

Study for urbanization corresponding to socio-economic activities in Savannaket, Laos using satellite remote sensing

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Abstract. In Greater Mekong Sub-region (GMS), economic liberalization and deregulation facilitated by GMS Regional Economic Corporation Program (GMS-ECP) has triggered urbanization in the region. However, the urbanization rate and its linkage to socio-economic activities are ambiguous. The objectives of this paper are to: (a) determine the changes in urban area from 1972 to 2013 using remote sensing data, and (b) analyse the relationships between urbanization with respect to socio-economic activities in central Laos. The study employed supervised classification and human visible interpretation to determine changes in urbanization rate. Regression analysis was used to analyze the correlation between the urbanization rate and socio-economic variables. The result shows that the urban area increased significantly from 1972 to 2013. The socio-economic variables such as school enrollment, labour force, mortality rate, water source and sanitation highly correlated with the rate of urbanization during the period. The study concluded that identifying the highly correlated socio-economic variables with urbanization rate could enable us to conduct a further urbanization simulation. The simulation helps in designing policies for sustainable development.

1. Introduction

Asian Development Bank (ADB) initiated the Economic Corporation Program (ECP) in the Greater Mekong Sub-region (GMS) in 1992 and is known as GMS-ECP. The GMS-ECP was started to promote mutual economic and social development by strengthening corporation among the GMS basin countries. The GMS basin countries include Cambodia, Lao People's Democratic Republic (Laos), Myanmar, Thailand, Vietnam and Yunnan Province in the People's Republic of China (PRC). The GMS-ECP facilitated the market-liberal policies which provide excellent opportunities to develop the sectors of 1) transportation; 2) telecommunication; 3) energy; 4) human resources; 5) environment; 6) trade; 7) investment; 8) tourism; and 9) agriculture in the region.

The impact of GMS-ECP, for example in case of Laos, can be indicated by the amount of investment, number of projects implemented in different sectors, and the growth of GDP mainly due to the program. Indeed, the total amount invested during 2000-2010 by the top 10 investing countries is 10,660 million US dollar. These donor countries are Australia, China, France, India, Japan, Korea, Malaysia, Norway, Thailand and Vietnam. Among these donor countries, 76.6 percent consists of investment from Vietnam, China and Thailand. Furthermore, the total number of projects implemented during the period is 1,280. Among them, major sectors invested are electricity generation, mining, service, agriculture and industry/handicraft (Investment Promotion Department, 2010). Additionally, the growth of GDP in Laos from 2006 to 2012 shows 6.5 to 8.5 percent by year and this higher growth rates are resulted from the development of resource sectors such as electricity generation, mining, agriculture and service (JETRO, 2013). These developments largely due to the GMS-ECP also



accelerated urbanization by providing basic needs such as infrastructure.

Although the GMS-ECP contributed significantly to the rate of urbanization over two decades, time series change of its rate is not clearly known in least developing country in the region like Laos. In case of developed country like USA, relationships between vegetation amount represented by Normalized Spectral Mixture Analysis (NDVI) and socio-economic variables were studied (Lo, *et al*, 1997; Lo, 1998; and Mennis, 2006). Similar case might be true for countries like Laos; however, literatures linking such changes in Laos including other developing countries in the region is sparsely documented.

Although many researches have been conducted in developing countries relating urbanization affecting land cover but its linkage to the socio-economic activities in sub-urban areas in developing country like Laos is not clearly known. One of the tools to measure the rate of urbanization over time is satellite remote sensing technology. Remote sensing technology is a powerful tool to observe land cover and detect amount of area by assigning classes without direct interaction. This would also help understanding the trend of urban development and interaction between the urbanization and socio-economic variables. Therefore this paper (a) determines the rate of urbanization from 1972 to 2013 by using Landsat MSS, TM and ETM+ remote sensing data and (b) analyzes the relationships between the rate of urbanization with respect to socio-economic activities such as education, literature rate, mortality, environmental facilities, labour force, telecommunication and FDIs in central Laos. This paper is expected to contribute to rank area-specific variables for a next step that is a simulation of urbanization.

