**DOUBT project**

# Land Use Change and its Impacts on Water Pumping in Bang Pakong River Basin, Thailand


by

Supaporn Pannon

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# ABSTRACT

Water resources management is a key issue for rational study in the Bang Pakong river basin. There is an increasing need to plan water use in Thailand, due to increased water requirements from various sectors. The purpose of this study was to assess land use change and agricultural water requirements in Bang Pakong river basin, Thailand. It also investigated the data of public organizations and projected the trend of land and water in the future. Spatial tools and in-depth interviews were applied in this study. Classified images from Landsat TM between 2002-2016 were conducted. Calculated water requirements for irrigation of rice and production of fish and shrimp crops in water assessment part then built a main scenario for land use changes and agricultural water requirements in the future.

Over the past 15 years, farming of perennial crops and aquaculture have been increasing while paddy field, field crop, and orchard have been decreasing. In terms of crop water requirement in the dry season, irrigated rice requires approximately 5,500 m3 per hectare while fish and shrimp farming requires 7,200 m3 per hectare. In a main business-as-usual scenario, rainfed rice will keep on decreasing while perennial crop will be increasing in the next 10 years. Main changes in terms of water requirements will probably come from the non-agricultural sector in the future.

# INTRODUCTION

The Bang Pakong river basin has an area around 10,707 km2. The basin serves as a water supply for drinking water, agriculture, aquaculture, and industry. There are several water issues in Bang Pakong river basin include salinity from seawater intrusion, floods, water shortage and water competition between water users. Water demand has increased over the last 3 decades. This has sometime led to tension among different water users, especially between agriculture and other sectors during dry period.

The forthcoming Water Act schedules the planning of water uses at catchment level. There is an opportunity to better understand land and water dynamics over the past 15 years, in order to support a discussion about what may be the changes in land and water use in the coming 10 years in the Bang Pakong Basin.

The main objectives of this study are to assess land use change and agricultural water requirements in Bang Pakong river basin. The study investigates past changes, compile the type of data collected by public organizations on land and water management, and project a main trend of changes in land and water use in the future.

This document is a synthesis of a Master Thesis[1] achieved at the Asian Institute of Technology in 2017-2018, under the supervision of Dr. Nicolas Faysse, Prof; Rajendra Shrestha and Dr. Duc . This study has taken place in the frame of the DOUBT research project.

# 1 STUDY AREA

The Bang Pakong River basin covers 4 provinces namely Nakhon Nayok, Chachoengsao, Prachinburi and Sa kaeo provinces. The major rivers in the basin are Bang Pakong river, Prachinburi river, Hanuman river and Klong Tha lat. The Figure 1 shows the whole basin. The Bang Pakong basin has a storage water capacity approximately 830 million cubic metre (mcm) while Prachinburi sub-basin has around 500 mcm. The Bang Pakong basin consists of three sub-basins: Nakhon Nayok, Thalat and Main Prachin buri basin while the Prachin buri river basin comprises of four sub-basins: Khlong Phra Sathung, Khlong Phra Prong, Mae Nam Hanuman, and Main Bang Pakong sub-basin (Kasetsart University, 2006). In this study, Tonlesap basin where located at the eastern part of the basin (Figure1) will be included to assess land use change as well as water requirement.

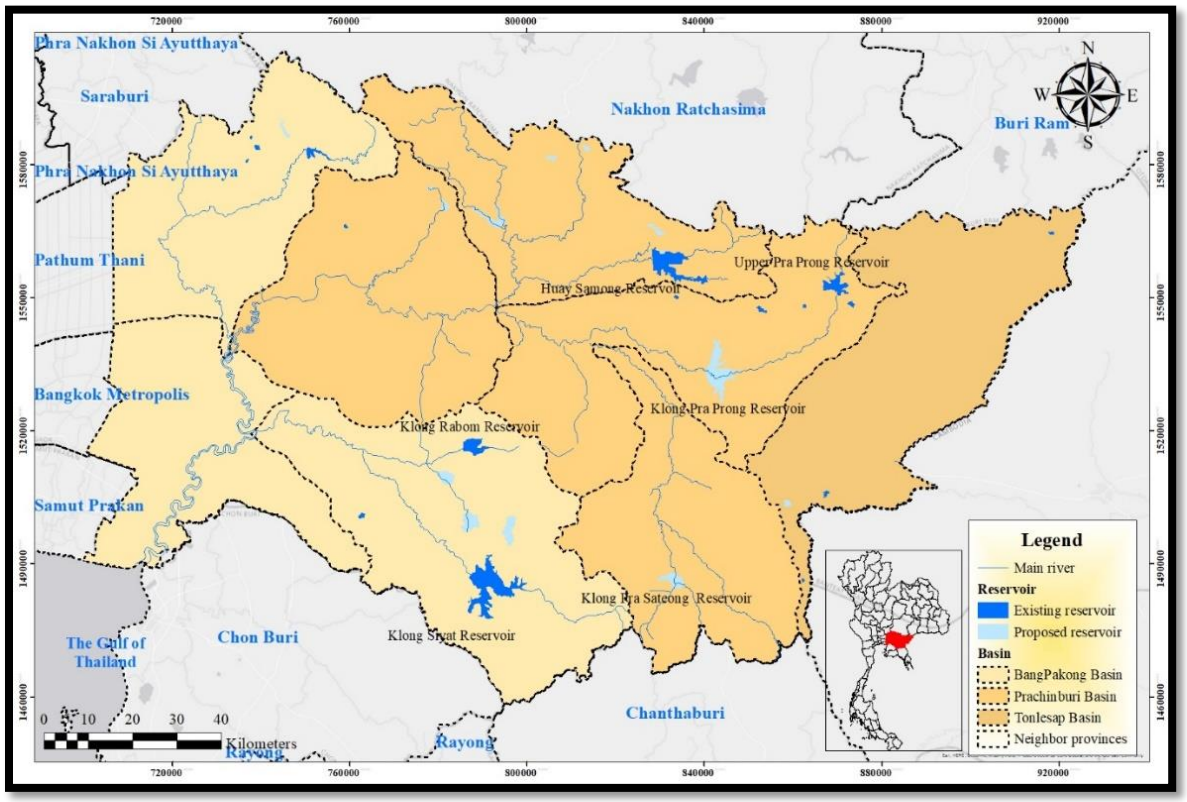


Figure 1. The Bang Pakong river basin and reservoirs

[1] Corresponding author. Email : supaporn.pannon@gmail.com

An average annual rainfall in the whole Bang Pakong basin is 1,416 mm according to a monthly rainfall from 35 Hydromet monitoring stations in the past 20 years (1980-2009). The main rainfall events take place between May-October while November-April, the amount of rainfall is quite low. As a rainfall is low in such period, in the dry season, the water source from rainfall is insufficient in the river basin, especially for several crops such as dry season rice, aquaculture and some others rainfed crops. Thus, irrigated areas are essential in the dry season.

# METHOD

The method will be separated into data collection and data analysis. For data collection, varieties of key informants which are relevant public organizations in terms of land and water were conducted in the study. For those organizations whom were interviewed were selected in the study area and work for land and water which are *Prachinburi Fisheries Office*, *Prachinburi Industries Office*, *Prachinburi Agricultural Extension Office (OAE*), *6th Regional Office of Agricultural Economic*s, *Prachinburi Provincial Waterworks Authority (PWA*), *Prachinburi Fisheries Offic*e , *Bang Phluang Irrigation Office and Regional Irrigation Office 9th* While the organizations which this study referred their secondary data and reports are *Land Development Department (LDD), Department of Water Resources (DWR) and The Geo-Informatics and Space Technology Development Agency (GISTDA).*

Land use change was analysed for five time periods by using data from 2002, 2006, 2009, 2013 and 2016, the satellite classified images were obtained from the Land Development Department (LDD) in digital format (Arcgis shape file) on request .The land use classes were regrouped for all the Bang Pakong river basin area into 5 major land uses classes which are agriculture land, forest land, miscellaneous land, urban land and water body. Miscellaneous land includes various types of land use, such as swamp, garbage dump, mine, pit, rangeland and salt flat.

Assessment of classification accuracy of 2016 images will be carried out to ensure verification of the accuracy of image interpretation and determine the quality of information derived from the data. To validate the accuracy of image classification result, field checks were conducted during October 2017 and November 2017. Relevant tools used in land use change analysis is Arcgis, to analyze and design the maps of land use types in the study area, the map of agricultural types in the whole basin.

Secondary data from relevant organizations were conducted for agricultural water assessment by calculating crop water requirement with Reference Crop Evapotranspiration of Penman-Monteith method. Crop Coefficient (Kc) and Reference Potential Evapotranspiration (Eto) was needed to collected in order to calculate water consumption of crops. Along with data of surface areas of crops that irrigated water in the dry season (irrigated dry season rice and fish and shrimp crops) in November to April.

