Development of land valuation approach based on hedonic model —A case study of Vientiane capital city Laos*

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Abstract: The aim of this study is to identify the variables affecting land value. Examined land was selected from the village in Vientiane capital city Laos. Data was collected from 100 villages in center of Vientiane capital city by using survey methods. A hedonic price analysis was conducted to determine the marginal return to different land characteristics using an econometric model corrected for correlation. Parcel characteristics such as distance to public park, village income, distance of population, number of the school within 500 meters buffer, distance to the temple, distance to the major market and distance to the business center (CBD). Arc GIS 9.2 was applied to calculate the distance of the factors, after that SPSS 15.0 was used to calculate the land price characteristic based on hedonic price model. The results showed that the distance to the center of population was the main factor influencing to the land price, and followed by school and village income. Map of the land price before and after hedonic price analysis were produced. The land price valuation approaches based on hedonic price model for Vientiane capital city were developed and land price map were predicted. Hedonic price model and GIS were very useful for this research, and finally the policy of the land valuation based on GIS was developed.

Key words: land price; hedonic price model; Vientiane; Laos

1. Introduction

Quantitative studies of urban spatial structure have been conducted mainly through analyzing population distribution and density (Batty & Kim, 1992), housing and land prices (Peiser, 1987), and firm location (Shukla & Waddell, 1991). Such studies often require a substantial amount of data from population census, records of property transactions, and firm-level data. Housing price and land value models have often been used to study urban spatial structure and urban economies, and are central to the debate on race and equity (Kim, 2000).

The uneven distribution of urban land values has attracted considerable scholarly attentions (Abelson, 1997; Bertaud, 1992; Brigham, 1965; Huh & Kwak, 1997; McDonald & McMillen, 1998; McMillen, 1990; McMillen,

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1996; McMillen & McDonald, 1991). Many of the studies deal with the determinants of land values using hedonic land price models, with the consideration of physical and socio-economic factors, such as race, housing attributes and neighborhood. Regression models have been developed to explain land values and housing prices with a number of independent variables (Erickson, 1986; Peiser, 1987). To simplify the models, many researchers focus on a singular determinant of land values, a singular type of urban land use, and/or the distance decay of urban land values.

Previous studies of urban land values, however, have several limitations. First, despite the change from a mono-centric to a polycentric structure of cities, traditional negative exponential density function is still widely used to model land values and urban spatial structure. Those models are over-simplified and therefore are less effective in examining spatial differences in land value distribution; Second, many studies on urban spatial structure primarily use aggregate zonal data. There are problems associated with this form of data, such as “modifiable areal unit problem” (Openshaw, 1984); Findings vary with the change in the level of aggregation and the configuration of the zoning system. Lastly, spatial statistics have great potential to improve the understanding of urban land use, housing markets and urban changes, but its application in modeling land values remains limited. Previous researches have been hampered by poor data and the limited usage of spatial statistics. Housing markets exhibit spatial dependency, and almost all hedonic models violate regression assumptions (Mulligan, et al., 2002). More studies of the spatial distribution of urban land values and the relationship among different types of urban land uses are needed.

Consequences of urban restructuring and extents of spatial segregation remain hotly debated issues for Milwaukee. While some have argued for the decline of residential segregation in the city, many others have maintained that segregation persists and inner-city neighborhoods are troubled by unemployment and poverty (Boardman & Field, 2002). Regarding land values, many studies have focused on cities like Chicago (McMillen, 1996), and few studies have examined Milwaukee. While Kim (2000) examined the relationship between race and home price appreciation by neighborhoods, no study has examined the spatial patterns of land values and the effects of residential segregation in the city.

According to the Lao custom and culture, most of the Lao people are interest in buying free land (without building) more than buy building. And price valuation model based on hedonic price model were not existed yet, therefore hedonic price model were applied in this research.

