

USING THEOS IMAGERY TO MONITOR LAND USE CHANGE IN NONG HAN CHALERMPHRAKIAT WETLAND PARK, SAKON NAKHON PROVINCE, THAILAND

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Abstract: This study applied remote sensing technique for mapping and monitoring major land use change over the large geographical area of Nong Han Chalermphrakiat Wetland Park (NHCWP). The study area size is about 112 ha and located about 410669 E and 1909315 N. Since, Sakon Nakhon province government promoted lotus and water lily project in NHCWP aiming to their biodiversity conservation and ecotourism. However, land use and land cover change in this area is one of the most important factor lead to loss of biodiversity. The main objective of this study was to use satellite imagery of Thailand Earth Observation System (THEOS) to examine wetland cover or land use changes in NHCWP. This work analyses environmental changes occurring between 2008 and 2009. We promote multitemporal Geo-link technique from ER Mapper 5.5 software to detect the changes of features cover. Raster to raster images rectification method was performed. We corrected at least 15 Ground Control Points (GCPs) associated with the values of Root Mean Square (RMS) errors < 1.00 of all GCPs. The area changes in the form of raster dataset were converted into binary image files, Band Interleaved by Line (BIL), and imported to ArcView 3.2 software for map annotation. There were 4 main types of land use changed namely; 1) Lotus and water lily area (112, 16 sq m), 2) Aquatic vegetation zone (20,971 sq m), 3) Paddy field (34,498 sq m) and 4) Adventure patch (52,368 sq m). Such land use types were validated their localities using Global Positioning System (GPS) together with actual field survey. The implications of this observation, in terms of the ability of remote sensing to map and monitor land use change are discussed in the context.

INTRODUCTION

Nong Han Chalermphrakiat Wetland Park (NHCWP) in past decade was served as spawning and nursery area of various species of aquatic fauna during rainy season (May-August) annually. Thus, land use and land cover change in this area are the main causes of biodiversity declines (Myers *et.al.*, 2000; Sims, 2010; Vitousek, 1997; Wang, 2010) particularly for freshwater fishes species. The government of Sakon Nakhon Province initiated the lotus and water lily for promoting their biodiversity conservation and tourism purpose. The important issue here is how to balance such project development and wetland conservation. Therefore, landscape mapping of NHCWP was examined their change for understanding aforementioned problem. Since NHCWP is connected with the Great Lake of Nong Han Luang, the biggest freshwater lake in Northeast of Thailand and this lake subjected to Great Mekong sub-regions (GMS). Therefore, anthropogenic disturbance and non-planning development activities of NHCWP will obviously be generated negative impacts to surrounding and vicinity environment.

Remote sensing is a crucial tool for mapping and monitoring land use and land cover change (Richards, 1993; Lillesand and Kiefer, 1994; Liu *et. al.*, 2001; Kennedy *et. al.*, 2009). Change detection method (Doydee and Siregar, 2006; Anongponyoskun *et. al.*, 2011) such as multitemporal Geo-link was promoted to determine landscape patches change in NHCWP. According to Sakon Nakhon province government development plan, NHCWP has been allocated for lotus and water lily conservation zone and adventure area. Wetland cover change is an essential matter to monitor for avoiding environmental problems. The main objective of this study was to use satellite imagery of Thailand Earth Observation System (THEOS) to examine land use changes in NHCWP.

MATERIALS & METHODS

Two dataset of THEOS imageries derived from Geo-Informatics and Space Technology Development Agency (GISTDA) were used as remotely sensed material for image processing. The acquisition date of the first dataset was on December 21, 2008 while the second image was on October 7, 2009. Both images employ the same sensor (Panchromatic) with spatial resolution of 2 X 2 m. Topographical map sheet (5843 III Sakon Nakhon) was used as map reference to the image associated with actual field survey in order to validate the type of wetland patches. The map sheet has scale of 1:50,000 and was published in 1999 by the Royal Thai survey department. This study needed some supporting tools to accomplishment in terms of software and hardware. ER Mapper 5.5 software was used for image processing (ER Mapper, 1997). ArcView 3.2 software brought spatial vector and attribute data. Hardware was included personal computer (PC) Microsoft Windows XP, Intel® Core™ 2 Quad CPU. Global Positioning System (GPS) version eTrex handheld with Universal Transverse Mercator (UTM) coordinate system perform at accuracy of 10 meters or better (Doydee and Siregar, 2006) and Laser Printer.

