Management of LUCC and Land-Use Transition in Phuket Island, Thailand

Orawit Thinnukool, Noodchanath Kongchouy, and Cornelia B. Appianing

***Abstract*—This study examines the problem from the different land-use data set from Thailand department of land development, that caused the use of uncertain land-use change code (LUCC). The LUCC previous which was classified didn't correlate to the new LUCC, hence it couldn't be used as a historical information. We classified LUCC from geographic information system data (GIS) into land-use change mapping for Phuket island from 1967 to 2000. The LUCC were classified and displayed in thematic map format in 1:1000 and demonstrated in freely available software. The results showed that the occupation of land-use in Phuket in 4 period by the unity LUCC will help the land-use planning and land-use policy for the future.**

***Index Terms*—Land-use code/ land-use cover (LUCC), Phuket island, GIS, thematic map.**

I. Introduction

Remote sensing data contain a lot of information that needs to be extracted, such as imagery, land properties, land valuation, soil data, and geography[1]-[3]. Thailand still owes its development to an agricultural base and part to the heavy industries. The important products such as para rubber, rice, mining, and palm are the natural resources that helped power the growth of Thailand's economy including tourism services. That cause is a direct effect to land-use changes. In Thailand, Ramesh focused on the land-use in Chang Mai area by secondary classification data from aerial photographs [4]. Raine studied land-use change in Chanthaburi province which was coastal zone especially agricultural area changes to different categories [5]. They also used the differences of LUCC to classify land-use.

Land use in the Phuket Province is very important because there are many land-use types, such as communities, factories, building, institutions, commercial, service and others such as allocated land project [6].

Phuket and its surroundings have been experiencing severe environmental problems, such as land transition, and deforestation in order to promote tourism in the cities.

Mostly, land utilization around the island has expanded without planning and good management or without following the plan to development. Land use data of Phuket have stored in ordinary format which much was constrained and used with GIS software and demonstrated in analog format. The land-use data with LUCC in the past and now have different relationship.

In the past, land-use and land-cover data had been sampled from digital land-use and land-cover files obtained from the USGS organization in the USA. The development of land use and land-cover characteristics has been defined. Some of land-use categories in US didn't correspond to UNESCO vegetation (the land-use categories have been defined by UNESCO). The classification has been defined into different names of LUCC but it can be used as information because the different countries have distinct definition for the LUCC [7].

Land-use classification is one point that refers to a representative of the area. It would be to consider the land-use categories. The conception of the Los Angeles country planning commission was also suggested to classification of land-use categories and how to define colour for land-use [8].

The basic step for classifying land-use category is to provide a good information to the system or tools to analyse land-use change in the future especially in Thailand.

Although, land-use classification can be classified by tools of GIS program some of them didn't correspond to real area. The difference in LUCC caused confusion in the land-use categories. Normally, LUCC are classified within 6 classes such as in Australia [9]. Classification for LUCC is as follow; Conservation and natural environments, Production from relatively natural environments, Production from dry-land agriculture and plantations, production from irrigated agriculture and plantations, intensive uses and water [10].

In Thailand, in 1967 Thai department of land development collected LUCC into 6 classes but in 1975 the LUCC had each type in sub-class. The problem was that growth of new LUCC changed to new categories which were not unified by LUCC [11], [12].

This paper will explain and discuss the unification of LUCC and show land-use change for example area in Phuket Province, Thailand. The map will be displayed in thematic map format in 1:1000 scale by R program. This program will compute the land-use map same as the license software such as Arc GIS. Restructuring LUCC provides unity of LUCC which will be assessed in this paper.

II. Land-Used Record

A. Definition of the Study Area

The study was conducted in Phuket province in Thailand. The island is mostly mountainous with a mountain range in the west of the island and from north to south of the island. The study area covers 543 square kilometers in three districts:

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Mueang Phuket, Kathu, and Thalang, situated along the Andaman Sea. The geographic location is between latitude 07°53'N and longitude 98°24'E (see in Fig. 1).

