THESIS APPROVAL

GRADUATE SCHOOL, KASETSART UNIVERSITY

Doctor of Philosophy (Soil Science)

DEGREE

Soil Science — **FIELD**

Soil Science — **DEPARTMENT**

TITLE: Assessment on Land Use of Phanom Dong Rak Mountain Range

NAME: Major Krittayaporn Charoenpol

THIS THESIS HAS BEEN ACCEPTED BY

(Professor Irb Kheoruenromne, Ph.D.) **THESIS ADVISOR**

(Associate Professor Anchalee Suddhiprakarn, Ph.D.) **THESIS CO-ADVISOR**

(Mr. Thongchai Charuppat, Ph.D.) **THESIS CO-ADVISOR**

(Assistant Professor Somchai Anusontpornperm, Ph.D.) **DEPARTMENT HEAD**

APPROVED BY THE GRADUATE SCHOOL ON _____

(Associate Professor Gunjana Theeragool, D.Agr.) **DEAN**

THESIS

ASSESSMENT ON LAND USE OF PHANOM DONG RAK MOUNTAIN RANGE

KRITTAYAPORN CHAROENPOL

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Doctor of Philosophy (Soil Science)
Graduate School, Kasetsart University
2013

Krittayaporn Charoenpol, Major 2013: Assessment on Land Use of Phanom Dong Rak Mountain Range. Doctor of Philosophy (Soil Science), Major Field: Soil Science, Department of Soil Science. Thesis Advisor: Professor Irb Kheoruenromne, Ph.D. 115 pages.

The assessment on land use of Phanom Dong Rak Mountain Range was designed to evaluate the change of land use at the border area in the Phanom Dong Rak mountain range as affected by the border conflict between Thailand and Cambodia over Phra Viharn Temple. Methods of study included land use classification from satellite images in 2001, 2006, and 2011 by using visual interpretation from imagine software, and land use change analysis by using post classification comparison method. The study area had been divided into 3 zones: Zone I, Zone II and Zone III, for land use change comparison in each period.

Results of the study revealed that in Zone I of Thailand territory, the whole area was situated in Phanom Dong Rak Wildlife Sanctuary outside the disputed area. The dry evergreen forest had increased in 2011 due to Thailand's policies on forest conservation and restoration. However, there were some areas that could not be controlled by authorities, therefore, the mixed deciduous forest had been reduced in 2011 because of deforestation by villagers. In Zone I of Cambodia territory, the natural forests tended to decrease. More villages and military construction had been built in 2011. New roads had been built near the Thai-Cambodia border. The political factors affected land use of this area. In Zone II of Thailand territory, the natural forests in Phra Viharn National Park and Phanom Dong Rak Wildlife Sanctuary had increased in 2011 due to the government policies on forest conservation and restoration. The areas surrounding Phra Viharn Temple in Thailand were invaded by the road built to the temple by Cambodia in 2006 and 2011. The factors affecting land uses were political factors. There had been an expansion of villages since 2001 in the area in vicinity of the Phra Viharn National Park and Phanom Dong Rak Wildlife Sanctuary outside the disputed area. Villagers had adopted their land uses to economic plantations for higher income. Hence socio-economic factors affected land use of this area. In Zone II of Cambodia territory, the natural forests had decreased tremendously by being converted to villages and military construction. Roads had been built near the border connecting the road to Phra Viharn Temple. The changes were driven by political factors. In Zone III of Thailand territory, the natural forests in Phra Viharn National Park had increased in 2011 due to the government policies. Regarding the area outside the national park, villages and building have increased in 2006 and 2011. The villagers had adopted their land uses to economic plantations for higher income. The socio-economic factors affected land use of this area. In Zone III of Cambodia territory, the natural forests had decreased tremendously in 2006 and 2011. The villages and military construction have been increasing significantly since 2001. Roads were also built to run to the Thai-Cambodian border. The changes were driven by political factors. Land use change in the study area was mostly induced by Cambodian's international politics aiming at a sole occupation of the area at the Thai-Cambodian border surrounding the disputed area.

/ /

Student's signature Thesis Advisor's signature

ACKNOWLEDGMENTS

I would like to express my deep and sincere gratitude to my thesis advisor, Professor Dr. Irb Kheoruenromne for his invaluable help and constant encouragement throughout the course of this research. I am most grateful for his teaching and advice, not only the research methodologies but also many other methodologies in life. I would not have achieved this far and this thesis would not have been completed without all the support that I have always received from him.

I am deeply grateful to the co-advisor, Associate Professor Anchalee Suddhiprakarn for many helpful suggestions, important advice and her support throughout this work.

I am also extremely grateful to my thesis co-advisor, Dr. Thongchai Charuppat for his encouragement, kind suggestions, and support.

My sincere thanks are to Col. Montakarn Meechuvet, Col. Thongkam Chumpol, Col. Thanawat Sangsuwan, Kampanat Deeudomchan, Maj. Pitchaya Muangmanee, Maj. Ormanee Rojanapiyawong, Cap. Kanoungnid Chittrong, and Natdawan Chaothieng for their kind suggestions and supports. I would like to thank Dr. Worachart Wisawapipat, Dr. Kamolwan Loapoolkit, Punpaporn Kongkaew, Khwunta Khawmee, Nantita Deeyai, Tanawan Limwikran, and all my friends in the Department of Soil Science at Kasetsart University for having shared many excellent times together and their supports.

I am grateful to the Geo-Informatics and Space Technology Development Agency (Public Organization) for the support on LANDSAT 5-TM, SPOT 5, and THEOS satellite data.

Most importantly, I wish to thank my family for helping me get through the tough times and for all the emotional support, love and caring they provided me throughout my life.

Krittayaporn Charoenpol
14 February 2013

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

ASSESSMENT ON LAND USE OF PHANOM DONG RAK MOUNTAIN RANGE

INTRODUCTION

Land is an essential natural resource, both for the survival and prosperity of human society, and for the maintenance of all terrestrial ecosystems. Over millennia, people have become progressively more expert in exploiting land resources for their own ends. The limits on these resources are finite while human demands on them are not (Kutter and Neely, 1999; Ziadat, 2007). Demand for land is driven by the need of certain land use types, which could be broadly categorized into residential use, commercial use, and government use. Within each of these there exists several subcategories (Clark, 2010). Politic and socio-economic conditions are related to the change in land use (Mather, 1989; Sietchiping, 2010). In socio-economic condition in tropical countries, one of the prominent characteristics of land use change is the decline in forest and woodlands due to land conversion, particularly from agricultural expansion for cash crop production (Barbier, 2003). In addition, changes in land use are the result of politics. The government of most countries exerts direct or indirect influence on land use (Mather, 1989; Verheye, 1997; Lewis and Kuttler, 2005; Clark, 2010; Sietchiping, 2010). Different countries have different emphases on the goals of their policies. This almost universal influence reflects something of ambivalent attributes held by man towards land (Amler *et al.*, 1999). The use of land, and government policy and action in controlling or directing this use, is fundamental to planning at national, regional, and local levels (FAO, 1995; Kutter and Neely, 1999). The state of knowledge about land use, and the degree of government control over it, differ greatly between developed and less developed countries (Young, 1998). Conflicts in land and resources often occur in the border area, between the neighboring countries that border each other**.** The conflict in the territory is classified as security issues. Often, the problems need be solved by political measures. The war is very often the deciding machine (Prunier, 1995; Young, 1998; Bamrungsuk, 2006a, 2006b).

This assessment on land use of Phanom Dong Rak mountain range was designed to evaluate the change of land use at the border area in the Phanom Dong Rak mountain range as effected by the border conflict between Thailand and Cambodia over Phra Viharn Temple. In geopolitical view, the conflict between two countries is often from each neighboring country (Young, 1998). In Thailand, there is an attempt to peacefully solve border dispute by appointing the joint border committee. However, a problem for Thailand is the preparation of the information. The preparation for solving the border dispute is not only by military guarding and border's control but also by having complete information and fact in order to be ready for the negotiation and military discussion. Military readiness alone does not guarantee the accomplishment on solving border dispute. Finally, border dispute will need be solved politically. Therefore, political advantage in term of treaty, history, topographic area information, and the change of land use and resources information are important to be ready for border dispute negotiation in the future (Bamrungsuk, 2006a, 2006b, 2006c, 2006d).

This study will focus on the information of the study area in term of land utilization, socio-economic and relevant policies, analysis on the changing of land use and factors that affect changing of land use both politically and socio-economically. This study will be useful as baseline data findings for the government to set up any preventive measures involved in national security.

OBJECTIVES

This study was carried out on assessment on land use of Phanom Dong Rak mountain range with the following objectives;

1. To study the land use types at Phanom Dong Rak mountain range.

2. To assess the changing of each land use type at Phanom Dong Rak mountain range.

3. To study bio-physical, socio-economic, and political factors affecting land use changes at Phanom Dong Rak mountain range.

Hypothesis

Socio-economic benefit and political conflict cause the change of land use at Phanom Dong Rak mountain range.

LITERATURE REVIEW

Land Resource and Land Use

1. Land Resource

1.1 Definition

Land is a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.) (FAO/UNEP, 1997). The components of the natural land unit can be termed land resources, including physical, biological, environmental, infrastructural, social and economic components, inasmuch as they are fixed to the land unit (FAO, 1995).

Land is an area of the earth’s surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area, including those of atmosphere, the soil and under rock (geology), the water (hydrology), the plant and animal populations and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man (Huizing, 1985).

Land is the terrestrial and aquatic part of the earth’s surface, including all elements of physical and biological environment that influence land use. Thus land refers not only to soil but also landforms, climate, hydrology, vegetation, and fauna, together with land improvements such as terraces and drainage work (FAO, 1993). Its ability to produce goods varies from place to place depending on the pattern and combination of the natural resources which control land productivity (Dent, 1985).

Natural resources, in the context of "land" as defined above, are taken to be those components of land units that are of direct economic use for human population groups living in the area, or expected to move into the area: near-surface climatic conditions; soil and terrain conditions; freshwater conditions; and vegetational and animal conditions in so far as they provide produce. To a large degree, these resources can be quantified in economic terms. This can be done irrespective of their location (intrinsic value) or in relation to their proximity to human settlements (situational value) (FAO, 1995).

Land is the basic natural resource. Over the span of human history, man has drawn most of his sustenance and much of his fuel, clothing, and shelter from the land. Land has been man habitat and living space; land has been a master of life and death of survival or starvation. That the use of land should have been of major importance to man (Mather, 1989).

Land is needed for many purposes, including regulation of the atmospheric and water cycles, mineral supply, nature conservation, settlement, and waste disposal. There is often conflict between competition uses. It is also the focus of conflict between a wide range of land use including agriculture, mining, forestry and nature protection, leisure, and urban and industrial development (Young, 1998).

Land is not the same everywhere. Land is, self-evidently, the other focus of land use planning. Capital, labour, management skills and technology can be moved to where they are needed. Land cannot be moved, and different areas present different opportunities and different management problems. This is obvious in the case of climate and vegetation, but examples such as the depletion of water resources or loss of soil by erosion or salinity are reminders that resources can be degraded, in some case irreversible. Good information about land resources is thus essential to land use planning (FAO, 1993).

1.2 Functions of Land

There is a wider range of functions which land offers to human society. These functions are as follows (FAO, 1995; Young, 1998):

1.2.1 Land is the basis for many life support systems, through the production of biomass that provides food, fodder, fiber, fuel, timber, and other biotic materials for human use, either directly or through animal husbandry including aquaculture and inland and coastal fishery (the production function).

1.2.2 Land is the basis of terrestrial biodiversity by providing the biological habitats and gene reserves for plants, animals and micro-organisms, above and below ground (the biotic environmental function).

1.2.3 Land and its use are a source and sink of greenhouse gases and a form of a co-determinant of the global energy balance reflection, absorption and transformation of radiative energy of the sun, and of the global hydrological cycle (the climate regulative function).

1.2.4 Land regulates the storage and flow of surface and groundwater resources, and influences their quality (the hydrologic function).

1.2.5 Land is a storehouse of raw materials and minerals for human use (the storage function).

1.2.6 Land has a receptive, filtering, buffering and transforming function of hazardous compounds (the waste and pollution control function).

1.2.7 Land provides the physical basis for human settlements, industrial plants, and social activities such as sports and recreation (the living space function).

1.2.8 Land is a medium to store and protect the evidence of the cultural history of mankind, and a source of information on past climatic conditions and past land uses (the archive or heritage function).

1.2.9 Land provides space for the transport of people, inputs and produce, and for the movement of plants and animals between discrete areas of natural ecosystems (the connective space function).

The suitability of the land for these functions varies greatly over the world. Landscape units, as natural resources units, have a dynamism of their own, but human influences affect this dynamism to a great extent, in space and time. The qualities of the land for one or more functions may be improved (for instance, through erosion control measures), but more often than not, the land has been or is being degraded by human action (FAO, 1995).

2. Land Use and Land Use Change

2.1 Land Use

Land is an essential natural resource. The limits on these resources are finite. Increased demand, or pressure on land resources, shows up as declining crop production, degradation of land quality and quantity, and competition for land (Kutter and Neely, 1999; Ziadat, 2007).

Land use is characterized by the arrangements, activities and inputs by people to produce, change or maintain a certain land cover type (Di Gregorio and Jansen, 1998). Land use defined in this way establishes a direct link between land cover and the actions of people in their environment (Kutter and Neely, 1999).

Land use is the management of land to meet the human needs. This includes rural land use and also urban and industrial uses (FAO, 1993). Land use is a basic element in human activity. For the most part, the same piece of land cannot be

used for more than one purpose at the same time. Thus competition between different kinds of activity is the theme which runs through any consideration of land use (Young, 1998).

Demand for land is driven by the need for land for certain use types, which could be broadly categorized into residential use, commercial use, and government use. Within each of these there exists several subcategories. Commercial use might include agricultural land, timber land, industrial land, and land for trade and commerce; residential land may be divided into high, medium, and low density; government land may be divided into municipal, county or parish, state and federal. Demanders of land thus consist of households, business firms, and government agencies. Suppliers of land also consist of members of these three broad groups. All parcels are assumed to be owned initially by some combination of households, business firms, and government. In addition to being primary demanders of land, government may affect the demand side of the market by influencing factors that determine household and business demand for land of various use types (Clark, 2010).

The state of knowledge about land use, and the degree of government control over it differs greatly between developed and less developed countries. In the developed world there is generally good statistical information on the use of land. There is intense competition between uses, and planning controls over change are, by and large, enforced. This applies not only to the densely settled regions, such as Europe and eastern United States, but also to sparsely populated areas such as much of Canada and Australia, on which proposals to change the type of land use must meet legislative controls and requirements. Even completely empty regions may be legally designated wilderness sites (Young, 1998; Kutter and Neely, 1999).

In the less developed world, by contrast, information about land use is often extremely poor. Empty land, not under any kind of use, existed formerly but is rapidly being reduced, and now mostly confined to arid regions and steeplands. Competition between uses is growing. Legal constants, such as forest reserves and urban planning restrictions, exist but are poorly enforced. One of the least enforced of

land use controls is found in countries which legally forbid cultivation of land of more than a certain steepness (Young, 1998).

2.2 Land Use Change

Politics and socio-economics are related to the change in land use (Mather, 1989; Callaghan, 1996; Young, 1998; Kutter and Neely, 1999).

In the socio-economic condition, because of population increase the demand for land is increasing to meet the needs of human living. In tropical countries, like Thailand, one of the prominent characteristics of land use and land cover change is the decline in forest and woodlands due to land conversion, particularly from agricultural expansion for cash crop production (FAO, 1997; 2003; Barbier and Burgess, 2001). Research conducted by FAO (2001) suggested that large-scale agriculture is the major cause of deforestation (about 32%), followed by small-scale agriculture (about 26%). Intensification and expansion of the agriculture in shifting cultivation practice comprise about 15% of tropical deforestation. Land expansion occurring in tropical regions is mainly related to structural features of the agricultural sectors of developing economies, such as low agricultural productivity and input use. Poor agricultural intensification and development in turn creates pressure on farmers to convert forest and other marginal lands to crop production. Usually, these structural condition are influenced, both directly and indirectly, by economic policy (Barbier, 2003). As such, transformations can have significant impacts on rural socio-economy and quality of natural environment, an understanding of the complex interactions of these changes overtime including their spatial patterns is crucially needed to enable decision makers to formulate better policy in rural development and environmental management (FAO, 2001).

In addition, changes in land use are the result of politics. The government of most countries exert direct or indirect influence on land use (Mather, 1989; Verheye, 1997; Lewis and Kuttler, 2005; Clark, 2010). Different countries have different emphases on the goals of their policies (Verheye, 1997; Amler *et al.*,

1999). This almost universal influence reflects something of ambivalent attributes held by man towards land. One of the fundamental reasons for government intervention in land use is that individual and societal utility do not always coincide. The relation between individual and societal utility and objective is therefore fundamental to the whole question of government influence on land use. The nature of this influence varies from country to countries, but in many countries at least three broad types of influence are felt (Mather, 1989).

At the first and most basic level, the type of land policy pursued is a pervasive influence on the structure of land ownership and on the extent of private property rights in land. A second level of government influence consists of support policies directed towards certain types of land use. Many western governments intervene in agriculture and forestry to safeguard home supplies, to stabilize production and to ensure the well-being of farmers and other land users. Thirdly, government may take direct action in using land at its own hand. In this case, government is the owner, controller and user of land, and pursues objectives that private land users are unwilling or unable to pursue (Mather, 1989; Verheye, 1997).

Land use or changes in land use can be subject to direct government control as well as to indirect influence through curbs on ownership. Some types of land use change can proceed almost regardless of the planning system and direct government control, while others are tightly constrained. Government intervention in controlling land use in this way can have a major effect on land values, as these are influenced by prospects for change and development as well as by current use (Mather, 1989; Young, 1998; Lewis and Kuttler, 2005; Clark, 2010).

Government has the ability to affect the demand side of the market for land in four essential ways: 1) By creating amenities (e.g., parks) or disamenities (e.g., landfills) government may directly affect the demand for particular parcels of land surrounding the amenities or disamenites, thereby influencing the expected net rents on those parcels relative to unaffected parcels; 2) Government may influence consumer preferences regarding housing density (e.g., some may view high-

density housing and public transit as complementary goods) and so an increase in the availability of public transit may increase the demand for high-density housing; 3) Through its use of tax incentives or other types of subsidies government may increase the demand for certain land use types beyond a level the market would have achieved otherwise; 4) Government is itself a demander of land, and so by increasing or decreasing its consumption of land directly affects the demand and the expected net rent for land in various use types (Clark, 2010).

Optimal land use and optimal forms of land management may therefore represent a compromise between political and economic criteria, and may result in an outcome that offers room for adjustment and maneuver in the future rather than a commitment to a policy that irrevocable, or from which it is difficult to change course (Young, 1998).

Land Use Planning

1. Definition

Land use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land-use options. Its purpose is to select and put into practice those land uses that will best meet the needs of the people while safeguarding resources for the future. The driving force in planning is the need for change, the need for improved management or the need for a quite different pattern of land use dictated by changing circumstances (FAO, 1993).

Land use does not consider production only, but also land functions such as protected areas, land recreation, road-building, waste disposal sides and use restricted areas such as buffer zones for exhaust gases, areas for regenerating groundwater, buffer zones for traffic noise pollution, and others (Amler *et al*., 1999). Land use planning is not only practiced when national authorities intervene or as a result of development co-operation projects. Land use planning happens in every society, even

if the term is not used. Land use planning in the technical co-operation is an iterative process based on the dialogue amongst all participants. It is aimed at the definition of decisions on a sustainable form of land use in rural areas and the initiation of the appropriate measures for implementation and monitoring.

Land use planning is carried out to assist decision-makers in deciding how to use an area of land. It combines land use objective, ways of using land, and natural resources so that needs are satisfied as fully as possible without causing damage to the land. The objective of land use planning are: 1) To make efficient use of the land by matching land uses to location where such land uses are most productive and least damaging, 2) To meet defined objective under the headings of production and protection, and 3) To make the process of land use decision open and visible (Dent, 1985; FAO, 1993; 1995; Callaghan, 1996; Young, 1998).

2. The Land Use Planning Process

Land use planning has three major elements composing of people, land, and organization (Dent, 1985).

People and their needs are the purposes of the planning and the eventual implementers and benefactors of planning process. The needs generally concern the production of goods and conflicts among land uses and land use methods (Dent, 1985).

Organization refers to the agency or governmental unit responsible for making the land use plan (Dent, 1985). Organization also refers to the framework within which the participants operate, and may relate to the interaction of the politicians, officials, and interested group (Mather, 1989).

FAO's Guideline for land use planning in 1993 suggested that the structure of guideline is to set out ten basic steps in land use planning. Each step is summarized by means of a checklist. There are 10 steps of land use planning: 1) Establishing

goals and terms of reference; 2) Organizing the work; 3) Analyzing the problems; 4) Identifying opportunities for change; 5) Evaluating land suitability; 6) Appraising the alternatives: environmental, economic and social analysis; 7) Choosing the best option; 8) Preparing the land-use plan; 9) Implementing the plan; and 10) Monitoring and revising the plan. Steps 1-6 are, in essence, part of procedures of land evaluation, whilst steps 7-10 cover what is done in preparing and executing a development plan. Funding is needed at two points: at the start, to prepare the plan, and, following the decision to go ahead with it, for implementation (FAO, 1993).

The evaluation of the land and planning for different actual or potential uses requires a series of steps (FAO, 1995), as follows: 1) In collaboration with the stakeholders, the establishment of achievable goals and objectives, framed within an enabling policy environment for sustainable land use; 2) The identification and delineation of land, on the basis of comparable physio-biotic characteristics (climate, elevation, landforms, soils, hydrology), into natural land units or zones; 3) The assessment of the inherent land qualities, and their constraints and opportunities, of the identified land units; 4) The identification and characterization of the present forms of land cover or land use per land unit or land zone; 5) The identification of prospective land utilization types or production systems in accordance with the wishes of the stakeholders; 6) The identification of the physio-biotic and socio-economic requirements of the agreed land utilization types; 7) The matching of the inherent land qualities of (3) with the requirements of the utilization types of (6); 8) The formulation of alternative land uses or non-use per land unit or zone as a result of (7); 9) The assessment of the alternative land uses against the needs and aspirations of all population groups (to be) involved and affected, through the use of platforms for negotiation and decision making that include all stakeholders; 10) The decision to proceed with one acceptable and recommended land use; and 11) The identification of policies, strategies and measures to be taken to move from the current to the recommended land use and with the active participation of all stakeholders.

3. Planning Systems in the Social and Political Context

Planning systems are an expression of social and political conditions in respect of space and time. They are expressed by means of legal regulations (planning laws), social conventions, and rules. In addition to codified agreements (laws, administrative regulations), there are others which have been agreed verbally in form of traditional rules of conduct. Those are significant at local level (Amler *et al.*, 1999).

3.1 Types of Planning System

Planning systems differ from country to country. A rough differentiation is made between three types: centralized, decentralized and heterogeneous planning systems (Amler *et al.*, 1999).

3.2 Policies in Various System Influencing Land Use Planning

Various components influence and control land use. Generally, this includes policies on infrastructure, taxes, credit and import/export as well as environmental and development policies. These political focal points create the framework for medium-term planning visions. But land use is planned at local level. Therefore national directives have to be translated into rules for planning land use at local level (Amler *et al.*, 1999).

Countries with a strongly centralized administration tend to regulate land use objectives even at local levels in a "top-down" manner. In contrast, in decentralized planning models land use regulations at community or village level should be agreed by the land users themselves, linked to each other at regional level and co-ordinated with national development projects. The prerequisite for this is that the stakeholders should have the capacity to co-operate and create suitable co-ordination mechanisms related to land use. In heterogeneous systems, land use decisions at local levels are made exclusively among the stakeholders, but they do not

have any legal protection against the intervention by third parties at a later stage (Amler *et al.*, 1999).

4. Factors in Land Use Planning

Land use planning has three major elements: people, land, and organization (Dent, 1985). Therefore, land use planning requires basic information about the land, the people, and the organization of administration. This information must include: 1) Land resources, including climate, hydrology, geology, landforms, soils, vegetation (including forest and pasture resources), fauna, pests and diseases. Sources include topographic base maps, air photographs and satellite imagery, existing surveys and departmental records; 2) Present land use; 3) Present infrastructure, including transport, communication and services to agriculture, livestock management and forestry; 4) Population, including numbers, age and sex structure, demographic trends and distribution, location of settlements, the role of women, ethnic groups, class structure, and leadership; 5) Land tenure, including legal and traditional ownership and user rights for land, trees and grazing; forest reserves, national parks; 6) Social structure and traditional practices, past and present; 7) Economics; 8) Government, including administrative structure and key authorities such as services provided and demands placed upon them; 9) Legislation, including laws and regulations that affect land use such as traditional law and custom; whether laws are enforced; 10) Non-governmental organizations (NGOs); and 11) Commercial organizations (FAO, 1993).

An evaluation of suitability of land for alternative kinds of use requires a survey to define and map the land units together with the collection of descriptive data of land characteristics and resources. The principle categories of data required are dealt with in the following sections under eight heading: general characterization of the project area, topography, soils, water resources, drainage, vegetation and fauna, social and economic data (FAO, 1985).

FAO (1993) and Dalal-Clayton and Dent (1993) provided extensive introduction to databases relevant to the management of land resources and to land use planning. This database must include: climate databases, database on soil and terrain conditions, water resources databases, land cover and biodiversity database, database on land uses, crop and production systems, database on social and related conditions, and database on economic aspect.

Bio-physical data of land resources and socio-economic factors influence land use and land use change (Turner *et al*., 1990; Bouman *et al*., 1999; Serneel and Lambin, 2001; Muller and Zeller, 2002; Barredo *et al*., 2003; Tenrivermis, 2003; McConnell *et al*., 2004; Verburg *et al*., 2004; Palo, 2008; Serra *et al*., 2008). In addition, politics is related to the change in land use (Mather, 1989; Verheye, 1997; Lewis and Kuttler, 2005; Clark, 2010). Therefore, land use planning needs to know the biophysical data, socio-economic data, and policies (FAO, 1993; 1995; Dalal-Clayton and Dent, 1993; Kutter and Neely, 1999).

Bio-physical data related to land resources include climate, hydrology, topography, geology, geomorphology, landforms, soils, land cover and vegetation (FAO, 1993; 1995; Kutter and Neely, 1999; Palo *et al*., 2008).

Socio-economic data includes household data or farm household data, population (age, growth rate, ethnic composition, gender distribution, etc.), legal and tenure aspects, infrastructure (roads, quality, etc.), wages, rent, taxes, income, access to markets, price development, product and marketing problem, credit and loans, supporting services, and intervening agencies (NGOs, GOs, etc.) (FAO, 1993; 1995; Kutter and Neely, 1999). The collection of information on the socio-economics in the planning unit should be geared to gaining an understanding of local communities and their natural, human and capital resources. This includes data on the community structure, in order to estimate the living conditions, gender-related issues, class and ethnicity, labour availability, data on agricultural or other land-use practices and data on access to land, land tenure and holding size, livestock, infrastructure, etc. (Kutter and Neely, 1999). One of the purposes of socio-economic data collection is to

identify and characterize specific groups that can be targeted with the land-use plan (FAO/ILO, 1998). Tokrisna *et al.* (2002) showed that the planning of sustainable land use needs to consider socio-economic factors. For social factors the need of examination includes: 1) Community's way of life i.e. historical background (numbers, age and sex structure, demographic trends and distribution, ethnic groups, class structure, and leadership), location of settlements and pattern of settlement, and race and language; 2) Social data i.e. transport facilities, career, family structure, infrastructure, and education; 3) Local administration i.e. community leaders, community centers, bureaucrats and government officials, and local organizations and activities; and 4) Social problems and conflict. For economic factors the examination includes economic household i.e. household structure, land ownership, incomes, spending household, debts, and allocation/settlement.

Politics is related to the change in land use. Government influence consists of support policies directed towards certain types of land use (Mather, 1989; Verheye, 1997; Lewis and Kuttler, 2005; Clark, 2010; Sietchiping, 2010).

Remote Sensing and GIS for Land Use Planning

1. Definition

Remote sensing is defined as the acquisition of information about an object without being in physical contact with it. Information is acquired by detecting and measuring changes that the object imposes on the surrounding field, be it electromagnetic, acoustic, or potential. This could include an electromagnetic field emitted or reflected by the object, acoustic waves reflected or perturbed by the object, or perturbations of the surrounding gravity or magnetic potential field due to the presence of the object (Elachi and Van Zyl, 2006). The term "remote sensing" is most commonly used in connection with electromagnetic techniques of information acquisition. These techniques cover the whole electromagnetic spectrum from low-frequency ratio waves through the microwave, sub-millimeter, far infrared, near infrared, visible, ultraviolet, x-ray, and gamma-ray regions of the spectrum (Elachi

and Van Zyl, 2006; Liang, 2008). Remote sensing data are obtained from satellite or aerial imagery, with control by ground observation of sample areas. This is primarily a source of information on land cover, with land use being inferred. It supplies map but not, directly, statistical data (Young, 1998).

Geographic information system (GIS) is a computer system for storage, analysis and retrieval of information, in which all data are spatially referenced by their geographic coordinates. GIS is composed of five sections: software, hardware, people, procedures, and data (Burrough, 1996; Burrough and McDonnell, 1998). In addition to primary data, such as climatic and soil characteristics, a GIS can be used to calculate derived values, such as erosion hazard, forest yield class, or land suitability for specified land use types. Data are usually derived from maps and derived values can be the print out maps (FAO, 1993; United Nations, 2000).

2. Remote Sensing and GIS for Analysis of Land Use Change and Land Use Planning

Satellite remote sensing, in conjunction with geographic information systems (GIS), has been widely applied and been recognized as a powerful and effective tool in detecting land use and land cover change in the process of land use planning (Ehlers *et al.*, 1990; Meaille and Wald, 1990; Treitz *et al*., 1992; Westmoreland and Stow, 1992; Harris and Ventura, 1995; Yeh and Li, 1996, 1997, 1999; Skidmore *et al*., 1997; Senes and Toccolini, 1998; Slaymaker, 2001; Rogan and Chen, 2004).