The study area (Figure 1) is located in Sakon Nakhon Province, Northeast of Thailand. The Size of the study area is approximately 112 ha with locality recorded about 410669 E and 1909315 N. Radiometric and geometric corrections were performed for removing errors in remotely sensed imagery. The image rectification has been done for setting up the multitemporal images to be the same geodetic datum (WGS84) and map projection (NUTM48) and azimuth angle. Pre-image processing was prepared by cropping the image of Area of Interest (AOI).

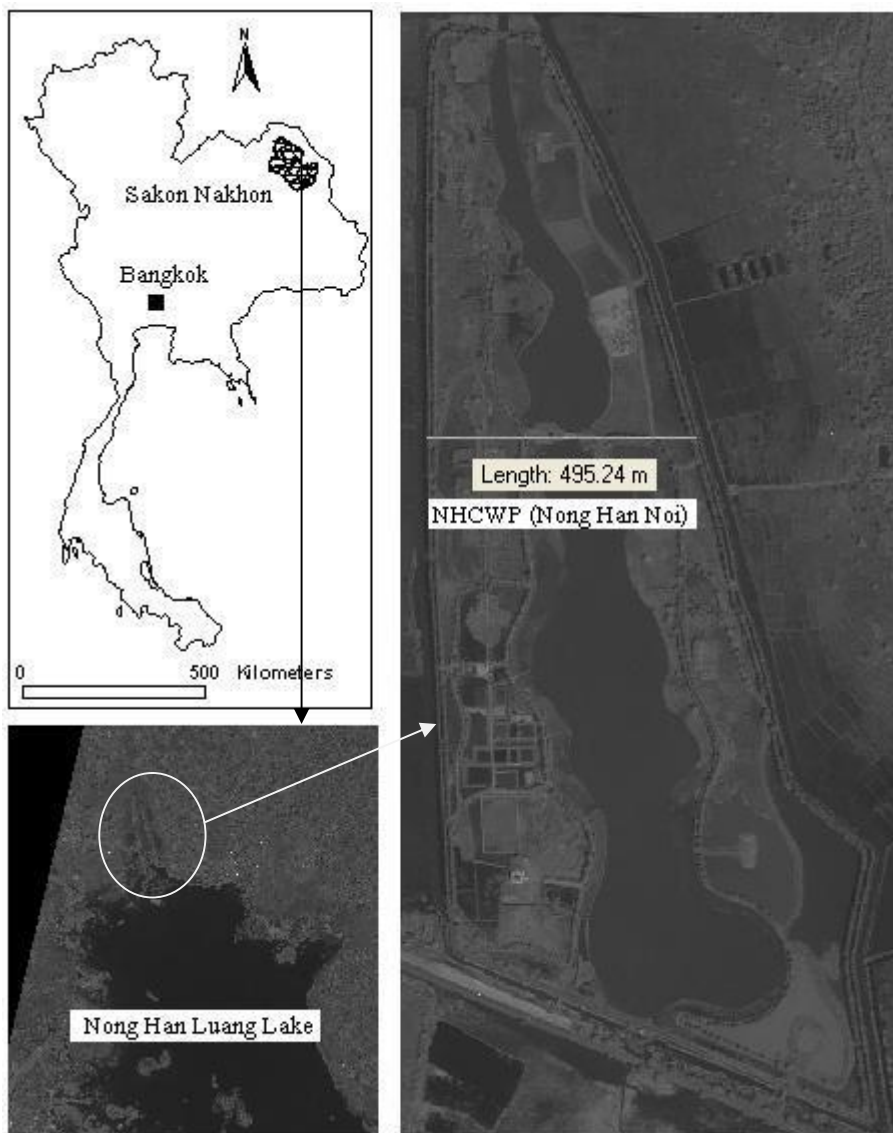


Figure 1: The study area (NHCWP) showing location of Sakon Nakhon Province and Nong Han Luang Lake based on image of THEOS with acquisition date on October 7, 2009 and derived from GISTDA

Before performing multitemporal Geo-link to window technique the corrected of at least 15 Ground Control Points (GCPs) associated with the values of Root Mean Square (RMS) errors < 1.00 of all GCPs must be executed (Table 1). Pixel-base statistic calculation in each land use types was created using screen digitizing method of ArcView 3.2 software. Comparing images to images of each patch or wetland cover changes was described and attribute of land use change was elaborated.