2. Data and methods

The data used for this study comprises of Landsat MMS, TM and ETM+ images and information from the ADB that includes education, literature rate, mortality, environmental facilities, labour force, land use, telecommunication and FDIs. The set of images included cloud-free parts acquired from January 22, 1973; December 22, 2000; November 22, 2001; November 10, 2002, December 15, 2003; January 2, 2005; December 15, 2006; November 18, 2007; January 29, 2009; December 15, 2009, December 26, 2010; January 6, 2012, and January 24, 2013. For image interpretation, the study used Environment for Visualizing Images (ENVI) and Earth Resources Data Analysis System (ERDAS) software. The complete process of the study can be envisioned as four major steps: 1) image preparation, 2) image classification, 3) area calculation and 4) analysis of urbanization corresponding to socio-economic activities.

2.1. Image preparation

The first step was to conduct gap filling of the Landsat 7 ETM+ Scan Line Corrector off imageries taken in 2003, 2005, 2007, 2009, 2010, 2012 and 2013 by using ERDAS. After the process, the study created subsets of central Savannaket.

2.2. Image classification

The study applied supervised classification and human visible interpretation in order to identify urban area in time series. For the supervised classification, the study created 30 training data (ROIs) and assigned different colors on each ROIs and conducted Maximum Likelihood classification. The study selected ground points from the latest image available from Google Earth captured in February 2012. The study selected totally 40 ground truth points for the accuracy assessment. The supervised classification showed 79.8 percent of accuracy. As visualization of the images was limited due to the Scan Line Corrector (SLC) problem of the Landsat ETM+, the study considered these accuracy rates acceptable. At the same time, for the human visible interpretation, digitization was done on images visualized by R:G:B (4:3:2) with the reference of GoogleMap and online data source in the ArcMap.

2.3. Area calculation

After checking the accuracy, the study calculated the urban areas generated from supervised classification by ENVI and human visible interpretation by ArcGIS in time series and visualize them.

2.4. Analysis of urbanization corresponding to socio-economic activities

The study obtained socio-economic variables from ADB. The selected socio-economic variables and available time period of data were 1) telephone lines (1960-2011), 2) literacy rate, youth total (% of people ages 15-24) (1995-2005), 3) school enrolment (primary) (1971-2011), 4) morality rate under 5 (per 1,000 live births) (1966-2011), 5) improved water source (% of population with access) (1994-2010), 6) improved sanitation facilities (% of population with access) (1994-2010), 7) labour force (1990- 2011) (1990-2011) and 8) FDI, net inflows (US\$) (1985-2011). The data is available only at country level. However the Savannaket province is the second largest province in Laos; therefore, the study considered that the country level data is applicable to the study area to find out correlations of parameters to the rate of urbanization. Furthermore, it is difficult to find out information of parameter-relating project implementations; therefore, this study considered the yearly data as an input activity. In order to find out scientific correlations between socio-economic variables and the rate of urbanization, the study employed regression model by using Microsoft Excel.