In the last decades, the technologies and methods of remote sensing have evolved dramatically to include a suit of sensors operating at a wide range of imaging scales with potential interest and importance to planner and land managers in monitoring land cover and land use change at a variety of spatial scales. Current remote sensing technology offers collection and analysis of data from ground based, atmospheric, and earth orbiting platforms, with linkages to GPS data, GIS data layers and functions, and emerging modeling capabilities (Franklin, 2001). This has made remote sensing a valuable source of land cover and land use information (Rogan and Chen, 2004). Remote sensing information, in concert with available enabling

technologies such as GPS and GIS, can form the information base upon which sound planning decisions can be made, which remaining cost effective (Steininger, 1996; Franklin *et al*., 2000).

Normally, most reports found in land use and land cover change studies are associated directly, or indirectly, to the analysis and prediction of land use and land cover change characteristics in particular area based on knowledge of past land use and land cover change pattern of the area. To identify patterns of land use and land cover change in the past, some remote sensed images, like aerial photographs or satellite images recorded on regular (or timely) basis, could be used as reference sources along with the field survey data (Hall *et al*., 1991; Tekle and Hedlund, 2000; Gautam *et al*., 2002). These changes of land use and land cover could be mapped and analyzed more conveniently recently due to the rapid advance and more applicable of geographic information system technology. The GIS are computer based programs which are highly capable in mapping, recording, displaying, and analyzing spatial data and interpreting the relationships among associated data for making inferences. These capabilities make them become a promising tool in land use and land cover change study, especially for the land use planning (Serneels and Limbin, 2001).

For a sustainable land use plan, nowadays land use planning approach requires more and more data integration, multi-disciplinary and complex analysis, and needs faster or more precise information for the participants in land use planning approaches. Certainly, GIS, which is strong capacity in data integration and analysis and visualization, become the main tool to support land use planning approaches. The application of GIS in land use planning is well documented such as land evaluation, land suitability assessment, and soil suitability assessment and soil mapping (Liengsakul *et al.*, 1993; Bocco *et al.*, 2001; Maji *et al.*, 2001; Zhou *et al.*, 2005; Martin and Saha, 2009; Walia *et al.*, 2010).

Land Uses in Thailand and Northeast Thailand

1. Land Uses in Thailand

Thailand is located in Southeast Asia which has a total area of approximately 513,115 km^2 (320,696,887 rai). The area is situated between 5° 37'N – 20° 27'N and 97° 22'E – 105° 37'E. It is bounded to the North by Myanmar and Laos, to the South by Malaysia, to the East by Laos and Cambodia, and to the West by Myanmar and Andaman Sea (Chanchai, 1993; Thongpussawan *et al.*, 2009; Department of Land Development, 2010). The area comprises mountain range, mountain, piedmont, rolling, undulating, terrace, plain, floodplain, and coast (Department of Mineral Resources, 2001; Worakawin, 2004). Thailand's climates consist of the tropical rainforest, tropical monsoonal, and tropical savanna climates with three main seasons being summer, rainy, and winter (Chanchai, 1993; Department of Mineral Resources, 2001).

Agricultural land uses of Thailand in 2009 accounted for 171,585,556 rai (53.5%). These included the areas of paddy fields, upland crops, perennials, orchards and rotating crops, aquaculture and other areas (*e.g.* horticultures and forage crops), respectively. Other types of land uses are forest 113,170,136 rai (35.3%), residential areas and building 15,111,800 rai (4.7%), miscellaneous areas 12,017,043 rai (3.7%), and water resources 8,812,352 rai (2.8%), respectively (Land Development Department, 2010).

2. Land Uses in Northeast Thailand

Northeast region occupies an area of 105,533,963 rai being approximately one third of the total area of the country. The prominent geology of this area is well recognized as the Khorat Plateau, where bounded to the North and East by the Mekong River, to the South by the Sankampang and Phanom Dong Rek mountain ranges and to the West by Petchabun and Dong Phrayayen mountain ranges. Additionally, the Phu Phan mountain range that lies in the northwest-southeast

direction separates the area into two basins, i.e., the Khorat and the Sakon Nakhon basins. The area is under the tropical savanna climate and has an average annual rainfall of 1,200 mm. with mean annual temperature of 26.7-27.1 ^{o}C (Chanchai *et al.*, 1993; Department of Mineral Resources, 2001; Meunpol, 2005; Thongpussawan *et al.*, 2009).

Arable lands of Northeast Thailand in 2009 were extensively used for agriculture accounting for 71,532,728 rai (67.7%). They included paddy field, upland crops, perennials, orchards and rotating crops, aquaculture, and other areas, respectively. Accompanying land uses are forest 20,784,463 rai (19.7%), residential areas and building 5,016,240 rai (4.8%), miscellaneous areas 4,934,071 rai (4.7%), and water resources 3,266,461 rai (3.1%), respectively (Land Development Department, 2010).

Conflicts on Land and Resources

Conflicts on land and resources often occur in the border area. Between the neighboring countries that border each other**.** The conflicts often lead to war (Prunier, 1995; Bamrungsuk, 2006a; Clark, 2010; Sietchiping, 2010). The link between environmental pressures and conflict-war, civil war, and civil unrest - is complex yet potentially strong. The warlike reputation of pastoral people is, in part, a response to their need to move to neighboring lands in time of drought. Post-war conflict over the water of Indus nearly brought about war between India and Pakistan. A serious potential for war exists over competing demands for the water of Nile, Mekong, and other major international rivers. The proximate cause of conflict, as in the recent example of Somalia, Sudan, Rwanda, Afghanistan, and Haiti, is political, but population pressure is a contributory factor; and where food supplies are already marginal, any disruption of the rural economy leads to hunger. The recent anarchy and genocide in Rwanda has as its apparent causes long-standing ethnic emmities and a recent breakdown of governance, but there is a case to be made that it fundamentally stems from overpopulation (Prunier, 1995).

It has been argued that environmental pressure will become the principal cause of conflict in twenty-first century (Myers, 1993; Kaplan, 1994). The link is indirect, the proximate cause being usually political strife or break down in law and order. Countries with good governance can achieve far higher levels of sustainable production and thus of food securities – a factor not taken into account in estimates of population-supporting capacity. In political history, one cannot argue in a scientific manner for a direct cause and effect between environmental pressures and conflicts; many factors of personalities and chance intervene. But population pressure upon and associated land degradation, will certainly continue to form a dangerous and possibility tragic underlying source of conflict (Young, 1998).

Territorial conflict is classified as security issues. The government often solves this conflict by using political measures and most likely end up with war. (Prunier, 1995; Bamrungsuk, 2006; Sietchiping, 2010). The examples for these included the conflict between Israel and Palestine at the Gaza strip, the conflict at Sino-Soviet border that is a series of armed border clashes between the Soviet Union and People's Republic of China at Zhenbao Island (Damanskii Island), the enclave and exclave in Netherland and Belgium border results from agreements, land-swaps and sales between the rulers before establish nation states and their borders, and the conflicting territorial claims in the South China Sea at the Spratly Islands between China, Vietnam, Malaysia, Taiwan, Philippines and Brunei (Robinson; 1972; Livingstone, 2006; Alexander, 2007; Matthews, 2007; United Nations Environment Programme, 2009; International Court of Justice, 2011).

Political Factors Affecting Dispute over Land Use of Thailand-Cambodia Border Surrounding Phra Viharn Temple

The ownership and land use dispute of Thailand-Cambodia border surrounding Phra Viharn Temple have been caused by political conflicts between the two countries. The major political factors that affect the conflict are sovereignty, government, government policy and political method (Bamrungsuk, 2006a, 2006b,

2006c; Bamrungsuk and Piwawattanapanit, 2006; Uwanno, 2008; Ministry of Foreign Affairs, 2008, 2011).

1. Sovereignty

The territorial dispute is considered as an international issue since international boundaries are regarded as state's sovereignty. The demarcation line is characterized as a state sovereignty when there are adjacent territories. Therefore the demarcation line is important to territorial integrity and national security. Whenever there is a territorial dispute, it may affect a state sovereignty and the national security, including international relations (Chotsiri, 2006).

The Phra Viharn Temple dispute is caused by the unclearness of the demarcation line mutually agreed on by Thailand and Cambodia. Thailand followed the Franco-Siamese Convention of 1904 which used the Phanom Dong Rak mountains watershed line as the demarcation, while Cambodia followed the demarcation in the 1:200,000 scale map issued by French officers in 1908. In 1959 Cambodia appealed to the International Court of Justice (ICJ) to rule that the temple lay in the Cambodian territory. In 1962, the International Court of Justice ruled that the Temple of Phra Viharn belonged to Cambodia. However, the court did not comment about the demarcation line, whether the two countries had to follow the 1: 200,000 scale map. Therefore, the area surrounding the temple is still under the sovereignty of Thailand. Cambodia still claims the validity of demarcation line on the 1:200,000 scale map which has no legal bearing. As a result, in 2011 Cambodia requested the International Court of Justice (ICJ) to interpret the Phra Viharn verdict of 1962 (Ministry of Foreign Affairs, 2008; 2011).

2. Government

Thai-Cambodian relations have been indefinite up to now. The major factors are caused by the domestic political situations and the territorial dispute. Cambodia has broken off diplomatic relations with Thailand twice. The first time was on 24

November 1958 during Prime Minister Field Marshal Sarit Thanarat's government (diplomatic relations resumed in February 1959). The second time was on 23 October 1961 (diplomatic relations resumed in 1966 during Prime Minister Field Marshal Tanom Kittikachorn's government). Both cases were caused by the Phra Viharn Temple dispute (Ministry of Foreign Affairs, 2010).

In the last 10 years (2001 – 2011) during Prime Minister Police Lieutenant General Thaksin Shinawatra's government (2001-2005 and 2006), Prime Minister General Surayud Chulanont's government (2006-2008), Mr. Samak Sundaravej's government (2008), Prime Minister Somchai Wongsawat's government (2008), and Prime Minister Abhisit Vejjajiva's government, the temple dispute has been the major problem for the international relation between the Thai governments and Hun Sen's government. During Prime Minister Police Lieutenant General Thaksin Shinawatra's government, the Thai embassy in Cambodia was burned down on 30 January 2003, after there was a news report in Cambodia that Suwanant Kongying, a Thai actress, looked down on Cambodian people and would like Thailand to reclaim the Phra Viharn Temple. The Government decided to reduce the diplomatic relations with Cambodia (to the level of consul-general). During Prime Minister Abhisit Vejjajiva's government, The Ministry of Foreign Affairs summoned the ambassador in Phnom Phen to return to Thailand on 5 November 2009. The Diplomatic response concerning the Pra Viharn dispute had been exchanged. Prime Minister Hun Sen had appointed Police Lieutenant General Thaksin Shinawatra to be an economic advisor of Cambodian government and his personal advisor. There was also domestic affair interference in Thailand (Ministry of Foreign Affairs, 2010).

3. Government Policy

Every Thai government in the last 10 years (2001-2011) tended to conduct the same policy in terms of national security and foreign affairs. They have maintained good relations with neighboring countries in order to create atmosphere for negotiation. They have extended cooperative relations to other countries-politics, security, economy, social and culture. They have adhere to international obligations

as per the treaties and agreements that Thailand has been a part of. They obliged international laws including the charter of the United Nations. Moreover, Thailand has conducted clear policies for the joint survey and demarcation of the land boundaries with neighboring countries by adhering to evidence and law in order to resolve the territorial conflict permanently, which will bring peace to the two bordering countries and increase cooperative relations. In 1997, Thai-Cambodian Joint Commission on Demarcation for Land Boundary (JBC) was appointed for negotiation and demarcation of land boundary. According to the MOU of joint survey and demarcation of land boundary between the Kingdom of Thailand and the Kingdom of Cambodia in 2000, item no. 5, it states that during the ongoing joint survey and demarcation of land boundary, both countries will not proceed with anything that will affect the environment of the territorial border. Moreover, in 2003, it was agreed in the Cambodian-Thai Council of Minister meeting that the Phra Viharn to be developed and renovated as a symbol of friendship and close permanent relations between the two countries and for the mutual benefit of the Thais and Cambodians in every aspect (Ministry of Foreign Affairs, 2008, 2011; The Secretariat of the Cabinet, 2012).

Concerning the Cambodian policies from the Cambodian-Thai Council of Minister meeting in 2003 and 2004, Cambodia had planned to submit an application to UNESCO requesting that the temple to be designated as World Heritage Site. Thailand had acknowledged and sought for cooperation and consulted with every section concerning world heritage inscription including area development and Phra Viharn renovation sections. During 2005 – 2006, Cambodia submitted the application to UNESCO requesting that the temple be designated as World Heritage Site and did not consult Thailand, whom they used to consult as Joint commission tasked to develop the temple as per the resolution of the Thai-Cambodian Council Minister. In 2006, Cambodia issued the royal decree of the demarcation of temple reservation that overlapped the Thai border (Ministry of Foreign Affairs, 2011, 2009). In 2010, Prime Minister Hun Sen announced the Rectangular Strategy for Growth, Employment, Equity and Efficiency in Cambodia and spent a lot of budget to tackle invasion from other countries including Thailand that had caused the Cambodia border area along

Thailand to be developed quickly during 2010 - 2011. The strategy includes 1) defense development, 2) social development 3) building strong army, and 4) development of life quality of people along the border (Directorate of intelligence, 2010).

4. Political Method

Every Thai government's political method on the border conflict has been passive by trying to negotiate as per the peace policies. Thailand maintained the relations with Cambodia by strictly obliging to the agreement between the two countries. They have focused on negotiation on the bilateral and military leader levels between the two countries (Chotsiri, 2006, Ministry of Foreign Affairs, 2011). Cambodia invaded Thai territory by building temples, roads markets, communities, and other activities which have caused violation of Thailand's sovereignty. In practice, there would be protests by local officials, then government level by Ministry of Foreign Affairs which is effective to the international laws of right and state sovereignty. Thailand has opted the negotiation to resolve the conflict peacefully which is the accepted method by civilized countries (Ministry of Foreign Affair, 2011).

Cambodia's political method has been proactive by submitting an application to the Court of Justice to rule in the temple dispute. They have also invaded Thai territory by building temples, roads, communities, and other activities in Thailand's area. They do not abide by the agreement between the two sides-filing an application of the temple as the world heritage inscription without consulting Thailand. They have issued the Royal decree of the demarcation of the area surrounding the temple that invaded the Thai territory. They sought for support from country members of World Heritage Commission. They appointed an international committee on the multilateral level to tackle the Phra Viharn Temple complex issue. There was political violation lobbying some powerful countries. Whenever there was the territorial dispute with Thailand, it had led to multilateral negotiation and involving

the United Nations with the two countries (Chotsiri, 2006; Bamrungsuk, 2006b, 2006c, 2006d; Ministry of Foreign Affairs, 2008, 2011; Uwanno, 2008).

MATERIALS AND METHODS

Materials

1. Topographic maps of Thailand (Scales 1:50,000) series L7018 sheet number 5937 IV published by the Royal Thai Survey Department (The Royal Thai Survey Department, 1994).

2. Geology maps of Thailand (scales 1:500,000 and 1:250,000) (Department of Mineral Resources, 1983).

3. Soil series maps of provinces in Thailand (Scale 1:100,000) published by Land Development Department (Land Development Department, 1986).

4. LANDSAT-5 TM satellite imagery (multispectral 30 m) acquired in 2001 (Geo-Informatics and Space Technology Development Agency, 2001).

5. SPOT-5 satellite imagery (pan-sharpen 2.5 m) acquired in 2006 (Geo-Informatics and Space Technology Development Agency, 2006).

6. THEOS satellite imagery (multispectral 15 m, panchromatic 2 m) acquired in 2011 (Geo-Informatics and Space Technology Development Agency, 2011).

7. Digital Elevation Model (DEM) 30 meters interval, from ASTER

8. Climatic data from Thai Meteorological Department (Thai Meteorological Department, 2011)

9. GPS receiver

10. Image processing programs (Erdas Imagine)

11. GIS software (ArcGIS)

12. Personal Computer

13. Digital camera with GPS receiver

14. The village's status database from Community Development Department

Methods

The study focused on land use and land cover changes over the period of 10 years, from 2001 to 2011 and the factors influencing the land use changes.

1. Data Collection

1.1 LANDSAT-5 TM satellite data taken in 2001, SPOT-5 satellite data taken in 2006, and THEOS satellite data taken in 2011 were used in this study.

1.2 Topographic maps at the scale 1:50,000 series number L7018.

1.3 Bio-physical data used in this study included: topography data (slope, elevation), geology data, geomorphology data (landforms), soil data (soil series), climatic data, water resources data, and land cover and land use data.

1.4 Socio-economic data used in the study were both primary data and secondary data. The primary data were collected through the field surveys and in-depth interviews of the focus groups in the study area. The secondary data were from the village's status database obtained from Community Development Department. The data, which would provide information at village level, had been collected for the period 1990 - 2011 with two year interval. Socio-economic data include:

1.4.1 Community's way of life

1) Historical background (numbers, age and sex structure, demographic trends and distribution, ethnic groups, class structure, and leadership)

2) Location of settlements and pattern of settlement

3) Race and language

1.4.2 Sociological data

1) Transport facilities

2) Career

3) Family structure

4) Infrastructure

5) Education

1.4.3 Social problems and conflict

1.4.4 Economic household

1) Household structure

2) Land ownership

3) Incomes

4) Spending household

5) Debts

6) Allocation/Settlement

1.5 Political data in the study were obtained from secondary data including:

1.5.1 Public policy

1.5.2 National security policy

1.5.3 Political conflict data

2. Data Analysis

Imagine software for image processing and ArcGIS for GIS data based management and analysis were used in this study.

2.1 Satellite data image processing. Geometric correction of LANDSAT-5 TM satellite image data taken in 2001 using image to map technique by employing 16 ground control points. The GCPs of the study area were collected from the topographic maps at the scale 1:50,000 UTM, WGS1984, Zone 48, of the area. Registration was then applied using second order polynomials with RMS error less than 1 pixel with resampling to 25 meters per pixel using nearest neighbor method.

2.2 Geometric correction of SPOT-5 satellite data taken in 2006, and THEOS satellite data taken in 2011 using image to image technique. The GCPs were collected from the result of geocoded satellite image data of year 2001. Registration was then applied using second order polynomials with RMS error less than 1 pixel, followed by resampling to 25 meters per pixel using nearest neighbor method.

2.3 Land use and land cover classification. Land use and land cover classification and mapping of the study sites were carried out on performed geocoded satellite data using visual interpretation.

2.4 Land use and land cover change detection. Land use and land cover change detection of the study sites were conducted by overlaying technique.

2.5 Land use and land cover change analysis. After the 3 classified land use and land cover maps (for 2001, 2006, 2011) were obtained, the patterns of land use and land cover changes during these periods were identified using post-classification comparison method which compare 2 classified land use and land cover maps of different dates and reports any changes found on a pixel by pixel basis.

2.6 Bio-physical data analysis. Descriptive statistics analysis of bio-physical data that affect the land use changes were carried out. Data included topography, geology, landforms, soil, climate, water resources, and land cover and land use**.**

2.7 Socio-economic data analysis. Descriptive analysis of socio-economic data that affect the land use changes were carried out. Data included community's way of life, sociological data, local administration, social problems and conflict, and economic household.

2.8 Political data and data on policy analysis. Descriptive analysis of political data and data on policy that affect the land use changes were carried out. Data included public policy, national security policy, and political conflict data.

3 Field Investigation

Field investigation was conducted to acquire data on land use types and land cover changes and to evaluate field sheet designed for the project. Coordinates of observation points were collected by using GPS digital camera.

RESULTS AND DISSCUSSION

Biophysical Resources of the Study Area

The study area is approximately 44,200 hectares (442 km^2) located on Phanom Dong Rak mountain range between the border line of Thailand and Cambodia. The Phanom Dong Rak mountain range is situated between 14° 19' 7" N – 14° 28' 19" N and 104° 32' 26" E – 104° 46' 55" E according to the Latitude/Longitude unit, whereas it ranges between 48P 1583000N – 1603000N to 450500E – 476500E basing on the UTM unit. The study area includes sub-districts of Sao Thong Chai, Lalai, Rung, and Phu Pha Mok, Kantharalak district, Srisaket province in Thailand and sub-district of Kantruat, Chomkrasan district, Preah Vihere province in Cambodia (Figure 1).

The area is bounded to:

North:	Cham, Muang Thung Yai, Bung Malu, and Non Samran sub-district, Kantharalak district, Srisaket province
South:	Cambodia
East:	Khok Sa At sub-district, Nam Khun district, Ubon Ratchathani province
West:	Bak Dong sub-district, Khun Han district, Srisaket province

1. Climate

The study area is under tropical savanna climate with three main seasons, i.e., summer, rainy season and winter. Summer is from March to May, rainy season is from June to October, and winter is from November to February. An eleven year record (2001-2011) at the weather station in Srisaket province, under Meteorology Department (Table 1) shows that the average annual rainfall in Srisaket province is 1,495.1 mm. Rainfall in 2001 was the highest of 2,048.4 mm. There is a degree of difference between the highest and the lowest temperature, according to the data from the weather station in Srisaket province. In eleven years the highest is 35.57

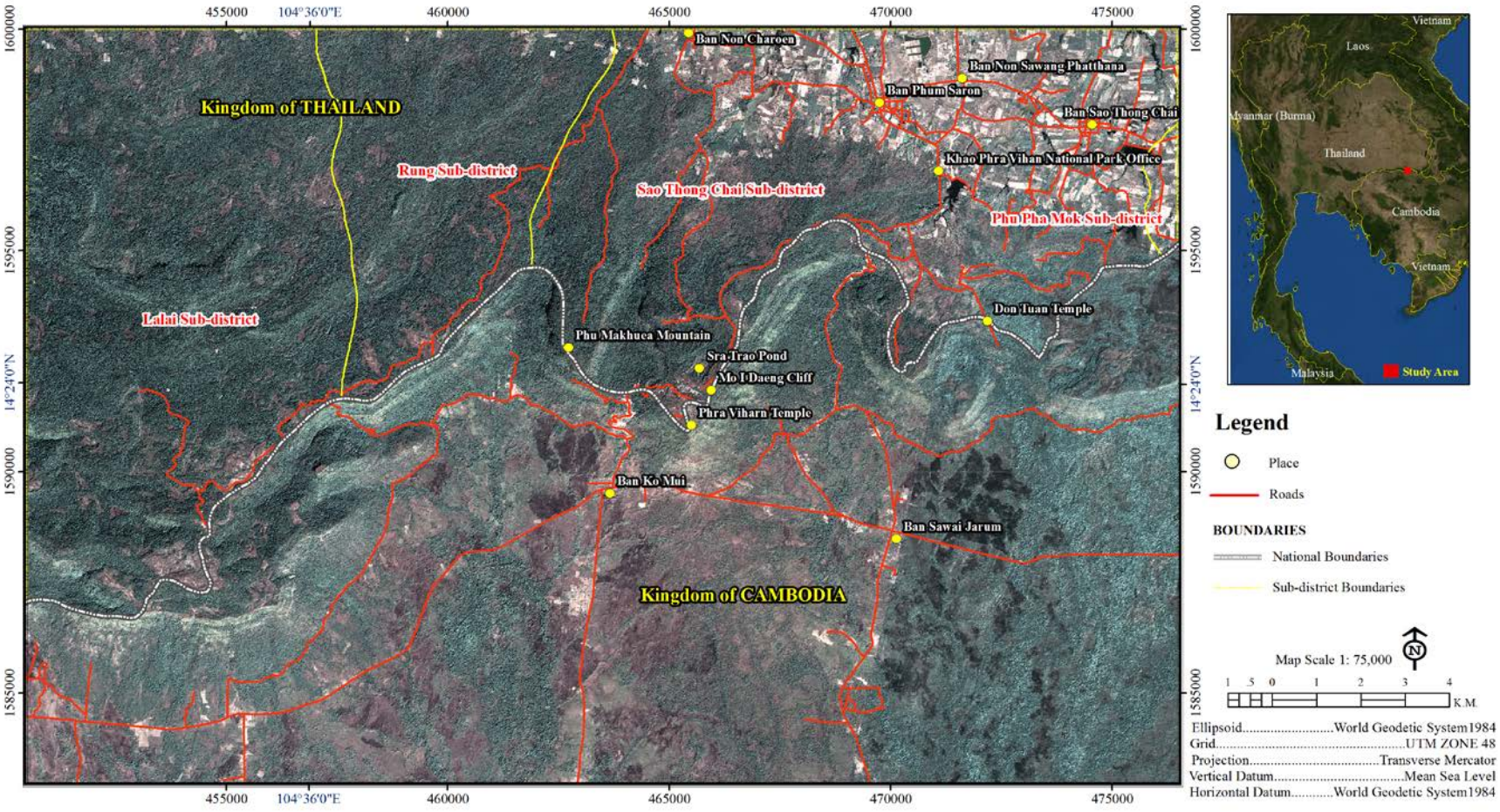

Figure 1 Study area.

and the lowest is 18.66 °C (Thai Meteorological Department, 2011).

Table 1 Meteorological data in Srisaket province.

Year	Rainfall (mm)	Temperature (°C)	
		Highest	Lowest
2001	2,048.4	35.36	19.46
2002	1,588.8	35.58	19.77
2003	1,520.3	35.64	18.96
2004	1,309.8	35.12	18.55
2005	1,232.0	36.40	18.63
2006	1,603.2	35.83	18.91
2007	1,427.2	35.72	18.58
2008	1,159.2	34.83	19.28
2009	1,597.7	35.50	18.82
2010	1,170.7	36.48	14.80
2011	1,788.7	34.79	19.45
Average	**1,495.1**	**35.57**	**18.66**

Source: Thai Meteorological Department (2011)

2. Topography

Phanom Dong Rak mountain range, the study area, is the mountain range along Thailand and Cambodia borders. Most of the areas are steep mountains and hills with different height ranging 200-600 meters above sea level. Phanom Dong Rak mountain range consists of Phanom Don Ao, Khao Phra Vihan, Phu Makhuea, Phanom Beng, Khao Sattasom, Phanom Rasai, and Phanom Ta Ngoen at the hight of 666, 646, 607, 572, 441, and 366 meters above sea level respectively. The area around Phanom Dong Rak mountain range in Thai territory are rolling, undulating, and plain but most of the areas in Cambodia (more than 90%) are plain (Royal Thai Survey Department, 1994) (Figure 2).

3. Geology

The geological characteristics of the study area in Thailand can be described in order of the youngest to the oldest rock as shown in (Department of Mineral Resources, 1983) (Figure 3).

3.1 Lower-Middle Cretaceous Rock: Phu Phan Rock Formation (Kpp)

Phu Phan Rock Formation in the study area of Thailand is 7,560.73 hectares (36.60%). This rock formation is in Khorat Group consisting of sandstone and gravel sandstone in grayish brown and orange colors. It's thick and slant array. This is the most common rock in this area from East to West.

3.2 Upper Cretaceous Rock: Khok Kruat Rock Formation (Kkk)

Khok Kruat Rock Formation of the study area in Thailand is 1,140.17 hectares (5.52%). This rock formation is in Khorat Group consisting of siltstone, sand stone, caliche-siltstone and conglomerate. This rock formation is notable for its fossils such as fossils of dinosaurs, sharks, fishes, turtles, crocodilians and pterosaurs. The thick layer of this rock formation is 709 meters.

3.3 Middle-Upper Jurassic Rock: Sao Khua Rock Formation (Jsk)

Sao Khua Rock Formation of the study area in Thailand is 11,955.94 hectares (57.88%). This rock formation is in Khorat Group consisting of sandstone in purple brown, purple gray and red brown colors, with the presence of lime. The formation was mostly found along southern borderline to Cambodia.

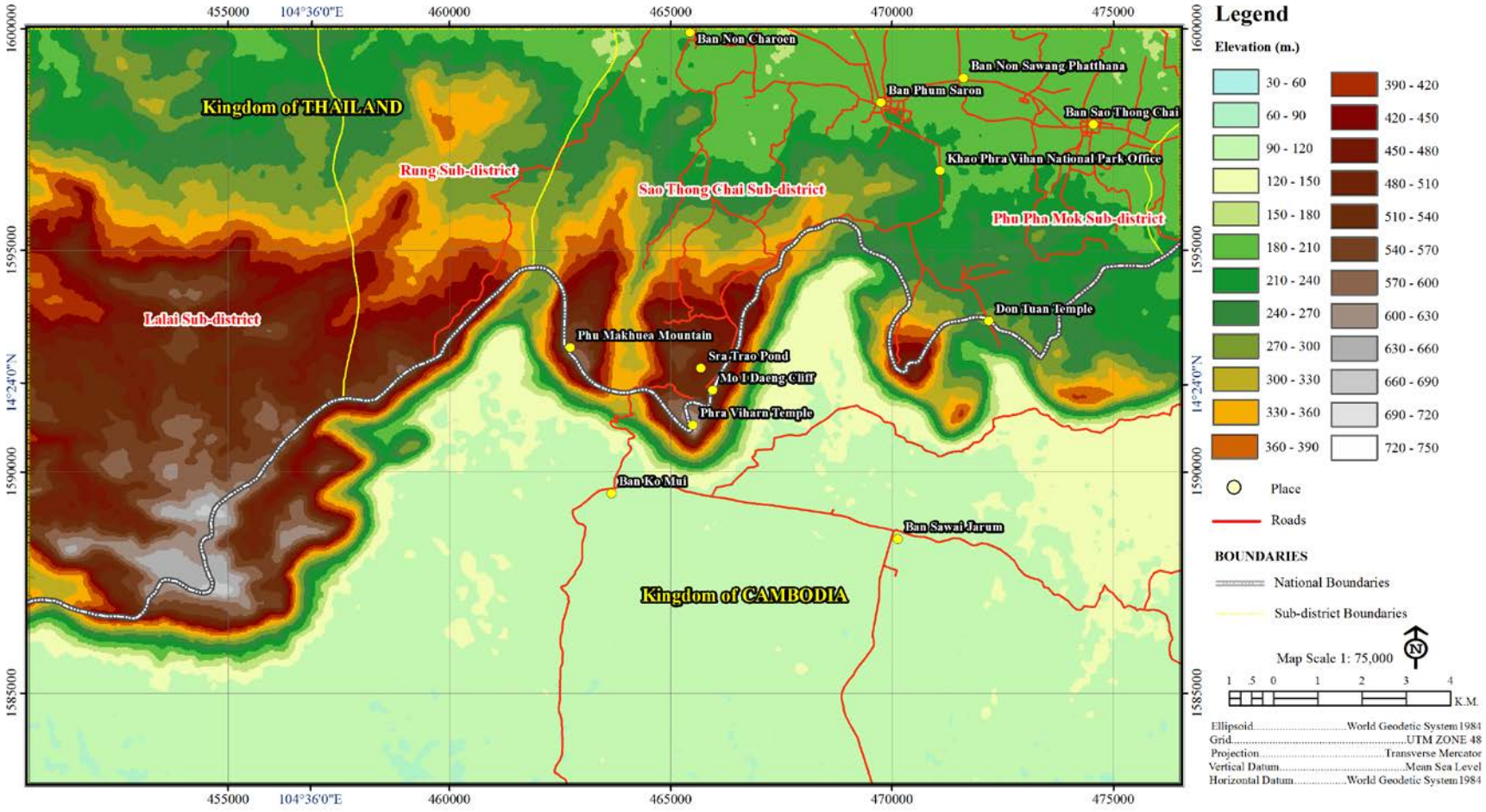

Figure 2 Elevation of the study area.

