

Land Use Changes in Pak Panang Bay using Aerial Photographs and Geographic Information System

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ABSTRACT

This study investigates land use changes around Pak Panang Bay, Nakhon Si Thammarat Province by using aerial photographs and geographic information system techniques. The aerial maps on 1:15,000 scale produced by The Royal Thai Survey Department in 1974, 1991 and 2003 were interpreted as a land use map in each year. The land use map of 1974 was then compared to those maps of 1999 and 2003. A prominent result of this study revealed that shrimp farm areas around the bay dramatically increased from zero hectares in 1974 to 1,954 hectares in 1995 and expanded to 2,592 hectares in 2003. An increase in shrimp farm areas in Pak Panang Bay in 2003 concurred with a decrease in 1,114 hectares of mangroves, 918 hectares of paddy fields and 560 hectares of other types of land uses in 1974, respectively. The severe expansion of shrimp farm areas into the mangrove areas has directly affected the eco-system of Pak Panang Bay, which was declared a Ramsar Site in 2000. The results of this study could be used for the management and conservation of the bay in order to meet the regulation standards of the Ramsar Site Convention.

Keywords: Land use, Pak Panang Bay, GIS, aerial photograph

INTRODUCTION

Pak Panang Bay, Nakhon Si Thammarat Province is approximately 14 kilometers long with a width of 3 kilometers at the mouth of the Pak Panang River to nearly 10 kilometers at the entrance to the bay, covering an area of nearly 126 square kilometers. The morphology of Pak Panang Bay is dominated by an elongated hook called Laem Thalumpuk, which in 1962 was hit by Typhoon Harriet with wind speeds of 90 kilometers per hour, killing more than 1,000 people and injuring 422 [1]. Pak Panang Bay was declared a Ramsar Site in August 2000. The declaration shows the importance of Pak Panang Bay as a perfect ecosystem, playing an essential and valuable role in the support of the livelihood of humans, plant and animal species. It is also important for ecological, economic, social and political sustainability at local, national and international levels [2]. In order to meet the international regulation standards of the Ramsar Site, many conservative measures will be set up to protect Pak Panang Bay such as a monitoring plan to observe ecological change, a zoning plan to prevent land intrusion, a pollution control plan at polluting sites such as agricultural communities and other activities [3]. Unfortunately, the general public including public and private organizations around Pak Panang Bay has not yet been informed of the value and the genuine benefits of Pak Panang Bay as a Ramsar Site. This ignorance leads to carelessness and land misuse in this area. For example, the expansion of shrimp farming into the mangrove and paddy field area causes water and soil pollution around the bay [4,5].

The objective of this research project was to examine changes in land use around the Pak Panang Bay by using a combination of aerial photographs and geographic information system techniques. The results of this project could be used as a guideline for conservation and management and for continuous monitoring of ecology around the bay, the activities which are required by the Ramsar Site Convention.

MATERIALS AND METHODS

Materials and Equipment

- Aerial photographs of 1974, 1995 and 2003 on 1:15,000 scale, pertaining to the Pak Panang Bay, produced by The Royal Thai Survey Department.

- Topographic map on 1:50,000 scales, pertaining to the Pak Panang Bay, produced by The Royal Thai Survey Department.
- Computer software, including PC ArcInfo version 3.5.1, Arcview Version 3.1 and Intergraph.

Methods

Preliminary methodology involved the rectification of digital aerial photographs by using Ground Control Points (GCPs) of a topographic map. Once the aerial photographs were rectified, they were transformed into the ArcInfo format. Further methodology involved the classification of land use of Pak Panang Bay from three periods; 1974, 1995 and 2003. By visual interpretation from aerial photographs, the land use was classified into 8 categories; 1) shrimp farms, 2) paddy fields, 3) village-mixed orchards, 4) mixed orchards, 5) mangroves, 6) river, 7) sand beaches, and 8) barren. With the overlaying technique provided by ArcInfo, the land use of a 1974 map was overlaid with a 1995 map and then a 2003 map respectively. The resulting map led to the land use changes map of Pak Panang Bay.