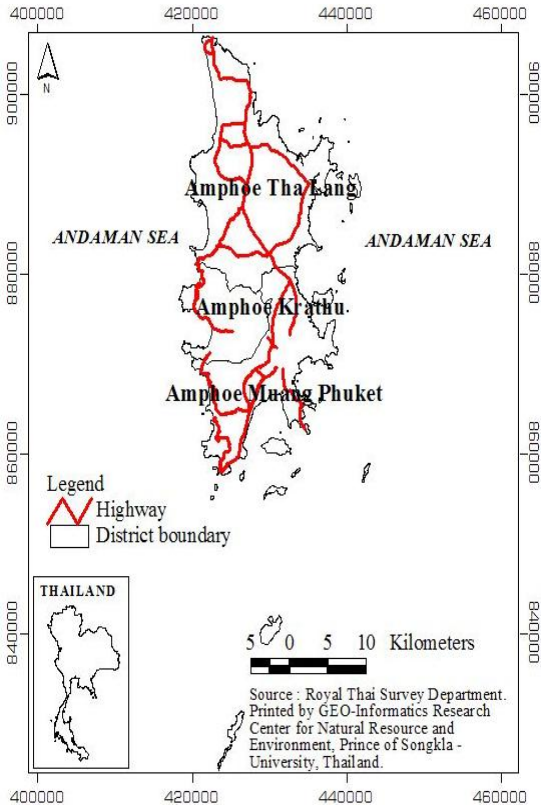

Fig. 1. Map of Phuket Island, Thailand.

B. Thailand Land-Use Record

Pattern for advantages of land-use have been increasing in Thailand since 1980 and these data contain a lot of information that needs to be extracted. The Thailand Department of Lands has recorded land-use for many specified categories, such as "transplanted paddy", "Para rubber", "rain forest", "village", "shrimp farm", "mixed orchard" in hundreds of plots within every sub-district of Thailand. The data collections of land-use have been stored in different forms where the project surveys would be of much benefit to the economy and also follow the national economic development plan. All of land-use categories in Thailand have been explained by LUCC such as in 1967 LUCC identified the infrastructure group and AXX code for agricultural group.

The problem is how to define the LUCC change since land use in 1967 has been replaced by new LUCC. Thematic map such as colour-codes of the polygonal is one problem which is a change in the outcome.The basic data sources are the remote sensing data in 1967-2000. We gauge the data from Landsat based on the topographic map at the scale of 1:1000 from shape file format. Thai department of land development has classified the LUCC into 3 level such as level 1 (explains main land use area), level 2 (contribute to type of main land use area) and level 3 (demonstrate the detail in Table I).

Land-use data stored in the data base of the Thai department of land development and thus, the GIS data from the data base requires the program to support, data that had been collected in shape file that contributed by GIS system. Shape file stored a data such as LUCC, area, point of polygon and the position. The position of land-use in data record have differences because the Department of land development survey only an important project and use the data for beneficial purpose such as project management and project that contribute to the road. When the GIS was used for the project, it did not develop a record that matched into the new data base. LUCC between 1967 till 1985 and 2000 was different, so the data structure could not have been used together at the same time. For instance, the land-use for rubber growing in 1967 (A2) and in 2009 (A302) was impossible to compare due to the differences in LUCC (Show that in Table II)

TABLE I: EXAMPLE FOR LUCC FOR 1967-1975 IN U GROUP FROM THAI DEPARTMENT OF LAND

Level 1	Level 2	Level 3
U	U1, City town	-
	U2, Village	U200, abandoned village
		U201, Village
		U202, Hill tribe village
	U3, Institutional	U300, School
	U4, Transportation	U401, Airport
		U402, Railway station
		U403, Bus station
		U404, Harbor