Source: Earth Remote Sensing Data Analysis Center (2011)

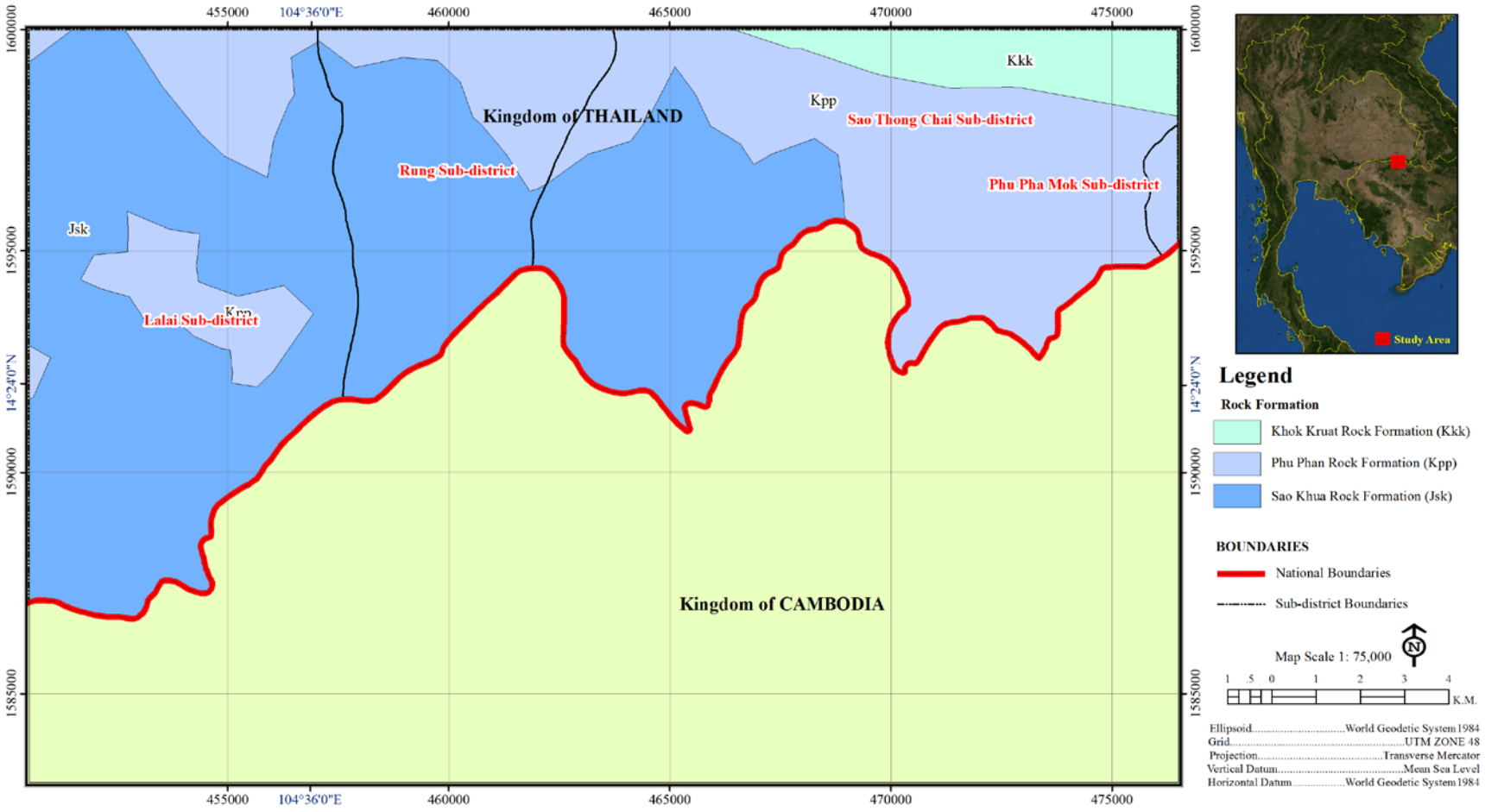

Figure 3 Geology of the study area

Source: Department of Mineral Resources (1983)

4. Geomorphology

Geomorphology of Phanom Dong Rak mountain range is sandstone cuesta of Khorat Group with riverine deposits tracking from leaf litter, fossil tracks and bivalve. The location of Phra Viharn Temple is a series of sandstone become hardening in fresh water. Geomorphological structure's change in the North-East concludes that there are at least 3 times resulting uplifted settlement of Khorat Group. The uplift is obviously remarkable from anticline (convex-upward fold mountain) and syncline mountain generally found in the North-East region. The uplift formed the plateau with 15-20° eastward dip angle. The escarpment of the area at the southern edge of Phra Viharn Temple, for Sao Khua Formation and Phuphan Formation, has a slope of fifteen degrees in North to South direction (aspect). The watershed boundary of Phanom Dong Rak mountain range is bordered by fold rocks. Some parts are cracked rock channels and some in water furrows, some hardening and some with rock hill being open space with gentle slope.

Phra Viharn Temple is located on Sao Khua Formation and Phuphan Formation. The study encompasses series of Khorat Group with several laying leaned in dip angle about 15-20° to Thailand. The upper end of watershed boundary transformed to be the natural border for Thailand and Cambodia.

Folding of world plate, rock uplifting of Khorat Group at Phra Viharn Temple and Sra Trao pond cause deep channel which are laters developed for furrow from rain erosion. The last development is now Huai Ta Ni and Huai Ta Maria stream following into Sra Trao pond. Remaining area with hardening rock hardening rock is open space with gentle slope. Ancient Khmer took this advantage as material site for construction of Phra Viharn Temple.

5. Water Resource

Water resources are from natural water sources and reservoirs. In Thailand, the important natural water resources are Huai Tani, Huai Ta Maria, Huai Takhop,

Huai Sangkot, Huai Ta Ngoet, Huai Tung, Huai Kaeo Masa, Huai Hin, Huai Takhrai, Huai Khayung, Huai Phlu, Huai Ta Nan, Huai Hin Lat, Huai Wa, and Huai Khanun streams and whereas the main reservoirs and pond are Huai Takhop reservoir, Wai Sib Song reservoirs, Ban Phum Saron reservoirs, and Sra Trao pond. In Cambodia, the important natural water resources are O Se, O Kokir, O Prony, O Preat, O Sambu, and O Sralan streams (Royal Thai Survey Department, 1994**)** (Figure 4).

6. Soil and Land Units

There are 5 soil and land units in the study area in Thailand composing of Khorat series (Kt), Dong Takhian Series (Dt), Satuek series (Suk), Nam Phong series (Ng), and Slope Complex (SC) (Figure 5).

6.1 Khorat series (Kt)

Khorat series in the study area scatteringly discovered in sub-districts of Sao Thong Chai and Rung coving the area of 1,823.04 hectares (8.83%). Khorat soils are formed from washed deposit of sandstone and occur on middle part of peneplain. Relief is gently undulating which slopes range from 2 to 6 percent. The climate is tropical savanna. Average annual precipitation varies from 1,100 to 1,400 mm The mean annual temperature is from 26 to 28 ^{o}C. The Khorat series is a member of the fine-loamy, siliceous, isohyperthermic Typic (Oxyaquic) Kandiustults. They are deep soils and are characterized by a dark brown or brown sandy loam or loamy sand A horizon overlying a brown, yellowish brown or light yellowish brown sandy clay loam kandic B horizon. Colors of pinkish gray, light gray or light brownish gray also occur in the lower B horizon. Common strong brown and/or reddish yellow mottles occur in the lower B horizon usually below 50 cm of the soil surface. They are moderately well drained soils. Permeability is moderate. Runoff is rapid. The soils are very strongly to strongly acid throughout the profile and they have low fertility (Malairojsiri *et al*., 2002).

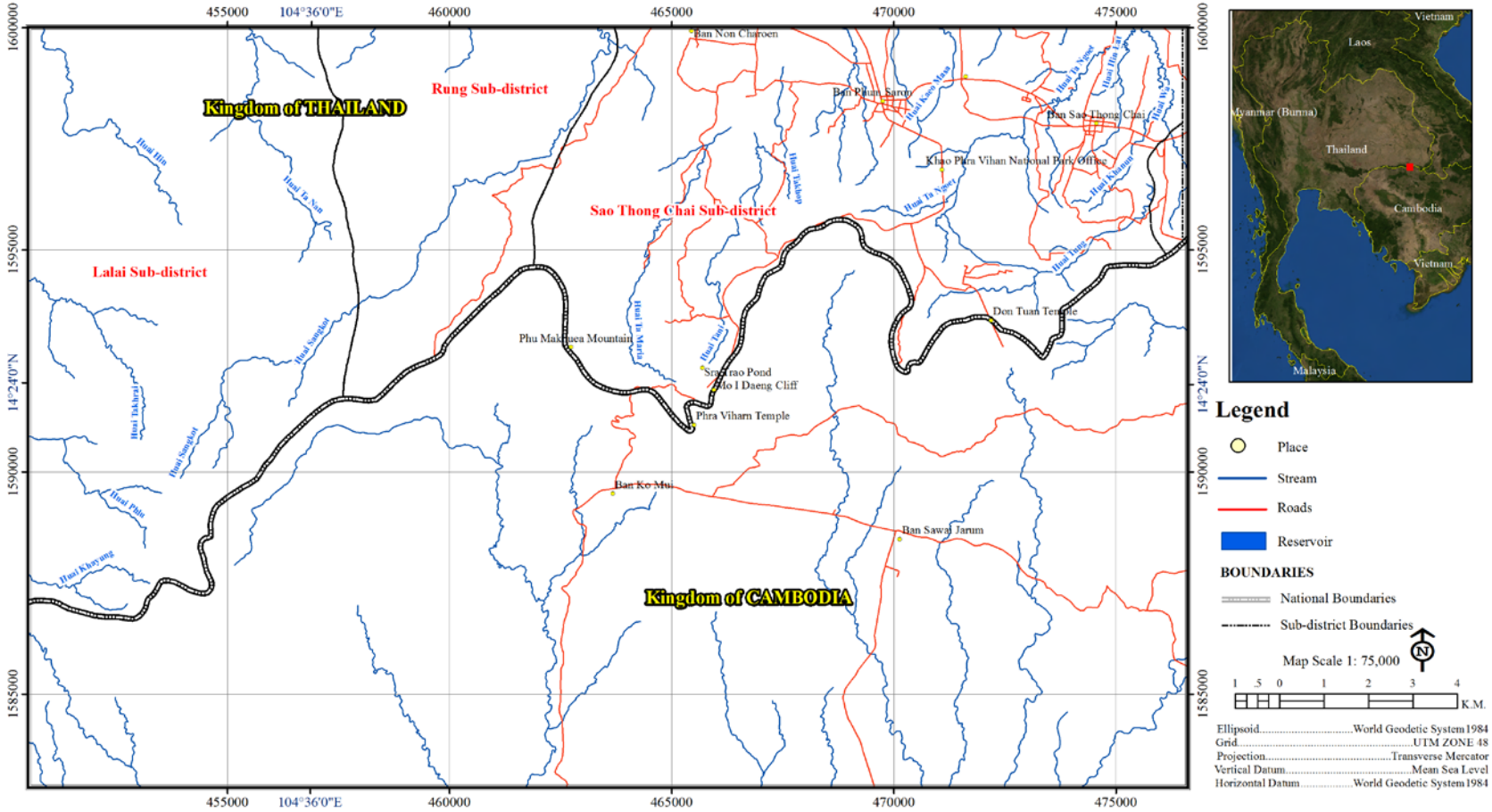

Figure 4 Water resources in the study area**.**

Source: Royal Thai Survey Department (1994**)**

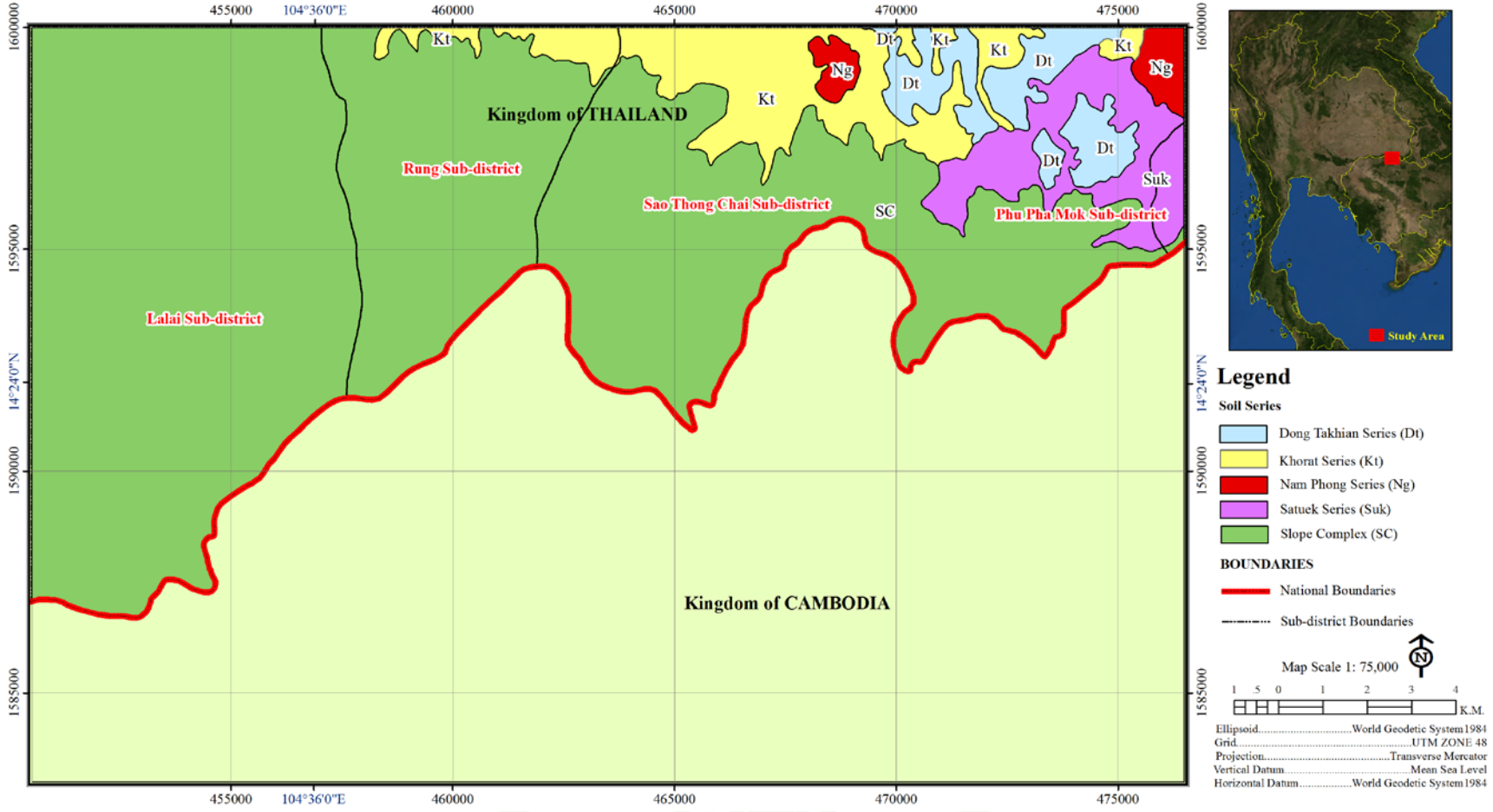

Figure 5 Soil and land units in the study area.

Source: Land Development Department (1986)

6.2 Dong Takhian series (Dt)

Dong Takhian series in the study area of Thailand scatteringly discovered in sub-districts of Sao Thong Chai covering the areas of 904.66 hectares (4.38%). Dong Takhian soils are formed from alluvium and local colluviums from granite and occur on high terraces. Relief is undulating with a range of slope from 2 to 4 percent. The climate is tropical savanna. Average annual precipitation is from 1,300 mm up to 1,800 mm. The mean annual temperature is 27 ^{o}C. Dong Takhian series is a member of the coated, isohyperthermic Lamellic Ustic Quartzipsamments. They are very deep, medium to slightly acid soils and are characterized by a dark colored loamy sand or sandy loam A horizon overlying a thick pinkish white, white, pinkish gray or light gray loamy sand or sand E horizon. This in turn overlies a brown or dark brown sandy C horizon which has an upper boundary at some depth below 1 m from the soil surface. They have a thin lamellae about 2-3 cm within 200 cm with sandy loam textures. They are excessively drained. Permeability is rapid. Runoff is slow to moderate. Groundwater level is below 1.5 m throughout the year. The soils are slightly to moderately acid and they have low fertility (Udomsri *et al*., 2002).

6.3 Satuek series (Suk)

Satuek series in the study area of Thailand scatteringly discovered in sub-districts of Sao Thong Chai covering the areas of 1,123.95 hectares (5.44%). Satuek soils are formed from wash deposit from sandstone and occur on the middle part of peneplain. Relief is undulating with range of slope from 2 to 8 percent. The climate is tropical savanna. Average annual precipitation is from 1,100 mm up to 2,200 mm The mean annual temperature is from 26 to 28 ^{o}C. Satuek series is a member of the fine-loamy, siliceous, subactive, isohyperthermic Typic Paleustults. They are very deep soils and are characterized by a very dark grayish brown, dark grayish brown or dark brown sandy loam A horizon overlying a strong brown or yellowish brown or reddish yellow sandy clay loam or clay loam argillic B horizon. They are well drained. Ground water table falls below 1.5 m most of the years. Permeability is

moderate and surface runoff is medium to rapid. The soils are slightly to moderately acid over strongly to very strongly acid and they have low fertility (Malairojsiri *et al*., 2002).

6.4 Nam Phong series (Ng)

Nam Phong series in the study area of Thailand scatteringly discovered in sub-districts of Sao Thong Chai covering the areas of 293.33 hectares (1.42%). Nam Phong soils are formed from wash deposit from sandstone and occur on upper part of peneplain. Relief is undulating which slopes range from 3 to 10 percent. Climate is tropical savanna. The average annual precipitation ranges from 1,100 to 1,500 mm. The mean annual temperature is from 25 to 28 °C. Nam Phong series is a member of the loamy, siliceous, isohyperthermic Grossarenic Haplustalfs. They are deep sandy soils and are characterized by a grayish brown or dark brown to brown loamy sand or sand A horizon overlying a pink or very pale brown loamy sand or sand E horizon. The argillic B horizon occurs at some depth below 100 cm of the soil surface with a pinkish gray, pale brown or very pale brown sandy loam grading to sandy clay loam layers. Common distinct reddish yellow and/or yellowish red mottles occur in the subsoils. They are well drained to somewhat excessively drained. Permeability and runoff are rapid. They are strongly to moderately acid over very strongly to strongly acid and they have low fertility (Malairojsiri *et al*., 2002).

6.5 Slope Complex (SC)

Slope Complex is the most extensive land unit along Phanom Dong Rak mountain range between the border line of Thailand and Cambodia. Slope Complex occupies 16,511.82 hectares or 77.93% of the study area in Thailand. Parent material, formed by erosion of various parent materials both on site and colluviated materials, erosion surface and peneplain. Hills are steep slope and mountainous mainly having over 35 percent slope. The soils are very well or too well drained. Soil characteristics such as texture, color, depth, pH, and natural soil fertility vary upon parent materials. But mostly they are shallow soils, with rock outcrops. Most of the area is covered by

forests such as mixed deciduous, dipterocarp deciduous, or evergreen forest. Many places are used for field crops without conservation measures, causing high erosion of soil surface. The main problems are soil erosion, and shallow soil with rock outcrops. It is therefore not suitable for agricultural activities and should be preserved for conservation purpose. The area is also highly environmental sensitive. In worst cases, it should be used for conservation or agro-forest activities. This combined soil group consists of various types of soil, and cannot be classified (Malairojsiri *et al*., 2002).

7. Forests

The Phanom Dong Rak mountain range is mostly steep mountainous and hilly. The natural forests of the study area in Thailand are located in Khao Phra Vihan National Park about 3,358.15 hectares (16.26%) and in Phanom Dong Rak Wildlife Sanctuary about 13,858.14 hectares (67.09%) (Figure 6). Forest types include dry evergreen forest, mixed deciduous forest, and dry dipterocarp forest alternately. Dry evergreen forest is mostly found near the borderline to Cambodia, under military control. Rock outcrops can also be found around the area. Grass types and pioneer species are found together with successive perennial plants. Human activities take place in the open area (National Park, Wildlife, and Plant Conversation Department, 2005).

7.1 Dry Evergreen Forest

Dry evergreen forest is equally composed of deciduous and non-deciduous plants. In dry season, despite a huge amount of leaf fall the canopy always stays green. Those plants are *Hopea ferrea, Dipterocarpus turbinatus* in the upper storey while *Lagerstroemia calyculata,* and *Dalbergia cochinchinensis* are deciduous plants of the upper canopy. In the secondary canopy are *Memecylon ovatum, M. garcinioides,* and *Hydoncarpus ilicifolius*. In the undergrowth are *Ixora cibdela,* and *Randia* spp. (National Park, Wildlife, and Plant Conversation Department, 2005).

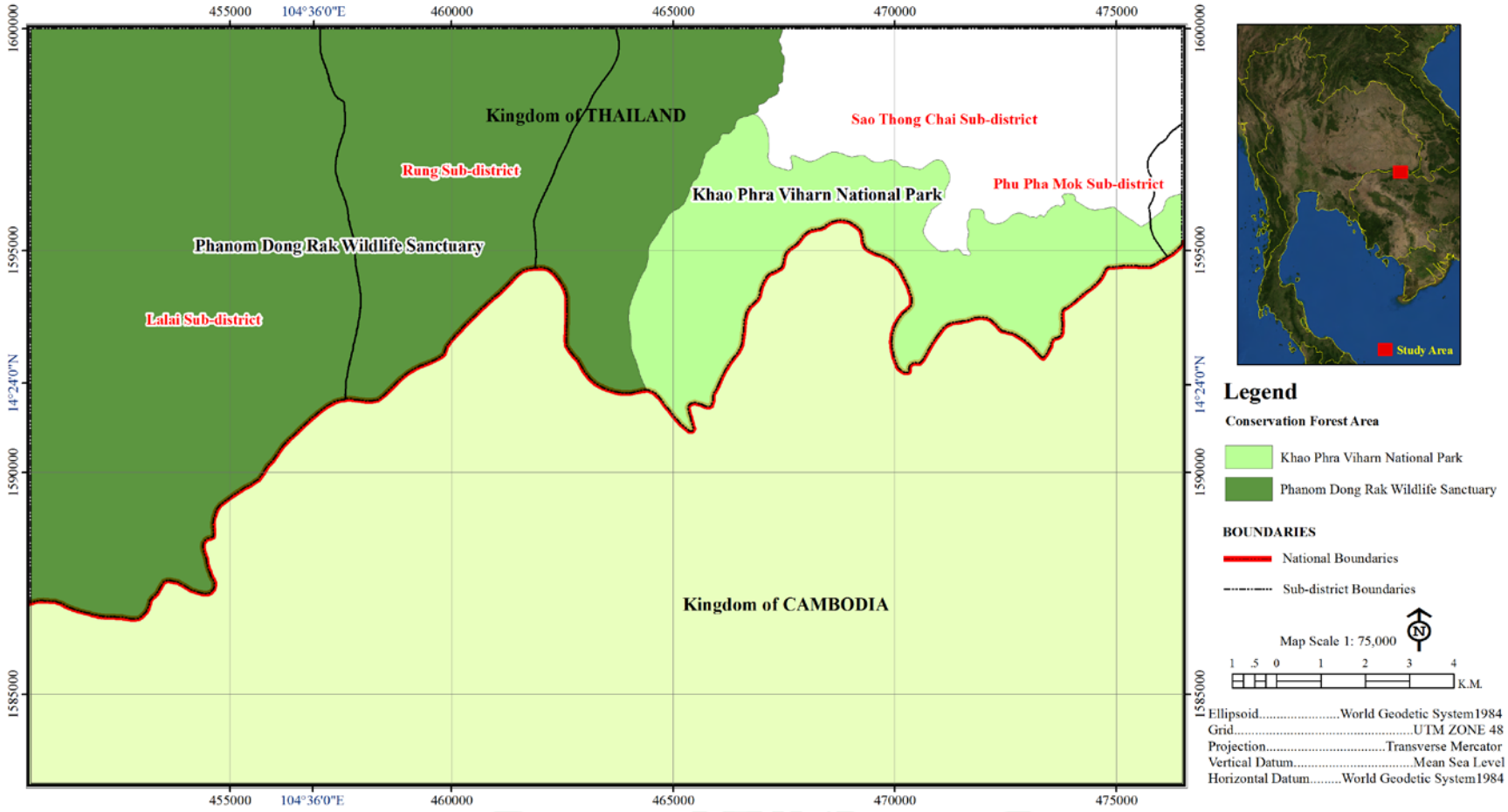

Figure 6 Conservation forest area in the study area.

Source: National Park, Wildlife, and Plant Conversation Department (2011)

The forest is dense because it grew on the ground with higher soil depth compared to mixed deciduous forest and dry dipterocarp forest. In addition, with high humidity, most trees are large especially *Hopea ferrea*. It has a full canopy with dense undergrowth, with succession of a high degree (National Park, Wildlife, and Plant Conversation Department, 2005).

7.2 Mixed Deciduous Forest

In general, vegetation in this forest is thin. Leaves fall off in part in dry season. This forest dispersal in the study area was found on high ground and in moist area near stream. Plants are of moderate size. Undergrowth is not dense. In deep soil area, mixed deciduous forest is found alternately with dry evergreen forest. Most trees are small due to dryness, shallow soil, and low soil humidity. Abundant species of top canopy are *Pterocarpus macrocapus*, *Bonbax ancepts*, *Peltophorum dasyrahis*, *Xylopia vielanna*, *Lithocarus fenestratus*, *Syzygium albiflorum*, and *Vatica harmandiana* (National Park, Wildlife, and Plant Conversation Department, 2005).

Mixed deciduous forest is denser than the dry dipterocarp forest because of deeper soils. Undergrowth is denser than of dry dipterocarp forest but in general it was rather sparse, difficult for succession. This forest is hardly found at the clearing around the temple (National Park, Wildlife, and Plant Conversation Department, 2005).

7.3 Dry Dipterocarp Forest

Dry dipterocarp forest is a prominent forest community of the northeast of Thailand. It is one of the deciduous forest communities that grow in the clear seasonal difference (rainy and season). Normally, the dry season lasts longer than 4 mouths per year. It is found at 50 meters above MSL up to 1,000 meters. In the study area, it is found alternately with mixed deciduous forest and dry evergreen forest, depending on soil condition. It is usually found on sandy soil, rock or lateritic soil with shallow laterite layer. Some were found with traces of natural fire. The

dominant plants are *Dipterocarpus obtusifolius*, *D. tuberculatus*, *Shorea siamensis*, *Sindora siamensis*, *Madhuca thorelii*, and *Terminalia pedicellata*. The undergrowth was *Arundinaria pusilla* (National Park, Wildlife, and Plant Conversation Department, 2005).

Dry dipterocarp forest is not dense because it grow on rocky ground with shallow soils at cracks or groves caused by erosion from water flow. Most trees are small, with incomplete canopy or being stunted. Undergrowth is clear of vegetation causing difficult succession (National Park, Wildlife, and Plant Conversation Department, 2005).

Most of the natural forests of the study area in Cambodia are in the plain. The extents of forest types in descending order are mixed deciduous forest, dry evergreen forest, and dry dipterocarp, respectively.

Land Use of Phanom Dong Rak Mountain Range

The study area covers Phanom Dong Rak mountain range where Phra Viharn Temple is situated. It covers a total area of 44,200 hectares in Thailand and Cambodia 20,656.84 hectares on the Thai side and 23,543.16 hectares on the Cambodian side (Figure 7). The major area is in the Thai territory, the area of 17,216.29 hectares (83.35%) located in Khao Phra Viharn National Park and Phanom Dong Rak Wildlife Sanctuary.

1. Overall Land Use of Thailand and Cambodia in 2001

1.1 Land Use of Thailand in 2001

The study area in the Thai territory covers 20,656.84 hectares. According to the interpretation of LANDSAT-5 TM satellite images for classification land use types in 2001. It was found that land use types consist of 11 categories: 1) Dry evergreen forest 14 ,036.19 hectares (67.95%), 2) Mixed deciduous forest 318.05 hectares (1.54%), 3) Dry dipterocarp forest 84.01 hectares (0.41%), 4) Paddy rice 2,890.31 hectares (13.99%), 5) Other field crops 420.42 hectares (2.04%), 6) Cassava 3.53 hectares (0.02%), 7) Village and building 167.21 hectares (0.81%), 8) Pond and reservoir 153.22 hectares (0.74%), 9) Rock outcrop 906.92 hectares (4.39%), 10) Secondary forest 1,403.08 hectares (6.79%), and 11) Disturbed forest 273.90 hectares (1.33%) as shown in Table 2, Figure 7, and Figure 8.