For water assessment of other sector apart from agricultural sector used the previous report from Department of Water Resources in terms of water needs for non-cultivation sectors.

In-depth interviews with staff of relevant organizations about land and water is conducted for investigating the data of public organizations. We finally projected a main business-as-usual scenario, which assumes a continuation of existing trends in terms of changes in agricultural water uses. We estimated the changes in land use and in agricultural requirement during the dry season in such a scenario, by 2028.

# RESULTS

## GENERAL LAND USE CHANGE

An accuracy assessment of the classified images was performed by assessing sample points to check with ground-truthing in the year 2017. Based on ground checking is shown that the overall accuracy of the images is 83.26 %. Therefore in this case, the accuracy of the data from LDD is good according to general standards.

In 2002, agriculture land is the crucial land use type in the study area as it covers more than 60% of the area, compared with forest land, miscellaneous land, urban land and water body, which covered around 24%, 3%, 5% and 1%, respectively. Agriculture land and forest land were also the major land uses in 14 years period while miscellaneous surprisingly decreased in the year 2016. Interestingly, water body (only includes as an artificial water body such as dam and reservoirs and natural water body) strongly increased up to 6% in 2016. The bar graph in Figure 2 below illustrates the percentage of land use type in the study area in 5 land use types: Agriculture land, forest land, miscellaneous land, urban land and water body during 2002- 2016. The percentage of agriculture land is the most proportion of all land use types following with forest land, urban land, miscellaneous and water body, respectively.

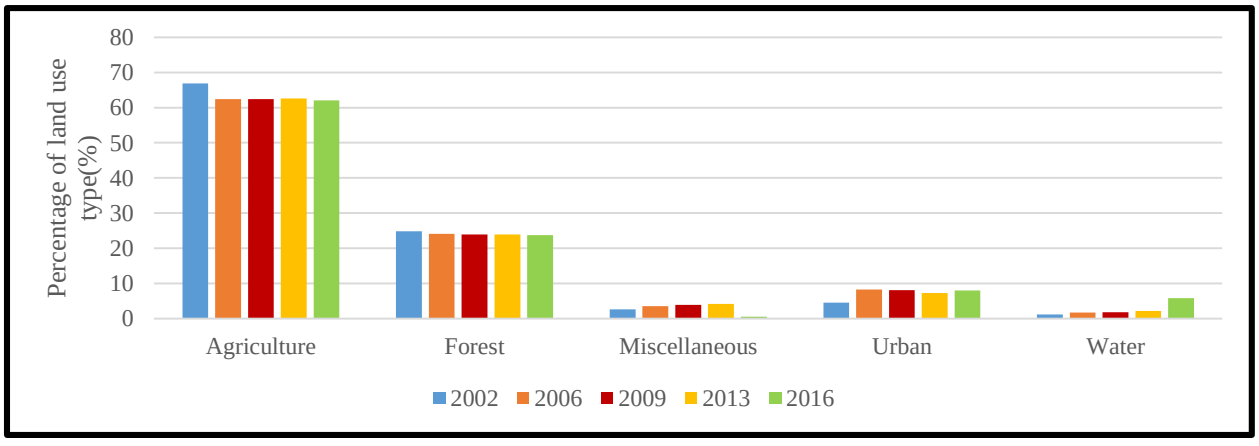


Figure 2 : Land use type in the study area (2002-2016)

Figures 3 to 7 and Table 1 shows the evolution of land use in the basin from 2002 to 2016. In particular Table 1 shows a percentage of changed land in the past 10 year (comparing 2002 and 2016). It can be clearly seen that agriculture land (which includes both crops and aquaculture

activities) is the most used of land in the basin (approximately 67 % in the year 2002 and 62% in 2016) following with forest land, urban, miscellaneous and water body, respectively.

Table 1. Land use change by each categories in the basin between 2002 and 2016

| Land use categories | 2002 (ha) | 2002 (%) | 2016 (ha) | 2016 (%) | Change (ha) | Change (%) |
|---|---|---|---|---|---|---|
| Agriculture | 1,280,500 | 66.92 | 1,187,400 | 62.06 | - 93,000 | -4.86 |
| Forest | 474,700 | 24.81 | 453,400 | 23.70 | -21,270 | -1.11 |
| Miscellaneous | 49,600 | 2.59 | 10,500 | 0.55 | -39,000 | -2.04 |
| No data | 700 | 0.04 | - | - | - 700 | -0.04 |
| Urban | 86,900 | 4.54 | 151,800 | 7.93 | 64,900 | 3.39 |
| Water body | 21,000 | 1.10 | 110,260 | 5.76 | 89,200 | 4.66 |