TABLE II: LAND LUCC OF 1967-1985 (1967 SERIES) AND 2000 SERIES

Descript	1967	2000	Descript	1967	2000
Abandoned paddy	-	A100	Wetland	-	M2
Transplanted paddy field	A1	A101	Abandoned mine	-	M300
Para rubber	A2	A302	Mining Area	U5	-
Teak	-	A305	Soil pit	-	M304
Coconut	A3	A405	Beach	M2	M402
Mixed orchard	A4	A401	Allocated land	-	U200
Truck crop	-	A502	Lowland village	-	U201
Pasture and farm house	-	A7	Urban, Commercial	U1	U1
Abandoned Aquaculture	-	A900	Village	U2	-
Shrimp farm	-	A903	Hotel	U3	U3
Upland forest	F1	-	Infrastructure	U4	-
Disturbed evergreen forest	-	F100	Airport	-	U401
Moist evergreen forest	-	F101	Harbor	-	U404
Beach forest	-	F107	Factory	-	U502
Shrub,Bush	F2	-	Recreation area	-	U601
Mangrove	F3	F106	Golf course	-	U602
Costal Woodland	F4	-	Reservoir woodland	W1	W201
Forest Plantation	F5	-	Mari culture Concession	W2	-
Marsh	M1	-	Un-classification	NA	NA

According to Table II, in 1967-1985 and 2000, the LUCC number was added, for example, LUCC in level 3 gained more detailed. In 1967, F1 was transferred into Upland Forest, but in 2000, it was replaced by F100 and transferred into Disturbed evergreen forest instead. Moreover, in the F category, there was F101, which meant moist evergreen forest. Then considering the difference between LUCC using in 1967 and 2000, it was necessary to re-organize the data structure so that LUCC had the same pattern. Hence, LU-Code in 2000

was applied to transfer the data in 1967 for more detailed mapping and gaining high accuracy.

Another example was the infrastructure in 1967 was (U4), but in 2000, it was divided into Airport, Harbor, Factory, Recreational area, and Golf course, which mentioned that it was re-organized into more detailed specification of land-use information. Thus, it was necessary to re-organize the consistence of applying LUCC.

C. Land-Used Classification

Land-use cover or land-use category, more than 187 countries was visually checked, said Zheng *et al.* [10]. If all countries can be used in the same LUCC, it will be beneficiary to the study of land-use change.

According to the Los Angeles country planning commission, the land just to be classified was distinguished. They classified it into 10 groups starting from 000 to 999, for example 000-099 refer to unused land, 100-199 for open use, 200-299 for farming, 300-399 for residence, 400-499 for commerce, 500-599 for industry, 600-699 for utility, 700-799 for instruction, 800-899 for recreation and 900-999 for problem uses. From above, it is a good idea for separate LUCC to correspond to real world land-use. In Thailand, we modified LUCC in support of the new LUCC in sub-class. Table 2 demonstrated the LUCC of 1967 – 1985 which were re-organized in the same pattern of the LUCC in 2000.

TABLE III: RESTRUCTURE OF LUCC TO THE UNITY OF LUCC FROM 1967 TO 2000.

LUCC	Descript	LUCC	Descript
A100	Abandoned paddy- field	F101	Dense evergreen forest
A101	Rice paddy	F106	Mangrove forest
A205	Pineapple	F107	Beach forest
A205-A302	Pineapple/ Para	M102	Scrub, grass
A219	Sweet potato	M2	Wetland
A301	Mixed perennial	M300	Abandoned mine
A302	Para rubber	M304	Soil pit
A303	Oil palm	M402	Beach
A305	Teak	U100	City, Town
A401	Mixed orchard	U2	Allocated land
A401-A405	Mixed orchard/ Coconut	U201	Lowland village
A404	Rambutan	U201-A401	Lowland / Mixed
A405	Coconut	U3	Institutional
A408	Cashew	U401	Airport
A502	Truck crop	U404	Harbour
A503	Floricultural	U502	Factory
A703	Poultry farm house	U601	Recreation area
A704	Swine farm	U602	Golf course
A900	Abandoned Aquacultural	W201	Reservoir
A902	Fish farm	UN	Unclassified
A903	Shrimp farm	XX-XX	Ratio 50/50%

Although, the LUCC in the unity format can be collected in the real area, it's complicated to analyse land-use change. This is due to the fact that some of the LUCC can be collected in the same group, for example, paddy field and mixed paddy field. New classification for the investigation of land-use change used to group LUCC in Phuket Island.