3. Result and discussion

The results are obtained using two methods (Fig1). Different methods showed different rate of urbanization. Such differences might have been occurred due to four technical errors and limitations; namely accuracy error during the gap-filling process; limited spatial resolutions; mixture of pixels; and misclassification of objects. USGU (2004) noted that the gap-filling technique performs well in homogenous landscape such as agricultural fields. However, it is difficult in heterogeneous landscape where feature size on surface is smaller than the local window size (normally 19x19 pixel). One multispectral pixel size of Landsat ETM+ is 30 meter; therefore, 19x19 pixel means 570m x 570m. Objects in the study area can be smaller than this size; therefore, the gap-filling process can be a factor which created errors. Furthermore, Weng (2012) also notes that results from image classifications are not satisfactory in terms of accuracy due to the limited spatial resolution in medium resolution satellite imagery and the heterogeneity of urban landscape mixture of trees, grassed, and soils. Moreover, Bauer *et al.* (2004) noted that as bare soil is spectrally similar to the impervious surface; therefore, these bare were misclassified as impervious surface in the case of the State Minnesota. In comparison to the case of Minnesota, the study area comprises of much bare land. Addition to that, many non-paved roads which are largely observed in the developing countries like Laos can be misclassified as a non-urban area. In this regard, the study found the human visible interpretation is the most accurate. The result from the human visible interpretation showed increase in the urban area from 9,721 square meters in 1973 to 5258,030 square meters in 2013. The urban area identified in 2013 is 541 times larger in comparison to that in 1973. The study utilized this data for the further analysis.

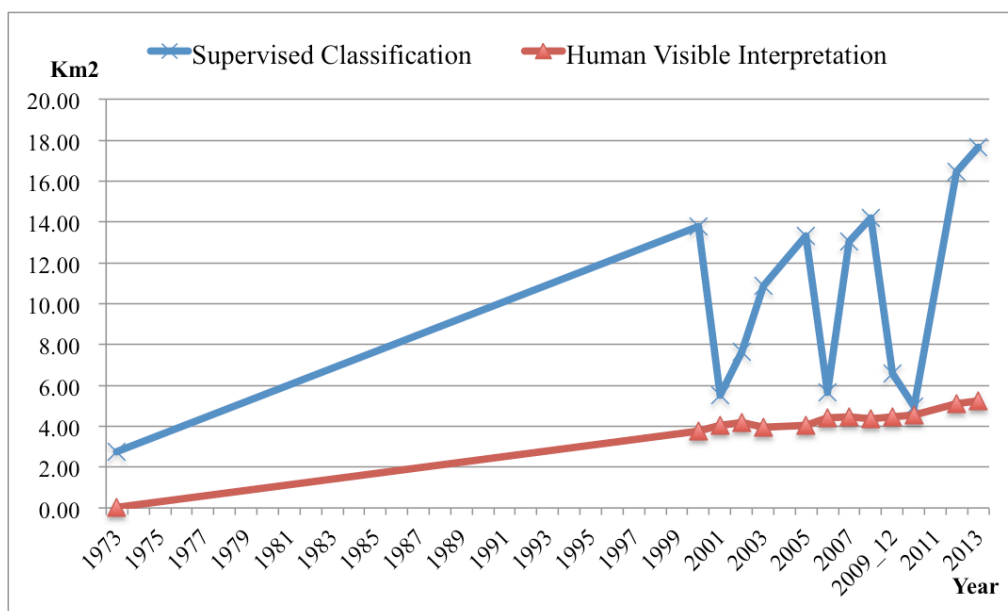


Figure 1. Comparison of urban area calculated by two methods.

Table 1 shows relationships between the rate of urbanization and socio-economic variables resulting from the regression model. As the accessibility of satellite images are limited and the availability of socio-economic data are different by variables, the regression equations were calculated from different range of time period. The study categorized each relationship based on the size of r as 1) very strong (0.9 to 1.0), 2) strong (0.8 to 0.9), 3) moderate (0.6 to 0.8), 4) weak (0.2 to 0.6) and 5) very weak or no relationship (0.0 to 0.2).

Table 1. Relationship between urbanization and socio-economic variables.

	Variables	R
1	School enrolment (Primary)	0.9664
2	Labour force	0.8877
3	Mortality rate, under-5 (per 1,000 live births)	0.8797
4	Improved water source (% of population with access)	0.8717
5	Improved sanitation facilities (% of population with access)	0.8702
6	Telephone lines	0.7497
7	Foreign direct investment, net inflows (US\$)	0.7075
8	Literacy rate, youth total (people ages 15-24)	0.0141

Very strong relationships were found among the variables namely school enrolment ($R=0.9664$). For the relationship between the rate of urbanization and school enrolment, it can be assumed that due to the population growth under the urbanization, provision of basic education to the increase population was highly demanded. As a result, proper educational programs were implemented in order to meet a basic educational demand.