1.2 Land Use of Cambodia in 2001

The study area in the Cambodian territory covers 23,543.16 hectares. According to the interpretation of LANDSAT-5 TM satellite images for classification land use types in 2001. It was found that land use types consist of 8 categories: 1) Dry evergreen forest 10 ,117.54 hectares (42.97%), 2) Mixed deciduous forest 10,395.91 hectares (44.16%), 3) Dry dipterocarp forest 3.08 hectares (0.01%), 4) Paddy rice 0.88 hectares (0.004%), 5) Village and building 100.10 hectares (0.43%),

6) Rock outcrop 394.08 hectares (1.67%), 7) Secondary forest 70.15 hectares (0.30%), and 8) Disturbed forest 2,461.43 hectares (10.45%) as shown in Table 3, Figure 7, and Figure 9.

Table 2 Overall land use types of the study area in Thailand.

Type Use Type	Area (ha)		
THAILAND	**2001**	**2006**	**2011**
1. Dry evergreen forest	14,036.19	14,004.09	14,679.57
2. Mixed deciduous forest	318.05	353.50	367.94
3. Dry dipterocarp forest	84.01	84.01	84.01
4. Paddy rice	2,890.31	1,614.24	1,419.19
5. Other field crops	420.42	1,599.73	360.62
6. Cassava	3.53	22.00	20.68
7. Para rubber	-	48.08	1,378.38
8. Oil palm	-	-	43.49
9. Eucalyptus	-	48.10	67.66
10. Mixed orchards	-	52.01	22.56
11. Village and building	167.21	278.26	281.16
12. Pond and reservoir	153.22	222.52	189.35
13. Rock outcrop	906.92	906.92	906.92
14. Secondary forest	1,403.08	1,294.13	814.15
15. Disturbed forest	273.90	129.26	21.16
Total		**20,656.84**	

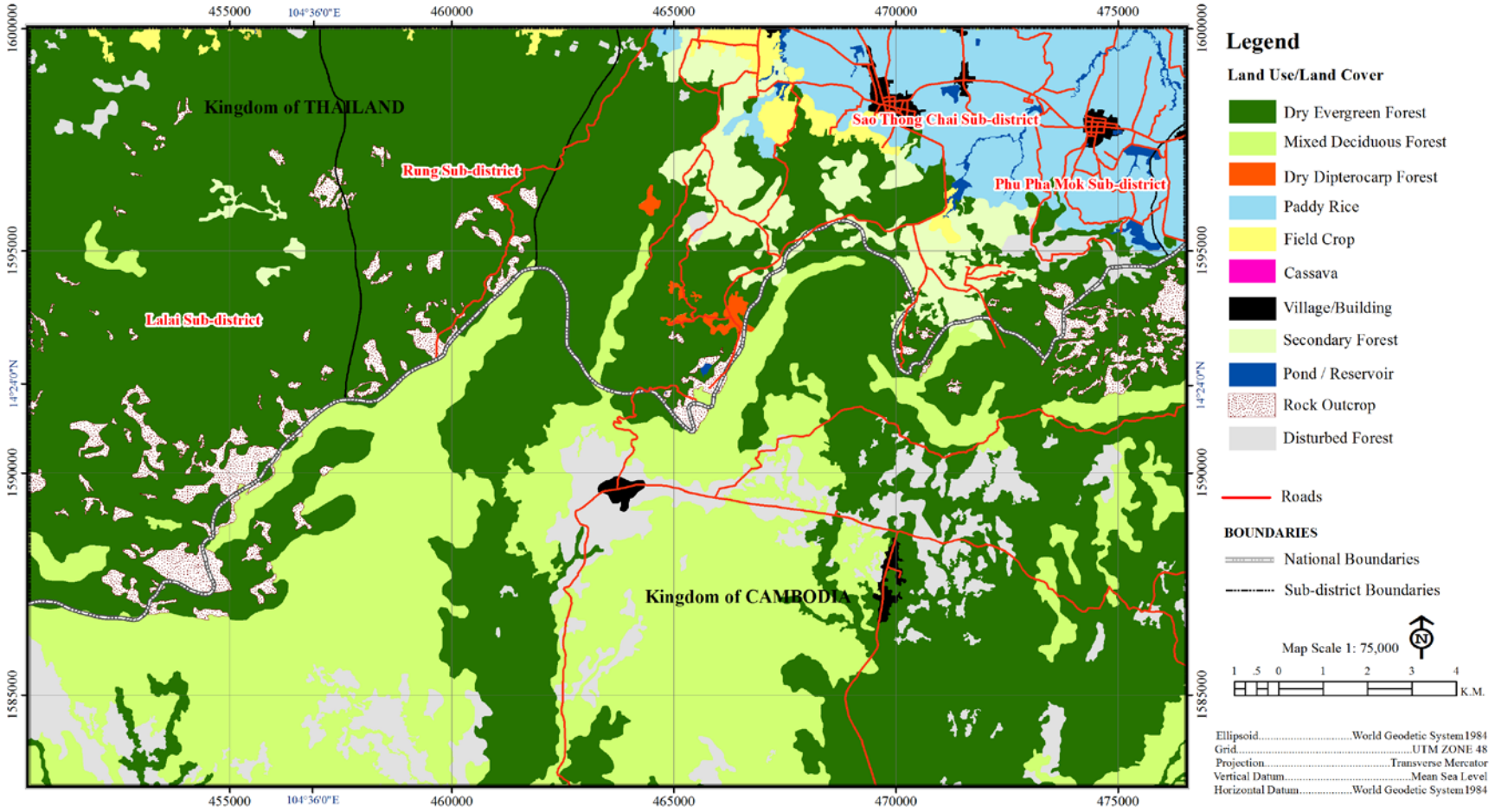

Figure 7 Overall land use types of Thailand and Cambodia in the study area in 2001.

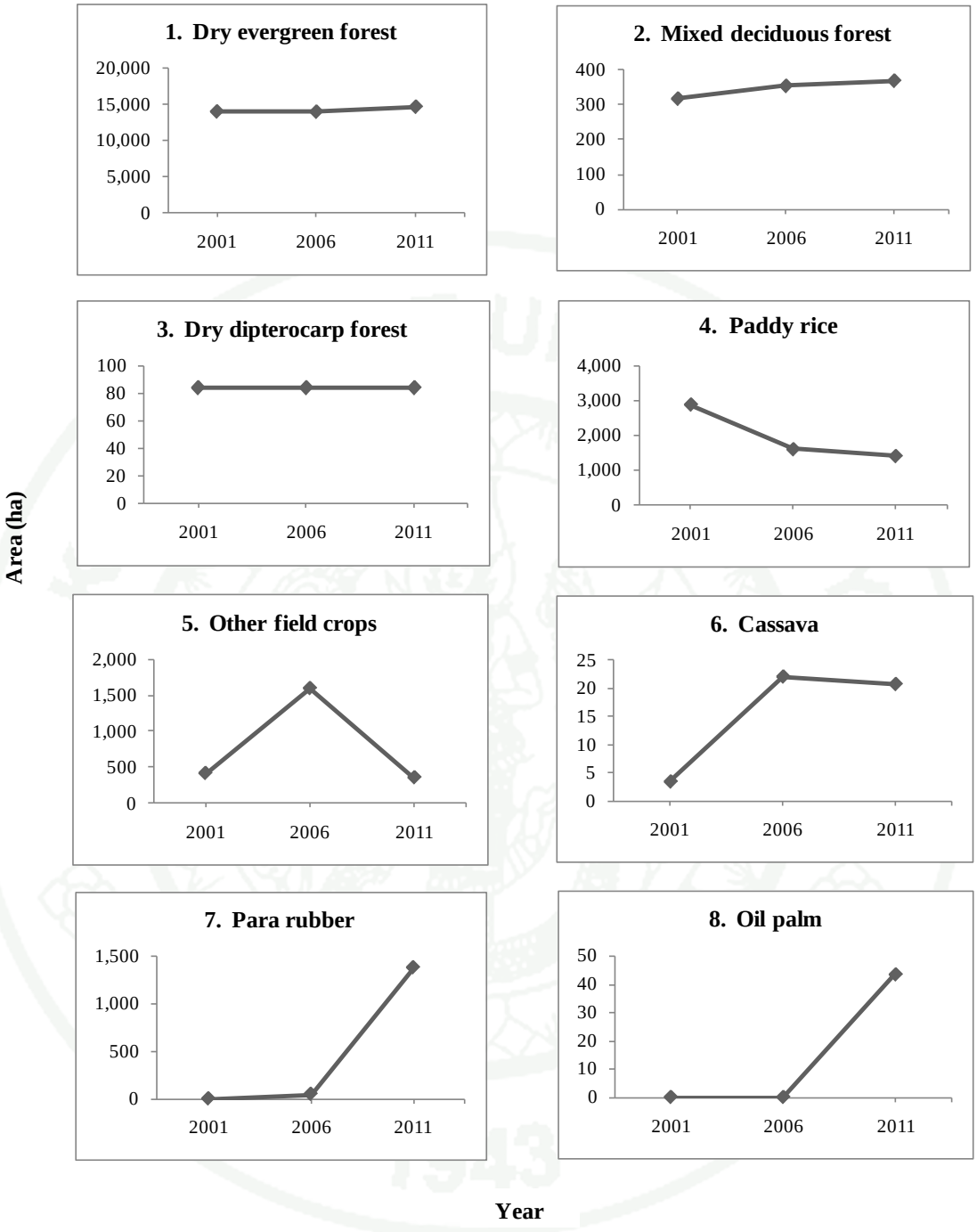

Figure 8 Land use types of Thailand in the study area in 2001, 2006, and 2011.

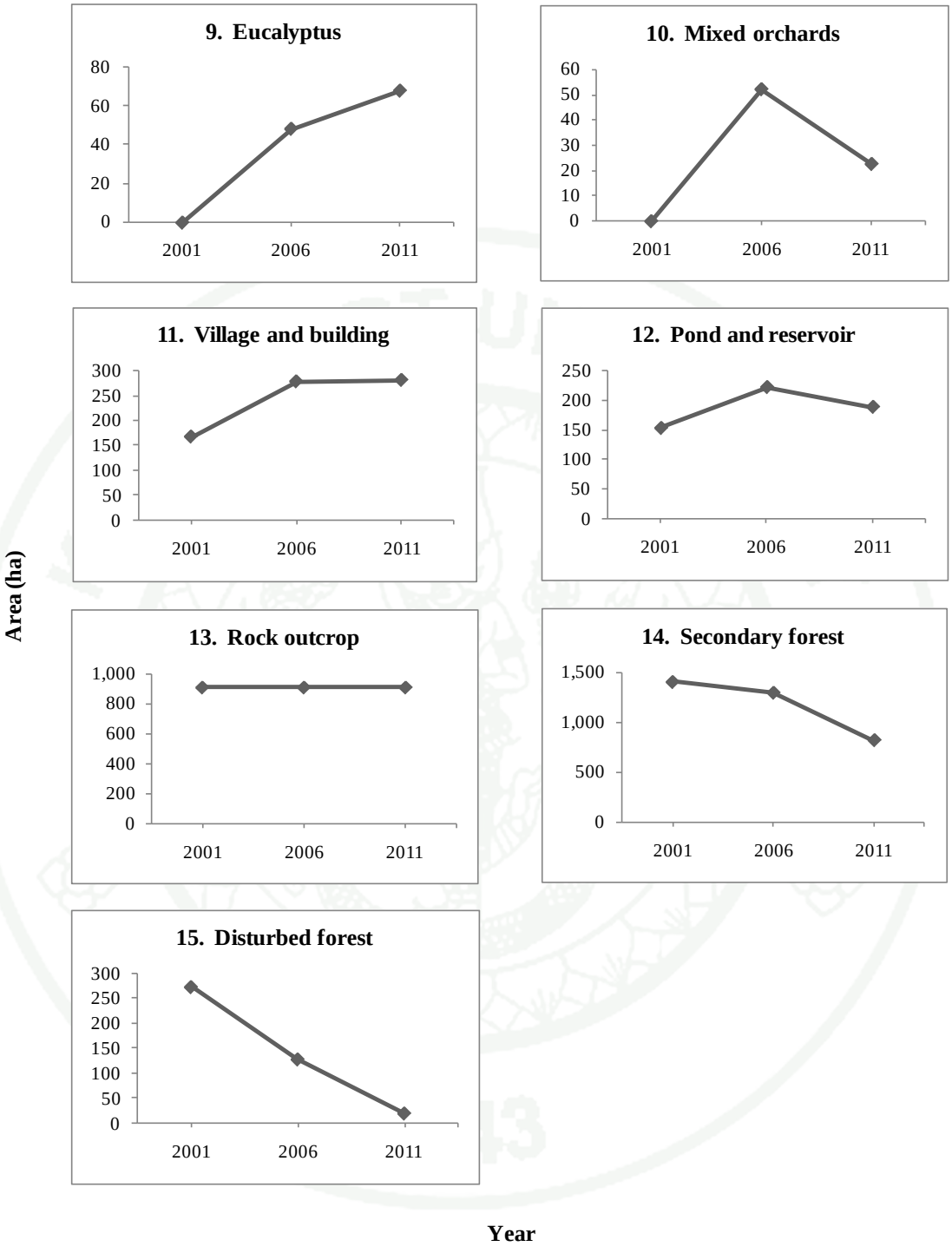

Figure 8 (Continued).

Table 3 Overall land use types of the study area in Cambodia.

Land Use Type	Area (ha)		
CAMBODIA	**2001**	**2006**	**2011**
1. Dry evergreen forest	10,117.54	9,937.20	7,891.20
2. Mixed deciduous forest	10,395.91	9,245.59	6,649.44
3. Dry dipterocarp forest	3.08	3.08	3.08
4. Paddy rice	0.88	0.88	-
5. Other field crops	-	3.75	3.71
6. Village and building	100.10	186.47	266.91
7. Pond and reservoir	-	-	0.47
8. Rock outcrop	394.08	396.72	396.58
9. Secondary forest	70.15	94.25	39.49
10. Disturbed forest	2,461.43	3,675.22	8,292.27
Total		**23,543.16**	

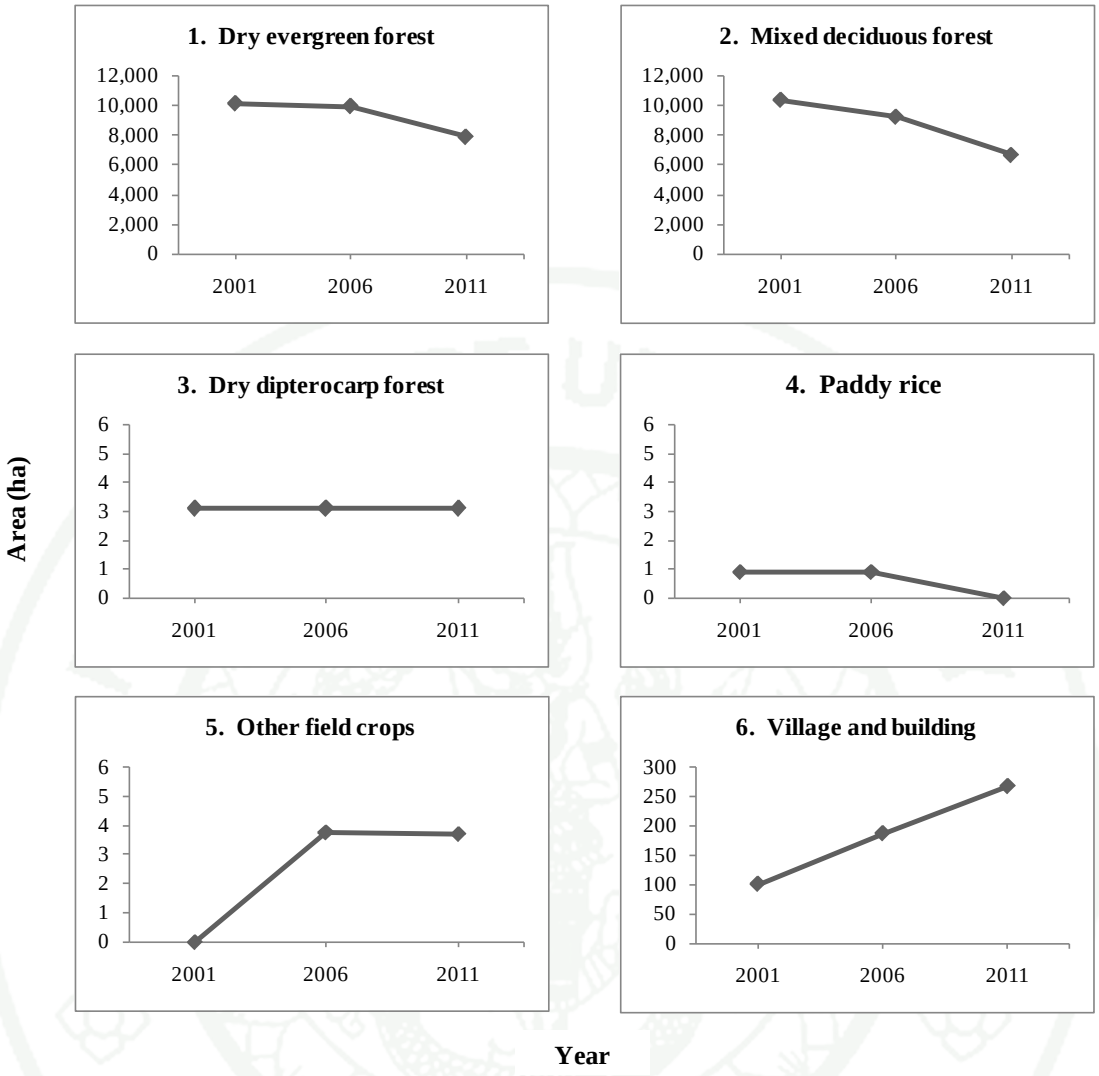

Figure 9 Land use types of Cambodia in the study area in 2001, 2006, and 2011**.**

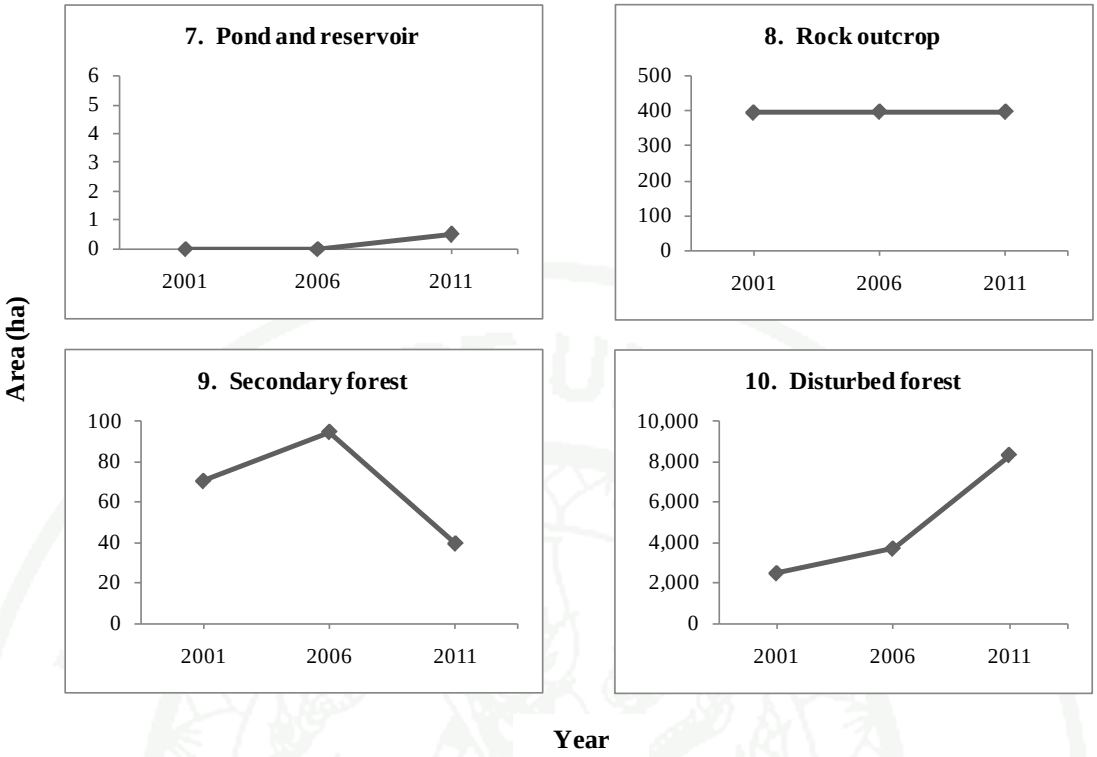

Figure 9 (Continued).

2. Overall Land Use of Thailand and Cambodia in 2006

2.1 Land Use of Thailand in 2006

The study area in the Thai territory covers 20,656.84 hectares. According to the interpretation of SPOT-5 satellite images for classification land use types in 2006. It was found that land use types consist of 14 categories: 1) Dry evergreen forest 14 ,004.09 hectares (67.79%), 2) Mixed deciduous forest 353.50 hectares (1.71%), 3) Dry dipterocarp forest 84.01 hectares (0.41%), 4) Paddy rice 1,614.24 hectares (7.81%), 5) Other field crops 1,599.73 hectares (7.74%), 6) Cassava 22 hectares (0.11%), 7) Para rubber 48.08 hectares (0.23%), 8) Eucalyptus 48.10 hectares (0.23%) 9) Mixed orchards 52.01 hectares (0.25%), 10) Village and building 278.26 hectares (1.35%), 11) Pond and reservoir 222.52 hectares (1.08%), 12) Rock outcrop 906.92 hectares (4.39%), 13) Secondary forest 1,294.13 hectares (6.26%), and 14) Disturbed forest 129.26 hectares (0.63%) as shown in Table 2, Figure 8, and Figure 10.

2.2 Land Use of Cambodia in 2006

The study area in the Cambodian territory covers 23,543.16 hectares. According to the interpretation of SPOT-5 satellite images for classification land use types in 2006. It was found that land use types consist of 9 categories: 1) Dry evergreen forest 9 ,937.20 hectares (42.21%), 2) Mixed deciduous forest 9,245.59 hectares (39.27%), 3) Dry dipterocarp forest 3.08 hectares (0.01%), 4) Paddy rice 0.88 hectares (0.004%), 5) Other field crops 3.75 hectares (0.02%), 6) Village and building 186.47 hectares (0.79%), 7) Rock outcrop 396.72 hectares (1.69%), 8) Secondary forest 94.25 hectares (0.40%), and 9) Disturbed forest 3,675.22 hectares (15.61%) as shown in Table 3, Figure 9, and Figure 10.

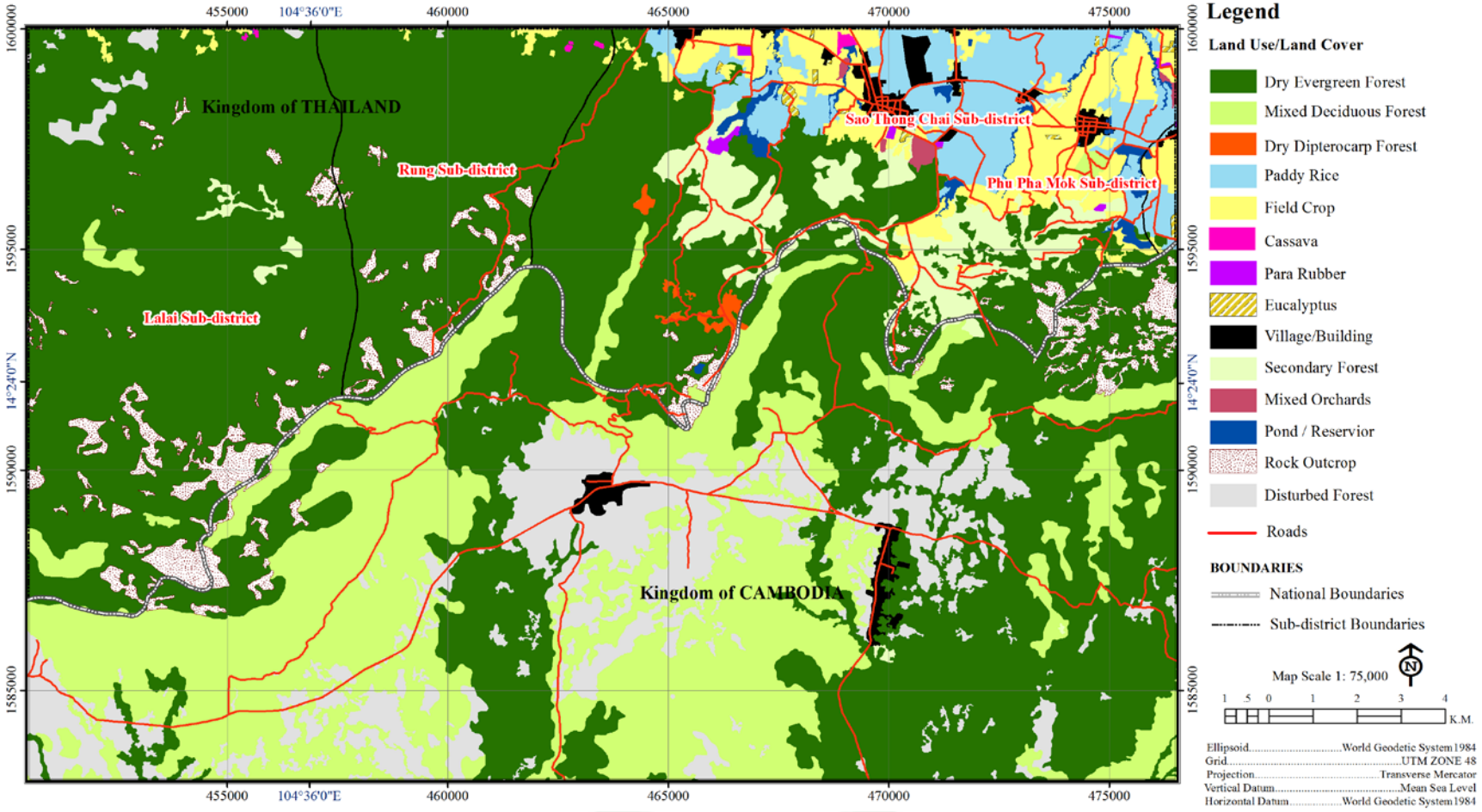

Figure 10 Overall land use types of Thailand and Cambodia in the study area in 2006.

3. Overall Land Use of Thailand and Cambodia in 2011

3.1 Land Use of Thailand in 2011

A study area in the Thai territory covers 20,656.84 hectares. According to the interpretation of THEOS satellite images for classification land use types in 2011. It was found that land use types consist of 15 categories: 1) Dry evergreen forest 14,679.57 hectares (71.06%), 2) Mixed deciduous forest 367.94 hectares (1.78%), 3) Dry dipterocarp forest 84.01 hectares (0.41%), 4) Paddy rice 1,419.19 hectares (6.87%), 5) Other field crops 360.62 hectares (1.75%), 6) Cassava 20.68 hectares (0.10%), 7) Para rubber 1 ,378.38 hectares (6.67%), 8) Oil palm 43.49 hectares (0.21%), 9) Eucalyptus 67.66 hectares (0.33%), 10) Mixed orchards 22.56 hectares (0.11%), 11) Village and building 281.16 hectares (1.36%), 12) Pond and reservoir 189.35 hectares (0.91%), 13) Rock outcrop 906.92 hectares (4.39%), 14) Secondary forest 814.15 hectares (3.94%), and 15) Disturbed forest 21.16 hectares (0.10%) as shown in Table 2, Figure 8, and Figure 11.

3.2 Land Use of Cambodia in 2011

The study area in the Cambodia territory covers 23,543.16 hectares. According to the interpretation of THEOS satellite images for classification land use types in 2011. It was found that land use types consist of 9 categories: 1) Dry evergreen forest 7 ,891.20 hectares (33.52%), 2) Mixed deciduous forest 6,649.44 hectares (28.24%), 3) Dry dipterocarp forest 3.08 hectares (0.01%), 4) Other field crops 3.71 hectares (0.02%), 5) Village and building 266.91 hectares (1.13%), 6) Pond and reservoir 0.47 hectares (0.002%), 7) Rock outcrop 396.58 hectares (1.68%), 8) Secondary forest 39.49 hectares (0.17%), and 9) Disturbed forest 8,292.27 hectares (35.22%) as shown in Table 3, Figure 9, and Figure 11.