In addition, Ax, Ux and Mx groups are the main classes of level 2 which still defines the old LUCC because this LUCC needs to be extended in the future when the categories have another group. Some of LUCC such as U2 has been extended to U201 for lowland village. In the future, U group need to be extended to correspond to a type of property for example U202 for a condominium, U301 for bank and U302 for hospital. For example, the real LUCC data from Thai department of land development and department of agricultural has been managed corresponding to old LUCC record. We compute the program to change the LUCC of old LUCC series in 1967 for using to 2000 (up to date). An example will demonstrate the classification for change LUCC follow in Fig. 2.

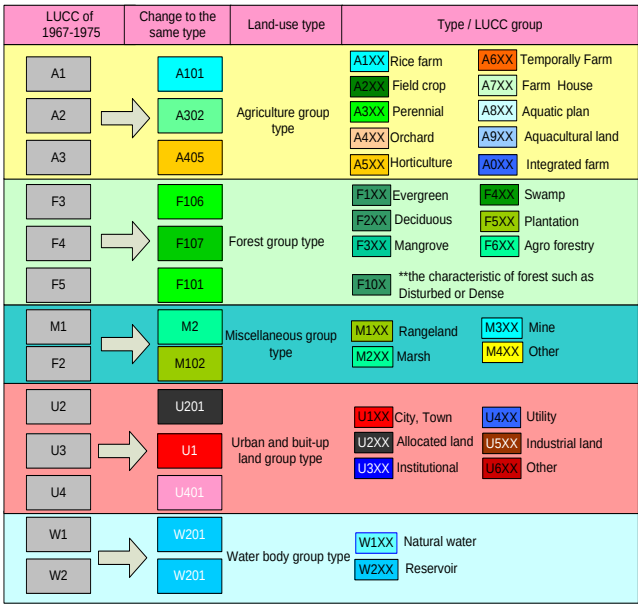

Fig. 2 Managed for LUCC data from Thai department of land development and department of agricultural. Note that some of LUCC has been changed to other type. Type /LUCC group indicated the sub type of LUCC for classification land-use form 1967-2000.

III. PHUKET LAND-USE

For example to use LUCC for Thailand, we compute the thematic map by R program. Current land-use for Phuket island since 1967-2000, four panels of mapping were conducted through digitization interpretation and the land-use categories were classified by the type of land-use.

To see occupation of land-use type of Phuket, thematic maps are useful to show the total land-use during 4 periods (show in the Fig. 1). Majority of the land-use only in 1967 and 1975 were found to be covered by forest group (FXX) and decrease in each year. An agricultural group (AXX) area increased in the following years; 1975, 1985 and decreased only in 2000. This is due to the fact that, in 1985-2000 majority of agricultural areas were mining areas, while some areas were been converted to abandoned mining areas. Other land-use categories, such as A4XX of LUCC were small in number every year. The urban area (UXX) was increased since 1967 to 1985 and increased again in 2000.

This caused agricultural categories to change to urban groups by property investment. Note that Z0 was a sea area around Phuket Island in the thematic map. Number of occupation of land-use types of Phuket will be shown next to LUCC label in hectare unit converter. See in Fig. 3(a)-(d).