Strong relationships were found among the variables namely labour force ($R=0.8877$), mortality rate under 5 ($R=0.8797$), improved water source ($R=0.8717$), and improved sanitation facility ($R=0.8712$). For labour force, it is obvious that many projects established by donor countries will require huge number of labour force to maintain their productivities. Additionally, Elgin and Oyvat (2013) studied relationships between the level of urbanization and size of informal economy with cross country dataset. The authors found out an inverted-U relationship between urbanization and the share of informal sector explained by the pull and push factors. The pull factor is a factor attracting many

individuals into the urban informal sector due to better employment opportunities and working conditions in comparison to rural area. On the other hand, the push factor is a factor facilitating many small-scale producers in rural sectors to engage in urban informal sectors due to economic damage caused by technical development under urban industrialization. These pull and push factors play an important role during the early stage of industrialization for meeting the demand of labour force. However, the impact of these factors tends to be reduced due to economic development of rural dwellers. As Laos may be considered in the early stage of industrialization, it can be said that labour force in informal sector will be continuously increased in the next a few decades. Thus, in addition to the formal employment opportunities, development of informal sectors in urban area is also a significant factor which increases labour force. For mortality rate under 5, Gong et al. (2012)'s study on urbanization and health conducted in China also pointed out a positive relationship between them. This is explained by 1) difficulty in access to health care, vaccination coverage, and accidents and insured among migrant population; 2) worse urban environmental quality such as air and water pollution; and 3) traffic-related accidents. The result of this study can be also explained by the circumstance observed in China. For provision of basic facility such as water source and sanitation facilities, it can be rationally assumed that urbanization with economic growth may become an opportunity to largely pay attention to basic human needs such as health and environmental facility developments.

Moderate relationships were identified among the variables namely telephone line ($R=0.7497$) and FDI ($R=0.7075$). For the telephone line, it can be assumed that the relationship with telephone line is not so significant due to the higher distribution of mobile phone in comparison to telephone line in Laos. In fact, the mobile cellular subscription (per 100 people) in Laos was reported at 3.6 in 2004 and 64.56 in 2010 (Trading Economics, 2013), which is approximately 18 times higher than it was in 2004. For the FDI, Sabu (2013) found a positive relationship between FDI growth and urbanization; however, it is not so significant in this study. This difference can be caused because of difference in targeted investment sectors among China and Laos. Chinese FDI is highly related to export-oriented industries which require establishment of many manufacturing industries. On the other hand, the main sectors largely invested in Laos are electricity generation, mining, service, agriculture and industry/handicraft which have not been largely carried out in the study area. Therefore, the relation between two were not so significant in this study.

Very weak or no relationship was identified among the variable namely literature rate (total youth) ($R=0.0141$). As data from the regression model was calculated by the data from 2000 to 2011, the study interpreted that literacy rate among youth has been developed already several decades before. Indeed, literacy rate of youth showed 71.13 percent in 1995; 80.6 percent in 2000; 78.46 percent in 2001; and 83.93 percent in 2005 (Index Mundi, 2013).

4. Conclusion

This study examined the change in the rate of urbanization in time series utilizing Landsat MSS, TM and ETM+ remote sensing data obtained from 1973 to 2013. The result from the human visible interpretation showed increase in urban area from 9,721 square meters in 1973 to 5,258,030 square meters in 2013 that is 541 times larger in comparison to that in 1973. The socio-economic variables such as school enrollment, labour force, mortality rate, water source and sanitation were highly correlated with the rate of urbanization during the period. Identifying the highly correlated socio-economic variables with urbanization rate could enable us to conduct a further urbanization simulation. The simulation helps in designing policies for sustainable development.

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