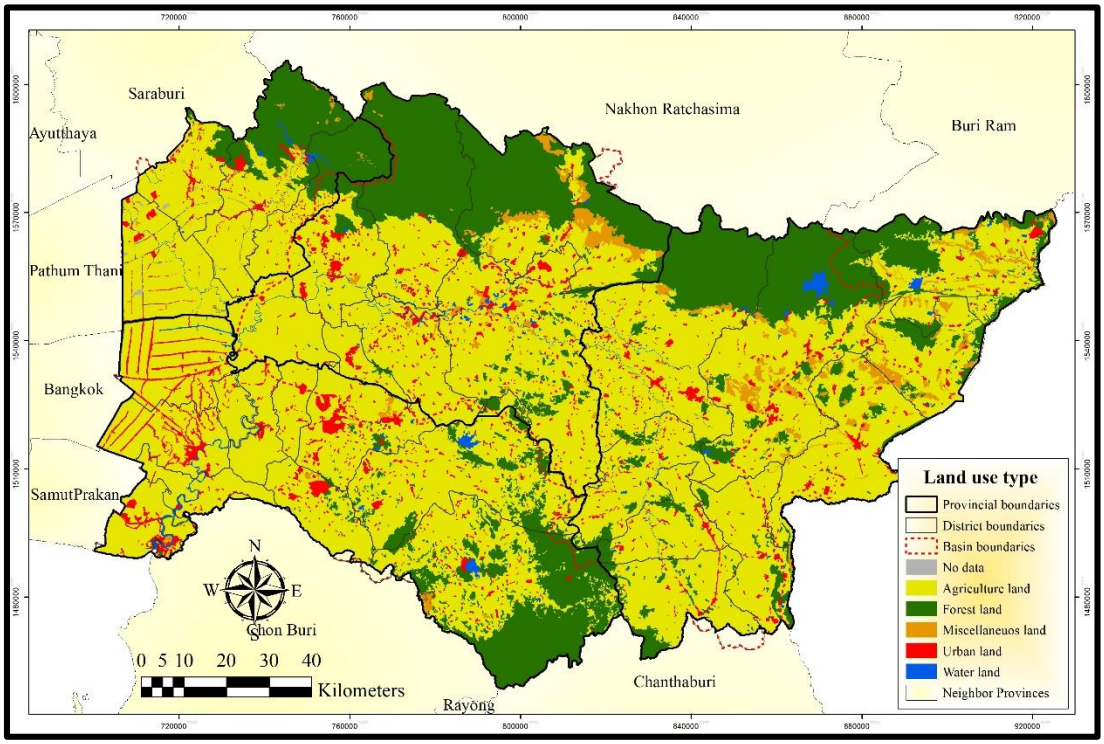


Figure 3. Land use type in the study area in 2002

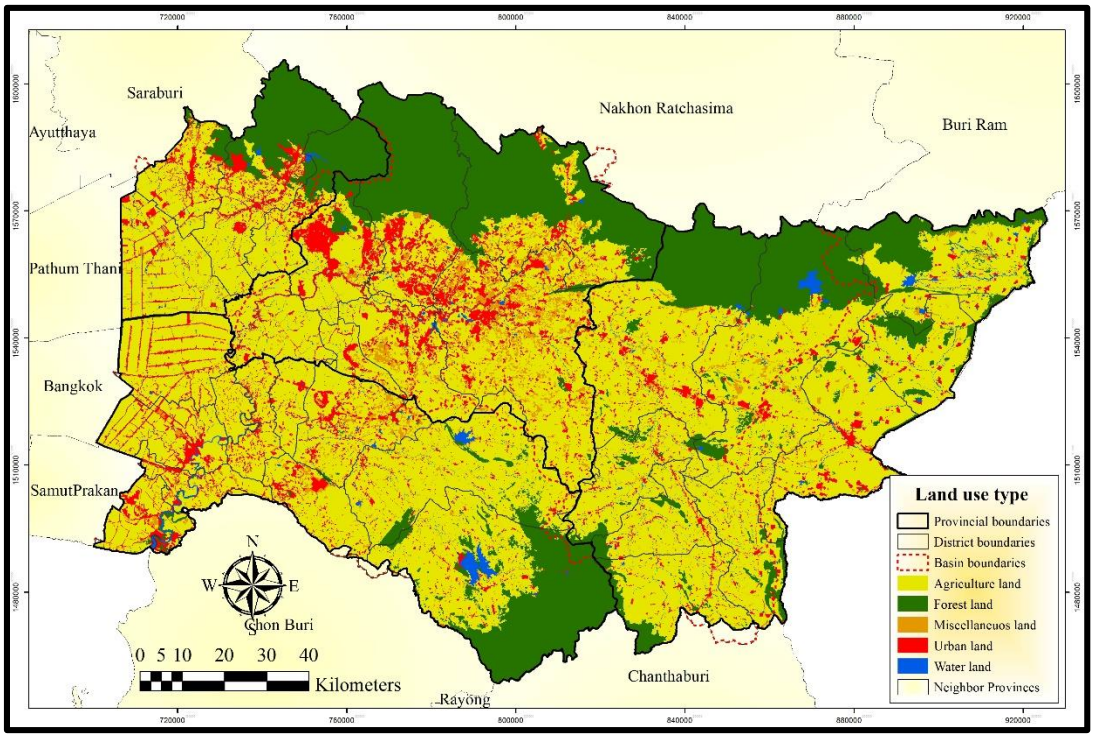


Figure 4. Land use type in the study area in 2006

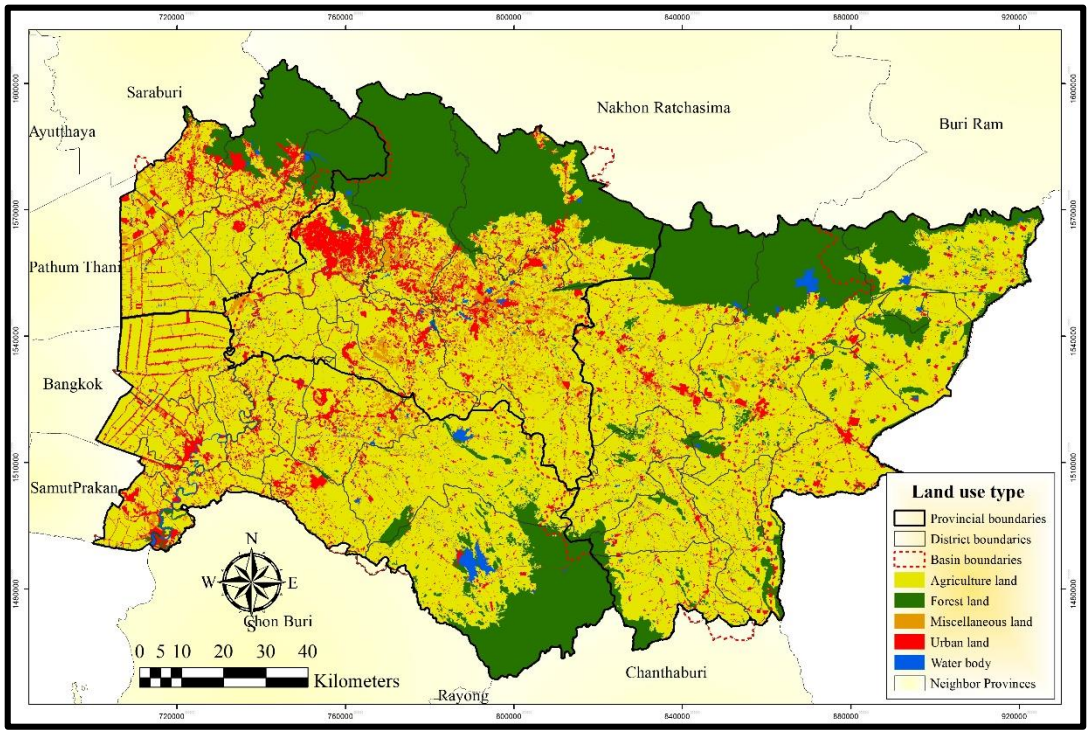


Figure 5. Land use type in the study area in 2009

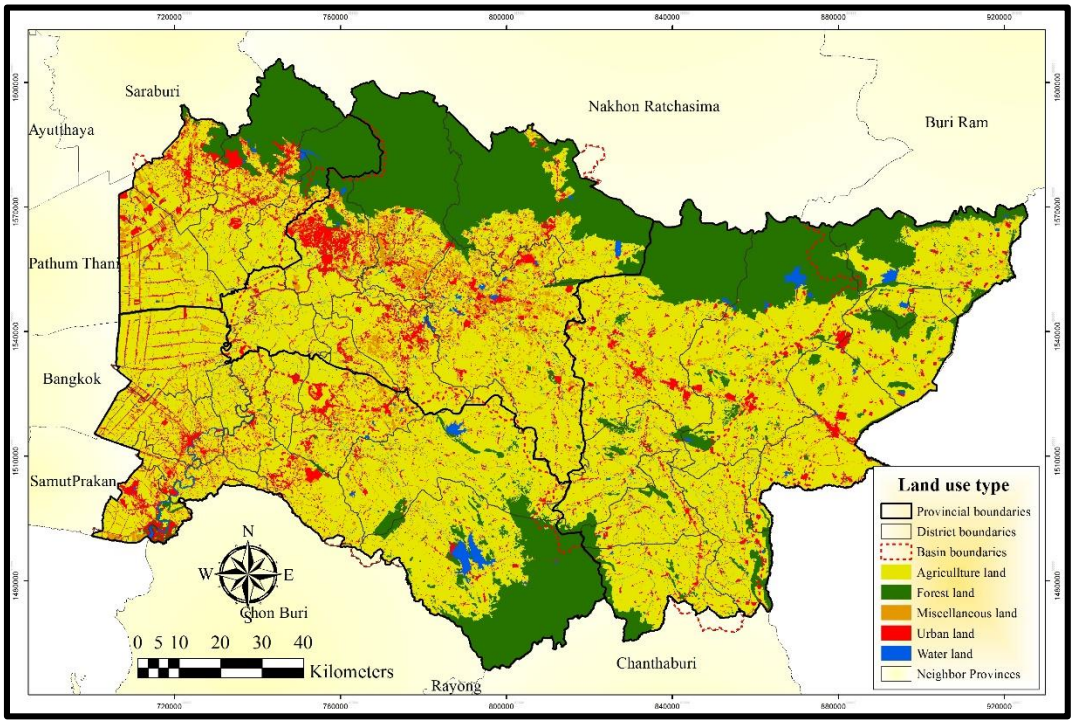


Figure 6. Land use type in the study area in 2013

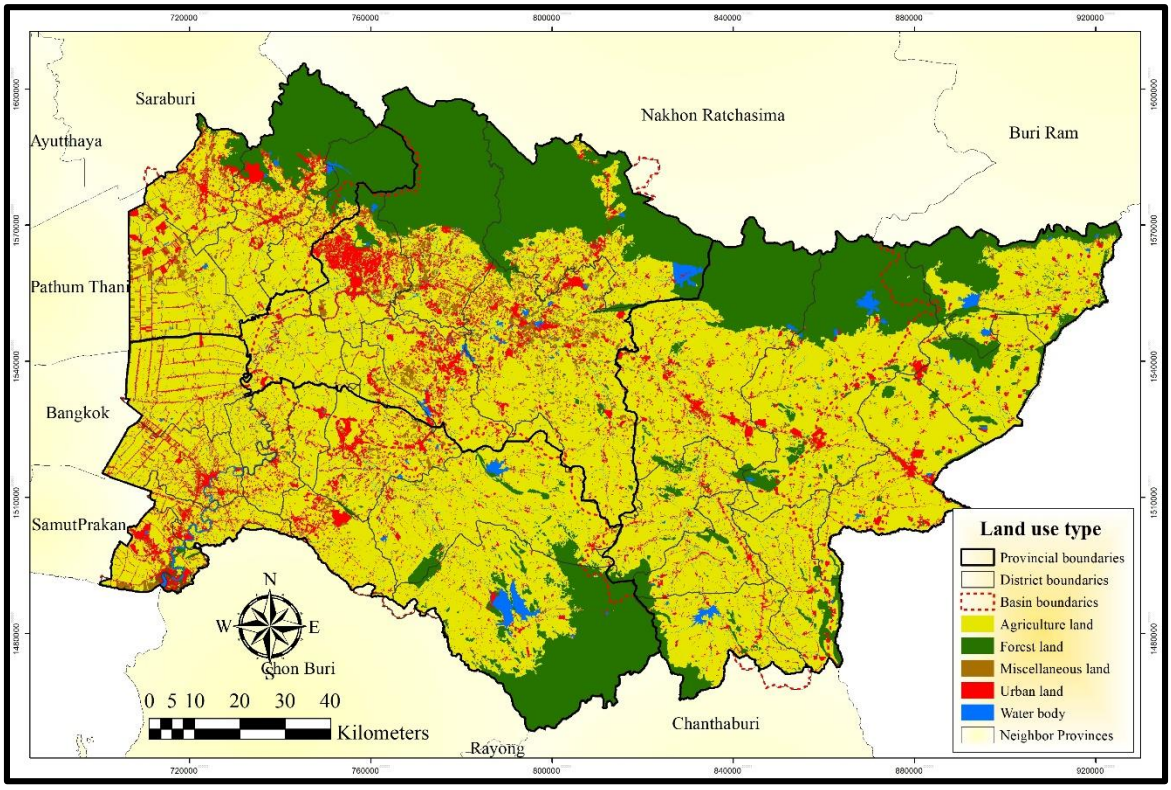


Figure 7. Land use type in the study area in 2016

There are 3 major changes of land which firstly is agriculture land following with water body and urban land. However, for water body and urban land, it increased used of land while agriculture land decreased in the past 10 years.