Table 1: The number of GCPs, UTM coordination and values of RMS errors from the raster to raster dataset (THEOS multitemporal images) rectification result, notice all RMS errors showing the values of less than 1.

GCPs No.	Cell X	Cell Y	Easting	Northing	RMS
1	156.98	101.48	409342.34	1910440.19	0.16
2	401.83	106.89	409832.05	1910426.76	0.15
3	510.63	105.98	410050.26	1910426.59	0.37
4	821.65	873.53	410673.81	1908893.37	0.05
5	815.42	1125.40	410661.53	1908391.27	0.11
6	429.20	965.75	409887.91	1908713.92	0.40
7	527.17	1011.23	410084.88	1908622.20	0.27
8	417.99	1031.19	409866.57	1908581.68	0.69
9	494.20	1071.74	410018.92	1908501.54	0.11
10	427.61	789.95	409974.95	1909063.50	0.08
11	543.92	495.95	410117.20	1909649.30	0.07
12	447.23	435.91	409923.97	1909769.99	0.13
13	924.77	942.24	410880.16	1908755.14	0.06
14	665.30	481.02	410360.01	1909677.89	0.10
15	701.75	334.97	410432.86	1909968.68	0.01

RESULTS & DISCUSSION

The results of THEOS imagery with acquisition date on October 7, 2009 in the form of raster dataset were converted into binary image files, Band Interleaved by Line (BIL), and imported to ArcView 3.2 software for map annotation by overlaying with partial images of THEOS imagery with acquisition date on December 21, 2008 and spatial data added in the form of polygon themes. There were 4 major types of land use or wetland cover changed in the study area namely; 1) Lotus and water lily area (112, 16 sq m), 2) Aquatic vegetation zone (20,971 sq m), 3) Paddy field (34,498 sq m) and 4) Adventure patch (52,368 sq m). Such land use types were validated their localities using Global Positioning System (GPS) together with actual field survey.

Among land use types, the lotus and water lily area was the largest patches (112,156 sq m) of changing in the study area. Their shape was polygon (figure 2 and table 1) most of aquatic plant in this patch are subjected to emergent vegetation growing in shallow water and this is the habitat and niche for invertebrate such as snail, bivalves, aquatic insect and benthos. Aquatic vegetation zone showing smallest area changed (20,970 sq m), the change in this area was caused from human activities for land leveling and bush slashing for agricultural purposed such as cassava and sugarcane plantation. Their shape was aligned as elongate (table 1) and since this land use type is located near the upper tip of water body (figure 2) thus it is the habitat for spawning and laying egg of freshwater fish during rainy reason due to the physical characteristics of aquatic environment in which composed of marginal plants and large floodplain area with various species of aquatic flora. Such elements are the best criteria for aquatic animal nursery site. Paddy has a shape as elongate with an area of 34,498 sq m. In 2008 this area was rainfed agricultural area and was changed in to paddy field due to the request from local communities who used to dwell in this area for their livelihood. The paddy field growing sticky rice and Thai jasmine rice using water pumping and small-scale irrigation for better crop production (ton/ha).