2. Hedonic price model for Vientiane capital city land market

According to the hedonic price theory, the relation between land price and land characteristics can be expressed as:

$$P = f(Z) \tag{1}$$

where, P is land price, and Z is land characteristics vector. By calculating the partial derivative of this equation with each land characteristic variable, we can get the corresponding implicit price of land characteristic. The hedonic price equation is:

$$P_{Z_i} = \frac{\partial P}{\partial Z_i} \tag{2}$$

2.1 Choices and measurements of characteristic variables

According to the literature reviews, Chang and Lee (1999), Chau, et al (2001), Chin and Chau (2003), Ma and Li (2003), Palmquist (1984) and Wen (2004) have pointed that there are three types of housing characteristic affect the housing price which are closely to land price namely: structure characteristic, neighborhood characteristic and location characteristic. Especially, Chin and Chao (2003) provided a critical literature review on the application of the hedonic price model, and identified as list of housing characteristic used in the estimation of the hedonic price models and their effects on housing. The list can be served as a useful basic checklist for the choice of characteristic variables of the hedonic price model in different market (see Table 1).

Table 1 List of key housing characteristics used in previous hedonic price model

	Housing characteristic	Expected sign on housing price
Structure characteristic	Number of rooms, bedrooms	+
	Floor area	+
	Basement, garage, patio	+
	Building services (e.g., lift air condition system)	+
	Floor level (multi-story building only)	+
	Structural quality (e.g., design, materials, fixtures)	+
	Facilities (e.g., swimming pool, gymnasium, tennis court)	+
	Age of the building	-
Neighborhood characteristic	Income of residents	+
	Proximity to good school	+
	Proximity to hospital	+
	Proximity to places of worship (e.g., mosques, churches, temples)	+
	Crime rate	-
	Traffic/airport noise	-
	Proximity to shopping center	+
	Proximity to forest	+
	Environmental quality (e.g., landscape, garden, playground)	+
Location characteristic	Distance to CBD	-
	View of the sea, lakes or rivers	+
	View of hills/valley/golf course	+
	O structured view	-
	Length of land lease	+

Data source: Chin and Chao (2003).

2.2 Function form and estimation methods

There are three kinds of function forms frequently adopted in hedonic price model: linear, logarithm and logarithm linear. After trying of model structuring, linear function was found to meet the requirements of this research, so it was selected to express the relation between the land characteristic and land price.

That is:

$$P = \alpha_0 + \sum \alpha_i Z_i + \varepsilon \qquad (i = 1, \ldots, 7) \tag{3}$$

where α_i are under-decided coefficients, Z_i are relevant land characteristic variables, ε is random error. Because independent variables are in the linear model, regression coefficients α_i in the corresponding hedonic prices is constants.

The model's estimation method was the ordinary least squares method (OLS), most frequently used. The multiple-regression was obtained by SPSS 15.0 software. And the law of "enter" was chosen as the analytical method, 7 independent variables were entered the hedonic price model. The index of *VIF* (variance inflation factor) was used to monitor the multicollinearity between independent variable.

3. Results and discussions

3.1 Study areas

The capital city of Laos is called “Vientiane”. Laos’ capital city is one of the smallest capital cities in the world and the total population is 711,919 (2006) with the population density of 24 persons per km^2 and its sleepy vibe is the perfect introduction to Laos’ life. Although slightly disheveled with dusty and potholed streets, the city offers many pleasant surprises for travelers. Situated on the Mekong River, directly across from Thailand, the city warrants two or three full days for traveling. Vientiane capital city Laos is consists of 9 districts, only 4 districts were selected as the study areas namely: Chanthabury district, Sikhot district, Xaisetha district and Sisattanak district (see Fig. 1).