RESULTS

The study focused on finding the land use changes around Pak Panang Bay, Amphur (district) Pak Panang - Nakhon Si Thammarat Province covering Tambon (sub-district) Laem Thalumpuk, East Pak Panang, West Pak Panang, Kong Noi and some parts of Tambom Khong Krabue and Bang Pha. The results of overlaying the land use of a 1974 map with those of 1995 and 2003 maps showed that there were explicit changes in land use around the bay during the 29 years from 1974 to 2003 (**Figures 1 and 2**). The area of paddy fields, mixed orchards, sand beaches, mangroves, barren and river decreased by a total of 2,046, 392, 380, 242, 88, and 2 hectares respectively. By contrast, the area of shrimp farms and village-mixed orchards increased by a total of 2,592 and 1,242 hectares respectively (**Table 1**).

The major change of land uses in this area was a rapid expansion of shrimp farms. It was found that an increase in shrimp farm area to 2,592 hectares in 2003 was due to decrease in other types of land use in 1974 as follows: converted from mangrove area, 1,114; paddy fields, 918; village-mixed orchards, 245; mixed orchards, 196; sand beaches, 68; barren, 50 and river, 1 hectares (**Table 2**).

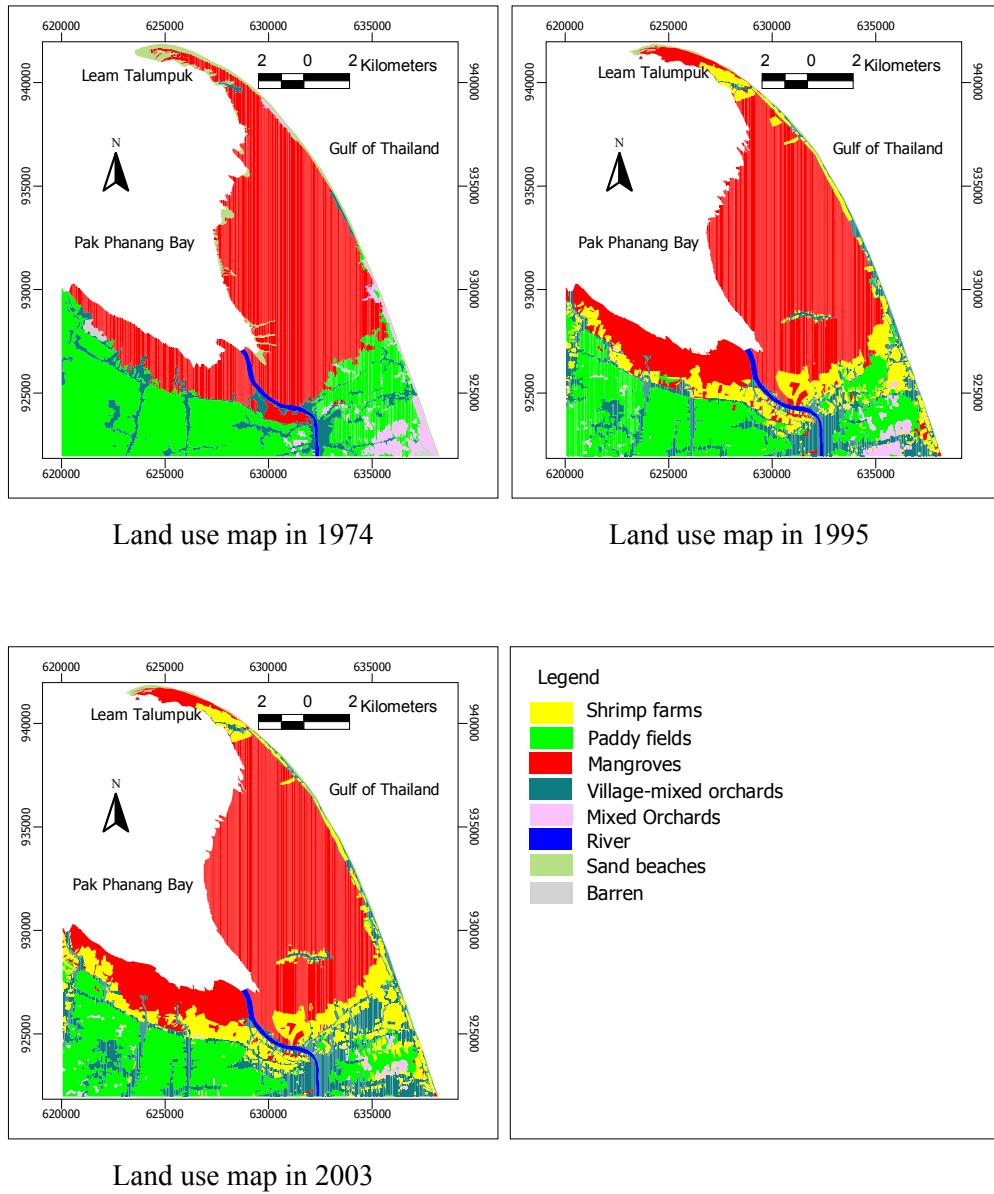


Figure 1 Land use maps after classification for 1974, 1995 and 2003.