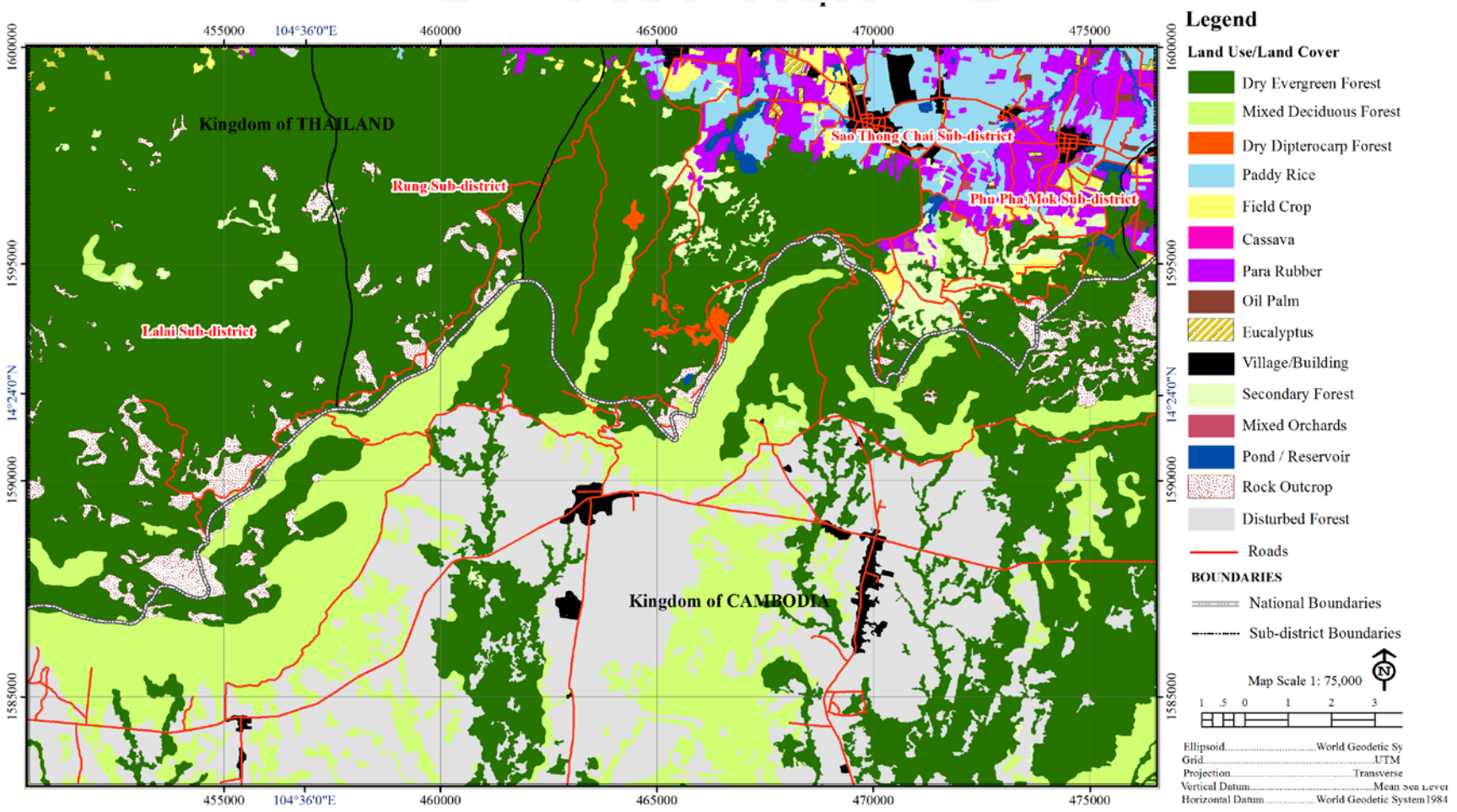

Figure 11 Overall land use types of Thailand and Cambodia in the study area in 2011.

Zoning of Land Use and Land Use Change in Thailand and Cambodia

According to the study of land use types of Thailand and Cambodia in 2001, 2006 and 2011, the study area has been divided into 3 zones: Zone I, Zone II and Zone III, for land use change comparison for each period as shown in Figure 12, 15, and Figure 18**.**

1. Land Use and Land Use Change of Zone I in Thailand and Cambodia

Zone I covers 14,733.37 hectares: an area of 9,444.10 hectares (61.10%) on the Thai side and an area of 5,289.26 hectares (35.89%) on the Cambodian side. Zone I is not the disputed area between Thailand and Cambodia.

1.1 Land Use and Land Use Change of Zone I in Thailand

The study area of Zone I in Thailand covers 9,444.10 hectares. It is located in Lalai and Rung sub-district, Kantharalak district, Srisaket province. The whole area of Zone I is situated in Phanom Dong Rak Wildlife Sanctuary. The landscape is mountainous particularly the border between Thailand and Cambodia. However, the northern area is composed of rolling and undulating plain. Therefore, it is easily invaded especially the during cultivation season, it would be converted to a cultivated area by villagers nearby.

In 2001, the land use classification consisted of 8 land use categories: 1) Dry evergreen forest 8,398.21 hectares (88.93%), 2) Mixed deciduous forest 192.49 hectares (2.04%), 3) Other field crops 57.90 hectares (0.61%), 4) Cassava 3.53 hectares (0.04%), 5) Pond and reservoir 0.36 hectares (0.004%), 6) Rock outcrop 635.37 hectares (6.73%), 7) Secondary forest 74.95 hectares (0.79%), and 8) Disturbed forest 81.29 hectares (0.86%) (Table 4 and Figure 12).

In 2006, the land use classification consisted of 8 land use categories: 1) Dry evergreen forest 8,376.94 hectares (88.70%), 2) Mixed deciduous forest 192.49 hectares (2.04%), 3) Other field crops 34.02 hectares (0.36%), 4) Cassava 3.53

hectares (0.04%), 5) Pond and reservoir 0.36 hectares (0.004%), 6) Rock outcrop 635.37 hectares (6.73%), 7) Secondary forest 74.95 hectares (0.79%), and 8) Disturbed forest 126.44 hectares (1.34%) (Table 4 and Figure 12).

In 2011, the land use classification consisted of 10 land use categories: 1) Dry evergreen forest 8,487.26 hectares (89.87%), 2) Mixed deciduous forest 178.04 hectares (1.89%), 3) Paddy rice 3.02 hectares (0.03%), 4) Other field crops 11.45 hectares (0.12%), 5) Cassava 20.68 hectares (0.22%), 6) Para rubber 3.33 hectares (0.04%), 7) Eucalyptus 2.62 hectares (0.03%), 8) Rock outcrop 635.37 hectares (6.73%), 9) Secondary forest 96.35 hectares (1.02%), and 10) Disturbed forest 5.97 hectares (0.06%) (Table 4 and Figure 12).

Regarding land use change comparison of Zone I in Thailand in 2001, 2006 and 2011, a total of 21.27 hectares (0.25%) of dry evergreen forest in 2006 had been reduced from 2001 due to degradation by villagers in the Phanom Dong Rak Wildlife Sanctuary (Figure 13). While a total of 89.05 hectares (1.06%) of the dry evergreen forest in 2011 had been increased from 2001, due to the Thai government's forest conservation and restoration policy i.e. measures, strategies, conservation plans and sustainable biodiversity in 2003-2007, the 9th national economic and social development plan during 2002 to 2006, the 10th national economic and social development plan during 2007 to 2011 and the government policy on natural resources and environment in 2006. However, there were some areas that could not be controlled by authorities, therefore, they were converted to agricultural areas i.e. cassava, other field crops, para rubber, paddy rice, and eucalyptus (Figure 13).

The mixed deciduous forest had not been reduced in 2006. However, a total of 14.45 hectaress (7.50%) of mixed deciduous forest had been reduced in 2011 compared to 2001 because of deforestation in the wildlife sanctuary by villagers. This had caused the mixed deciduous forest to decrease by being converted to the secondary forest (Figure 13).

Regarding other changes in 2011, two roads had been built near the border since there are the natural tourist attractions nearby: Plan Hin Paet Kon and Plan Hin San. Transportation routes were, therefore, built in the mentioned area (Figure 12).

There have not been significant changes in Zone I of Thailand since the Phanom Dong Rak Wildlife Sanctuary was established under the Wildlife Preservation and Protection Act 1961. In addition, it is not in the disputed area between Thailand and Cambodia. Therefore, changes have been in accordance with the forest conservation and restoration in order to increase the forest as per the government's policy i.e. strategies, measures, conversation and land use plans, sustainable biodiversity in 2003-2007, the 9th national economic and social development plan during 2002 to 2006, the 10th national economic and social development plan during 2007 to 2011 and the government policy on natural resources and environment in 2006.

1.2 Land Use and Land Use Change of Zone I in Cambodia

The study area of Zone I in Cambodia covers 5,289.27 hectares. It is located in Kantruat sub-district, Chaomkrasan district, Preah Vihear province. The major landscape of area is the plain terrain covered by natural forest. The area features mixed deciduous forest. The rest of the area is dry evergreen forest.

In 2001, the land use classification consisted of 4 land use categories: 1) Dry evergreen forest 793.10 hectares (14.99%), 2) Mixed deciduous forest 3,717.30 hectares (70.28%), 3) Rock outcrop 129.10 hectares (2.44%), and 4) Disturbed forest 649.77 hectares (12.28%) (Table 4 and Figure 12).

In 2006, the land use classification consisted of 4 land use categories: 1) Dry evergreen forest 800.53 hectares (15.13%), 2) Mixed deciduous forest 3,533.46 hectares (66.80%), 3) Rock outcrop 129.10 hectares (2.44%), and 4) Disturbed forest 826.18 hectares (15.62%) (Table 4 and Figure 12).

In 2011, the land use classification consisted of 5 land use categories: 1) Dry evergreen forest 785.46 hectares (14.85%), 2) Mixed deciduous forest 2,807.51 hectares (53.08%), 3) Village and building (military construction) 21.64 hectares (0.41%), 4) Rock outcrop 129.10 hectares (2.44%), and 5) Disturbed forest 1,545.55 hectares (12.28%) (Table 4 and Figure 12).

Regarding the land use change comparison of Zone I in Cambodia in 2001, 2006 and 2011, only 7.64 hectares (0.96%) of the dry evergreen forest had been decreased in 2011, when compared to 2001 since the major dry evergreen forest covering the mountainous and steep slope area makes it difficult to invade the forest. While the mixed deciduous forest had been dramatically decreased – a total of 183.84 hectares (4.94%) of mixed deciduous forest decreased in 2006 and a total 909.79 hectares (24.47%) of mixed deciduous forest decreased in 2011 as compared to 2001. This is because the plain terrain which makes it easy for Cambodian villagers to invade the forest. In 2011, villages and military construction had been built which caused the mixed deciduous forest to decrease tremendously (Figure 14).

Regarding other changes in the area, three major roads had been built. The first road was built parallel to the Thai-Cambodian border. The second road was built to connect to the first road and approach the road to Phra Viharn Temple. The third road was built to the Thai-Cambodian borderline. Moreover, in 2011, two north - south roads had been built connecting to the first road built in 2006. The area that roads had been built caused forest degradation (Figure 12).

In general, in Zone I of Cambodia, the natural forests had tended to decrease especially the mixed deciduous forest on the plain terrain. More villages and military construction had been built. New roads had also been built near the Thai-Cambodian border. Some roads were built to connect with the road to Phra Viharn Temple. The mentioned changes are likely to be a result of the political factor on their demand for state's sovereignty and the state's policies. The border around the temple has been a point of conflict between Thailand and Cambodia since they adhere to the different demarcation lines. Zone I adjoins the Phra Viharn Temple disputed

area. The change therefore is a result of the Cambodian government's policy on ownership over the disputed area. In 2010, Cambodian Prime Minister announced Rectangular Strategy for Growth, Employment, Equity and Efficiency in Cambodia aiming at tackling invasion from other countries. It has caused the Thai - Cambodian border surrounding the Phra Viharn Temple to be developed: transportation routes, national defense and building of a strong army etc. resulting more villages near by the border, military construction, roads connecting to road to the border and connecting to main road to Phra Viharn Temple.

Table 4 Land use comparison of Zone I between Thailand and Cambodia.

Land Use Type	**Area (ha)**		
THAILAND	**2001**	**2006**	**2011**
1. Dry evergreen forest	8,398.21	8,376.94	8,487.26
2. Mixed deciduous forest	192.49	192.49	178.04
3. Paddy rice	-	-	2.66
4. Other field crops	57.90	34.02	11.45
5. Cassava	3.53	3.53	20.68
6. Para rubber	-	-	3.33
7. Eucalyptus	-	-	2.62
8. Pond and reservoir	0.36	0.36	0.36
9. Rock outcrop	635.37	635.37	635.37
10. Secondary forest	74.95	74.95	96.35
11. Disturbed forest	81.29	126.44	5.97
Total	**9,444.10**		
CAMBODIA	**2001**	**2006**	**2011**
1. Dry evergreen forest	793.10	800.53	785.46
2. Mixed deciduous forest	3,717.30	3,533.46	2,807.51
3. Village and building	-	-	21.64
4. Rock outcrop	129.10	129.10	129.10
5. Disturbed forest	649.77	826.18	1,545.55
Total	**5,289.27**		

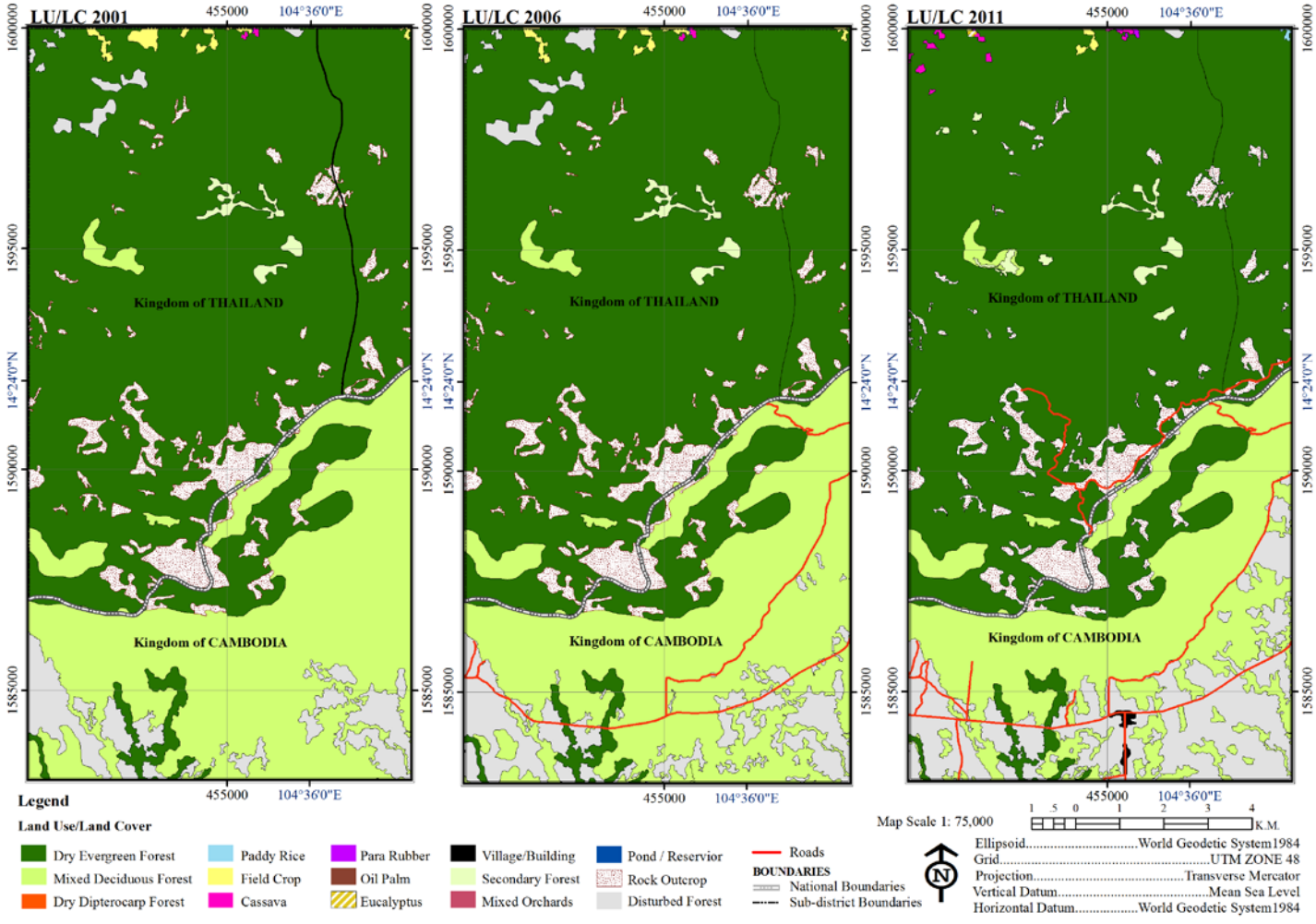

Figure 12 Land use comparison of Zone I between Thailand and Cambodia.

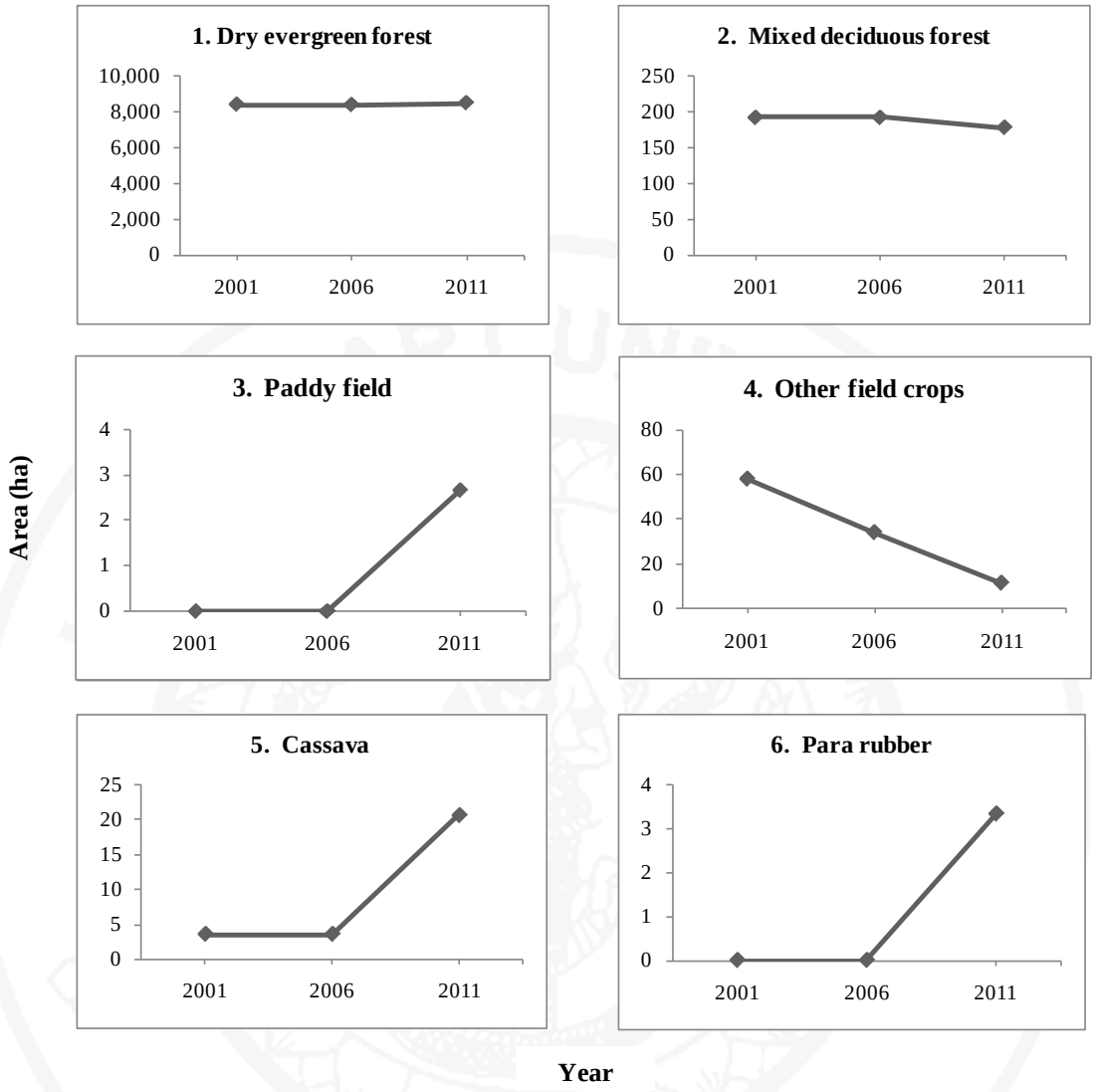

Figure 13 Land use change of Zone I in Thailand in 2001, 2006, and 2011.

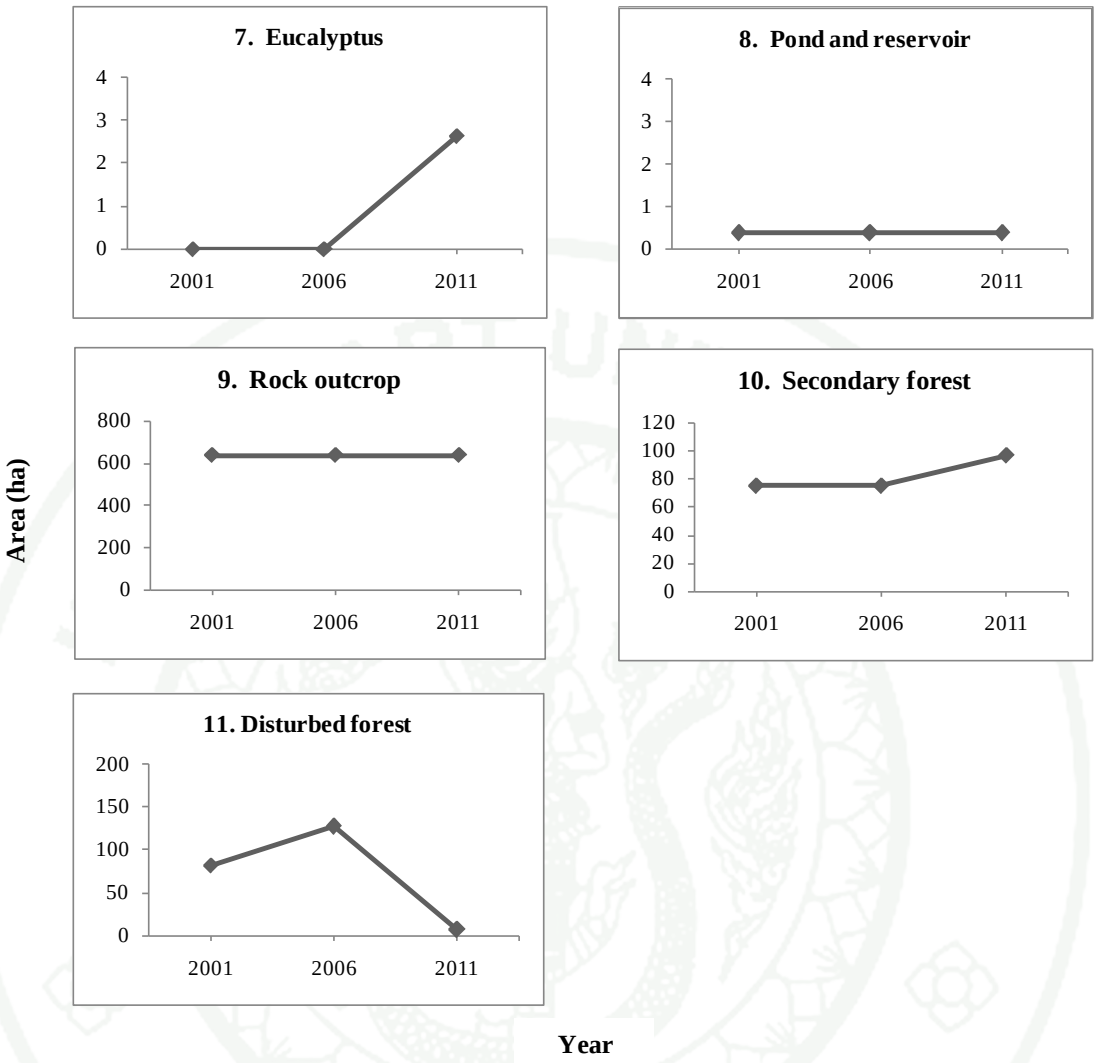

Figure 13 (Continued)**.**

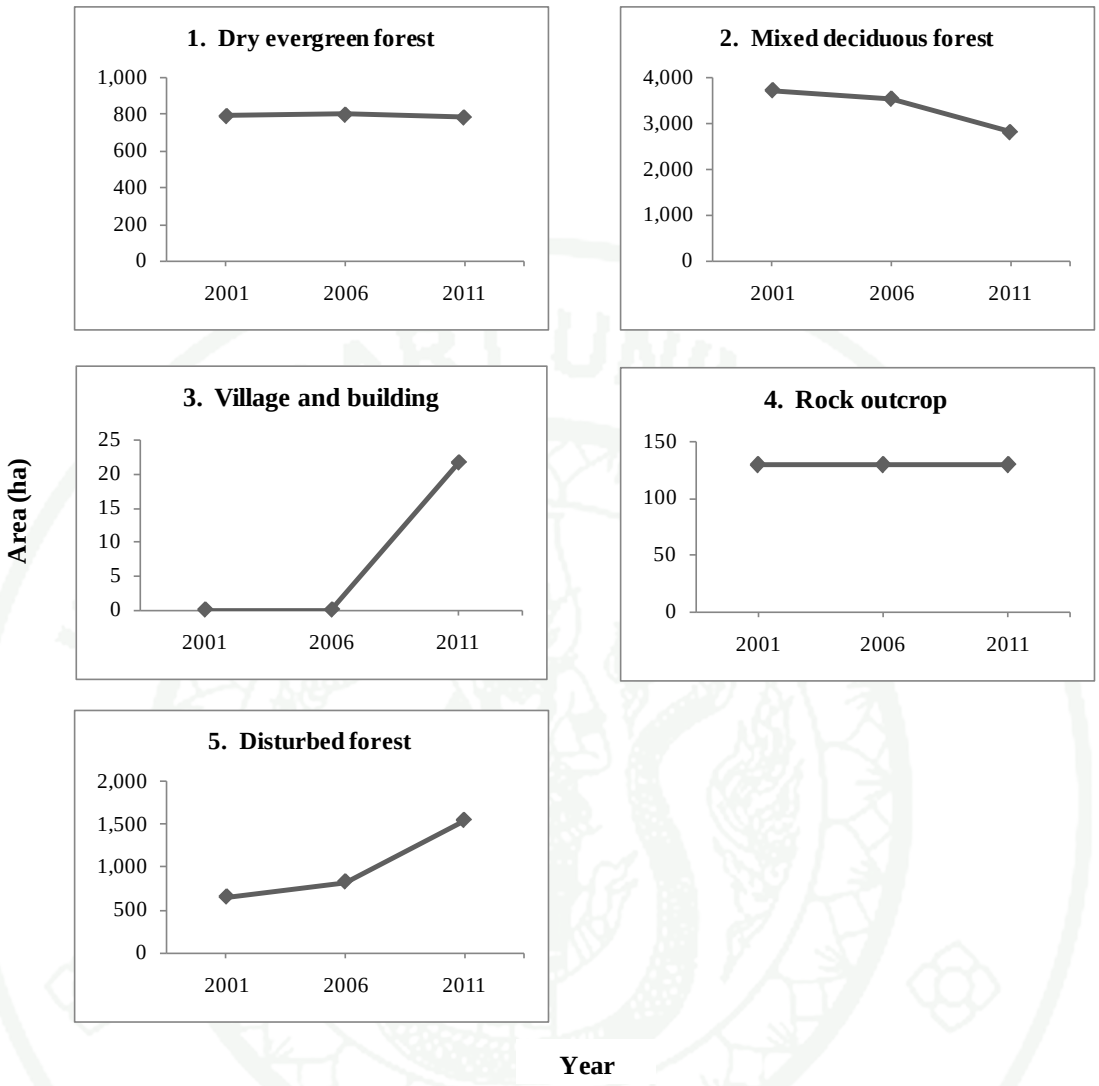

Figure 14 Land use change of Zone I in Cambodia in 2001, 2006, and 2011.

2. Land Use and Land Use Change of Zone II in Thailand and Cambodia

The Zone II covers a total area of 14,733.37 hectaress: an area of 6,092.25 hectaress (41.35%) on the Thai side and an area of 8,641.02 hectaress (58.65%) on the Cambodian side. The study area in Zone II is the Thai-Cambodian disputed area involving the area surrounding Phra Viharn Temple.

2.1 Land Use and Land Use Change of Zone II in Thailand

The study area in Zone II of Thailand covers 6,092.25 hectaress. It is located in Rung and Sao Thong Chai sub-district, Kantharalak district, Srisaket province. This study area is the disputed area between Thailand and Cambodia involving the Phra Viharn Temple. Thailand and Cambodia adhere to the different international boundary lines. In 1962, the International Court of Justice (ICJ) ruled that the temple was under the sovereignty of Cambodia but left the demarcate lines unsolved. The resolution of Council of Ministers cut off the temple from the Thai territory.

Zone II of this study area is divided into 2 parts. Part one is in the Phanom Dong Rak Wildlife Sanctuary and Khao Phra Viharn National Park. The major area where located south of the study area, covers 5,918.02 hectares (97.14%) of Zone II. Part two is outside Panom Dong Rak Wildlife Sanctuary and Khao Phra Viharn National Park. It is a minor area located north of the study area. It is not part of the disputed area, covering 174.23 hectares (2.86%) of Zone II. The south landscape in the Thai-Cambodian border, where the Phra Viharn Temple is situated, consists of the steep mountains. The terrain elevates up 15 degrees along the north and south direction that forms the watershed line of Phanom Dong Rak mountain range. Thailand has followed the watershed line as the demarcation. The area outside Panom Dong Rak Wildlife Sanctuary and Khao Phra Viharn National Park is consists of rolling and undulating plains, and plain where Phum Saron and Non Charoen villages are located. A major occupation of the people is agriculture. Land use in this area is economic plantation.

In 2001, the land use classification consisted of 10 land use categories: 1) Dry evergreen forest 4,569.09 hectares (75%), 2) Mixed deciduous forest 125.15 hectares (2.05%), 3) Dry dipterocarp forest 84.01 hectares (1.38%), 4) Paddy rice 119.08 hectares (1.95%), 5) Other field crops 227.90 hectares (3.74%), 6) Village and building 3.75 hectares (0.06%), 7) Pond and reservoir 22.71 hectares (0.37%), 8) Rock outcrop 210.58 hectares (3.46%), 9) Secondary forest 678.06 hectares (11.13%), and 10) Disturbed forest 51.92 hectares (0.85%) (Table 5 and Figure 15)

In 2006, the land use classification consisted of 13 land use categories: 1) Dry evergreen forest 4,564.31 hectares (74.92%), 2) Mixed deciduous forest 125.15 hectares (2.05%), 3) Dry dipterocarp forest 84.01 hectares (1.38%), 4) Paddy rice 248.74 hectares (4.08%), 5) Other field crops 253.60 hectares (4.16%), 6) Cassava 5.85 hectares (0.10%), 7) Para rubber 27.55 hectares (0.45%), 8) Eucalyptus 13.98 hectares (0.23%), 9) Village and building 21.35 hectares (0.35%), 10) Pond and reservoir 75.75 hectares (1.24%), 11) Rock outcrop 210.58 hectares (3.46%), 12) Secondary forest 458.57 hectares (7.53%), and 13) Disturbed forest 2.81 hectares (0.05%) (Table 5 and Figure 15)

In 2011, the land use classification consisted of 13 land use categories: 1) Dry evergreen forest 4,757.75 hectares (78.10%), 2) Mixed deciduous forest 125.15 hectares (2.05%), 3) Dry dipterocarp forest 84.01 hectares (1.38%), 4) Paddy rice 224.97 hectares (3.69%), 5) Other field crops 91.26 hectares (1.50%), 6) Para rubber 260.92 hectares (4.28%), 7) Oil palm 1.71 hectares (0.03%), 8) Eucalyptus 8.57 hectares (0.14%), 9) Village and building 21.17 hectares (0.35%), 10) Pond and reservoir 76.47 hectares (1.26%), 11) Rock outcrop 210.58 hectares (3.46%), 12) Secondary forest 228.23 hectares (3.75%), and 13) Disturbed forest 1.45 hectares (0.02%) (Table 5 and Figure 15)

Regarding land use change comparison of Zone II in Thailand in 2001, 2006, and 2011, an area of 4.78 hectaress (0.10%) of dry evergreen forest had been decreased in 2006 when compared to the forest in 2001 due to degradation by villagers (Figure 16). The major degraded forest is north of the Phra Viharn Temple

since it was not established as a national park officially. Also the undulating plain and plain landscape close to Non Charoen and Phum Saron villages has caused continuous forest invasion by villagers. As a result, the dry evergreen forest had become disturbed forest and agricultural land for economic plants i.e. rice, eucalyptus, and other field crops etc. In 2011, an area of 188.66 hectaress (4.12%) of dry evergreen forest has been increased when compared to 2001 due to the forest conservation and restoration policy of Thailand (Figure 16).