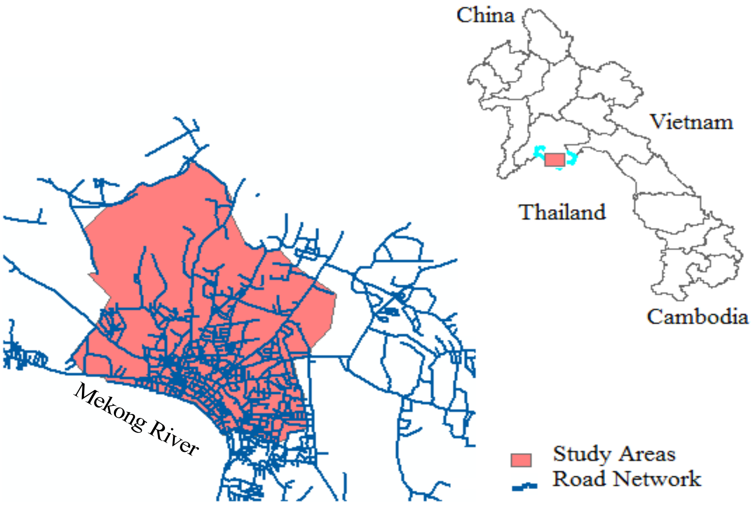

Fig. 1 Study area

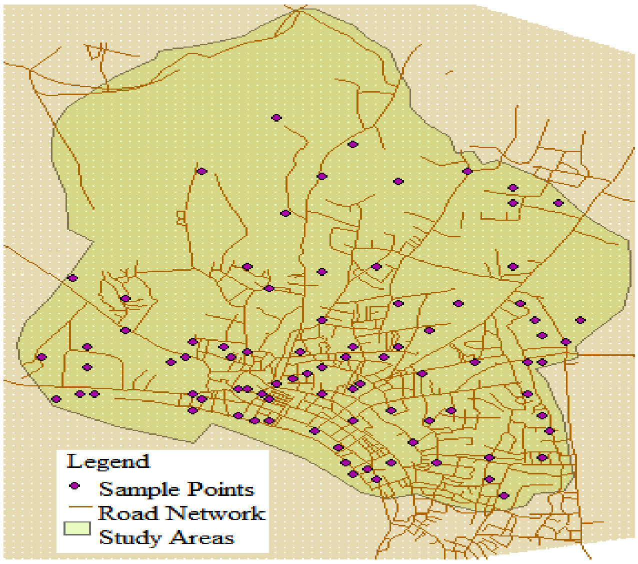

Fig. 2 Distributions of land value samples

3.2 Distribution of the land value sample

According to the Laos' customs and culture, it is more interesting to buy free land without building. Therefore first, the authors selected the land value samples without building for the study. Nearly 100 sample points were selected as randomly and it located in the 4 districts of Vientiane capital (see Fig. 2). And the market selling land prices of the study areas (2009) were ranged from 20 $USD to 1200 $USD per m^2.

3.3 Measurement of independent variables

According to the land price characteristic in Vientiane capital city Laos, three characteristics of the land price were selected namely: structure characteristic, neighborhood characteristic and location characteristic. Distance of population variable was contained in structure characteristic, distance of major market and 500 meters of school buffer was contained in neighborhood characteristic, while distance to the public park, distance to the center business center (CBD), distance to the temple and the total income of the study point were contained in the location characteristics (see Table 2). Due to lack of the data of population density of the study point, distance of the population was calculated as bellows.

Table 2 Measure methods of land characteristic variable in Vientiane Laos

Characteristic	Variable	Variable meanings and measure methods
Structure characteristic	DIS-POP	Distance of the center of population
Neighborhood characteristic	DIS-MJMAKET	Distance of the major market to the study points
	BUF500CO	Number of school in 500 meters buffer
Location characteristic	DIS-PUPAK	Distance of the public park to the study point
	DIS-CBD	Distance of the study point to center of business center
	DIS-WAT	Distance of the temple to the study point
	VILINCOME	The total income of each study point

3.4 Distance from center of population to point of land price

The center of population is the point at which an imaginary, weightless, rigid and flat (no elevation effects) surface representation of the study area would balance if weights of identical size were placed on it so that each weight represented the location on one person.

The center of population of study area is:

$$\left(\sum p_i x_i / \sum p_i, \quad \sum p_i y_i / \sum p_i\right) \tag{4}$$

where (x_i, y_i) is coordinate of i village; p_i is population of i village.

3.5 Hedonic regression modeling

After all the information about land value (dependent variable) and the influencing factors (independent variables) were collected, the authors employ hedonic regression model to estimate the equation about land value. Land value changes are the results of complex social, economic, human and physical driving forces interactions acting over temporal and spatial scales. The hedonic regression will model land value as the function of these characteristics. The major concern here is to identify the variables that explain the maximum variance in land values. The function can be expressed as follows by using the factors identified above:

LandVi=g (DIS-PUPAK, DIS-WAT, DIS-MJMARKET, DIS-CBD, DIS-POP, BUF500CO, VILINCOME)

where, *LandVi* is the unit land value; *DIS-PUPAK* is the nearest distance to public park; *DIS-WAT* is the nearest distance to the temple; *DIS-MJMARKET* is the nearest distance to major market; *DIS-CBD* is the nearest distance to the CBD; *DIS-POP* is the nearest distance to the center of population; *BUF500CO* is the number of school in 500 meters buffer; *VILICOME* is the village income within study areas.