As agriculture are the major activities in the basin, it is not surprisingly that agriculture land is the most proportion of land in the basin, there are various types of agriculture activities which includes both crops and aquaculture land. In the past 10 years, the use of agriculture land seems to be decreased but that is not a huge percentage in this case except for converting into urban land as it is well know that a conversion of agriculture into urban is common as urbanization can take place throughout the time due to the population increase.

On one hand, forest land covers more than 25% in the basin (normally covers in the upper part of the basin from the maps above), but it also did not convert much into other land uses because firstly, it is a National Park area under Conservative Forest. Thus, there is no allowance of land encroachment in the forest area. Interestingly that another obvious change of land is water body, around 3% of agriculture converted into water body. In the year 2002-2013, the changed area of water body did not changed much but it can be seen the huge changed in the year 2016. It is because in 2016, new reservoir projects were built in the upper part of the basin, especially Huay Samong Dam.

A small amount of urban land in the study area has been converted a lot into agriculture land due to the farmers invest more for fish and shrimp farming, they dig the pond in their own land or rent the land for it. Moreover, some farmers cultivate Eucalyptus tree along the road.

## AGRICULTURAL LAND USE CHANGE

*General pattern*

Based on Land Development Department (LDD) image interpretation, agriculture is classified into 9 types which are integrated farm, paddy field, field crop, perennial crop, orchard, horticulture, pasture and farm house, aquatic plant and aquaculture land. Field crops are mainly cassava, sugarcane, maize and watermelon.

The graph in Figure 8 (and Table 2) shows a trend of change by each type of agriculture from 2002 to 2016. It illustrates that Paddy field, Field crop and Orchard tend to decrease while perennial crops and aquaculture land tend to increase in the future.

Moreover, from the Figure 9-14 below, the maps show the main type of agriculture land in the basin. Perennial crops were expanded from 2002 until 2016 mostly in the middle of the basin in Prachinburi and Chachoengsao provinces while aquaculture land was expanded in Paddy field area in the West side of the basin, covers some parts of Nakhon Nayok and Prachinburi provinces and mostly part where it located along with Bang Pakong river in Chachoengsao province due to a suitable geography as the Bang Pakong river discharges into the Gulf of Thailand.

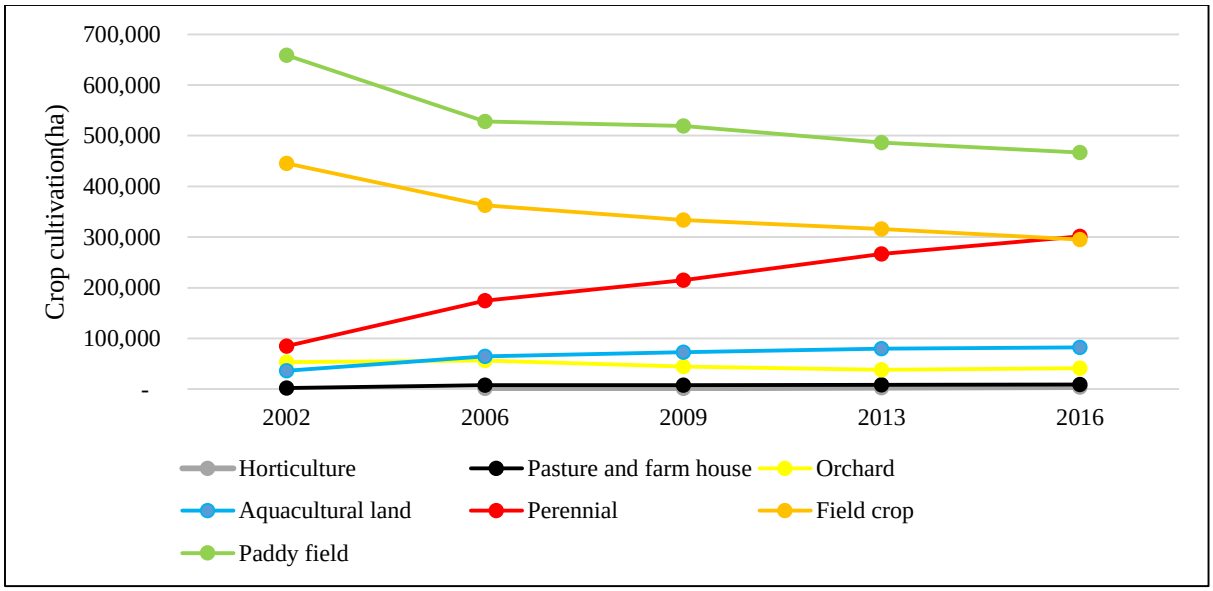


Figure 8. Main types of agriculture land in the study area.

Table 2. Surface area of agriculture crops in the basin from 2006-2016

| | Year | | | |
|---|---|---|---|---|
| **Cropped area** | **2006** | **2009** | **2013** | **2016** |
| Paddy field (ha) | 528,000 | 519,400 | 486,400 | 466,800 |
| Field crop (ha) | 362,500 | 333,800 | 315,800 | 295,000 |
| Perennial crops (ha) | 174,700 | 214,600 | 267,000 | 301,000 |
| Orchard (ha) | 56,200 | 44,300 | 38,000 | 41,200 |
| Aquaculture land (ha) | 67,600 | 76,300 | 83,300 | 87,900 |

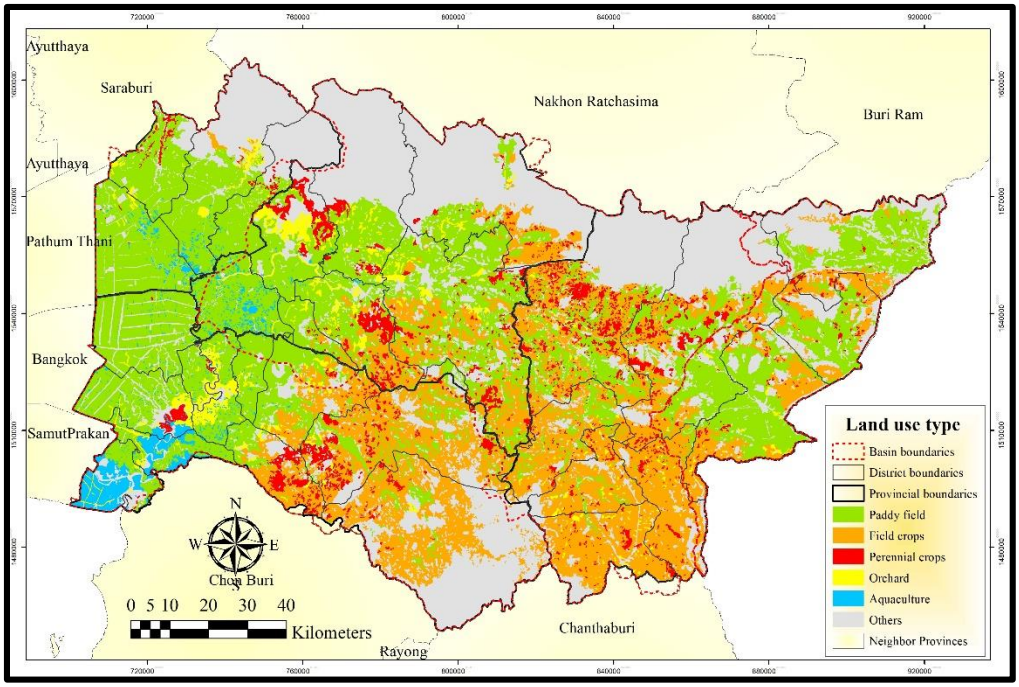


Figure 9. Main types of agriculture land in the study area in 2002.