Concerning mixed deciduous forest and dry dipterocarp forest, there has not been land use change as they are mountainous and steep slope. It is also close to the natural attractions which makes it more difficult to invade the area.

In 2001, it was found that in the agricultural area outside the Khao Phra Viharn National Park and Phanom Dong Rak Wildlife Sanctuary farmers preferred to grow rice and other field crops. In 2006, plantation crops had expanded i.e. cassava, para rubber, oil palm, and eucalyptus. However, in 2011, paddy rice and other field crop areas had decreased since the farmers had converted them to grow economic plants since they have higher return i.e. para rubber, oil palm, and eucalyptus (Figure 16).

Villages, buildings, ponds and reservoir had been built since 2001. Disturbed forests had decreased in 2006 and 2011 respectively since 2001 due to the state's policies on forest conservation and restoration (Figure 16).

Regarding other changes, in 2001, a road being built in Cambodia had invaded the Thai territory. The road is from Komui village and runs to Phra Viharn Temple (Figure 15). It was built in 1999. Apart from the road, Cambodia has also invaded Thai territory surrounding the temple by building temple, markets and military family accommodations. In 2006, another road had been built connecting to the road that invades the Thai territory and runs to Phra Viharn Temple. Such actions had violated Thailand's sovereignty. There had been protests by local officials and government level by Ministry of Foreign Affairs, during 2002-2011. There have been

bilateral negotiations by the peaceful mean accepted by international countries. However, Cambodia has not responded to that up until now since Cambodia considers the mentioned area under Cambodia sovereignty as well.

In summary for the land use change of Zone II in Thailand, the natural forest in Khao Phra Viharn National Park and Phanom Dong Rak Wildlife Sanctuary had increased in 2011 due to Thailand's policies on forest conservation and restoration mentioned above. While the areas surrounding Phra Viharn Temple in Thailand were invaded by the roads built to the temple. Temple, markets, and military family accommodations were also built in the area surrounding the temple complex in the Thai territory. Therefore the political factors affected the land use of this area. Regarding the area in the vicinity of the Khao Phra Viharn National Park and Phanom Dong Rak Wildlife Sanctuary outside the disputed area, there had been an expansion of villages since 2001. The land use of villagers has been agricultural. They have converted to the economic crops as per the prices of the products, especially the higher income of the crops i.e. para rubber as the mentioned area has been expanded in 2011 due to the state's policy in 2003: one-million-rai para rubber project to improve income and livelihood of farmers in the northeast region. The government had encouraged farmers to grow para rubber by supporting some necessary cost for farmers. The para rubber price had increased continuously - the 2001 raw rubber price was 21.45 baht per kilogram, the 2006 price was 69.96 baht per kilogram and the 2011 price was 129.96 baht per kilogram. Therefore, socio-economic factors have driven land use change on agriculture in this area of Thailand.

The significant change affecting the country's security is around the boundary since Cambodia has moved to encroach the Thai territory by constructing roads, temple, markets and military family accommodations. The mentioned change is likely to be a result of the political factors on the sovereignty over the territory, political dispute between the two governments, the state policies and the political method. Cambodia demands to seek for the sovereignty over the area surrounding the temple that lies on the Thai side. Thai and Cambodian governments cannot settle the territorial issue since they adhere to the different demarcation. The Phra Viharn

conflict has always been the major problem of their relations of every Thai government and Hun Sen's government. Moreover, Hun Sen's policies are proactive by attempting to occupy the area surrounding the temple i.e. a policy to list the temple as World Heritage by UNESCO in 2003. In 2006 Cambodia submitted the application to UNESCO requesting the temple to be designated as World Heritage site without consulting Thailand, whom they used to consult as joint commission tasked to develop the temple as per the resolution of Thai – Cambodian Council of Ministers. Cambodia's political method has been active by constructing roads, temple, markets, military family accommodations and other activities in Thailand without obligating as per the borderline agreement between the two countries. Moreover, Cambodia issued the royal decree of the demarcation of temple reservation that overlapped the Thai border in 2006. They claim that it is the area under Cambodia's sovereignty. Cambodia also develops the infrastructure near the border in order to reduce dependence from Thailand when accessing the temple by connecting the routes within Cambodia itself. The roads were built to run to the temple and surrounding the temple complex area.

In 2011, Cambodia requested the International Court of Justice to interpret the 1962 verdict regarding the area surrounding the temple. Cambodian claimed that Thailand had not obligated as per the verdict withdrawing their forces from the temple and the surrounding area and requested the ICJ to issue the provisional measures – an immediate and unconditional withdrawal of all Thai forces from areas around the temple - prior to judgement interpretation. Regarding those requests, Cambodia has followed the demarcation in the 1: 200,000 scale map. Thailand has followed the obligation in accordance with the 1962 verdict. However, the court did not rule on the matter of using that map to demarcate the borderline. Thailand has lodged formal protests and negotiations, but Cambodia has not responded up until now. Thailand has also protested the royal decree defining the scope of the temple area and the map attached to the inscription of the temple as World Heritage encroaching into the Thai territory in order to protect the right of Thailand. These protests are rightful as international political process in order to protect territorial integrity.

Regarding the area in vicinity of the Khao Phra Viharn National Park and the Phanom Dong Rak Wildlife Sanctuary outside the disputed area, there had been an expansion of villages since 2001. Land use of villagers has been agricultural. They convert economic plantations as per the crop prices emphasizing on high profit plants i.e. para rubber since the government policy on encouraging farmers to grow rubber to improve incomes and livelihood. The rubber price tended to go up continuously also. Therefore the socio-economic factors affected the land use of this agricultural area of Thailand.

2.2 Land Use and Land Use Change of Zone II in Cambodia

The study area of Zone II in Cambodia covers 8,641.02 hectares. It is situated in Kantruat sub-district, Chom Krasan district, Preah Vihear province. The landscape consists of plain terrain covered by natural forests - mixed deciduous forest, evergreen forest and dry dipterocarp forest respectively. Komui village, big ancient village, is situated in this area. There are also military constructions on the main routes.

In 2001, the land use classification consisted of 7 land use categories: 1) Dry evergreen forest 2,564.35 hectares (29.68%), 2) Mixed deciduous forest 5,026.06 hectares (58.17%), 3) Dry dipterocarp forest 3.08 hectares (0.04%), 4) Village and building (military construction) 45.60 hectares (0.53%), 5) Rock outcrop 24.26 hectares (0.28%), 6) Secondary forest 14.80 hectares (0.17%), and 7) Disturbed forest 962.87 hectares (11.14%) (Table 5 and Figure 15)

In 2006, the land use classification consisted of 7 land use categories: 1) Dry evergreen forest 2 ,494.61 hectares (28.87%), 2) Mixed deciduous forest 4,090.74 hectares (47.34%), 3) Dry dipterocarp forest 3.08 hectares (0.04%), 4) Village and building (military construction) 81.28 hectares (0.94%), 5) Rock outcrop 24.26 hectares (0.28%), 6) Secondary forest 14.80 hectares (0.17%), and 7) Disturbed forest 1,932.25 hectares (22.36%) (Table 5 and Figure 15)

In 2011, the land use classification consisted of 8 land use categories: 1) Dry evergreen forest 1,892.12 hectares (21.90%), 2) Mixed deciduous forest 2,704.45 hectares (31.30%), 3) Dry dipterocarp forest 3.08 hectares (0.04%), 4) Village and building (military construction) 112.53 hectares (1.30%), 5) Pond and reservoir 0.27 hectares (0.003%), 6) Rock outcrop 24.26 hectares (0.28%), 7) Secondary forest 10.16 hectares (0.12%), and 8) Disturbed forest 3,894.14 hectares (45.07%) (Table 5 and Figure 15)

Regarding the land use change of Zone II in Cambodia in 2001, 2006 and 2011, the dry evergreen forest and mixed deciduous forest had decreased in 2006, and they have decreased tremendously in 2011. An area of 69.74 hectares or (2.71%) of dry evergreen forest had decreased in 2006. An area of 672.73 hectares (26.21%) of the dry evergreen forest had decreased in 2011 when compared to that in 2001. An area of 935.32 hectares (46.19%) of mixed deciduous forest had decreased in 2006. An area of 2,361 hectares (46.19%) of mixed deciduous forest had decreased in 2011. The major area of dry evergreen forest and mixed deciduous forest had turned into disturbed forest, and villages and buildings (Figure 17).

Regarding other changes, 2 major roads had been built. The first road runs from southwest to the main road that parallels with the Thai-Cambodian borderline where Komui village of Cambodia is located. The second road starts from the west and runs to the current road to the Phra Viharn Temple. A field survey revealed that dirt roads have been converted to asphalt and concrete roads with wider lanes (Figure 15).

Regarding, land use change of Zone II in Cambodia, the natural forests had decreased by being converted to villages and military construction tremendously. Moreover, there had been road construction to the Phra Viharn Temple. The mentioned change is probably because of the political factors: demand of sovereignty over the territory, government, state policy, and political method. Cambodia requires the territorial sovereignty surrounding the temple in the Thai territory. Hun Sen's government policies and political method have been active in order to occupy the area

surrounding the temple i.e. submitting the application to UNESCO requesting that the temple be designated as World Heritage site and did not consult Thailand, whom they used to consult as joint commission task force to develop the temple as per the resolution of the Thai – Cambodian Council of Ministers. In 2006, Cambodia issued the royal decree of the demarcation of temple reservation that overlapped the Thai border. In 2010, Prime Minister Hun Sen announced the Rectangular Strategy for Growth, Employment, Equity and Efficiency in Cambodia and spent a lot of budget to tackle the so-called invasion from other countries particularly Thailand causing the border area along Thailand and Cambodia to be developed quickly i.e. transportation development, community development along the borderline, defense development and building of a strong army etc. Regarding the study and the field survey, new concrete and asphalt roads, villages, and military buildings have been built along the main roads.

Table 5 Land use comparison of Zone II between Thailand and Cambodia

Land Use Type	Area (ha)		
THAILAND	**2001**	**2006**	**2011**
1. Dry evergreen forest	4,569.09	4,564.31	4,757.75
2. Mixed deciduous forest	125.15	125.15	125.15
3. Dry dipterocarp forest	84.01	84.01	84.01
4. Paddy rice	119.08	248.74	224.97
5. Other field crops	227.90	253.60	91.26
6. Cassava	-	5.85	-
7. Para rubber	-	27.55	260.92
8. Oil palm	-	-	1.71
9. Eucalyptus	-	13.98	8.57
10. Village and building	3.75	21.35	21.17
11. Pond and reservoir	22.71	75.75	76.47
12. Rock outcrop	210.58	210.58	210.58
13. Secondary forest	678.06	458.57	228.23
14. Disturbed forest	51.92	2.81	1.45
Total		**6,092.25**	
CAMBODIA	**2001**	**2006**	**2011**
1. Dry evergreen forest	2,564.35	2,494.61	1,892.12
2. Mixed deciduous forest	5,026.06	4,090.74	2,704.45
3. Dry dipterocarp forest	3.08	3.08	3.08
4. Village and building	45.60	81.28	112.53
5. Pond and reservoir	-	-	0.27
6. Rock outcrop	24.26	24.26	24.26
7. Secondary forest	14.80	14.80	10.16
8. Disturbed forest	962.87	1,932.25	3,894.14
Total		**8,641.02**	

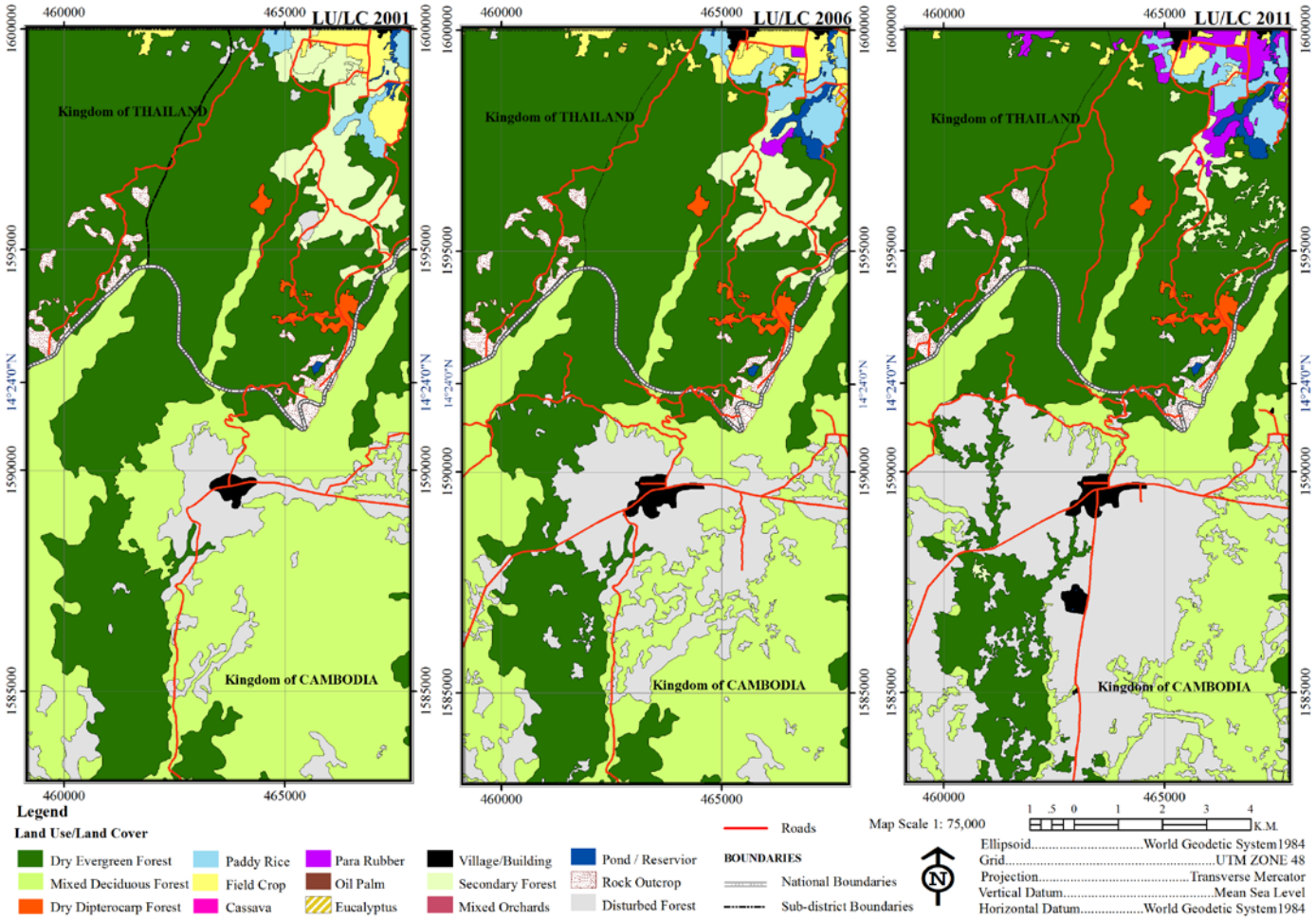

Figure 15 Land use comparison of Zone II between Thailand and Cambodia.

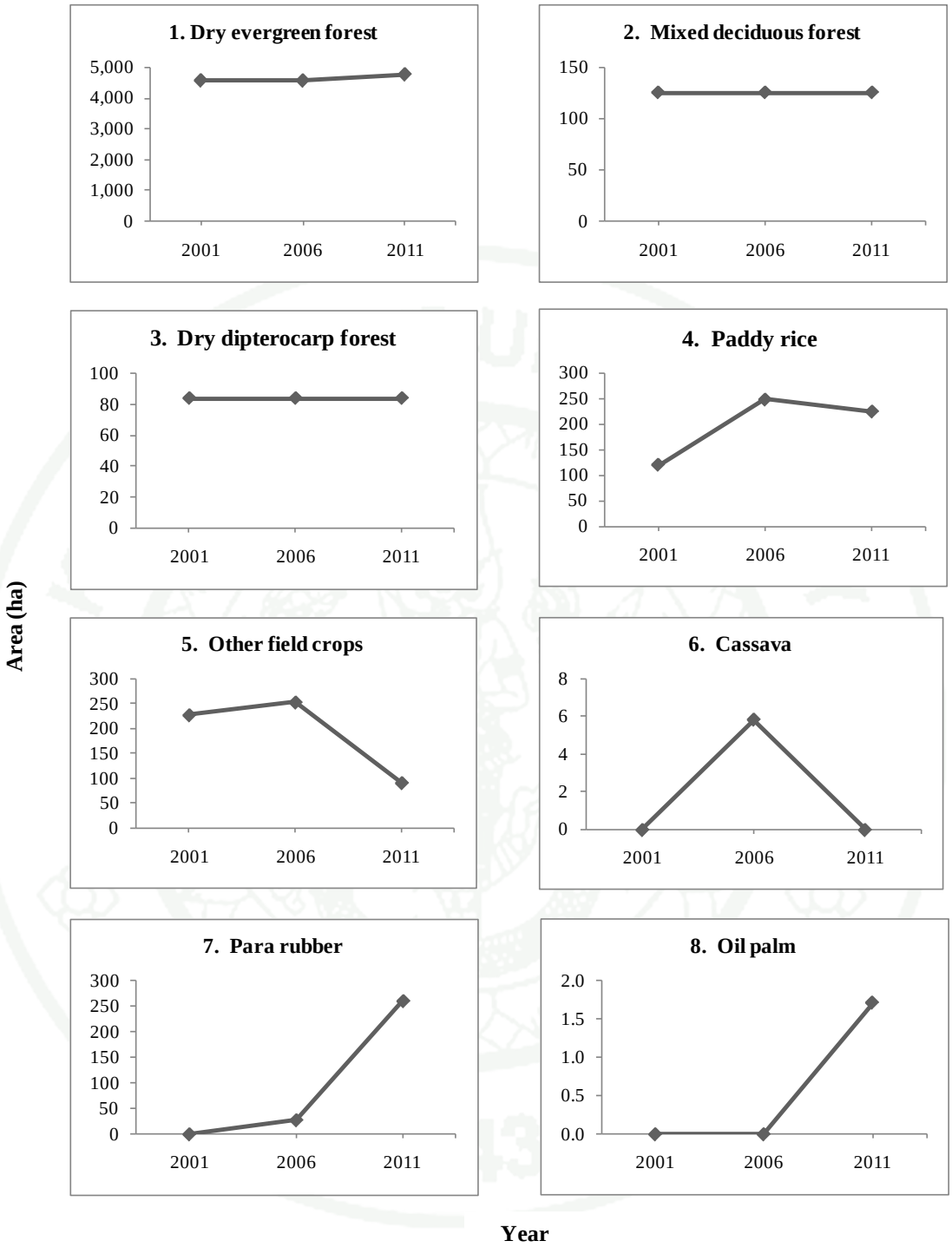

Figure 16 Land use change of Zone II in Thailand in 2001, 2006, and 2011.

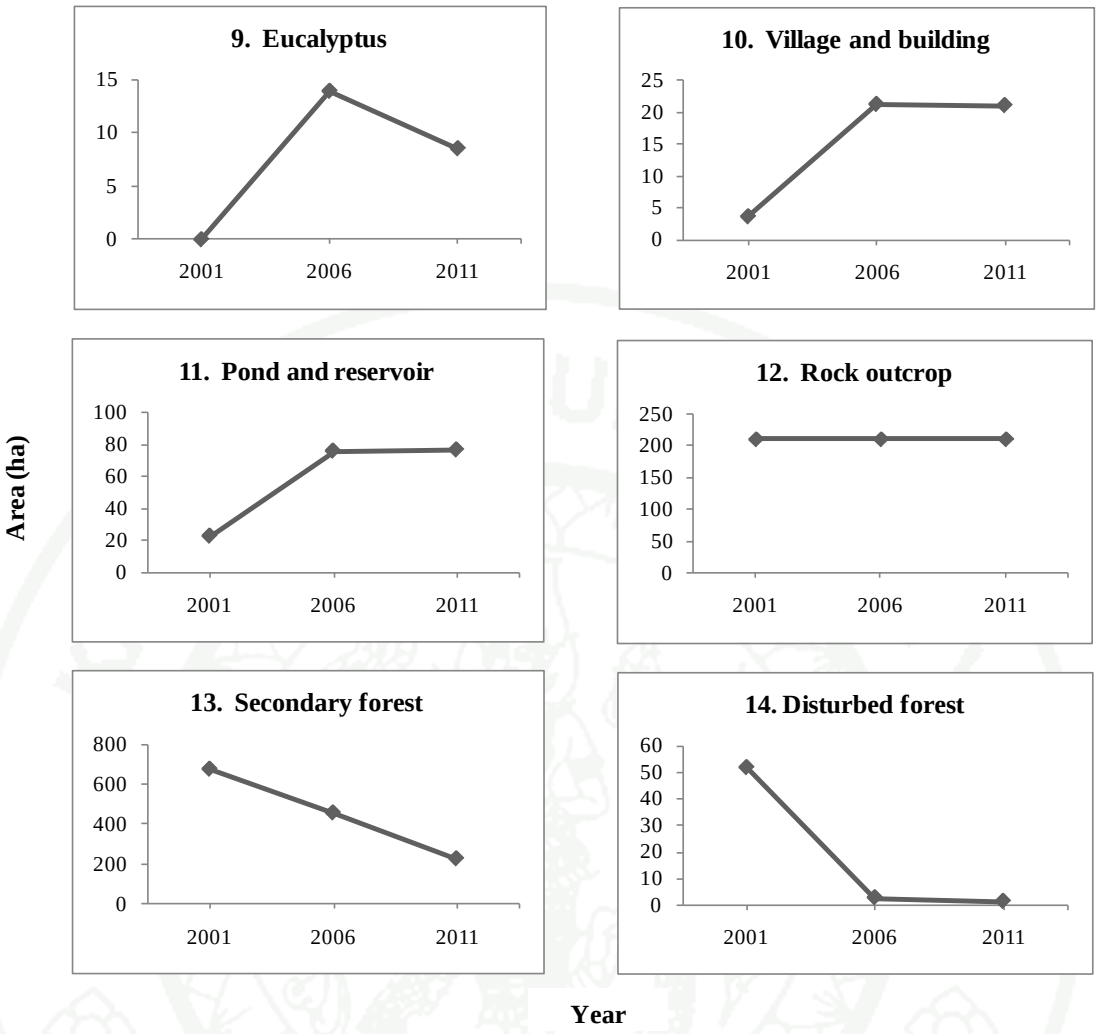

Figure 16 (Continued)**.**

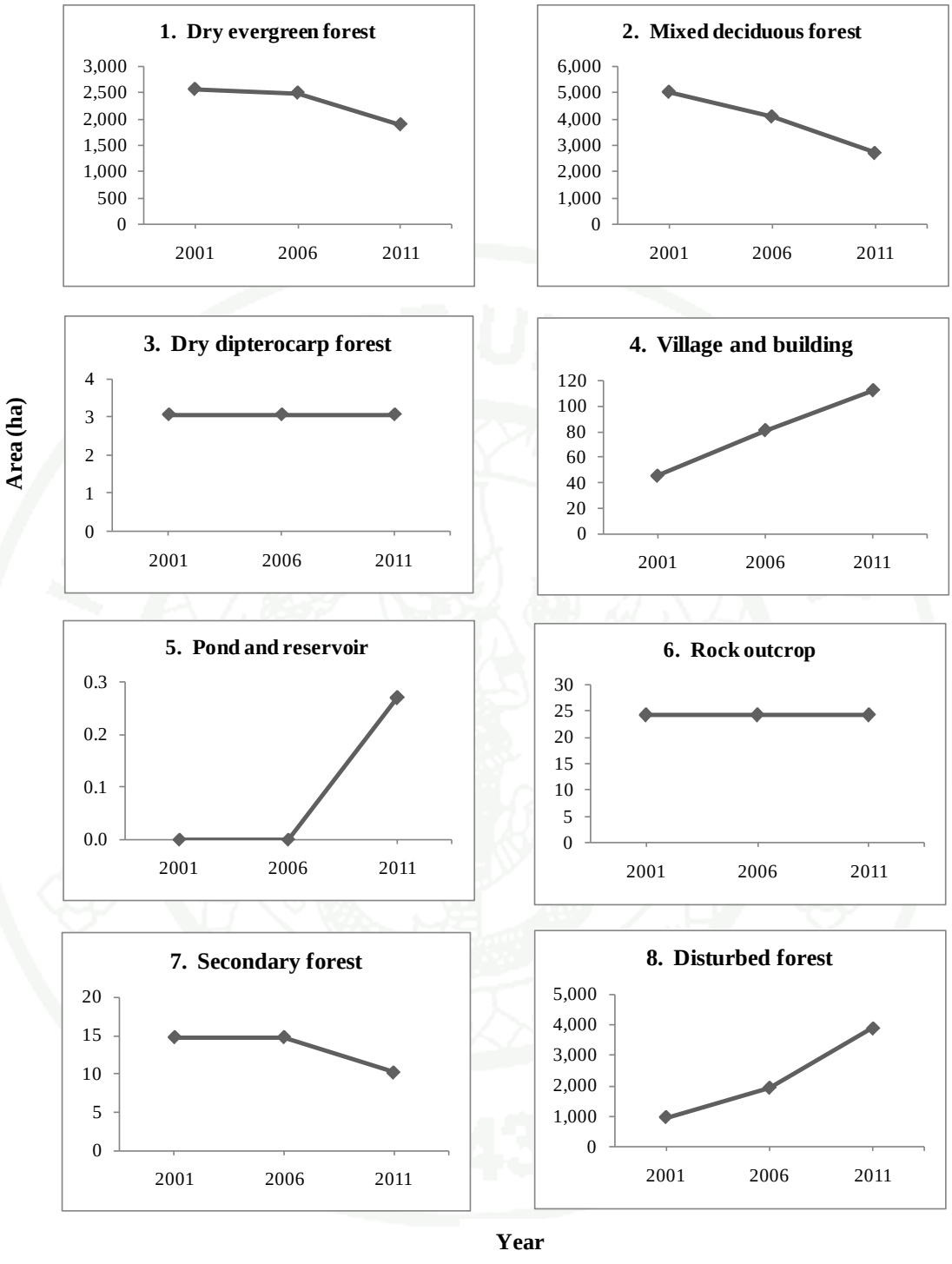

Figure 17 Land use change of Zone II in Cambodia in 2001, 2006, and 2011.

3. Land Use and Land Use Change of Zone III in Thailand and Cambodia

The zone III covers 14,733.37 hectares - an area of 5,120.49 hectares (34.75%) on the Thai side and 9,612.88 hectares (65.25%) is on the Cambodian side. Zone III is not the disputed area between the two countries.

3.1 Land Use and Land Use Change of Zone III in Thailand

Zone III covers 5,120.49 hectares. It is situated in Sao Thong Chai and Phu Pha Mok sub-district, Kantharalak district, Srisaket province. Zone III can be divided into two areas of similar sizes. These two areas are not in the disputed area: 1) The area in Khao Phra Viharn National Park is southern part in the study area, covering an area of 1,854.18 hectares (36.21%) of Zone III in Thailand. The landscape is composed of high mountains covered by a natural forest. 2) The area outside Khao Phra Viharn National Park is northern part of the study area, covering 3,266.32 hectares (63.79%) of Zone III in Thailand. The landscape is composed of rolling and undulating plains and plain. It is located in Phum Saron, Non Sawang Phatthana, and Sao Thong Chai villages. The main occupation of the people in these villages is agriculture. Therefore, the major land use is economic plantation in this agricultural area.

In 2001, the land use classification consisted of 9 land use categories: 1) Dry evergreen forest 1,068.90 hectares (20.88%), 2) Mixed deciduous forest 0.40 hectares (0.01%), 3) Paddy rice 2,771.23 hectares (54.12%), 4) Other field crops 134.61 hectares (2.36%), 5) Village and building 163.46 hectares (3.19%), 6) Pond and reservoir 130.15 hectares (2.54%), 7) Rock outcrop 60.97 hectares (1.19%) 8) Secondary forest 650.07 hectares (12.70%), and 9) Disturbed forest 140.70 hectares (2.75%) (Table 6 and Figure 18).

In 2006, the land use classification consisted of 12 land use categories: 1) Dry evergreen forest 1,062.85 hectares (20.76%), 2) Mixed deciduous forest 35.86 hectares (0.70%), 3) Paddy rice 1,365.51 hectares (26.67%), 4) Other field crops

1,312.11 hectares (25.62%), 5) Cassava 12.62 hectares (0.25%), 6) Para rubber 20.53 hectares (0.40%), 7) Eucalyptus 34.12 hectares (0.67%), 8) Village and building 256.91 hectares (5.02%), 9) Mixed orchards 52.01 hectares (1.02%), 10) Pond and reservoir 146.41 hectares (2.86%), 11) Rock outcrop 60.97 hectares (1.19%), and 12) Secondary forest 760.61 hectares (14.85%) (Table 6 and Figure 18).