By using these variables, the hedonic regression model can be hypothesized as follows:

LandVi=b1DIS−PUPAK+b2DIS−WAT+b3DIS−MJMARKET+b4DIS−CBD+b5DIS −POP+b6BUF500CO+b7VILINCOME+e

where *e* is the regression constant and *b1-b7* are the value rating for the independent variables.

3.6 Data exploration

First to get the descriptive analysis and correlation analysis to get some basic information about variables and tried to get a better understanding of the data. The means and standard deviation for each independent variable are displayed in Table 3.

Table 3 Independent variable descriptive

	Minimum	Maximum	Mean	Std. deviation
DIS-PUPAK	88.776	3,574.809	1,660.208	998.044
VILINCOME	1,440,000.000	11,760,000.000	5,182,235.294	2,892,435.474
DIS-POP	526.999	4,182.690	2193.220	950.784
BUF500CO	2.000	13.000	8.471	3.378
DIS-WAT	37.768	2,040.685	827.240	619.261
DIS-MJMKET	97.800	2,179.392	790.495	490.046
DIS-CBD	0.000	4,364.021	1,979.389	1,261.299

The correlation matrix is displayed in Table 4, from which we can find how two variables are correlated and how much they can explain each other. Generally speaking, the variable is considered highly correlated when their correlations are more than 0.7. From Table 4 we can find that most significant correlation is 0.555, which is much smaller than 0.7. So we can refer that all the variables are weakly correlated and there is no need to eliminate the possible multicollinearity at this stage.

Table 4 Correlative matrix

	DIS-PUPAK	VILINCOME	DIS-POP	BUF500CO	DIS-WAT	DIS-MJMKET	DIS-CBD
DIS-PUPAK	1.000	0.158	0.101	0.438	0.284	0.058	0.555
VILINCOME	0.158	1.000	-0.373	0.303	0.339	-0.168	-0.028
DIS-POP	0.101	-0.373	1.000	-0.064	-0.334	-0.002	0.293
BUF500CO	0.438	0.303	-0.064	1.000	0.384	0.141	0.490
DIS-WAT	0.284	0.339	-0.334	0.384	1.000	-0.252	0.192
DIS-MJMKET	0.058	-0.168	-0.002	0.141	-0.252	1.000	-0.208
DIS-CBD	0.555	-0.028	0.293	0.490	0.192	-0.208	1.000

3.7 Regression

The stepwise method will start by including all the variables, and then discard those who do not have significant role in determining land value. Only those variables that are significant in explaining variations in the dependent variables are included.

From Fig. 3 of dependent variables we can find that it is not a normal distribution. Therefore, the authors used the normal regression model which is particularly useful because land value data sets can be transformed through logarithm transformation to yield approximations of the normal distribution. The transformed distribution is displayed in Fig. 4 and the regression outputs are shown in Table 5 and Table 6.

(1) Model 1 (DIS-POP)

At the first step, variable *DIS-POP* enters the equation and the result shows that it is the dominant variable that determines land value. Therefore, the land value will decrease with the increase of distance from land parcels to central of the population. The relationship between *DIS-POP* and land value independently of other variables can be given by:

$$LogY = 17.680 – 0.414X1$$

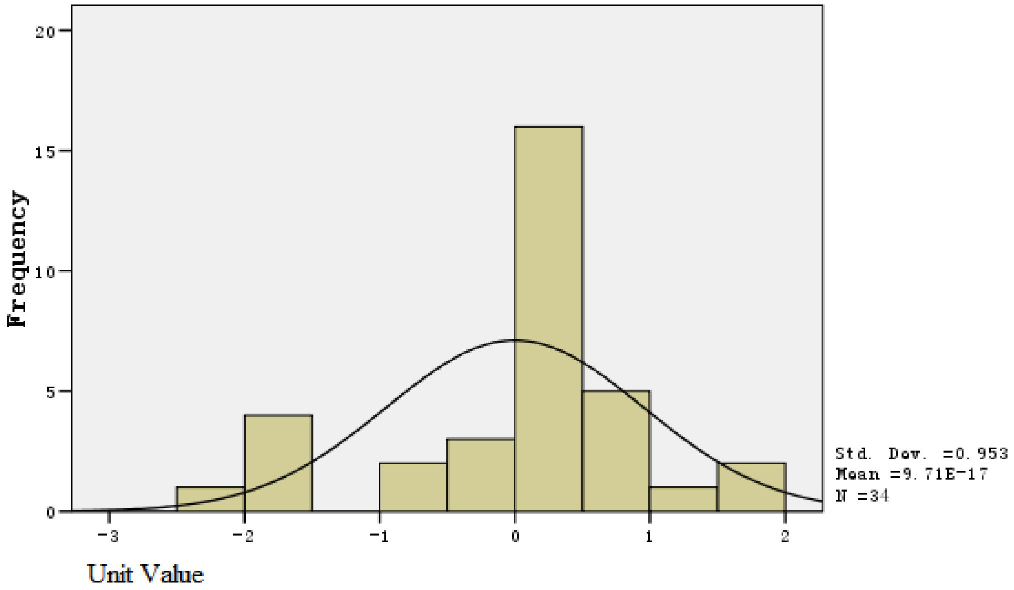

Fig. 3 Histogram of dependent variable before logarithm transformation

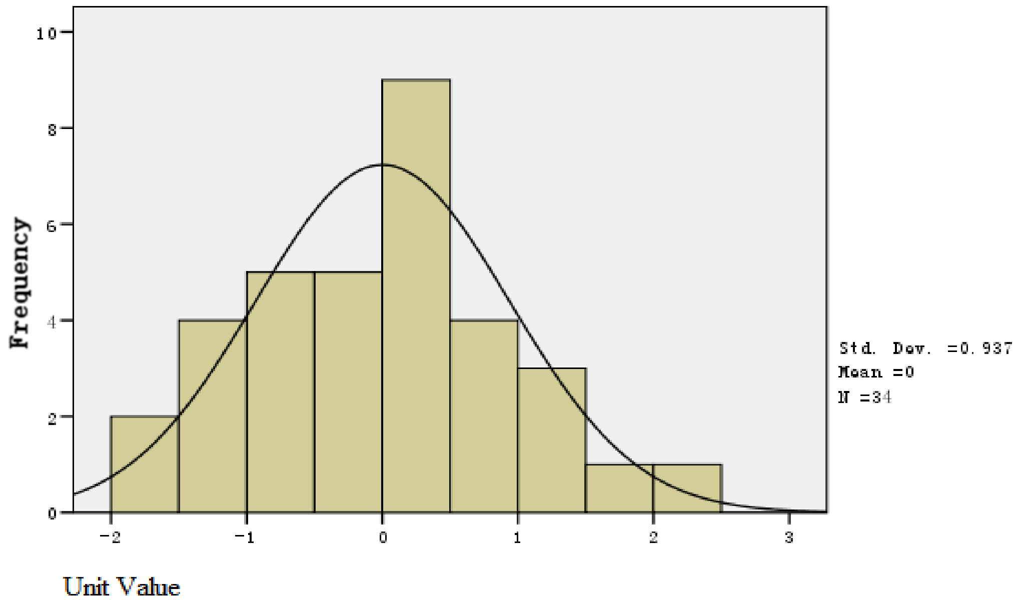

Fig. 4 Histogram of dependent variable after logarithm transformation

As we all know, the adjust R^2 is commonly used as the best measure of the goodness of the model fit and the closer R^2 is to 1, the more completely the independent variables can account for the variation of dependent variable. From Table 6 we can find that the adjust R^2 is 0.511, which means this model built with *DIS-POP* only, can account for 51.1% of the total land value variations and other factors account for 48.9% of the total land values. According to real situation of Laos as the poorest country that the population is the most impact factor to the land market, it is not the same like other country that CBD is the main impact factor in the land market.