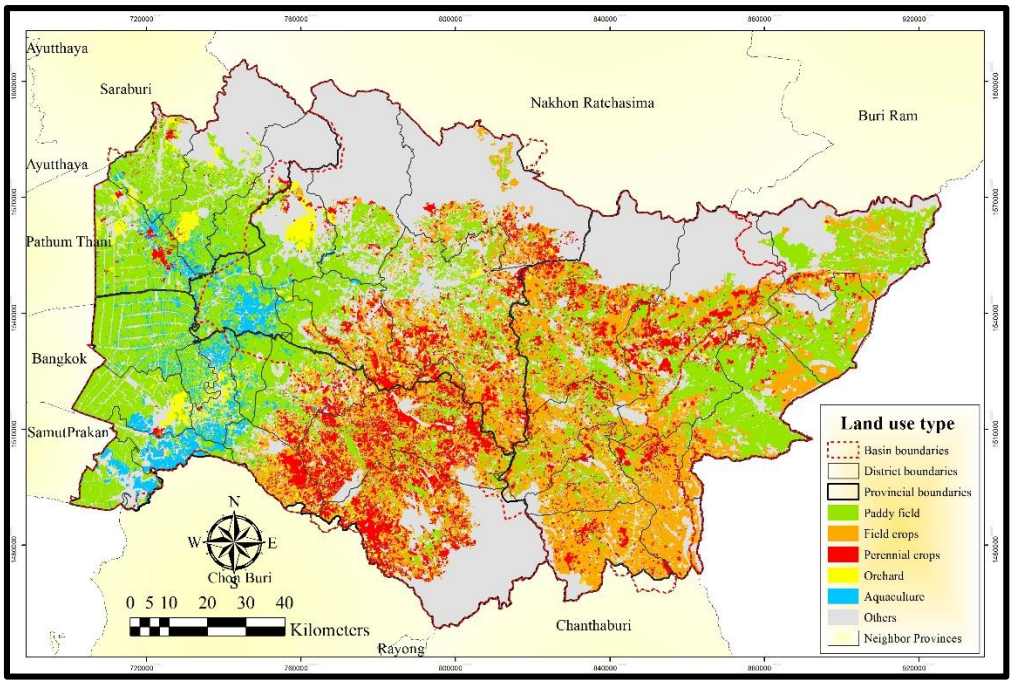


Figure 10. Main types of agriculture land in the study area in 2006.

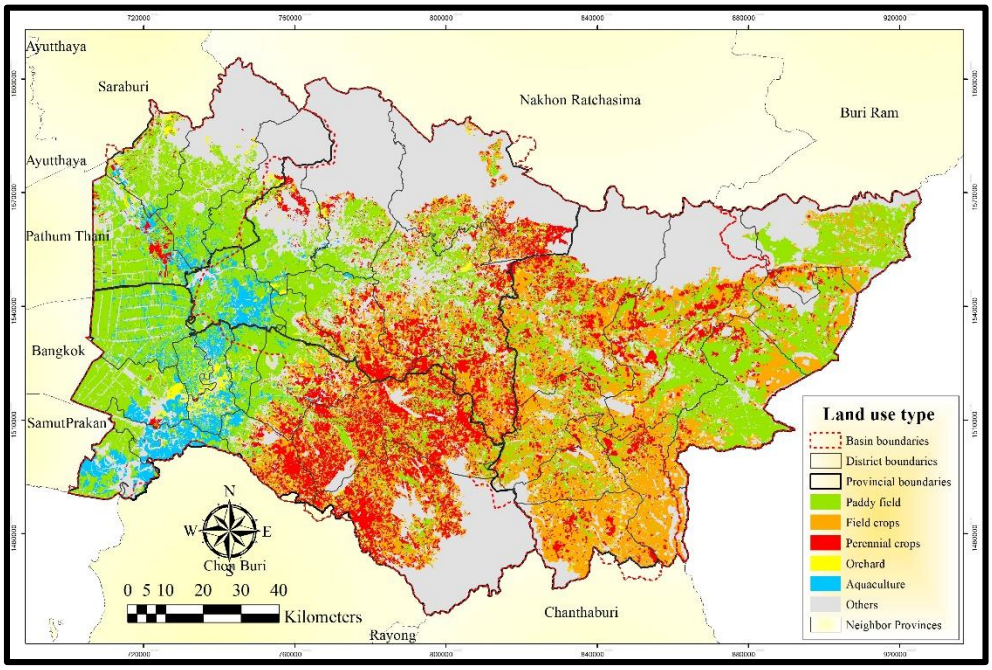


Figure 11. Main types of agriculture land in the study area in 2009.

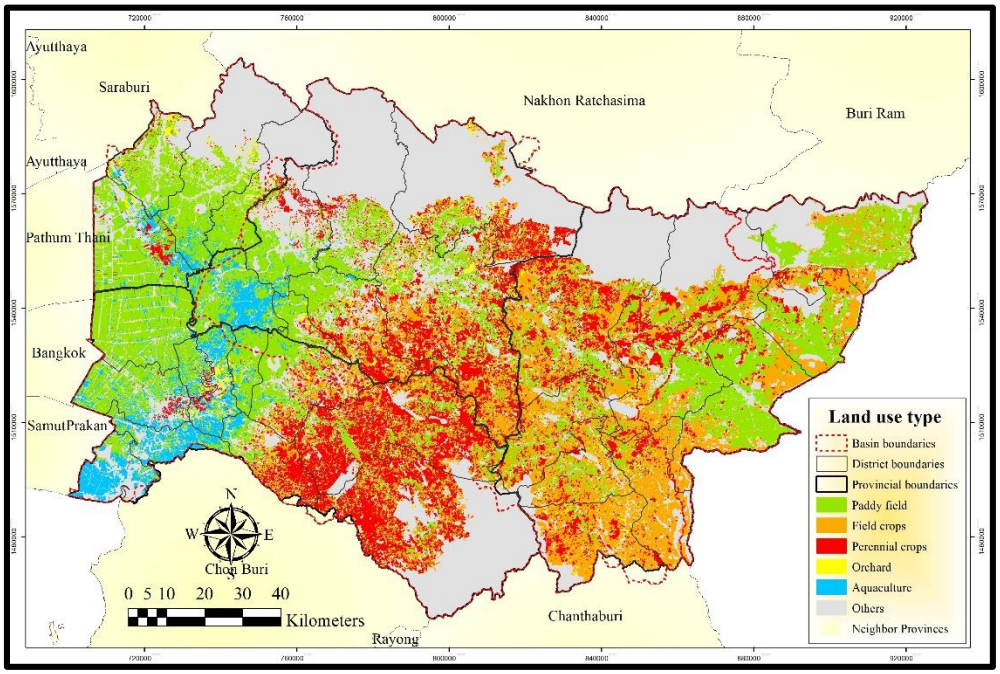


Figure 12. Main types of agriculture land in the study area in 2013.

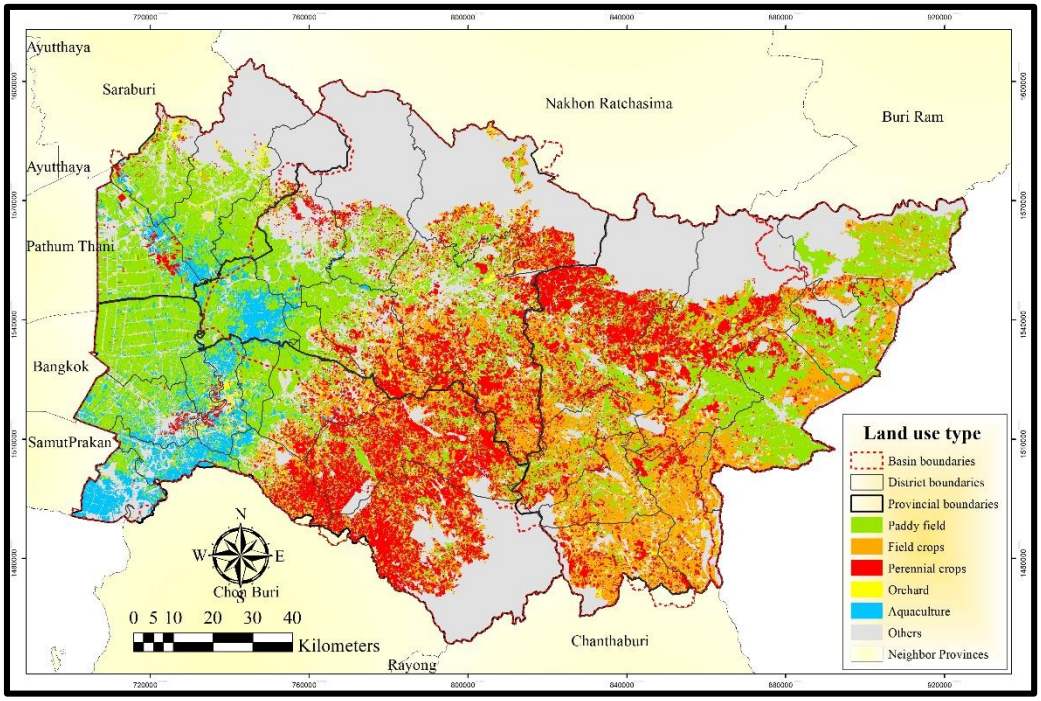


Figure 13. Main types of agriculture land in the study area in 2016

*Perennial crops*

As shown in the Figure 8**,** the graph demonstrates an increase of perennial crops (Para rubber tree, bamboo, Eucalyptus and oil palm) and aquaculture land in the study area while other agriculture land use decreased. The maps below (Figure 14-18) show an expansion of perennial crops from the year 2002-2016 for the whole Bang Pakong river basin. It can be seen from the maps that there a big increase of perennial crops is from 2002 to 2006, especially in the middle and eastern sides of the basin or mostly in Prachinburi and Chachoengsao and Sa Kaew provinces. From the map in 2002 (Figure 14), perennial crops were cultivated mainly parts in Prachinburi, Chachoengsao and Sa Kaew provinces. Then the big increase in the year 2006, a concentration of perennial crops was found mostly in Chachoengsao province.