In 2011, the land use classification consisted of 13 land use categories:1) Dry evergreen forest 1,434.56 hectares (28.02%), 2) Mixed deciduous forest 64.74 hectares (1.26%), 3) Paddy rice 1,191.55 hectares (23.27%), 4) Other field crops 257.90 hectares (5.04%), 5) Para rubber 1,114.13 hectares (21.76%), 6) Oil palm 41.78 hectares (0.82%), 7) Eucalyptus 56.47 hectares (1.10%), 8) Village and building 259.99 hectares (5.08%), 9) Mixed orchards 22.56 hectares (0.44%), 10) Pond and reservoir 112.53 hectares (2.20%), 11) Rock outcrop 60.97 hectares (1.19%), 12) Secondary forest 489.57 hectares (9.56%), and 13) Disturbed forest 13.73hectares (0.27%) (Table 6 and Figure 18).

Regarding the land use change of Zone III in Thailand in 2001, 2006, and 2011, and area of 6.05 hectares (0.56%) of dry evergreen forest had been decreased in 2006 when compared to that in 2001 because of Khao Phra Viharn National Park invasion by villagers. Trees had been cut down and the dry evergreen forest had been converted to disturbed forest and agricultural land – rice and other field crops. In 2011, an area of 365.66 hectares (34.20%) of dry evergreen forest had been increased when compared with 2001, and an area of 371.72 hectares (34.97%) of dry evergreen forest had increased when compared with that in 2006 (Figure 19). This is because the Thai government policies on forest conservation and restoration. However, some areas that could not be controlled by authorities, had been invaded and converted to agricultural land i.e. other field crops, para rubber, and rice etc.

Mixed deciduous forest had increased slightly in 2006 and 2011. It is because Thai government policies on forest conservation and restoration (Figure 19).

Regarding the agricultural area outside Khao Phra Viharn National Park, an area of 1,405.72 hectares (50.23%) of the paddy rice had decreased in 2006 when

compared to that in 2001. Villagers had converted some of the paddy rice to other field crops, cassava, and para rubber. An area of 173.95 hectares (12.73%) of paddy rice and an area of 1,054.21 hectares (80.34%) of other field crops had decreased in 2011 when compared to that in 2006 since villagers had changed the paddy rice and other field crops to para rubber, oil palm, and eucalyptus due to higher return particularly para rubber which had increased significantly in 2011 (Figure 19). The government launched a million-rai rubber project to improve farmer's income and livelihood in the new area in the northeast. The government also supported partial expenses for farmers. The rubber prices tended to go up continuously - 21.45 baht per kilogram in 2001, 69.96 baht per kilogram in 2006 and 129.96 baht per kilogram in 2011.

In summary for land use change of Zone III in Thailand, natural forest in the Khao Phra Viharn National Park had increased in 2011. Therefore, major change was in accordance with the government policy on the forest conservation and restoration as mentioned above. Meanwhile there had been village expansion in the area outside Khao Phra Viharn National Park since 2001. Villagers had changed their land use to economic plantations for higher income. In 2006 and 2011 they had adopted their land use from other field crops and paddy rice to para rubber as per the government policy in 2003 encouraging farmers to grow rubber for better income and livelihood. The price tended to go up continuously also. Therefore, socio-economic factors have driven land use change of agriculture in this area of Thailand.

3.2 Land Use and Land Use Change of Zone III in Cambodia

The study area of Zone III in Cambodia covers 9,612.88 hectaress. It is situated in Kantruat sub-district, Chom Krasan district, Preah Vihear province. The landscape is a plain covered by dry evergreen forest. The rest of the area is mixed deciduous forest. Swai Jarum, an ancient Cambodian village, is located in this area. There is also military construction all over the main roads in this area.

In 2001, the land use classification consisted of 7 land use categories: 1) Dry evergreen forest 6 ,760.10 hectares (70.32%), 2) Mixed deciduous forest

1,652.55 hectares (17.19%), 3) Paddy rice 0.88 hectares (0.01%), 4) Village and building (military construction) 54.50 hectares (0.57%), 5) Rock outcrop 240.72 hectares (2.50%), 6) Secondary forest 55.34 hectares (0.58%), and 7) Disturbed forest 848.79 hectares (8.83%) (Table 6 and Figure 18)

In 2006, the land use classification consisted of 8 land use categories: 1) Dry evergreen forest 6,642.07 hectares (69.10%), 2) Mixed deciduous forest 1,621.39 hectares (16.87%), 3) Paddy rice 0.88 hectares (0.01%), 4) Other field crops 3.75 hectares (0.04%), 5) Village and building (military construction) 105.18 hectares (1.09%), 6) Rock outcrop 243.36 hectares (2.53%), 7) Secondary forest 79.44 hectares (0.83%), and 8) Disturbed forest 916.80 hectares (9.54%) (Table 6 and Figure 18)

In 2011, the land use classification consisted of 8 land use categories: 1) Dry evergreen forest 5,213.62 hectares (54.24%), 2) Mixed deciduous forest 1,137.47 hectares (11.83%), 3) Other field crops 3.71 hectares (0.04%), 4) Village and building (military construction) 132.74 hectares (1.38%), 5) Pond and reservoir 0.20 hectares (0.002%), 6) Rock outcrop 243.22 hectares (2.53%), 7) Secondary forest 29.32 hectares (0.31%), and 8) Disturbed forest 2,852.58 hectares (29.67%) (Table 6 and Figure 18)

Regarding land use change of Zone III in Cambodia in 2001, 2006 and 2011, an area of 118.03 hectares (1.74%) of dry evergreen forest and an area of 31.16 hectares (0.46%) of mixed deciduous forest had decreased in 2006 when compared to that in 2001. While an area of 50.68 hectares (92.99%) of villages and military construction had increased significantly. An area of 1,546.48 hectares (22.87%) of dry evergreen forest and 515.08 hectares (31.16%) of mixed deciduous had decreased in 2011 when compared to that in 2001. A total of 78.24 hectares (143.55%) of villages and military construction had increased since 2001. That had caused an area of 2003.79 hectares (236%) of disturbed forest to increase when compared to that in 2001 (Figure 20).

Regarding other changes, one road had been built connecting the current road that parallels to the border and runs to the Thai – Cambodian border in 2006. Another road had been built in 2011, connecting Swai Jarum village to the road that parallels to the border (Figure 18).

In summary for land use change of Zone III in Cambodia, natural forest had been decreased significantly because of village and military construction. Roads were also built to run to the Thai – Cambodian border. The mentioned change was due to the political factors on the state policies – this area surrounding the temple that has been a territorial issue. As a result, transportation development, army development and strength of villages are crucial to tackle the border conflicts. In 2010, Cambodian Prime Minister Hun Sen announced the Rectangular Strategy for Growth, Employment, Equity and Efficiency in Cambodia to tackle the so-called invasion from other countries and that had caused transportation routes, defense, building of a strong army, and villages along Thailand and Cambodia to be developed. As a result, there have been village expansion, military construction, and roads connecting the road to the Thai – Cambodian border.

Table 6 Land use comparison of Zone III between Thailand and Cambodia.

Land Use Type	Area (ha)		
THAILAND	**2001**	**2006**	**2011**
1. Dry evergreen forest	1,068.90	1,062.85	1,434.56
2. Mixed deciduous forest	0.40	35.86	64.74
3. Paddy rice	2,771.23	1,365.51	1,191.55
4. Other field crops	134.61	1,312.11	257.90
5. Cassava	-	12.62	-
6. Para rubber	-	20.53	1,114.13
7. Oil palm	-	-	41.78
8. Eucalyptus	-	34.12	56.47
9. Village and building	163.46	256.91	259.99
10. Mixed orchards	-	52.01	22.56
11. Pond and reservoir	130.15	146.41	112.53
12. Rock outcrop	60.97	60.97	60.97
13. Secondary forest	650.07	760.61	489.57
14. Disturbed forest	140.70	-	13.73
Total		**5,120.49**	
CAMBODIA	**2001**	**2006**	**2011**
1. Dry evergreen forest	6,760.10	6,642.07	5,213.62
2. Mixed deciduous forest	1,652.55	1,621.39	1,137.47
3. Paddy rice	0.88	0.88	-
4. Other field crops	-	3.75	3.71
5. Village and building	54.50	105.18	132.74
6. Pond and reservoir	-	-	0.20
7. Rock outcrop	240.72	243.36	243.22
8. Secondary forest	55.34	79.44	29.32
9. Disturbed forest	848.79	916.80	2,852.58
Total		**9,612.88**	

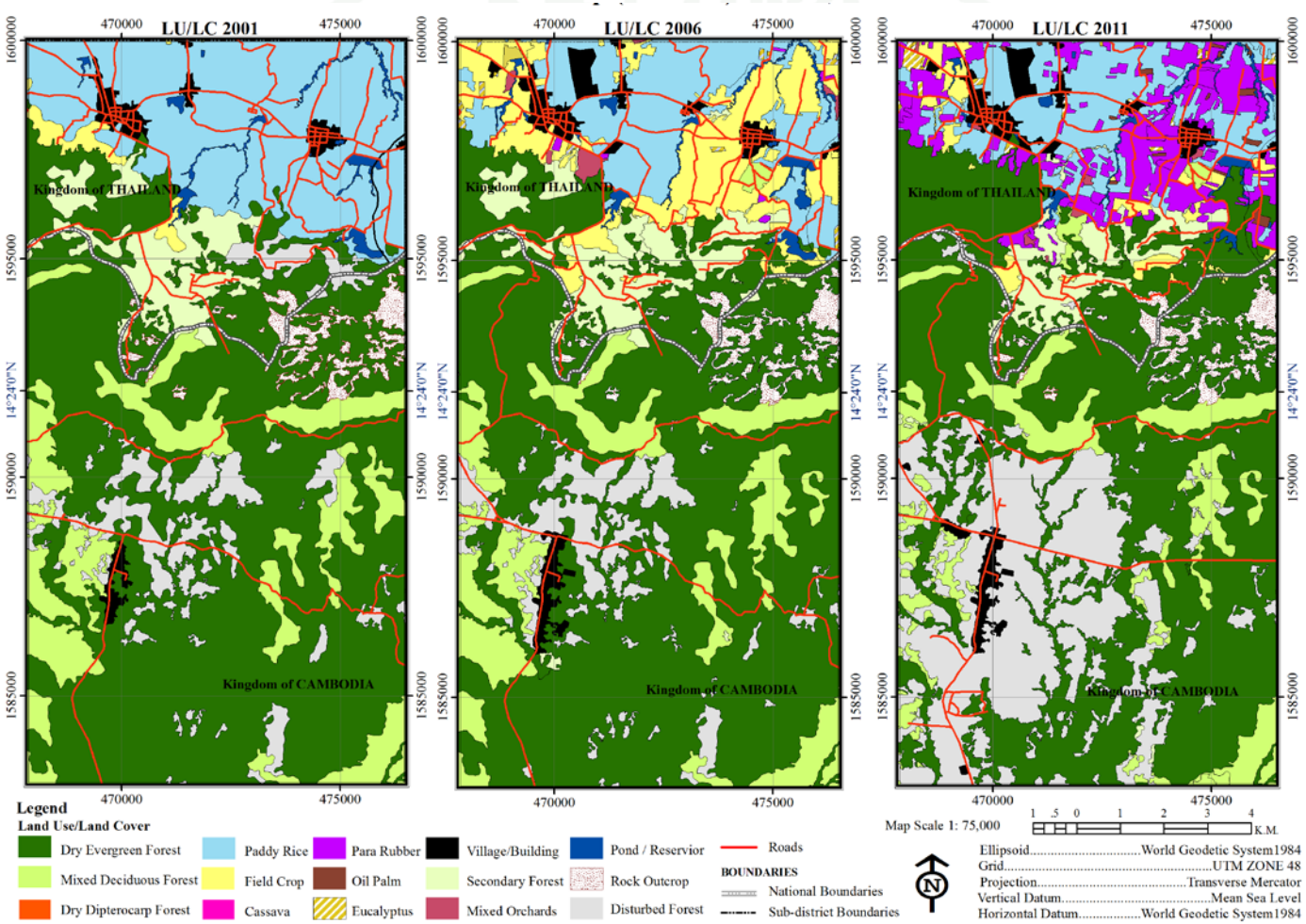

Figure 18 Land use comparison of Zone III between Thailand and Cambodia.

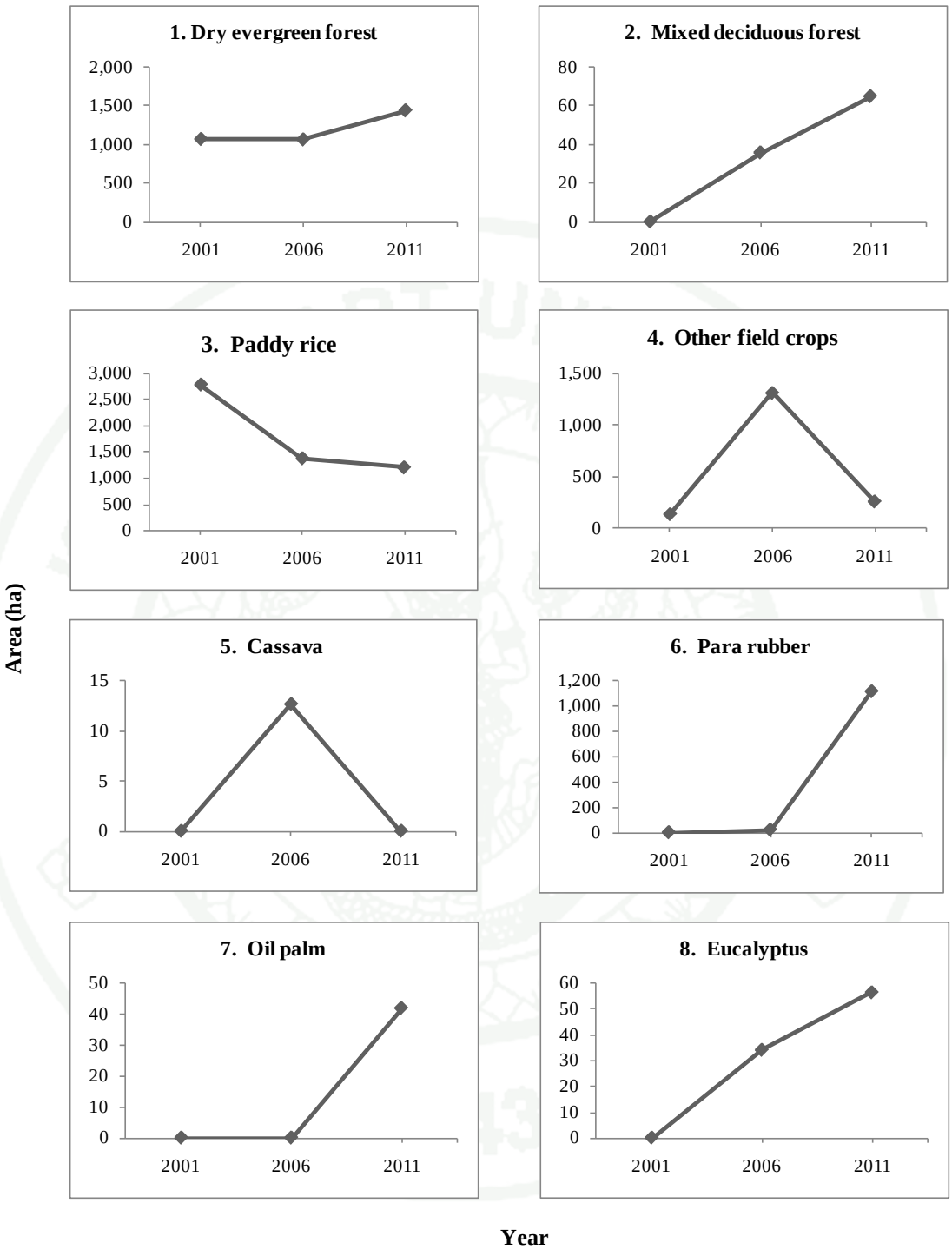

Figure 19 Land use change of Zone III in Thailand in 2001, 2006, and 2011.

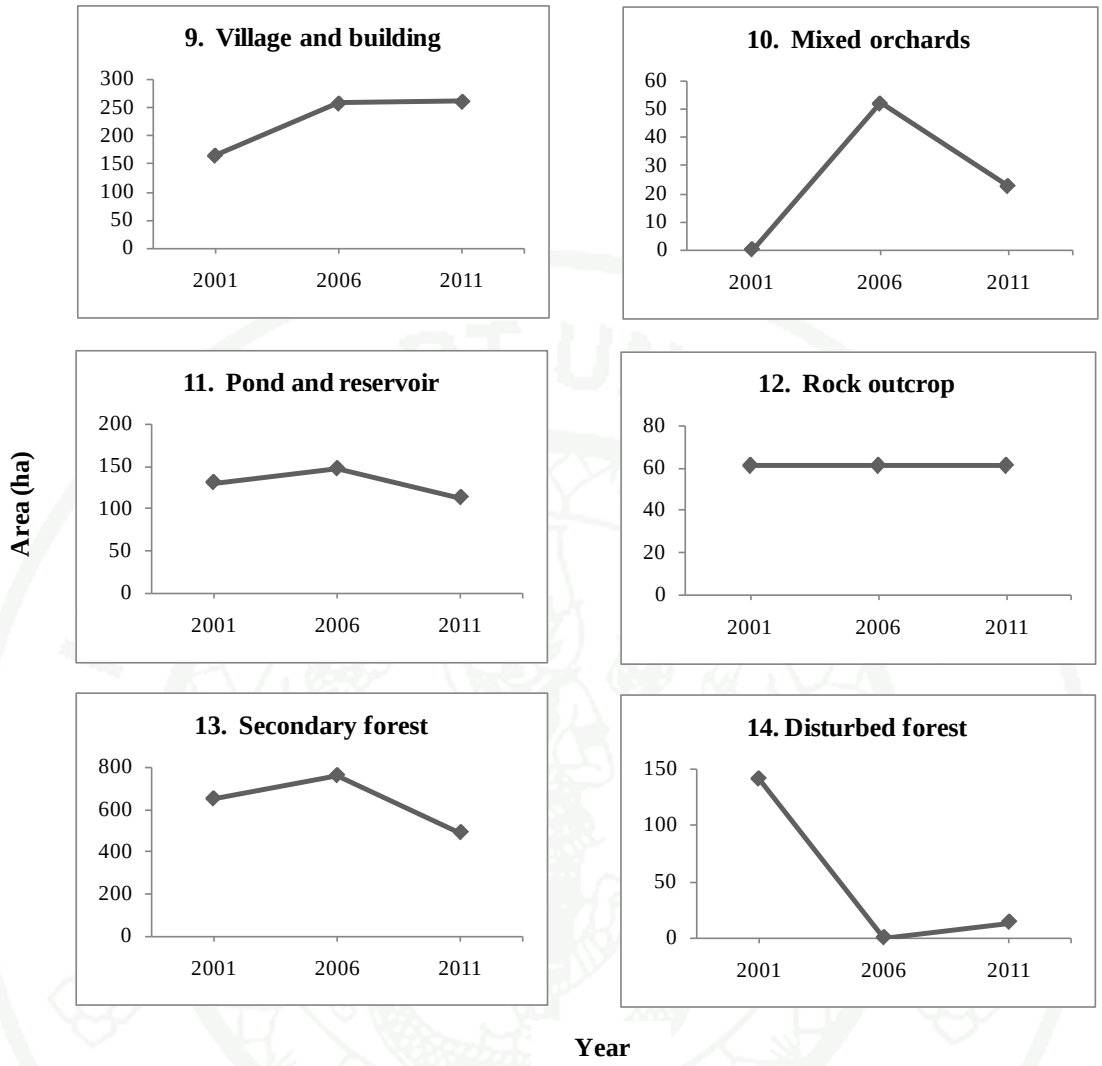

Figure 19 (Continued).

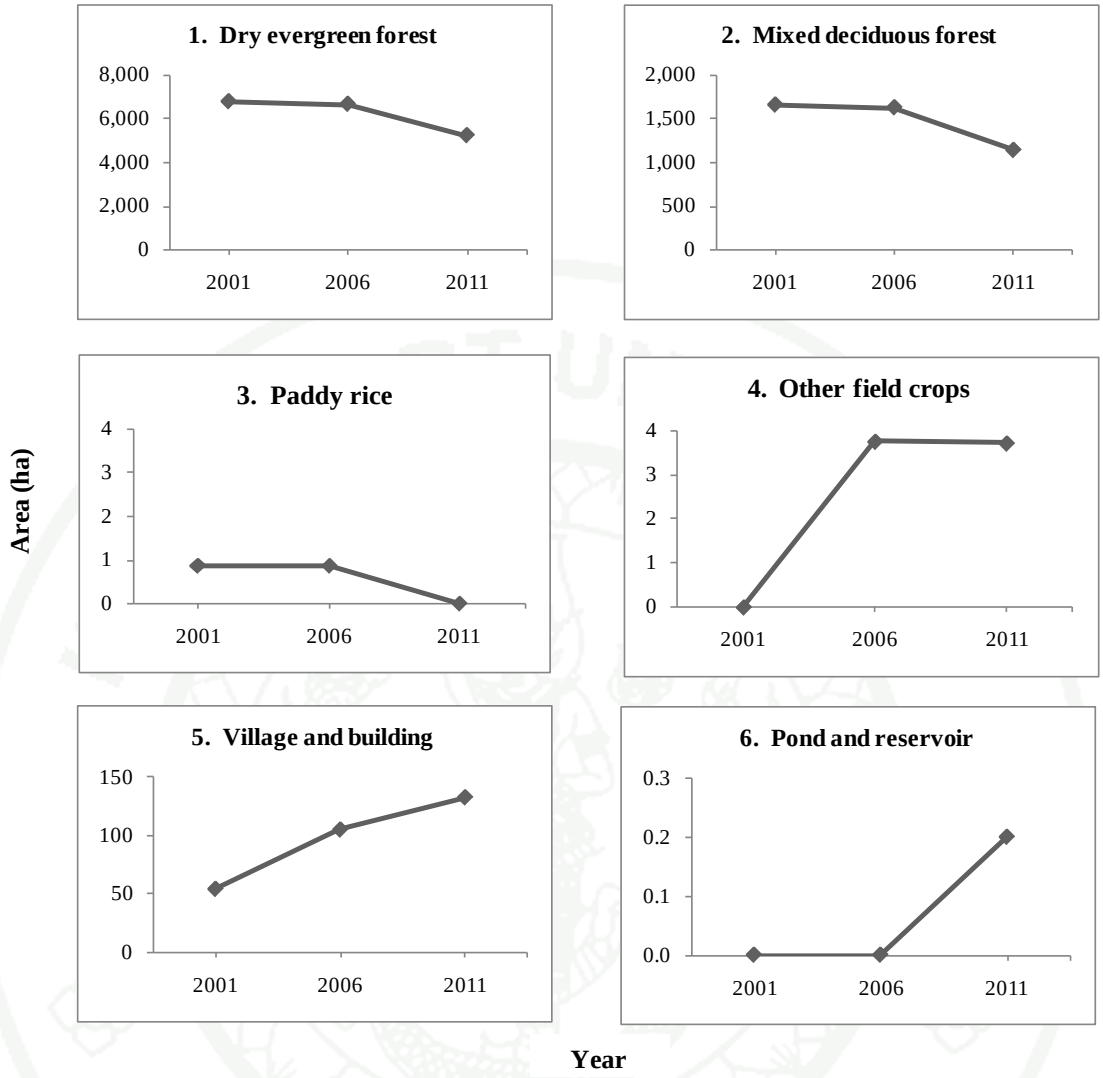

Figure 20 Land use change of Zone III in Cambodia in 2001, 2006, and 2011.

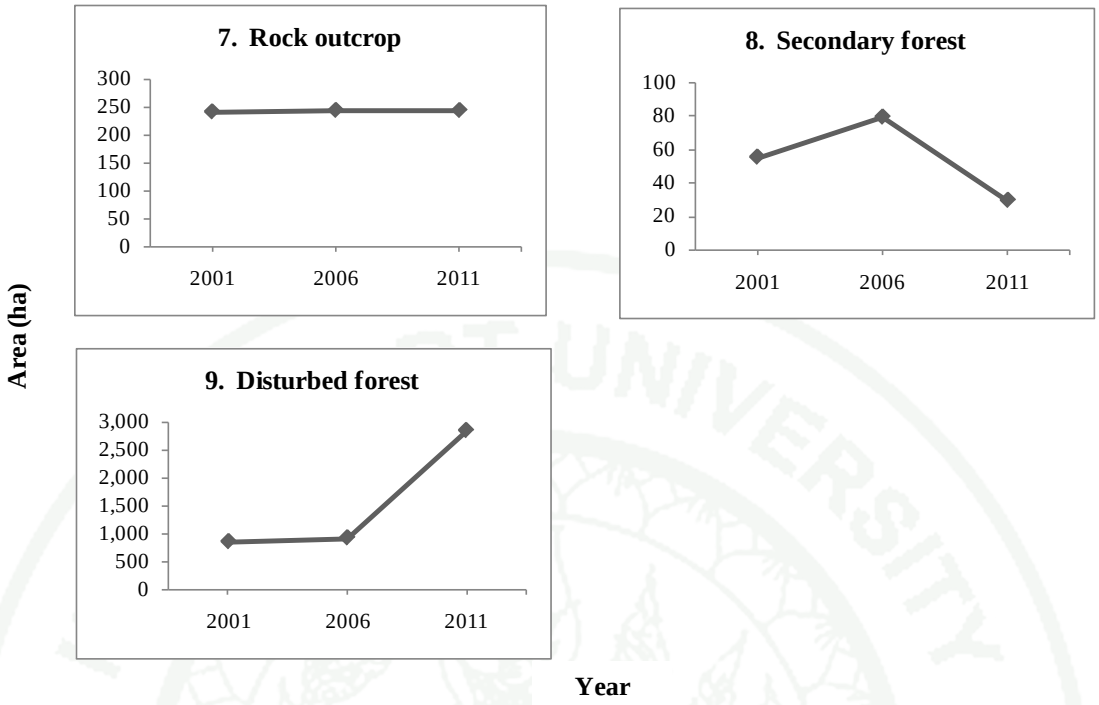

Figure 20 (Continued).

According to the result of land use change of Zone I, Zone II and Zone III in Thailand and Cambodia, there are no significant changes in Zone I of Thailand since it is located in the Phanom Dong Rak Wildlife Sanctuary established under the Forest and Wildlife Preservation and Protection Act and the state's policy on forest conservation and restoration. As a result, the dry evergreen forest had been increased while disturbed forest had been decreased in 2011. However, there are some areas that could not be controlled by the authorities; therefore the mixed deciduous forest had slightly decreased in 2011 because of deforestation by villagers.

In Zone II of Thailand the natural forests composing of dry evergreen forest and mixed deciduous forest in Phanom Dong Rak Wildlife Sanctuary and Khao Phra Viharn National Park had increased in 2011 due to the state policies on forest conservation and restoration. While there have been temples, markets, and military family villages of Cambodia built surrounding Phra Viharn Temple since 1999. In addition, Cambodia had built roads to the Phra Viharn Temple which had invaded the Thai territory. The changes are a result of the political factors on the sovereignty over

the territory, political dispute between the two governments, the state policies and the political method. Cambodia demands for the sovereignty over the area surrounding the temple that lies on the Thai side. Thai and Cambodian governments cannot settle the territorial issue since they adhere to the different demarcation. The Phra Viharn conflict has always been the major problem of their relations of every Thai government and Hun Sen's government. Moreover, Hun Sen's policies are active by attempting to occupy the area surrounding the temple i.e. a policy to list the temple as World Heritage by UNESCO in 2003. In 2006 Cambodia submitted the application to UNESCO requesting the temple to be designated as World Heritage site without consulting Thailand, whom they used to consult as joint commission task force to develop the temple as per the resolution of Thai – Cambodian Council of Ministers. Cambodia's political method has been active by constructing roads, temple, markets, military family accommodations and other activities in Thailand without obligating as per the borderline agreement between the two countries.

Moreover, Cambodia issued the royal decree of the demarcation of temple reservation that overlapped the Thai border in 2006. They claimed that it is the area under Cambodia's sovereignty. Cambodia also developed the infrastructure near the border in order to reduce dependence from Thailand when accessing the temple by connecting the routes within Cambodia itself. The roads were built to run to the temple and surrounding area of the temple complex. In 2011, Cambodia requested the International Court of Justice to interpret the 1962 verdict regarding the area surrounding the temple. Cambodian claimed that Thailand had not obligated as per the verdict withdrawing their forces from the temple and the surrounding area and request the International Court of Justice to issue the provisional measures – an immediate and unconditional withdrawal of all Thai forces from areas around the temple - prior to judgement interpretation. Regarding those requests, Cambodia had followed the demarcation in the 1: 200,000 scale map. Thailand had followed the obligation in accordance with the 1962 verdict. However, the court did not rule on the matter of using that map to demarcate the borderline. Thailand had lodged formal protests and negotiations, but Cambodia has not responded up until now. Thailand has also protested the royal decree defining the scope of the Temple area and the map

attached to the inscription of the temple as World Heritage encroaching into the Thai territory in order to protect the right of Thailand. These protests are rightful as international political process to protect territorial integrity.

The area outside the Wildlife Sanctuary and National Park that is not the disputed area between the two countries. It had been found that there had been more villages and building due to population growth. Agriculture is the main occupation of villagers in this area. Their land use is the agricultural. Their economic crops were rice and other field crops. In 2011, they had been converted to para rubber due to the government's policy - to increase farmers' income and livelihood. During 2001-2011, the para rubber price had gone up continuously so the para rubber area had expanded in 2011. Therefore, socio-economic factors affect land use in agriculture in Zone II of Thailand.

