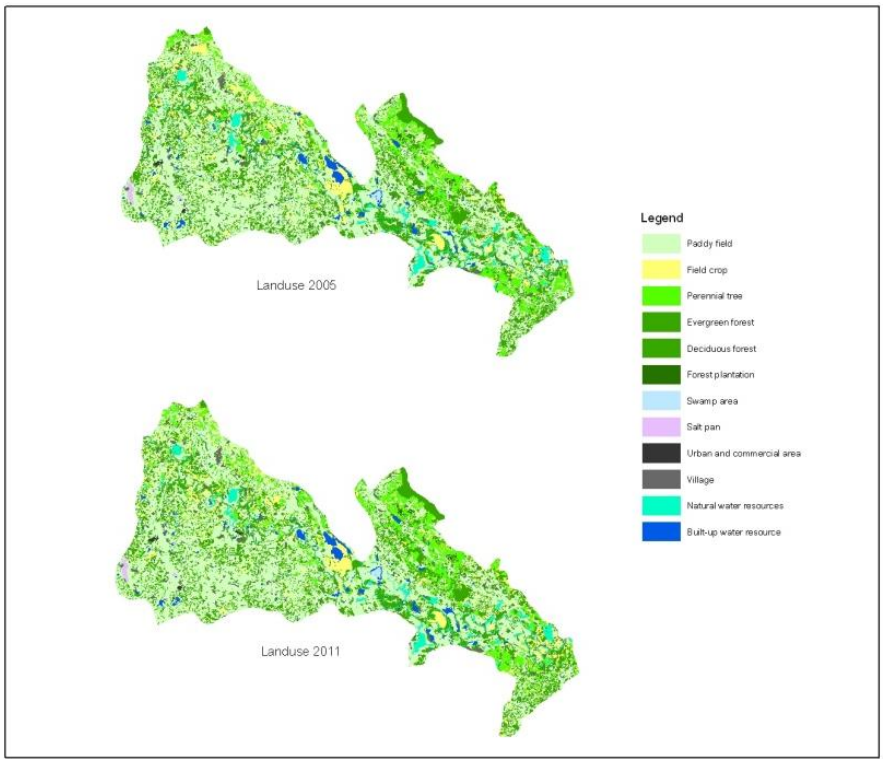

Figure 3. Land use Maps of the Lower Songkhram River Basin in 2005 and 2011.

Table 1: Land use of the Lower Songkhram River Basin in 2005 and 2011.

Land use type	Area in 2005		Area in 2011	
	Hectares	Percent	Hectares	Percent
Paddy field	154,498.92	50.66	154,568.86	50.69
Field crop	22,481.48	7.37	23,210.99	7.61
Perennial tree	27,410.60	8.99	30,029.52	9.85
Evergreen forest	23,698.78	7.77	22,846.76	7.49
Deciduous forest	51,667.03	16.94	49,275.52	16.16
Forest plantation	878.62	0.29	866.09	0.28
Swamp area	384.29	0.13	390.57	0.13
Salt pan	651.5	0.21	651.5	0.21
Urban and commercial area	333.28	0.11	334.95	0.11
Village	7,433.89	2.44	7,455.81	2.44
Natural water resources	9,298.91	3.05	8,841.88	2.9
Built-up water resources	6,212.31	2.04	6,477.16	2.12
Total	304,949.61	100	304,949.61	100

Land use change analysis: According to the land use in the past six years (2005-2011), the types of land use that increases the most are perennial plants (rubber and eucalyptus trees), farm plants, and man-made water sources with the increased area of 2,618.92(0.86%), 729.51(0.24%), and 264.85(0.29%) hectare. The type of land use that increases the least is deciduous forest, tropical evergreen forest(flood plain forest), and natural water sources with the decreased area of 2,391.51(0.78%), 852.02(0.28%), and 457.03(0.15%) hectare. The majority of land-use change is altered from forests to agricultural area (farm and perennial plants such as sugar cane, cassava, rubber, eucalyptus) which is dispersed in all the area (Figure 4 and Table 2).