According to contacted staff of the Ministry of Agriculture and Cooperatives, the main change of perennial crops in Prachinburi, Sa Kaew and Chachoengsao provinces are due to Eucalyptus tree instead of Para rubber or oil palm because recently, the price of Para rubber is decreasing. In terms of oil palm, even though, it is increasing but it is not expanded in the large area. Therefore, Eucalyptus tree is the most possible crops that has been increasing instead because the farmers might cultivate the Eucalyptus tree to support the paper's industries.

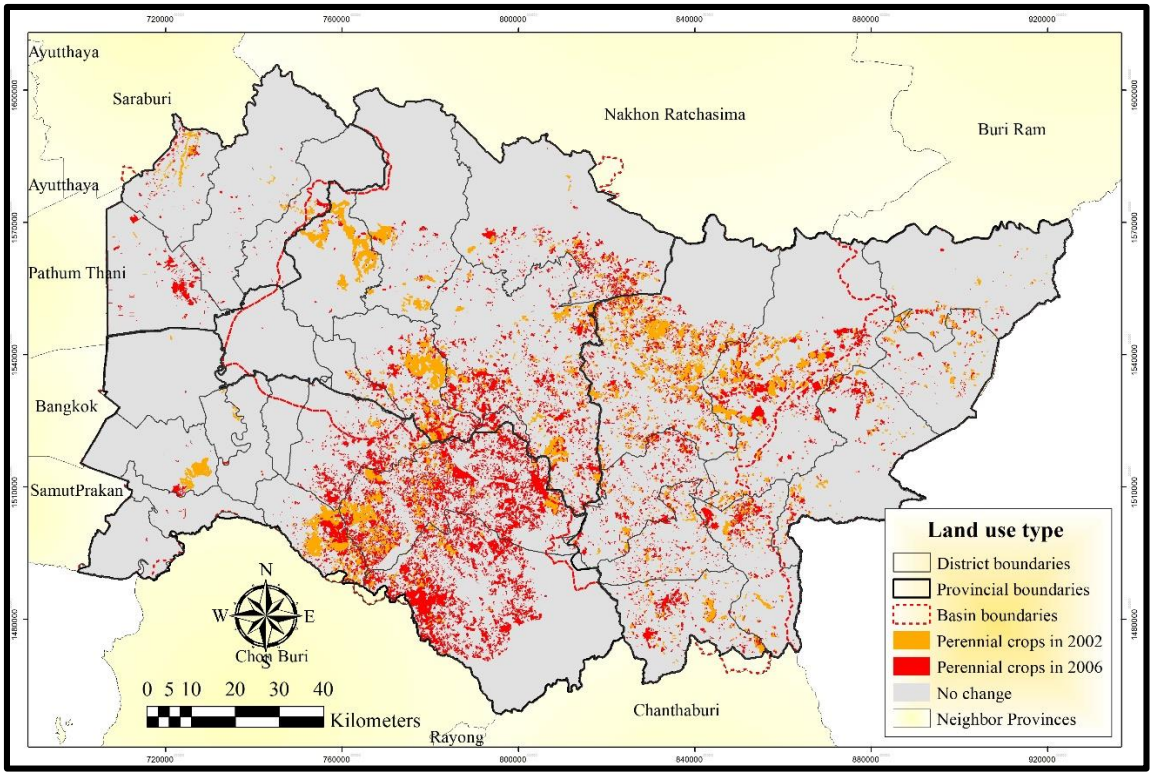


Figure 14. Expansion of perennial crops in the study area compared between 2002 and 2006

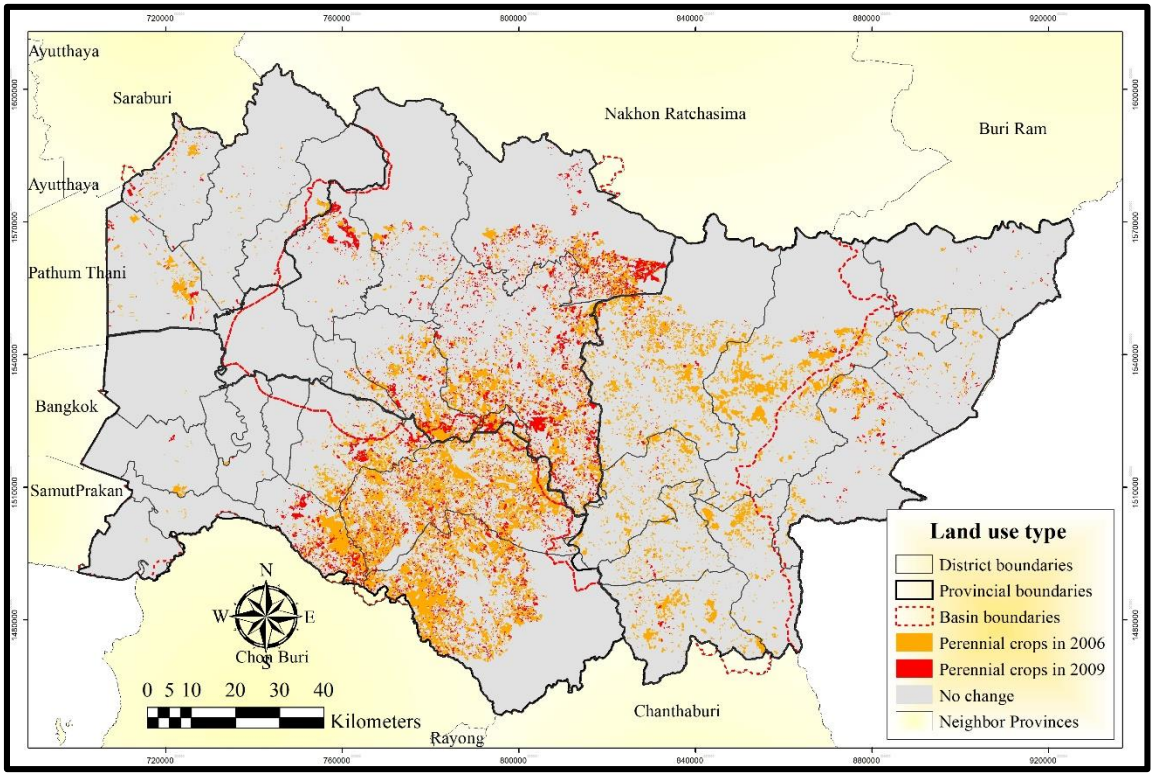


Figure 15. Expansion of perennial crops in the study area compared between 2006 and 2009