In Zone III of Thailand the natural forests composing of dry evergreen forest and mixed deciduous forest in Khao Phra Viharn National Park had increased in 2011 due to the government policies on forest conservation and restoration. There had been more villages and buildings outside the national park in 2006 and 2011 due to population growth. Moreover, in 2006 and 2011, villagers had converted other field crops and paddy rice to para rubber because of the government's policy in 2003 encouraging farmers to grow para rubber and the price of para rubber had gone up continuously during 2001-2011. Therefore, many farmers had adopted to grow para rubber instead in 2011. Hence, socio-economic factors affect land use in agriculture in Zone III of Thailand.

Regarding land use change comparison between Zone I, II and III in Thailand, there are most significant changes on Zone II that affect the national security over the Thai-Cambodian border. The mentioned changes are caused by the political factors especially sovereignty over the territory.

Regarding changes of Zone I, Zone II, and Zone III in Cambodia: Natural forests of Zone I in Cambodia had been decreased especially mixed deciduous forest

which had been decreased dramatically in 2011. That had caused disturbed forest to increase dramatically. There had been more villages and military construction in 2011. Regarding other changes, new roads had been built - some routes have been built near to the Thai-Cambodian border, some had been built to connect with a road to Phra Viharn Temple. The reason that forests had been decreased drastically is because the mixed deciduous forest is scattered on the plain which is easy for villagers to invade the forest and log Thailand Rosewood or *Dalbergia cochinchinensis Pierre*, the very expensive wood, and sell them. Cambodia has no policies on forest conservation and restoration in this area which had caused the forest to be decreased continuously. Moreover, Cambodia had submitted the application to UNESCO requesting the Phra Viharn Temple to be designated as World Heritage site and issued the royal decree of the demarcation of temple reservation that overlapped the Thai border in 2006. Therefore, there had been road construction and area development in order to access the Phra Viharn Temple more conveniently. The Cambodian Prime Minister announced Rectangular Strategy for Growth, Employment, Equity and Efficiency in 2010 aiming at tacking invasion from other countries. It had caused the Thai - Cambodian border surrounding the Phra Viharn Temple to be developed: transportation routes, national defense and building of a strong army etc., resulting in more villages by the border, military construction, and roads connecting to the border and the main road to Phra Viharn Temple. Due to the reasons mentioned above, it is concluded that the changes are likely to be a result of the political factors with their demand for state's sovereignty and the state's policies.

Natural forests in Zone II in Cambodia especially dry evergreen forest and mixed deciduous forest had been decreased dramatically in 2006 and 2011. The size of villages and military construction had doubled in 2006 and 2011. Forest loss had been caused by the forest encroachment and illegal logging by villagers. Cambodian government has no policies on forest conservation and restoration or controlling measures. Therefore, it had caused the forest to decrease tremendously. The forests had also been converted into villages and military construction. Zone II is close to Phra Viharn Temple, so there has been significant transportation development – road construction aiming at connecting the previous road to Phra Viharn Temple. A field

survey revealed that dirt roads had been converted to asphalt and concrete roads with wider lanes. The mentioned changes are probably because of the political factors: demand for sovereignty over the territory, government, state policy, and political methods. Cambodia claimed the territorial sovereignty surrounding the temple in the Thai territory. Hun Sen's government policies and political actions have been active in order to occupy the area surrounding the temple, i.e. submitting the application to UNESCO requesting that the temple be designated as World Heritage site and not consulting Thailand, whom they used to consult with as the joint commission task force to develop the temple as per the resolution of the Thai – Cambodian Council of Ministers. In 2006, Cambodia issued the royal decree of the demarcation of temple reservation that overlapped the Thai border. In 2010, Prime Minister Hun Sen announced the Rectangular Strategy for Growth, Employment, Equity and Efficiency in Cambodia and spent a large amount of money to tackle the so-called invasion from other countries particularly Thailand causing the border area along Thailand and Cambodia to be developed quickly, i.e. transportation development, community development along the borderline, defense development and building of a strong army etc. Regarding the study and the field survey, new concrete and asphalt roads, villages, and military buildings have been built along the main roads.

Natural forests of Zone III in Cambodia composing of the dry evergreen forest and mixed deciduous forest had been decreased tremendously in 2006 and 2011. There had been villages and military construction in 2006 and 2011 also. Forest loss was caused by the forest encroachment and illegal logging by villagers. Cambodian government has no policies on forest conservation and restoration or controlling measures. Therefore, it had caused the forests to continuously decrease. Some forests had also been converted into villages and military construction. Regarding other changes, roads had been built to run to the Thai – Cambodian border. The changes are due to the political factors with the state policies – this area surrounding the temple that has been a territorial issue. As a result, transportation development, army development and strength of villages are crucial to tackle the border conflicts. Moreover, Cambodian Prime Minister Hun Sen announced the Rectangular Strategy for Growth, Employment, Equity and Efficiency in 2010 to tackle the so-called

invasion from other countries and that had caused transportation routes, defense, building of a strong army, and villages along Thailand and Cambodia to be developed. As a result, there have been village expansion, military construction, and roads connecting the road to the Thai – Cambodian border.

CONCLUSION

Regarding assessment study of the land use change and factors affecting land use change in the Phanom Dong Rak mountain range, it can be concluded as follows:

The major area in Thailand is in Phanom Dong Rak Wildlife Sanctuary and Phra Viharn Temple National Park. The major land use is natural forest which had been increased in 2011. The change depends on the government policy on forest conservation and restoration. The changed areas affecting national security were the area around the Phra Viharn Temple complex. The issue regards the ownership claim and land use between Thailand and Cambodia since they adhere to different boundary lines. Roads, temple, markets, and military family accommodations built from 2001 to 2011 by Cambodia had invaded Thailand territory. Road construction by Cambodia has invaded the Thai territory surrounding the temple in 2006 and 2011. Therefore, the factors affecting land use in this area are political factors on sovereignty, government, state policy, and political method. The major factor is their demand for sovereignty over the area surrounding the Phra Viharn Temple. Regarding the area outside the wildlife sanctuary and the national park adjacent to the disputed area, more villages and buildings have been built. Land use is the economic plantation. Villagers had changed their land use from paddy fields, other field crops, and mixed orchards to para rubber, oil palm, and eucalyptus. Therefore, in 2011, the para rubber had increased dramatically as the state encouraging farmers to grow para rubber more in northeast Thailand. In addition, the rubber price goes up every year and that had urged villagers to expand the planting area for higher incomes. Hence socio-economic factors affected land use of this area.

In Cambodia it was found that the natural forests had been decreased dramatically in 2006 and 2011. The size of villages and military construction has doubled in 2006 and 2011. Forest loss had been caused by the forest encroachment and illegal logging by villagers. Cambodian government has no policies on forest conservation and restoration or controlling measures. Therefore, it had caused the forest to decrease tremendously. Roads had been built near the border connecting the road to Phra Viharn Temple. The changes were driven by political factors on sovereignty, government, policies, and

political method. The main factor is demand for sovereignty over the area surrounding the temple complex. Bumrungsuk (2008) mentioned that Cambodia has invaded the Thai territory constantly by: 1) Seeking support from members of World Heritage Committee regard world heritage inscription and has caused them to tend to support request of Cambodia, 2) Appointing an international committee on a multilateral level to tackle the Pra Viharn Temple complex issue, and 3) Developing infrastructure on the Cambodian side in order to reduce dependence from Thailand when travelling to the Phra Viharn site, also connecting tourist routes in Cambodia after the inscription as World Heritage. In 2010, Prime Minister Hun Sen announced the Rectangular Strategy for Growth, Employment, Equity and Efficiency in Cambodia and spent a lot of budget to tackle invasion from other countries causing the border area along Thailand and Cambodia to be developed quickly– transportation routes development, defense development, and building of a strong army. In 2011, Cambodian proceeded with the political method by filing an application of the judgement rendered in 1962 by International Court of Justice in the case of ownership of the area surrounding Phra Viharn Temple.

Land use change in this area was mostly induced by the international politics aiming at solely occupying the area and military security at the Thai – Cambodian border surrounding disputed area. The main reason of the dispute concerning land occupation and use along the Thai - Cambodian border around Phanom Dong Rak mountain range, is their demand to maintain benefit of their country, unclearness of the borderline in the past which cannot be amended or corrected simply. Also attitude between the two countries have caused paranoia. The government of Thailand should find a solution as an important foundation in order to resolve the conflict permanently, protect, and keep the benefit for their countries as much as possible. The government of Thailand should make straight forward negotiation with Cambodia on the demarcation line at the conflict area in order that Cambodia will withdraw its case from the International Court of Justice, reveal the fact to Thai people and make the people understand the advantage and disadvantage from the decision to get well-prepared for thing that might happen in the future, and make the referendum and public hearing for Thai people and listen to the people as well to solve the problem for reducing the current conflict in Thai society.

LITERATURE CITED

Alexander, J. 2007. **Conflict, Economic Closure and Human Security in Gaza**. Oxford Research Group, London.

Amler, B., D. Betke, H. Eger, C. Ehrich, U. Hoesle, A. Kohler, C. Kosel, A.V. Lossau, W. Lutz, U. Muller, T. Schwedersky, S. Seidemann, M. Siebert, A. Trux and W. Zimmermann. 1999. **Land Use Planning Methods, Strategies and Tools GTZ**. Eschborn, Germany.

Bamrungsuk, S. 2006a. Geo-politics of Thai National Security. **Thai National Securities Study No.13**. Square Print 93 Co., Ltd., Bangkok (in Thai).

_____. 2006b. The Mount Phra Viharn Case. **Thai National Securities Study No.38**. Square Print 93 Co., Ltd., Bangkok (in Thai).

_____. 2006c. The Phra Viharn Forum. **Thai National Securities Study No.47**. Square Print 93 Co., Ltd., Bangkok (in Thai).

_____. 2006d. The Phra Viharn Incident. **Thai National Securities Study No.45.** Square Print 93 Co., Ltd., Bangkok (in Thai).

_____ and P. *Piwawattanapanit*. 2006. The Temple of Phra Viharn: Legal & Political Perspective. **Thai National Securities Study No.46.** Square Print 93 Co., Ltd., Bangkok (in Thai).

Barbier, E.B. 2003. Habitat fishery linkages and mangrove loss in Thailand. **Contemporary Economic Policy** 21(1): 59-77.

Barbier, E.B. and J.C. Burgess. 2001. The economics of tropical deforestation. **J. Econ. Surv.** 15(3): 413-33.

Barredo, J.I., M. Kasanko, N. McCormick and C. Lavalle. 2003. Modelling dynamic spatial processes: simulation of urban future scenarios through cellular automata. **Land. Urb. Plan**. 64: 145-160.

Bocco, G., M. Mendoza and A. Velazquez. 2001. Remote sensing and GIS-based regional geomorphological mapping, a tool for land use planning in developing countries. **Geomorphology** 39: 211-219.

Bouman, B.A.M., H.G.P. Jansen, R.A. Schipper, A. Nieuwenhuyse, H. Hengsdijk and J. Bouma. 1999. A framework for integrated biophysical and economic land use analysis at different scales. **Agr. Eco. Env.** 75: 55-73.

Brown, L.R., N. Lenssen, H. Kane and L. Stark. 1994. **Vital Signs**. Norton, New York.

Burrough, P.A. 1996. **Principles of Geographic Information Systems for Land Resource Assessment.** Clarendon Press, New York.

_____. and R.A. McDonnell. 1998. **Principles of Geographical Information Systems**. Oxford University Press, New York.

Callaghan, J.R.O. 1996. **Land Use: The Interaction of Economics, Ecology and Hydrology**. Chapman and Hall, New York.

Chanchai, W. 1993. **Land Use Plan of Thailand**. Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok (in Thai).

Chanchai, W., S. Makepiboonwattana, D. Srisanga, W. Thonhchuta, P. Kadeetham and P. Suwatrungkul. 1993. **Land Use Plan of Northeast Thailand**. Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok (in Thai).

Chotsiri, N. 2006. Thai Border. **Thai National Securities Study No. 43.** Square Print 93 Co., Ltd., Bangkok (in Thai).

Clark, A.S. 2010. The political institutional determinants of land use change and SPRAWL: a conceptual model. **Theoretical and Empirical Researches in Urban Management** 7(16): 1-14.

Community Development Department. 2001. **The village's status database.** (CD- ROM). Community Development Department, Ministry of Interior, Bangkok (in Thai).

_____. 2006. **The village's status database.** (CD- ROM). Community Development Department, Ministry of Interior, Bangkok (in Thai).

_____. 2011. **The village's status database.** (CD- ROM). Community Development Department, Ministry of Interior, Bangkok (in Thai).

Dalal-Clayton, D.B. and D.L. Dent. 1993. **Surveys, Plans and People: A Review of Land Resource Information and Its Use in Developing Countries**. The International Institute for Environment and Development, London.

Dent, F.J. 1985. Principles and prerequisites for land use planning, pp.1-22. *In* Department of Land Development and FAO. **The Application of the FAO Framework for Land Use Planning in Thailand**. Proceedings, Rome.

Department of Mineral Resources. 1983. **Geology Map of Thailand (Scale 1:250,000).** Department of Mineral Resources, Ministry of Industry, Bangkok.

_____. 1983. **Geology Map of Thailand (Scale 1:500,000).** Department of Mineral Resources, Ministry of Industry, Bangkok.

Department of Mineral Resources. 2001. **Thai Geology**. Department of Mineral Resources, Ministry of Industry, Bangkok (in Thai).

Di Gregorio, A. and L.J.M. Jansen. 1998. **Land Cover Classification System (LCCS): Classification Concepts and User Manual for Software Version 1.0.** Nairobi, Rome.

Directorate of Intelligence. 2010. **Rectangular Strategy of Cambodia**. Directorate of Intelligence, Royal Thai Army, Ministry of Defence, Bangkok (in Thai) (Mimeographed).

Earth Remote Sensing Data Analysis Center. 2011. **Global Digital Elevation Model**. (Global Digital Elevation Model File). Earth Remote Sensing Data Analysis Center, The Ministry of Economy, Trade and Industry of Japan and the National Aeronautics and Space Administration (NASA), Japan.

Elachi, C. and J. Van Zyl. 2006. **Introduction to the Physics and Techniques of Remote Sensing**. John Wiley and Sons, Inc., New York.

Ehlers, M., M.A. Jadkowski, R.R. Howard and D.E. Brostuen. 1990. Application of SPOT data for regional growth analysis and local planning. **Photo. Eng. Remo. Sens.** 56: 175–180.

FAO. 1985. **Guidelines: Land Evaluation for Irrigated Agriculture**. FAO and United Nation, Rome.

_____. 1993. **Guidelines for Land-Use Planning**. FAO and United Nation, Rome.

_____. 1995. **Planning for Sustainable Use of Land Resources: Towards a new Approach**. FAO Land and Water Bulletin 2, Rome.

FAO. 1997. **State of the World's Forests 1997**. United Nations/Food and Agricultural Organization, Rome.

_____. **Land Quality Indicators and Their Use in Sustainable Agriculture and Rural Development**. FAO Land and Water Bulletin 2, Rome.

_____. 2001. **Forest Resources Assessment (2000)**. FAO and UNEP, Rome.

_____. 2003. **State of the World's Forests 2003**. FAO and UNEP, Rome.

FAO and ILO. 1998. **Socio-economic and Gender Approach (SEAGA) Handbook**. FAO and UNEP, Rome.

FAO and UNEP. 1997. **Negotiating a Sustainable Future for Land**. FAO and UNEP, Rome.

Franklin, J., C.E. Woodcock and R. Warbington. 2000. Digital vegetation maps of forest lands in California: integrating satellite imagery, GIS modeling and field data in support of resource management. **Photo. Eng. Remo. Sens.** 66: 1209-1217.

Franklin, S.E. 2001. **Remote Sensing for Sustainable Forest Management**. Lewis Publishers, Boca Raton.

Gautam, A.P., E.L. Webb and A. Eiumnok. 2002. GIS assessment of land use-land cover changes associated with community forestry implementation in middle hills of Nepal. **Mt. Res. Dev.** 22(1): 63-69.

Geo-Informatics and Space Technology Development Agency. 2008. **IKONOS Satellite Imagery (1 m)**. Geo-Informatics and Space Technology Development Agency, Ministry of Science and Technology, Bangkok.

Geo-Informatics and Space Technology Development Agency. 2000. **LANDSAT-5 TM Satellite Imagery (multispectral 30 m)**. Geo-Informatics and Space Technology Development Agency, Ministry of Science and Technology, Bangkok.

_____. 2001. **LANDSAT-5 TM Satellite Imagery (multispectral 30 m)**. Geo-Informatics and Space Technology Development Agency, Ministry of Science and Technology, Bangkok.

_____. 2005. **LANDSAT-5 TM Satellite Imagery (multispectral 30 m)**. Geo-Informatics and Space Technology Development Agency, Ministry of Science and Technology, Bangkok.

_____. 2010. **LANDSAT-5 TM Satellite Imagery (multispectral 30 m.)**. Geo-Informatics and Space Technology Development Agency, Ministry of Science and Technology, Bangkok.

_____. 2006. **SPOT-5 Satellite Imagery (pan-sharpen 2.5 m).** Geo-Informatics and Space Technology Development Agency, Ministry of Science and Technology, Bangkok.

_____. 2011. **THEOS Satellite Imagery (multispectral 15 m, panchromatic 2 m)**. Geo-Informatics and Space Technology Development Agency, Ministry of Science and Technology, Bangkok.

Hall, F.G., D.B. Botkin, D.E. Strebel, K.D. Woods and S.J. Goetz. 1991. Large-scale patterns of forest succession as determined by remote sensing. **Ecol.** 72: 628–640.

Harris, P.M. and S.J. Ventura. 1995. The integration of geographic data with remotely sensed imagery to improve classification in an urban area. **Photo. Eng. Remo. Sens.** 61: 993–998.

Huizing, H. 1985. Land Evaluation, pp. 98-146. *In* Land Development Department and FAO. **The Application of the FAO Framework for Land Use Planning in Thailand**. Proceedings, Rome.

International Court of Justice. 2011. **Cases**. Case Concerning Sovereignty Over Certain Frontier Land Judgement of 20 June 1959. Available Source: http://www.icj-cij.org/docket/files/38/4807.pdf, March 15, 2011

Kaplan, R.D. 1994. The coming anarchy. **Atl. Month.** 273(2): 44-76.

Kauzeni, A.S., I.S. Kikula, S.A. Mohamed, J.G. Lyimo and D.B. Dalal-Clayton. 1993. **Land Use Planning and Resource Assessment in Tanzania: A Case Study**. International Institute for Environment and Development, London.

Kutter, A. and C.L. Neely. 1999. **The Future of Our Land: Facing the Challenge**. FAO and UNEP, Rome.

Land Development Department. 2010. **Conclusion of Land Use Types in Thailand 2009/2010**. Information in Land Use Planning. Available Source: http://www.ldd.go.th/thai-html/work2.htm, June 19, 2010 (in Thai).

Land Development Department. 2008. **Land Use Zoning in Sao Thong Chai, Kantharalak District, Sisaket Province**. Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok (in Thai).

_____. 1986. **Soil Series Maps of Provinces in Thailand (Scale 1:100,000)**. Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok**.**

Lewis, W.C. and W.E. Kuttler. 2005. Land use controls and the political process. **Ann. Reg. Sci.** 12(1): 24-35.

Li, X. and A.G. Yei. 2004. Analyzing spatial restructuring of land use patterns in a fast growing region using remote sensing and GIS. **Land. Urb. Plan.** 69(4): 335-354.

Liang, S. 2008. **Advances in Land Remote Sensing: System, Modeling, Inversion and Application**. Springer, New York.

Liengsakul, M., S. Mekpaiboonwatana, P. Pramojanee, K. Bronsveld and H. Huizing. 1993. Use of GIS and remote sensing for soil mapping and for locating new sites for permanent cropland, A case study in the highlands of northern Thailand. **Geoderma** 60: 293-307.

Livingstone, D. 2006. The Spratly Islands; A Regional Perspective. **J. Wash. Inst. Chi. Stud.** 1(2): 149-160.

Maji, A.K., D.C. Nayak, N.D.R. Krishna, C.V. Srinivas, K. Kamble, G.P.O. Reddy and M. Velayutham. 2001. Soil information system of Arunachal Pradesh in a GIS environment for land use planning. **JAG**. 3(1): 69-77.

Malairojsiri K., A. Sujinai, and K. Huntrakul. 2002. **Characterization of Established Soil Series in the Northeast Region of Thailand Reclassified According to Soil Taxonomy 2003**. Department of Land Development, Ministry of Agricultural and Cooperatives, Bangkok.

Martin, D. and S.K. Saha. 2009. Land evaluation by integrating remote sensing and GIS for cropping system analysis in a watershed. **Curr. Sci.** 96(4): 569-575.

Mather, A.S. 1989. **Land Use**. John Wiley and Sons, Inc., New York.

Matthews, M.M. 2007. **The US Army on the Mexican Border: A Historical Perspective**. Combat Studies Institute Press, Fort Leavenworth, Kansas.

Mayers, N. 1993. **Ultimate Security: The Environmental Basis of Political Stability**. Norton, New York.

Mcconnell, W.J., S.P. Sweeney and B. Mulley. 2004. Physical and social access to land: spatio-temporal patterns of agricultural expansion in Madagascar. **Agr. Eco. Env.** 101(1): 171-184.

Meaille, R. and L. Wald. 1990. Using geographic information system and satellite imagery within a numerical simulation of regional urban growth. **Int. J. Geog. Inform. Sys.** 4: 445-456.

Meunpol, C. 2005. **Soil Resources of Lower Northeast Thailand: Status, Problems and Recommendations for Proper Utilization for Agriculture**. Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok (in Thai).

Ministry of Foreign Affairs. 2011. **Information Thai People Should Know about the Phra Viharn Temple and Thailand – Cambodian Negotiation**. Ministry of Foreign Affairs, Bangkok (in Thai).

_____. 2010. **Kingdom of Cambodia**. Thailand and the World. Available Source: http://www.mfa.go.th, December 10, 2010 (in Thai).

_____. 2008. **The Inscription of the Temple of Phra Viharn on the World Heritage Case**. Ministry of Foreign Affairs, Bangkok (in Thai).

Muller, D. and M. Zeller. 2002. Land use dynamics in the central highlands of Vietnam: a spatial model combining village survey data with satellite imagery interpretation. **Agr. Econ.** 27(3): 333-354.

National Park, Wildlife, and Plant Conversation Department. 2005. **Master Plan Khao Phra Viharn National Park Srisaket**. Aadecon Corporation Ltd., Bangkok (in Thai).

_____. 2011. **Conservation Forest Area Map**. (Conservation Forest Area Map File) National Park, Wildlife, and Plant Conversation Department, Bangkok.

Palo, A., M. Linder, J. Truu and U. Mander. 2008. The influence of biophysical factors and former land use on forest floristic variability on Saaremaa and Muhu islands, Estonia. **J. Nat. Cons.** 16: 123-134.

Prunier, G. 1995. **The Rwanda Crisis, 1959-1994: History of a Genocide**. Hurst, London.

Robinson, W.T. 1972. The Sino-Soviet Border Dispute: background, development, and the March 1969 clashes. **Amer. Polit. Sci. Rev.** 66(4): 1175-1202.

Rogan, J. and D. Chen. 2004. Remote sensing technology for mapping and monitoring land cover and land use change. **Progress in Plan** 61: 301-325.

Senes, G. and A. Toccolini. 1998. Sustainable land use planning in protected rural areas in Italy. **Land. Urb. Plan.** 41: 107-117.

Serneels, S. and E.F. Limbin. 2001. Proximate causes of land use change in Narok District, Kenya: A spatial statistical mode. **Agr. Eco. Env.** 85(1-3): 65-81.

Serra, P., X. Pons and D. Saur. 2008. Land-cover and land-use change in a Mediterranean landscape: a spatial analysis of driving forces integrating biophysical and human factors. **Applied Geography** 28: 189-209.

Sietchiping, R. 2010. **Political Economy of Land Access And Control Over Natural and Land-Based Resources: A Means for Conflicts Prevention and Management.** CAPRi Workshop on Collective Action, Property Rights and Conflict in Natural Resources Management. Available Source: http://www.capri.cgiar.org/pdf/CAPRi_Conflict_Sietchiping.pdf, January 19, 2011.

Skidmore, A.K., W. Bijker, K. Schmidt and L. Kumar. 1997. Use of remote sensing and GIS for sustainable land management. **ITC. J.** 3/4: 302-315.

Slaymaker, O. 2001. The role of remote sensing in geomorphology and terrain analysis in the Canadian Cordillera. **JAG.** 3(1): 11-17.

Steininger, M. K. 1996. Tropical secondary forest regrowth in the Amazon: age, area and change estimation with Thematic Mapper data. **Int. J. Remo. Sens.** 17: 9-27.

Thai Meteorological Department. 2011. **Meteorological Data in Srisaket province**. (Meteorological Data File). Thai Meteorological Department, Bangkok.

Tanrivermis, H. 2003. Agricultural land use change and sustainable use of land resources in the Mediterranean region of Turkey. **J. Ari. Env.** 54: 553-564.

Tekle, K and L. Hedlund. 2000. Land cover changes between 1958 and 1986 in Kalu district, southern Wello, Ethiopia. **Mt. Res. Dev.** 20(1): 212-231.

The Secretariat of the Cabinet. 2012. **Government's Policy**. Information about the Cabinet. Available Source: http://www.cabinet.thaigov.go.th, March 10, 2012 (in Thai).

The Royal Thai Survey Department. 1994. **Topographic Maps of Thailand (Scale 1:50,000).** Ministry of Defence. Bangkok.

Thongpussawan, S., P. Chaisongkram, S. Sakdayengyong, P. Pornprommin and K. Wornanuwattanakul. 2009**. Land Use Zoning of Economic Crops: Rainfed Rice**. Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok (in Thai).

Tokrisna, R., S. Tongpan, P. Duangpatra, J. Duangpatra, P. Saksoong, V. Jintana, P. Sichun, P. Narangjavana and N. Mungkung. 2002. **Land Use and Socio-economic in the Forest at Phu Luang, Wang Nam Kheo: A Case Study of Ban Klong Saton**. Kasetsart University, Bangkok (in Thai).

Treitz, P.M., P.J. Howard and P. Gong. 1992. Application of satellite and GIS technologies for land-cover and land-use mapping at the rural-urban fringe: a case study. **Photo. Eng. Remo. Sens.** 58: 439-448.

Turner, B.L., R.E. Kasperson, W.B. Meyer, K.M. Dow, D. Golding, J.X. Kasperson, R.C. Mitchel and S.J. Ratick. 1990. Two types of global environmental change: definitional and spatial-scale issues in their human dimensions. **Global Env. Change** 1: 14-22.

Udomsri S., K. Huntrakul, and S. Wattana. 2002. **Characterization of Established Soil Series in the Central Plain Region of Thailand Reclassified According to Soil Taxonomy 2003**. Department of Land Development, Ministry of Agricultural and Cooperatives, Bangkok.

United Nations Environment Programme. 2009. **Environmental Assessment of the Gaza Strip.** United Nations Environment Programme, Nairobi, Kenya.

United Nations. 2000. **Handbook on Geographic Information Systems and Digital Mapping**. Department of Economic and Social Affairs, Statistics Division, New York.

Uwanno, B. 2008. **Disclosure of Phra Viharn "Classified" Document 1962-2008**. Matichon Public Co.,Ltd., Bangkok (in Thai).

Verburg, P.H., T.C.M. De Nijs, J. Ritsema vanEck, H. Visser and K. De Jong. 2004. A method to analyse neighborhood characteristics of land use patterns. **Compt. Env. Urb. Sys.** 28: 667–690.

Verheye, W.H. 1997**.** Land Use Planning and National Soils Policies. **Agr. Sys.** 53: 161-174.

Walia, C.S., S.P. Singh, R.P. Dhankar, J. Ram, K.H. Kamble and D.K. Katiyar. 2010. Watershed characterization and soil resource mapping for land use planning of Moolbari Watershed, Shimla district, Himachal Pradesh in Lesser Himalayas. **Curr. Sci.** 98(2): 176-182.

Westmoreland, S. and D.A. Stow. 1992. Category identification of changed land use polygons in an integrated image processing/geographic information system. **Photo. Eng. Remo. Sens.** 58: 1593-1599.

Worakawin, K. 2004. **Thai Local Knowledge Mapping: Northeast Thailand**. Institute Academic Development, Bangkok (in Thai).

Yeh, A.G.O. and X. Li. 1996. Urban growth management in the Pearl River delta an integrated remote sensing and GIS approach. **ITC. J.** 1: 77-85.

_____. 1997. An integrated remote sensing-GIS approach in the monitoring and evaluation of rapid urban growth for sustainable development in the Pearl River Delta, China. **Int. Plan. Stud.** 2: 193-210.

Yeh, A.G.O. and X. Li. . 1999. Economic development and agricultural land loss in the Pearl River Delta, China. **Habitat Int.** 23: 373-390.

Young, A. 1998. **Land Resources**. Cambridge University Press, Cambridge, United Kingdom.

Ziadat, F.M. 2007. Land suitability classification using different sources of information: Soil maps and predicted soil attributes in Jordan. **Geoderma** 140: 73-78.

Zhou, W., G. Liu, L. Xu and X. Chu. 2005. Suitability evaluation of land in yellow river delta in China based on GIS. **Geosci. Remo. Sens. Symp.** 4: 2426-2429.

CURRICULUM VITAE

NAME : Major Krittayaporn Charoenpol

BIRTH DATE : April 25, 1979

BIRTH PLACE : Ratchaburi, Thailand

EDUCATION :

YEAR	**INSTITUTE**	**DEGREE**
2000	Silpakorn Univ.	B.Sc.(Environmental Science)
2003	Mahidol Univ.	M.Sc. (Technology of Environmental Management)

POSITION/TITLE : Assistant Professor

WORK PLACE : Chulachomklao Royal Military Academy

PUBLICATION : Charoenpol, K. 2003. A comparative study on physical and chemical soil properties in dry dipterocarp forest and dry evergreen forest in the Sakaerat environmental research station, Changwat Nakorn Ratchasima. **M.Sc. Thesis**. Mahidol University.

: Charoenpol, K. 2008. Application of Geo-Informatics Technology to Study Land Use at Chulachomklao Royal Military Academy and its Immediate Vicinities. **Journal of the Faculty Senate, The Academic Division, CRMA** 6(6): 30-40 (in Thai).