Analyzing dynamic land use: The analysis of dynamic land use shows trends of land use change and also the better understanding about the complexity of land-use change. We can conclude that perennial plants, man-made water sources, farm plants, lowland, cities & trade center, villages, and rice fields have the most positive rates of change per year, which are 1.59, 0.71, 0.54, 0.27, 0.08, 0.05, and 0.01 respectively. On the other hand, natural water sources, deciduous forest, tropical evergreen forest, and wood lot have the least negative rates of change per year, which are 0.82, 0.77, 0.60, and 0.24 respectively. The type of dynamic land use that has no change is salt pan (Table 3).

The analysis of environmental factors affecting land-use change: According to Binary Logit Model (Table 4), the explanation of the relationship between land-use changes has an accuracy of 61.3%, 0.08 Nagelkerke R2, and 18.552 Chi-Square. Also, at 18.552 degree of freedom, there is 0.05 logistical significance, which means the level of certainty of the relationship between land-use changes and independent variables of the equation is 95%. The result of the research of the relationship between physical and socio-economic factors affecting the land use change expressed that population (P) and distance from the canal (St) are independent variables which have a negative relationship with the land-use change without 0.05 logistical significance. Height above mean sea level (Sl), numbers of female (F), numbers of male (M), numbers of household (H), distance from road (T), and distance from village (V) are independent variables which have a positive relationship with the land-use change without 0.05 logistical significance.

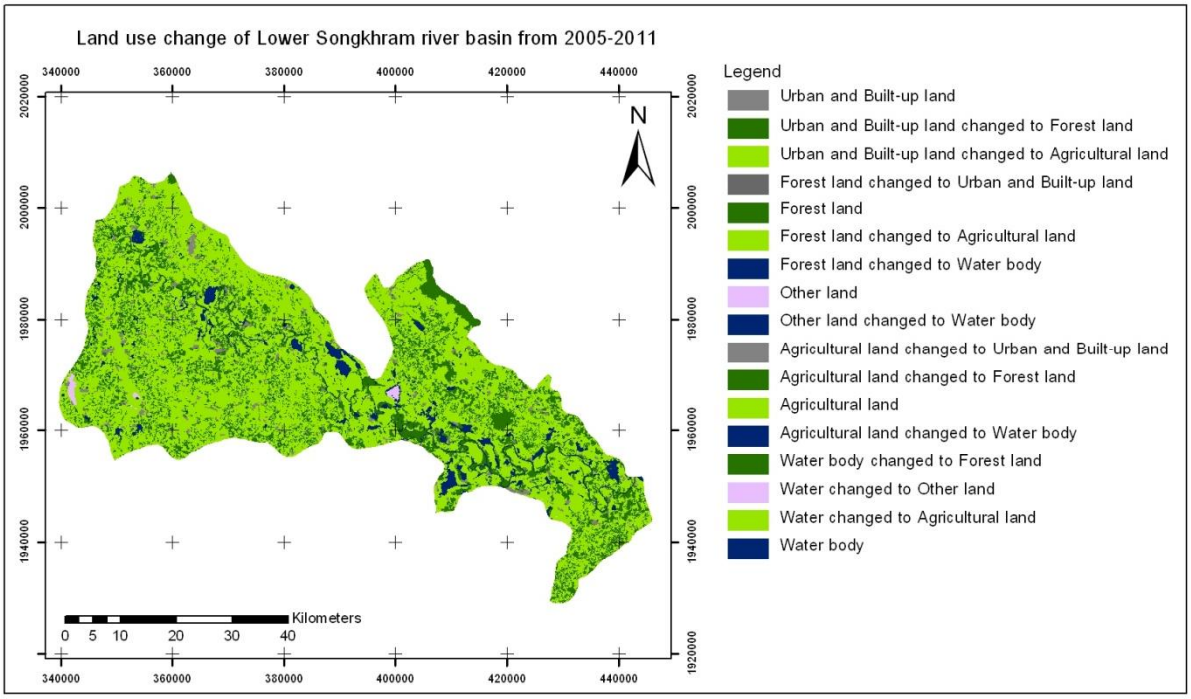

Figure 4. Land use change map of the Lower Songkhram River Basin from 2005-2011.

Table 2: The change of Land use type in the Lower Songkhram River Basin from 2005-2011.