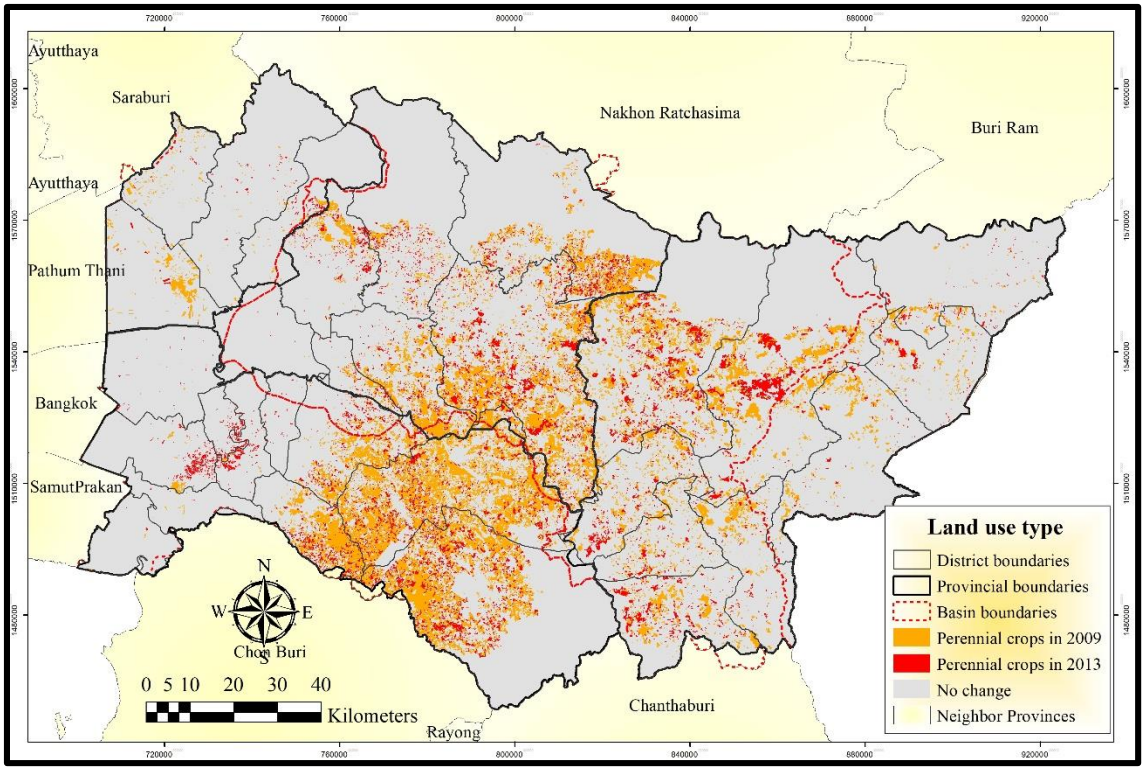


Figure 16. Expansion of perennial crops in the study area compared between 2009 and 2013

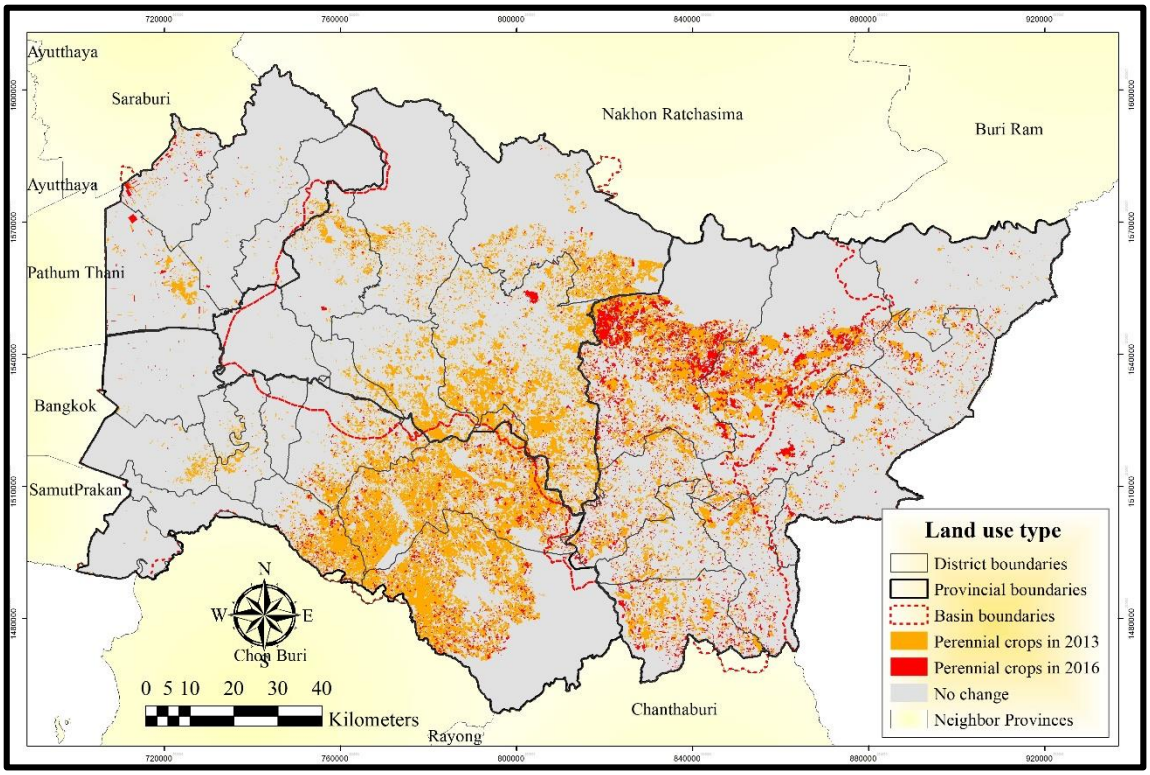


Figure 17. Expansion of perennial crops in the study area compared between 2013 and 2016

*Aquaculture land*

Aquaculture land has not expanded throughout the basin compared with the expansion of perennial crops. However, aquaculture land in the year 2002, was found in some part of Chachoengsao, Prachinburi and Nakhon Nayok provinces. Especially at the lowest part of Chachoengsao province where it is nearby Samut Prakarn province. That area is the densest area of aquaculture land because it is the most suitable of land. Most of the aquaculture land located nearby the Bang Pakong River which discharges into the Gulf of Thailand.

Until in the year 2006, the expansion of aquaculture is expanded differently, it encroached more into inland. It expanded in the middle part of Chaochoengsao province instead (Ban Phoe, Bang Khla and Bang Pakong districts). In Prachinburi province, a concentration of aquaculture is in Ban Sang District. For Nakhon Nayok provinces is in Muang and Ongkhalak District. However, in Sra kaeo province, aquaculture is very less proportion because of an unsuitable geography.

The first obviously change of fish and shrimp production area is in the lower part of Chachoengsao Province (Bang Pakong district) , in the year 2006 to 2009, fish and shrimp farming expanded very strong then in the next 4 years later (in 2013-2016) development of aquaculture became less strong. According to interviews with staff from Prachinburi Fisheries Office, most of fish and shrimp farmers in Prachinburi (Ban Sang District) and Nakhon Nayok (Ongkarak and Muang Districts) are originally from Samut Prakarn province (Nong Ngu Hao District) then moved to do fish and shrimp production to Prachinburi and Nakhon Nayok due to a suitable geography as it has Bang Pakong and Prachinburi rivers flow through. Thus, selecting a suitable areas for fish and shrimp farming is needed to relate with a good condition of sources of water. As it is be seen in the following figures of Expansion of aquaculture land, expansion of fish and shrimp farming is along the rivers or inside an irrigation area.

In the year 2002, fish and shrimp farmers moved to do fish and shrimp production in the upper areas due to a good condition of sources of water. Then in the year 2006 – 2009, as it is seen in the following figures, fish and shrimp farmers expanded very fast in Prachinburi and Nakhon Nayok provinces. At that time, fish and shrimp farming were very famous because fish and shrimp got high prices. After that more farmers invested in fish and shrimp production until it expanded very fast all the areas. After 2009, fish and shrimp farming cannot expand more as there is no more areas to dig the ponds.

Regarding to the study of Agricultural dynamics in the Bang Pakong River (Aguilhon, 2017), the factors of change for fish and shrimp production are lack of savings and the impossibility for the farmers to invest. Fish and shrimp production is quite costly, it needs to invest for labors and several inputs such as machine (water pumping, oxygen paddle and maintenance), fish and shrimp foods and products.

Secondly, lack of knowledge is risky for the farmers because the production requires skills. Also, if the farmers do not own their own land, they have to rent the land of someone else. Or in some cases, the farmers do not want to do fish and shrimp farming in the first place if they do not own their own land because they do not want to invest on someone else land.

Finally, lack of water resources. As mentioned above about the water need for fish and shrimp production, it needs a lot more water than rice paddy. In one crop/season of raising fish and shrimp, it needs to fill water in the pond several times. After the fishes and shrimps are harvested, in the

same time water is drained out and the farmers will fill the water to their ponds again. The main water sources of fish and shrimp are from the canal and river. Most of them raise fish and shrimp in an irrigation area. Thus, they pump the water from the canal where connect to Prachinburi river. However, if the water is too saline (over 1 ppm), RID will close ¾ of the gate in order to block saline water into the canal because those water will be effected with agriculture crops. For shrimps, it can survive in the brackish water but it will be a huge impact on fishes.