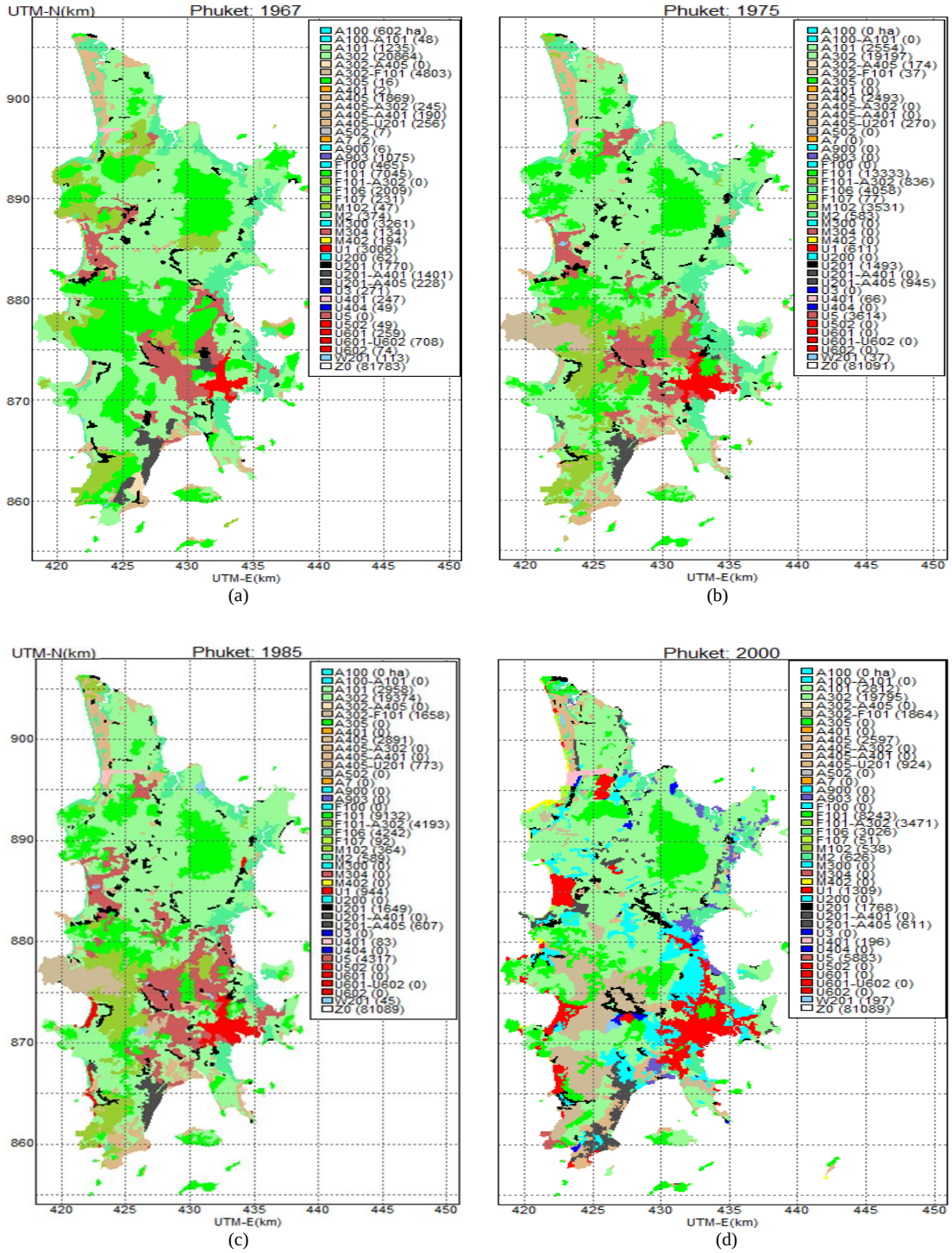

Fig. 3. Summary of occupation of land-use type of Phuket from1967-2000 in 41 groups of the classification.

IV. Conclusion

This article expands the problem for LUCC of Thai land-use data from 1967 to 2000 it's classified the LUCC for unity of Thai land-use data.

In our study, we classified the LUCC of Phuket Island to correspond to the new LUCC. The result showed land-use occupation very clearly by thematic map using freely available software; R program. This study, gives more idea for the management of LUCC in the clouded area in the big city of Phuket. Suitable data management can be further researched into Thus:

1) Change of LUCC to unity code would be extended to cover all the land-use type corresponding to real area.
2) Land-use data would be analysed by comparison and show land-use loss and gain.

What we have to do next, we will develop program to compute land-use data from polygonal shape to raster format which can analyze land-use change by a high statistical analysis especially third country in the world.

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