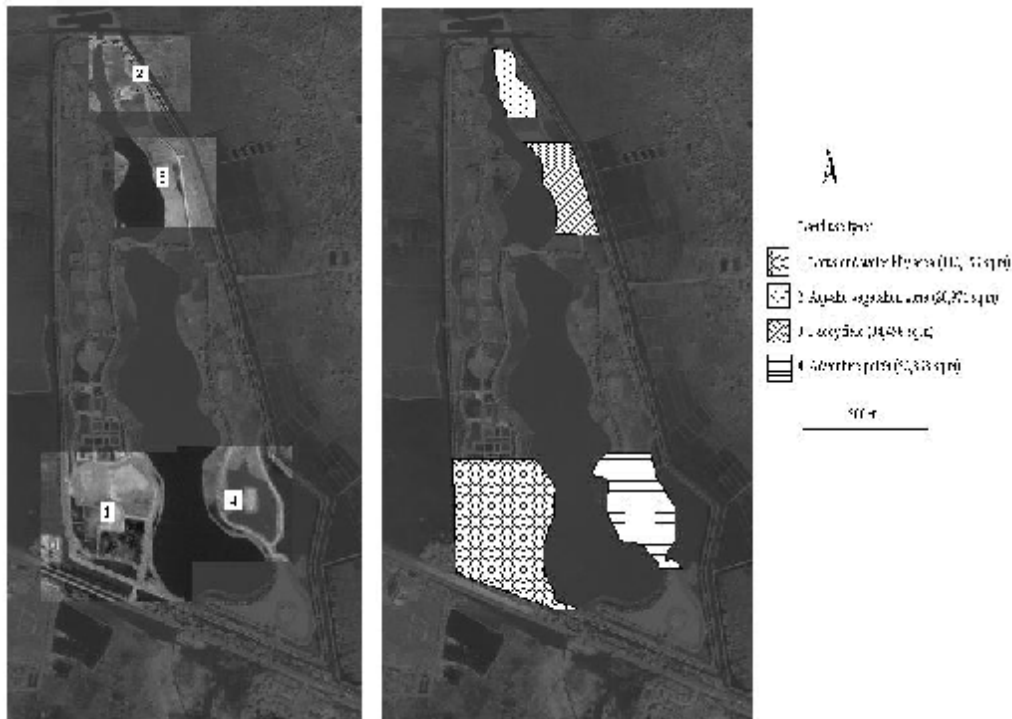


Figure 2: The layout of land use types change in the study area showing 4 major zone namely; 1) Lotus and water lily area (112, 16 sq m), 2) Aquatic vegetation zone (20,971 sq m), 3) Paddy field (34,498 sq m) and 4) Adventure patch (52,368 sq m)

Land use class no. 4 was adventure patch, currently the adventure zone project have been developing to establish the complex of ecotourism and related activities for example fishing game, camping, canoeing, bicycling and pseudomountain climbing. Adventure patch has polygon shape and is located at the lower right corner of study area. Their habitat types were bare soils with marginal vegetation (table 2). The ecotourism is one of attractive activity for tourists but they need to understand the impact of human that may disturb to the nature. Thus, the balance of ecotourism project and natural resources conservation must be taken into account (Nash, 2009; Karanth and DeFries, 2011; Yu *et. al.*, 1997)

Table 2: The attributes of land use types change in Nong Han Chalermphrakiat Wetland Park, Sakon Nakhon Province, Thailand (based on THEOS image October 7, 2009).

Land use types	Area (sq m)	Shape	Habitat types
Lotus and water lily area	112,156	Polygon	Emergent aquatic vegetation, shallow water
Aquatic vegetation zone	20,970	Elongate	Marginal plants, flooding area, littoral zone
Paddy field	34,498	Elongate	Agricultural habitat
Adventure patch	52,368	Polygon	Bare soils, marginal vegetation

The THEOS Panchromatic image with spatial resolution of 2 X 2 m is possible for visual image interpretation and be able to compare the change of multitemporal satellite data. Image on December 21, 2008 found that there were seven earth ponds with one research building in the center of the area while image on October 7, 2009 recovered the presents of lotus and water lily garden with particularly at the right hand side of the image. There are various species of lotus and water lily area collected in this area aiming for biodiversity conservation and academic services for aquatic botanist and researchers (Figure 3).



Figure 3: THEOS image of lotus and water lily area comparing feature elements change between December 21, 2008 [1(a)] dataset and October 7, 2009 [1(b)] dataset

The vegetation area was converted due to land development. In the center of THEOS image of 2008 can observe the change from grey scale element which based on actual field observation found that this area was floodplain associated with marginal aquatic plants called littoral zone. However, THEOS image in the year of 2009 revealed the change from such element into base soil allocating for building and infrastructure (Figure 4).



Figure 4: THEOS image of aquatic vegetation zone comparing feature elements change between December 21, 2008 [1(a)] dataset and October 7, 2009 [1(b)] dataset

General layout of THEOS Image on December 21, 2008 found two elements which composed of water body (black color) and bare soil with bushing area (bright color) while THEOS image on October 7, 2009 presents the three white features of land use (paddy field during land preparing) and one dark feature which was the area of rice field as well (Figure 3). The paddy filed in this area serves to local community need to improve their income from rice production due to they have a limitation of land ownership. The rice production in this paddy field including of sticky rice and jasmine rice grows using conservation agricultural (CA) approaches. A concepts of CA farming systems have been developed based on 1) minimal soil disturbance (no-tillage), 2) direct seeding and 3) residue management (mulch) associated with weeds integrated management (slashing, rolling, herbicide), moderate fertilizer use to correct soil nutrients deficiencies and balance nutrients exported with grain harvest in small-scale of paddy field.