Table 1 Land use changes after classification for 1974, 1995 and 2003.

Land use types	Area (hectares)			Change (hectares)		
	1974	1995	2003	1974-1995	1995-2003	1974-2003
Shrimp farms	-	1,954	2,592	+1,954	+638	+2,592
Paddy fields	5,350	3,734	3,304	-1,616	-430	-2,046
Village-mixed orchards	1,153	2,254	2,395	+1,101	+141	+1,242
Sand beaches	533	146	153	-387	+7	-380
Mixed orchards	601	318	209	-283	-109	-392
Mangroves	8,928	8,743	8,686	-185	-57	-242
River	144	142	142	-2	-	-2
Barren	88	-	-	-88	-	-88
Total	16,797*	17,291*	17481*	+494	+190	+684

* Areas derived from aerial photographs in 1974, 1995 and 2003 by visual interpretation, the difference in total area in 1995 and 2003 is due to increasing mangrove areas in Pak Panang Bay.

Table 2 The increase in shrimp farm area in Pak Panang Bay in 2003 due to the decrease in other types of land use in 1974.

Year	Land use types	Area (hectare)	%
1974	Mangroves	1,114	42.98
	Paddy fields	918	35.42
	Village-mixed orchards	245	9.45
	Mixed Orchards	196	7.57
	Sand beaches	68	2.63
	River	1	0.01
	Barren	50	1.94
2003	Shrimp farms	2,592	100