Land use type	Area in 2005		Area in 2011		Area Change	
	Hectares	Percent	Hectares	Percent	Hectares	Percent
Paddy field	154,498.92	50.66	154,568.86	50.69	69.94	0.02
Field crop	22,481.48	7.37	23,210.99	7.61	729.51	0.24
Perennial tree	27,410.60	8.99	30,029.52	9.85	2,618.92	0.86
Evergreen forest	23,698.78	7.77	22,846.76	7.49	-852.02	-0.28
Deciduous forest	51,667.03	16.94	49,275.52	16.16	-2,391.51	-0.78
Forest plantation	878.62	0.29	866.09	0.28	-12.53	0.00
Swamp area	384.29	0.13	390.57	0.13	6.28	0.00
Salt pan	651.50	0.21	651.50	0.21	0.00	0.00
Urban and commercial area	333.28	0.11	334.95	0.11	1.67	0.00
Village	7,433.89	2.44	7,455.81	2.44	21.92	0.01
Natural water resources	9,298.91	3.05	8,841.88	2.90	-457.03	-0.15
Built-up water resources	6,212.31	2.04	6,477.16	2.12	264.85	0.09
Total	304,949.61	100.00	304,949.61	100	-	-

Table 3: The result of dynamic land use analysis

Land use type	Area (Hectares)		Dynamic
	2005	2011	(percent/year)
Paddy field	154,498.92	154,568.86	0.01
Field crop	22,481.48	23,210.99	0.54
Perennial tree	27,410.60	30,029.52	1.59
Evergreen forest	23,698.78	22,846.76	-0.60
Deciduous forest	51,667.03	49,275.52	-0.77
Forest plantation	878.62	866.09	-0.24
Swamp area	384.29	390.57	0.27
Salt pan	651.50	651.50	0.00
Urban and commercial area	333.28	334.95	0.08
Village	7,433.89	7,455.81	0.05
Natural water resources	9,298.91	8,841.88	-0.82
Built-up water resources	6,212.31	6,477.16	0.71

Table 4: The results of the Binary logit model estimation.

Independent variables	Coefficient(B)	S.E	Sig	Exp(B)
Height above mean sea level (Sl)	0.199	0.279	0.475	1.221
Rain fall (R)	0.087	0.031	0.005	1.091
Population (P)	-0.002	0.021	0.939	0.998
numbers of female (F)	0.001	0.021	0.990	1.000
numbers of male (M)	0.003	0.021	0.877	1.003
numbers of household (H)	0.001	0.001	0.996	1.000
distance from road (T)	0.001	0.000	0.629	1.000
distance from Stream (St)	-0.001	0.000	0.062	0.999
distance from village (V)	0.001	0.000	0.274	1.000
Constant	-0.108	0.735	0.884	0.898
Log-Likelihood = 397.34	**Nagelkerke R^2 = 0.08**			
Chi-Square = 18.552, df = 9	**Significance level = < 0.029**			

CONCLUSION AND DISCUSSION

According to the trends of land-use change from the interpretation of the LANDSAT images in 2005 and the THAICHOTE images in 2011, forests (deciduous and tropical evergreen forests) have been decreased noticeably. 3,243.53 hectare, or 1.06%, is decreased from the original. The types of land use that has been increased noticeably are 729.51 hectare of farm plants, or 0.24% of the area, are increased from the original while 2,618.92 hectare of perennial plants, or 0.86% of the area, are increased from the original. Using the dynamic model for land use helps us to visualize the trends of land-use change and to get a better understanding about the complexity of land-use change. We can conclude that perennial plants, man-made water sources, and farm plants have the most positive rates of change, which are 1.59, 0.71, and 0.54 respectively. On the other hand, natural water sources, deciduous forest, and tropical evergreen forest have the least negative rates of change, which are 0.82, 0.77, and 0.60 respectively. The type of land use that has no change is salt pan (Table 3). The integration of Binary Logit Model and GIS in the research of the relationship between environmental factors affecting land-use change and land cover in

the lower Songkhram River basin demonstrates that population and distance from the canal have a negative relationship with the land-use change without 0.05 logistical significance. Height above mean sea level, numbers of female, numbers of male, numbers of household, distance from road, and distance from village have a positive relationship with the land-use change without 0.05 logistical significance.

RECOMMENDATIONS

Satellite images used in the interpretation of land use should have the same quality.
Only the data from the two time periods were used in the research (2005 and 2011). As a result, the relationship between environmental factors and land-use change were not comprehended well enough. Therefore, as a plan for the future, five time periods will be utilized for a better understanding of land-use change and the relationship between environmental factors affecting the land use change.

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