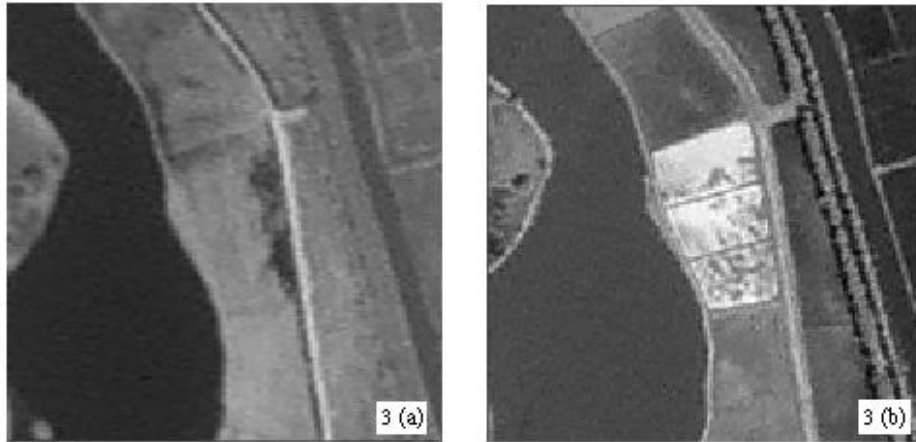


Figure 5: THEOS image of paddy field comparing feature elements change between December 21, 2008 [1(a)] dataset and October 7, 2009 [1(b)] dataset

THEOS satellite data receiving on December 21, 2008 was used for visual interpretation and shows bare soils and water body. Bare soils have been changed to establish the adventure landscape in 2009 which confirmed by THEOS image on October 7, 2009 together with actual field survey and topographical map (Figure 3). The land use type in 2008 was excavated for landfill purposes associated with various species of trees that were planted along the rib edge at the left hand site of development land. The road lines have been approved for accessible of visitors. This area will serve as ecotourism site and academic services for the Thai people as well as foreigners particularly from neighboring counties such as Cambodia, Lao PDR, Vietnam and Myanmar (CLVM).

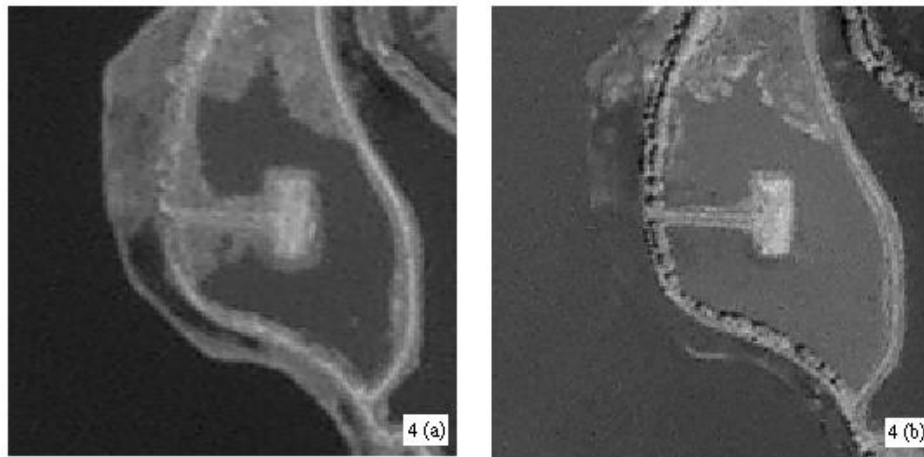


Figure 6. THEOS image of adventure patch comparing feature elements change between December 21, 2008 [1(a)] dataset and October 7, 2009 [1(b)] dataset.

CONCLUSIONS

Remote sensing was used for monitoring wetland cover and land use change and obtained satisfied result in landscape planning and mapping. There were 4 major types of land use changed in the study area namely; 1) Lotus and water lily area (112, 16 sq m), 2) Aquatic vegetation zone (20,971 sq m), 3) Paddy field (34,498 sq m) and 4) Adventure patch (52,368 sq m). Among land use types, lotus and water lily was the main land cover changed from floodplain into ornamental aquatic plants collection zone. There were many species of lotus and water lily existing in this area for biodiversity conservation and ecotourism purpose. Government of Sakon Nakhon province supported budget to this project for establishing the core center of lotus and water lily studies in Thailand.

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