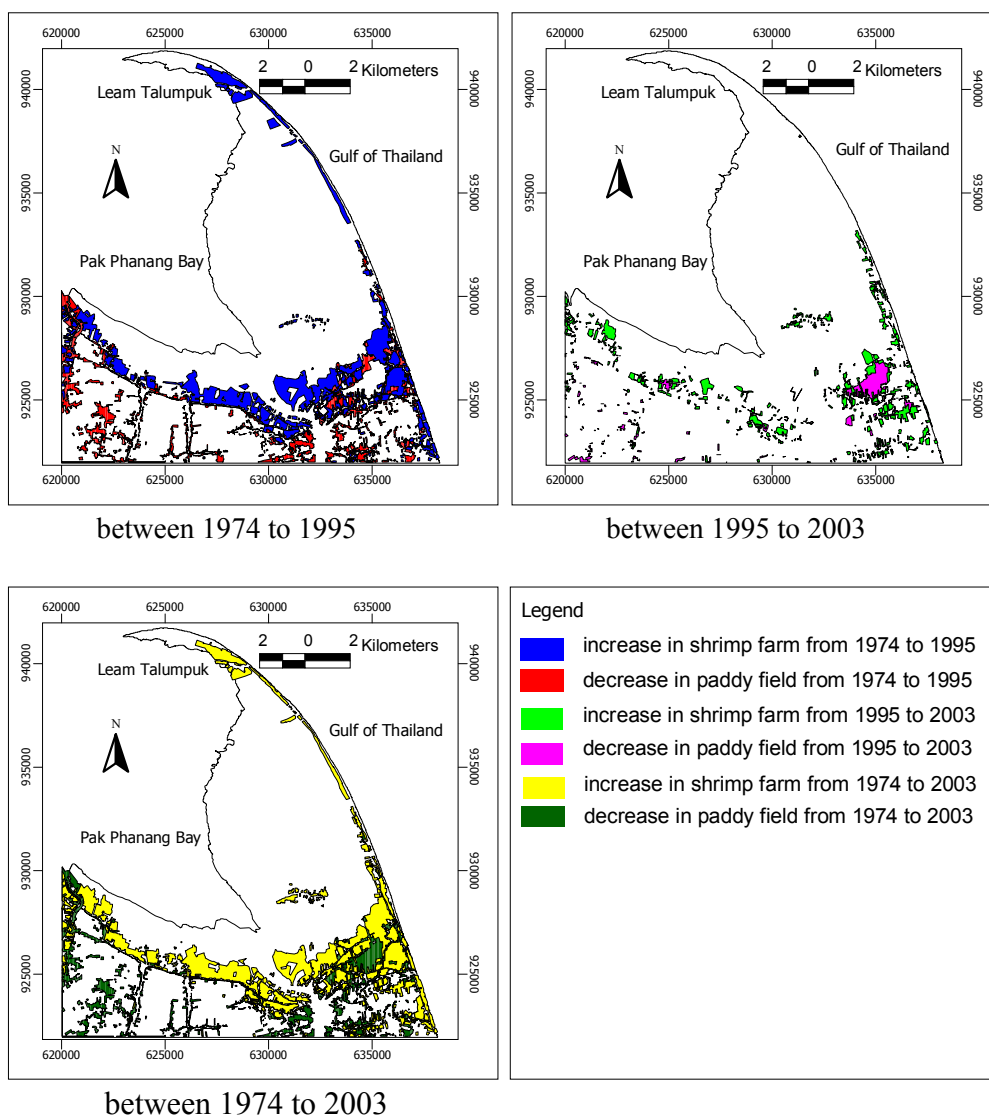


Figure 2 Land use changes between 1974, 1995 and 2003.

DISCUSSION AND CONCLUSIONS

The results of overlaying the land use 1974 map with those of 1995 and 2003 maps show that land uses around Pak Panang Bay have changed during the 29 years between 1974 and 2003. It was found that the major change of land uses in this area was the rapid expansion of shrimp farm areas, which increased from zero hectares in 1974 to 1,954 hectares in 1995 and expanded to 2,592 hectares in 2003. The increase in shrimp farm area was mostly due to a decrease in mangrove and paddy field areas. This disaster occurred because shrimp farming had become a highly profitable agricultural enterprise [6]. Even though 1,114 hectares of the mangrove areas was converted into shrimp farms, the total area of mangroves was only reduced by 242 hectares due to an increase in mangrove plants growing on sediment areas around the bay. The reduction of mangrove forests caused a deterioration in the ecosystem around the bay. This is because mangrove forests were working as a nursing ground for juvenile animals, as a screening tool for reducing toxics and sewage running into the bay and as a shield to prevent coastal damage from natural hazards [7]. Further, activities of the shrimp farms have harmful effects on the environment of the bay. Most of the farms in the area adopt a system of an intensive farming for shrimp production, which only aim for high yields. Thus, more chemicals and antibiotics are used for success. Whenever wastewater is drained out of the shrimp pond (mostly without treatment), these materials are left to pollute the environment [8]. Saline water from shrimp farms could penetrate into the adjacent paddy fields and then damage the physical and chemical properties of the paddy field's soil, leading to inhibited rice growth and low production [4,9].

The use of this Geographic Information System (GIS) to study the land use changes around Pak Panang Bay has become an effective tool for understanding more clearly the whole picture of land use changes. In order to preserve and protect the environment around the bay, the suggestions of this study are as follows:

- 1) Educate the public about the importance of the Pak Panang Bay as a Ramsar Site and raise public awareness among the communities around the bay especially in Tambon Laem Thalumpuk, East Pak Panang, West Pak Panang, and Kong Noi where numerous mangrove forests have been converted to shrimp farms.

- 2) Control land use by zoning the area around the bay especially the mangrove forests. As stated before, mangrove forests work like a barrier to protect the ecosystem of the bay, a land zoning may help to

compromise the utilization of mangrove forests and prevent land intrusion. A dummy-zoning plan may be implemented as follows: a) *Preservation zone* may be defined as an area that will not allow activities other than academic research. In this area, emphasis is given to maintaining environmental and ecosystem integrity, conserving biological diversity and enhancing wildlife habitats. Within the preservation zone, existing national conservation legislation, including the National Park Act and Wildlife Conservation Act, should be strictly enforced by the authorities concerned [10]. This area will be the inner area around the bay where the mangrove forests are not disturbed. b) *Buffer zone* is defined to protect the preservation zone from exploitation and degradation [10,11]. Within this zone, areas adjacent to the preservation zone should focus on protection through enrichment and improvement of mangrove forests while areas in close proximity to the development zone should focus on rural community development [10,12]. Recently, buffer zones have been proposed in developing countries to halt further encroachment arising from increasing pressure for agricultural and aquaculture land by subsistence farmers [10,13]. c) *Development zone* is designated as a multipurpose economic development zone where local communities are free to pursue a variety of income-producing activities including agriculture, aquaculture and tourism, for example, the area at the end of Laem Thalumpuk with a potential to be developed as a tourist attraction.