(2) Model 2 (DIS-POPU, BUF500CO)

The second variable entering the equation is *BUF500CO*, the second most important variable in explaining land value variations. The adjust R^2 for this model is 0.666, meaning that the two variables account for 66.6% of the variations of the land value variations. We can see that the entry of *BUF500CO* increase R^2 only by 9.1%. Therefore, *BUF500CO* is obviously not as dominant as *DIS-POP*. The regression model now is as follows:

$$LogY = 18.391 – 0.449X1 – 0.220X2$$

(3) Model 3 (DIS-POP, BUF500CO, VILINCOME)

The third and the last variable to enter the model is *VILINCOME*. The adjust R^2 increases from 66.6 to 75.7, meaning that three variables altogether account for 75.5% of the total variations and *VILINCOME* factor account for only 8.8%, a very small fraction of the total variations. The model can now be written as:

$$LogY = 15.146 – 0.391X1 – 0.274X2 + 0.190X3$$

Among the above 3 models, model 3 is adapted as the appropriate hedonic model since its R^2 is the highest one and closest to 1 and it has the lowest standard error of the estimate.

Table 5 Model coefficient

Model		B	Std. error	Beta	Lower bound
1	(Constant)	17.680	0.553		31.948
	Dis-POP	-0.414	0.073	-0.715	-5.690
2	(Constant)	18.391	0.502		36.609
	DIS-POP	-0.449	0.062	-0.774	-7.257
	BUF500CO	-0.220	0.059	-0.398	-3.733
3	(Constant)	15.146	1.077		14.061
	DIS-POP	-0.391	0.056	-0.675	-6.930
	BUF500CO	-0.274	0.054	-0.495	-5.099
	VILINCOME	0.190	0.058	0.336	3.294

Table 6 Model summary

Model	R	R^2	Adjusted R^2	Std. error of the estimate
1	0.715	0.511	0.495	0.217
2	0.816	0.666	0.644	0.182
3	0.870	0.757	0.732	0.158

3.8 Land price prediction

Land registration and transaction fees (land tax) which issued by the Lao government namely: Decree No. 52/PM, of 13 March 1993, on registration and registration fees, the Ministerial Direction No. 191/MoF, of 10 November 1994, on the registration fees on the issuance of the land title, and the Ministerial direction No. 2232, of 27 November 1997, on the registration rates for the registration on the issuance of land titles were used as the price of the land in the study areas. Based on the result of the data analysis, map of the land tax before and after hedonic price model were produced. Land tax collection rate in the study areas were classified into 6 grades. Fig. 5 and Fig. 6 showed the land tax grade one was ranged from 1,188,673.625 to 1,740,137 LAK (Lao KIP) or from 959.67 to 1,404.89 Chinese Yuan CNY and the land tax grade six were ranged from 2,698,418.052 LAK to 3,493,972 LAK (Lao KIP) or from 2,178.55 to 2,820.83 Chinese Yuan CNY.

3.9 Land price matrix

Table 7 shows the land tax before and after hedonic price analysis. The areas of the land tax grade one and grade two were increased while the areas of the land tax grade three, grade four, grade five and grade six were decreased.