3) Encourage public participation relating to the zoning issue and promote a tripartite agreement among local communities, government functions and academic institutes.

4) Seriously control pollution discharged into waterways, which penetrates into paddy fields from shrimp farms.

5) Promote environmental friendly technologies for shrimp farming and set up a goal of sustainable aquaculture. There are two keywords that may help to approach friendly aquaculture:

Organic aquaculture: An aquaculture system in which food production is managed as an integrated, whole system where all individual parts are meshed together. All parts of the operation are connected to each other: the nutrient inputs, the shrimps, the environment, and the waste. The use of antibiotics, genetically engineered organisms, or animal products in the feed is prohibited under most organic culture system standards [14].

Recirculating system: Recirculating systems are closed, or semi-closed, systems in which most, or all, of the water is recirculated throughout the system and very little is discharged. Water that would

otherwise be discharged as waste is treated and recirculated for re-use within the system [14].

6) Reforestation of mangrove forests in the areas that are not used by shrimp farms or other activities.

7) Continuously monitor the area by using the technology of aerial photography and satellite image incorporated with GIS for proper planning of area use. To remain effective, the land use changes map needs to be updated on a regular basis, preferably every five years. In this regard, remote sensing and GIS techniques have significant advantages over the traditional use of paper maps for their rapid ability to update data [10].

In summary, the work reported here has illustrated how Geographic Information System (GIS) technologies could be effectively used to investigate land use changes around Pak Panang Bay. The dramatic increase of shrimp farm areas into the mangrove areas has directly affected the eco-system of Pak Panang Bay. It is hoped that the suggestions in this study will be used for the management and conservation of the Pak Panang Bay in order to meet the regulation standards of the Ramsar Site Convention.

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บทคัดย่อ

พิภพ ปรามณรงค์ และ สุธีระ ทองขาว

การเปลี่ยนแปลงการใช้ที่ดินบริเวณอ่าวปากพนังโดยใช้ภาพถ่ายทางอากาศและระบบสารสนเทศทางภูมิศาสตร์

การศึกษาการเปลี่ยนแปลงการใช้ประโยชน์ที่ดินบริเวณอ่าวปากพนัง จังหวัดนครศรีธรรมราช โดยการจำแนกการใช้ประโยชน์ที่ดิน และซ้อนทับข้อมูล จากภาพถ่ายทางอากาศ มาตราส่วน 1:15,000 ปี พ.ศ. 2517 ปี พ.ศ. 2534 และปี พ.ศ. 2546 ของกรมแผนที่ทหารบก ร่วมกับระบบสารสนเทศทางภูมิศาสตร์ ผลการศึกษาพบการเปลี่ยนแปลงที่สำคัญในช่วงระหว่างปี 2517 ถึง 2546 คือ การขยายตัวของพื้นที่เพาะเลี้ยงกุ้งกุลาดำอย่างมากบริเวณรอบอ่าวปากพนังจากไม่มีเลยในปี 2517 เป็น 12,212 ไร่ (19.5 ตารางกิโลเมตร) ในปี 2534 และเพิ่มขึ้นเป็น 16,197 ไร่ (25.9 ตารางกิโลเมตร) ในปี 2546 ตามลำดับ ทั้งนี้พื้นที่เพาะเลี้ยงกุ้งที่เพิ่มขึ้นเปลี่ยนแปลงมาจากพื้นที่ป่าชายเลน 6,962 ไร่ (11.1 ตารางกิโลเมตร) พื้นที่นาข้าว 5,736 ไร่ (9.2 ตารางกิโลเมตร) และอื่น ๆ อีก 3,499 ไร่ (5.6 ตารางกิโลเมตร) การเพิ่มขึ้นของพื้นที่เพาะเลี้ยงกุ้งในบริเวณพื้นที่ป่าชายเลน ได้ก่อให้เกิดผลกระทบโดยตรงต่อระบบนิเวศของอ่าวปากพนัง ซึ่งได้รับประกาศให้เป็นพื้นที่ชุ่มน้ำ (Ramsar Site) ตั้งแต่ปี 2543 ผลของการศึกษาสามารถใช้เป็นข้อมูลในการจัดการและอนุรักษ์อ่าวปากพนังให้เป็นไปตามข้อกำหนดของการรักษาพื้นที่ชุ่มน้ำ