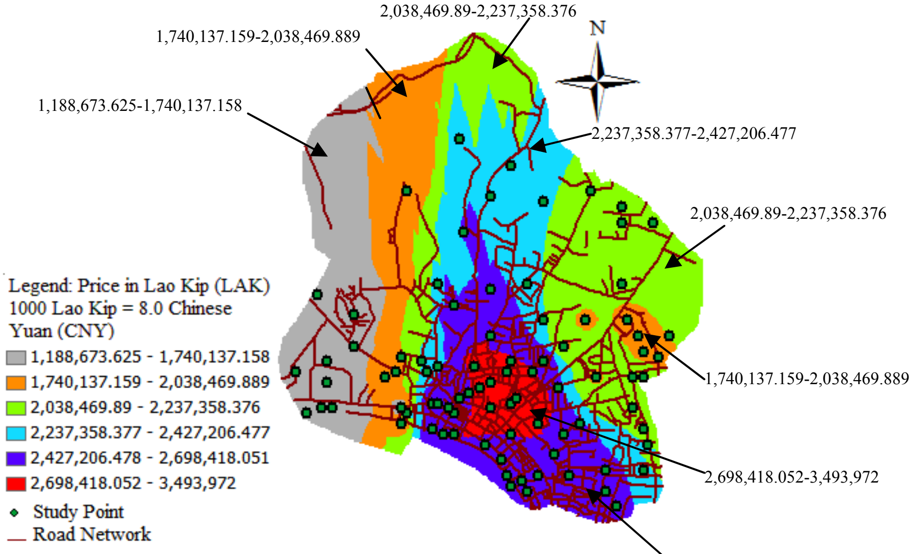

Fig. 5 Land tax map before hedonic price analysis

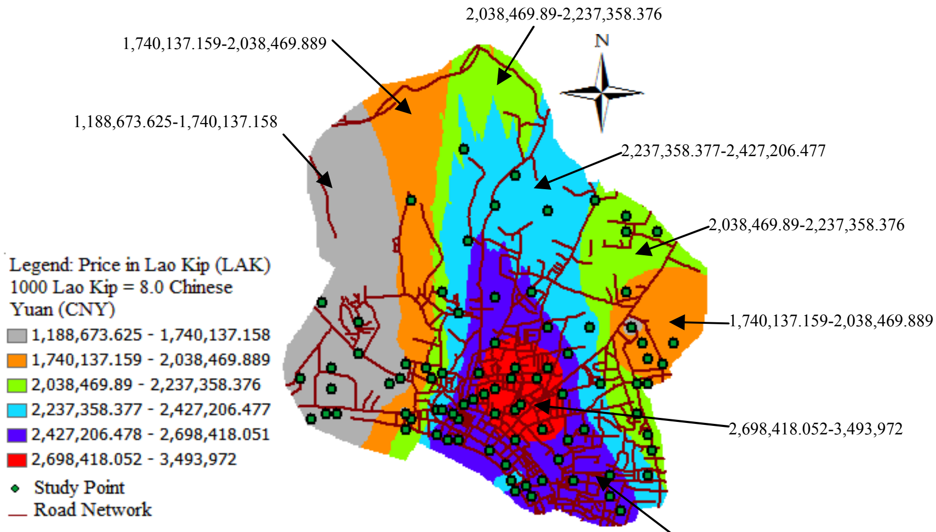

Fig. 6 Land tax map based on model 3

2,427,206.478-2,698,418.051

Table 7 Land price matrix

	Land tax before hedonic price (per ha)							
		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Totals
Land tax after hedonic price (per ha)	Grade 1	301.500	667.440	68.580	0.000	0.000	0.000	1037.520
	Grade 2	0.000	89.730	753.930	38.520	0.990	0.000	883.170
	Grade 3	0.000	1.170	167.220	685.710	26.730	0.000	880.830
	Grade 4	0.000	0.000	85.140	771.120	236.340	7.290	1099.890
	Grade 5	0.000	0.000	8.820	66.690	571.410	203.310	850.230
	Grade 6	0.000	0.000	0.000	0.000	36.000	237.060	273.060
	Totals	301.500	758.340	1083.690	1562.040	871.470	447.660	5024.700
	Different	736.020	124.830	-202.860	-462.150	-21.240	-174.600	

4. Conclusion

In this paper, the authors focused on some part of Vientiane capital city Laos, and nearly 100 villages were selected as the study areas. Hedonic price model has been proposed in order to evaluate the land price characteristics. Arc GIS 9.2 and SPSS were used as the main tool to analyze the data. And based on the data analysis, it found that the hedonic regression model could identify the factors that play important roles in influencing the land value. The distance of the population is the most important factor which influencing to the land value of the study area, followed by school and village income.

Laos is one of the least development countries in the region and so far Laos has had developed the "Land Titling Project" aiming at the development of the land administration capacity to support the country's economic development and poverty reduction goals and the main objectives of the project are to (1) improve the security o f land tenure; (2) develop transparent and efficient land administration institutions at the national and provincial levels; and (3) improve the government's capacity of providing social and economic services through broader revenue base from property related fees and taxes, based on the results of the project Laos has also good methods concerning to land management and administration. But the land valuation method based on the geographical information was not developed in Laos.

In order to support the main objectives of the project and the development strategy of the Lao government, it is necessary to promote the land valuation based on geographical information system, because the role and important of GIS and information technology to natural resources management cannot be ignored. This study only highlights a few uses that it may be employed to land management.

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