**Therefore, for both perennial crops and aquaculture land, there is a difference of increased period, in the year 2002-2009, there is a big increase of aquaculture crop while in the year 2009 until present, it is a big increase perennial crops based on classified images from LDD.**

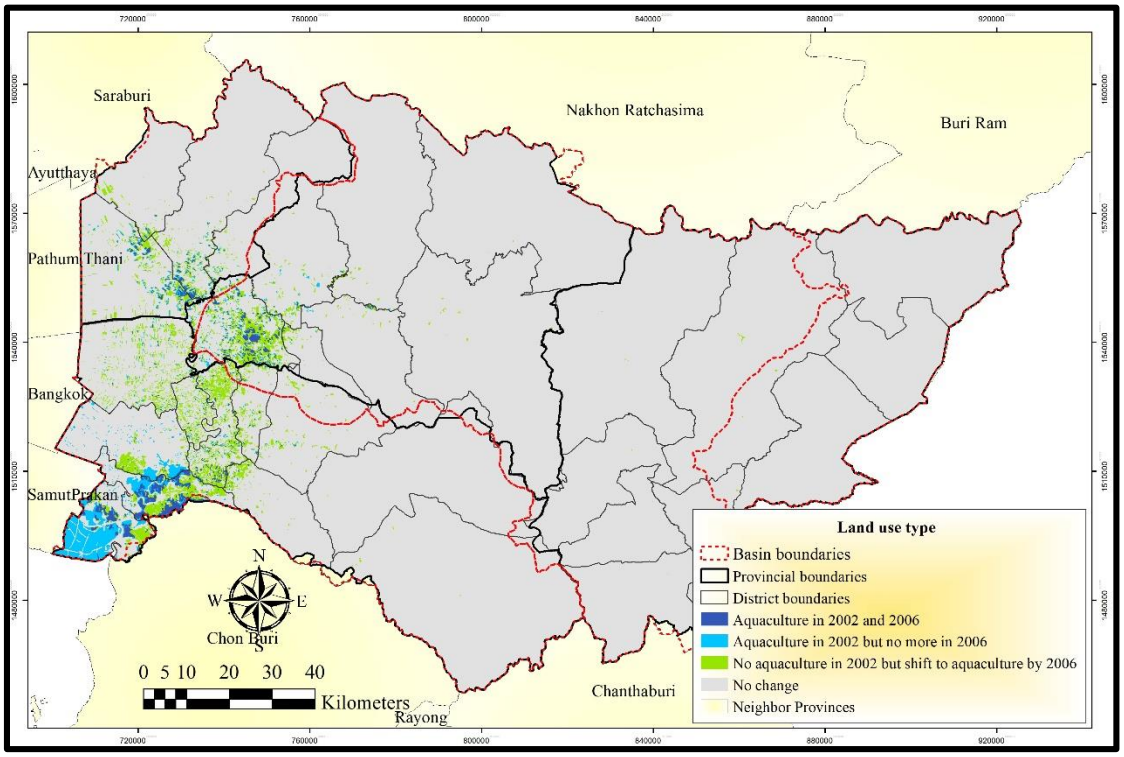


Figure 18. Expansion of aquaculture land in the study area compared between 2002 and 2006

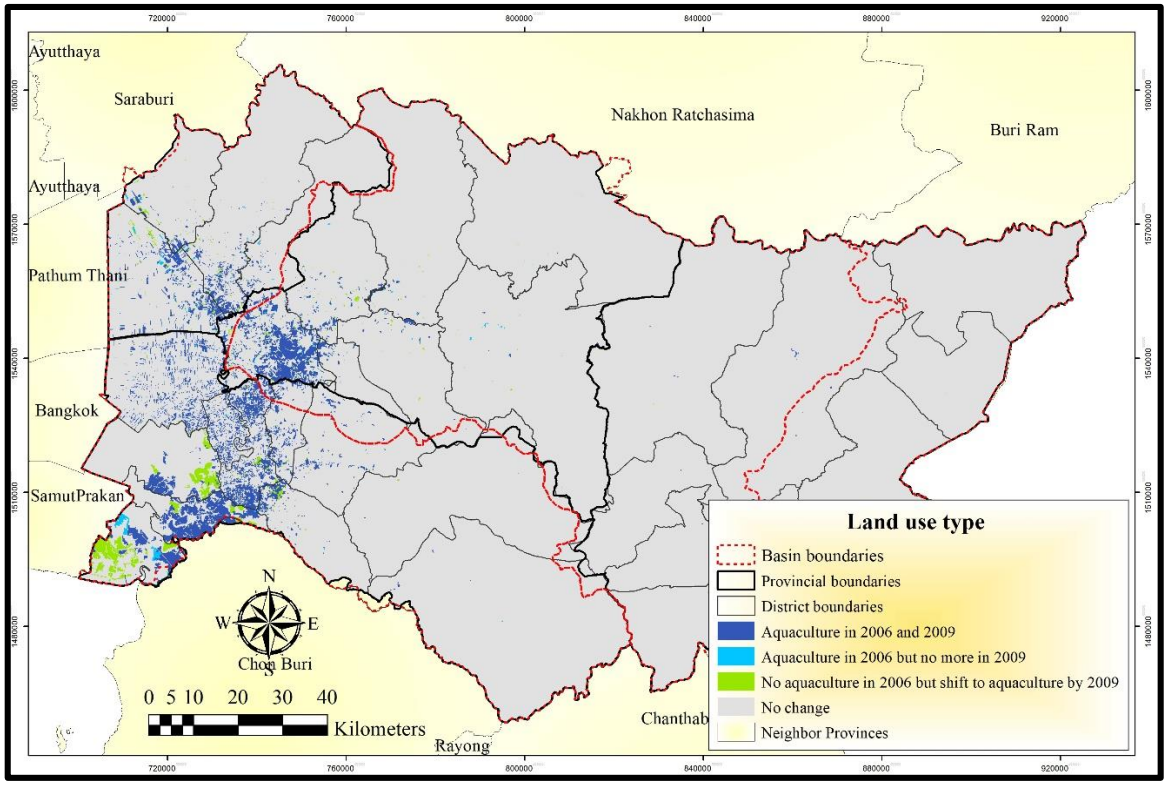


Figure 19. Expansion of aquaculture land in the study area compared between 2006 and 2009

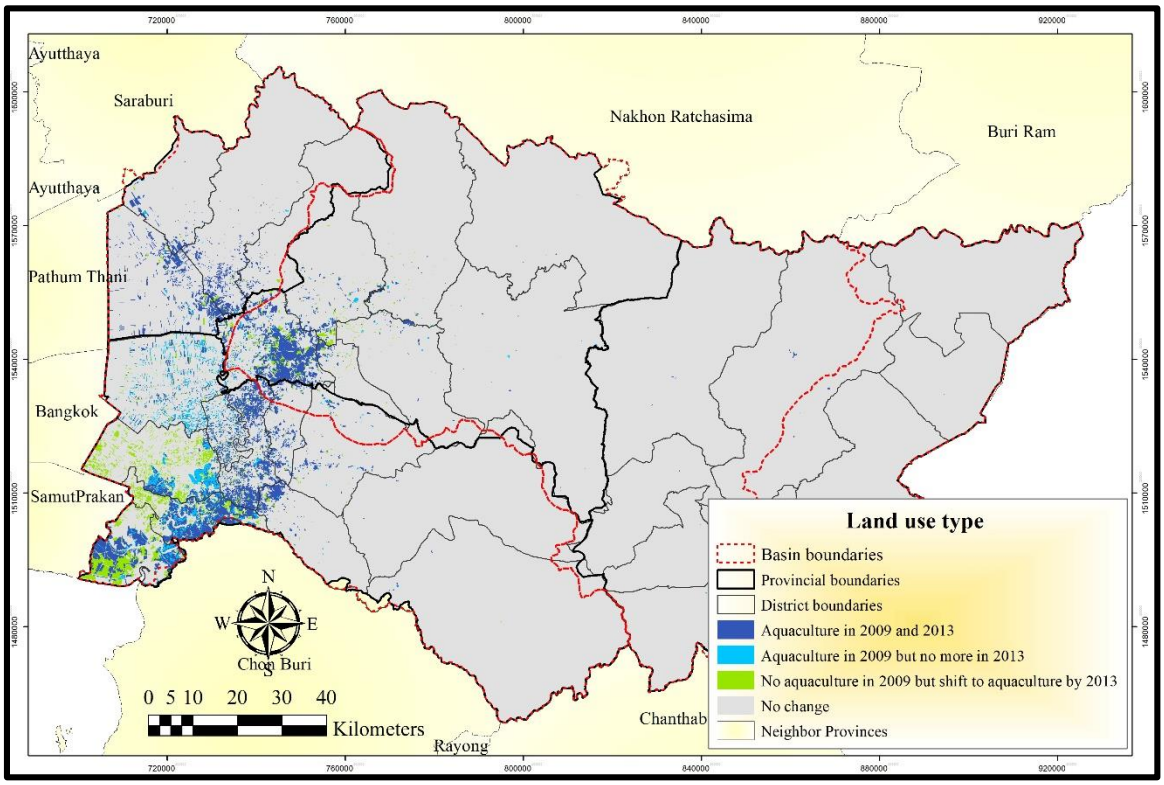


Figure 20. Expansion of aquaculture land in the study area compared between 2009 and 2013

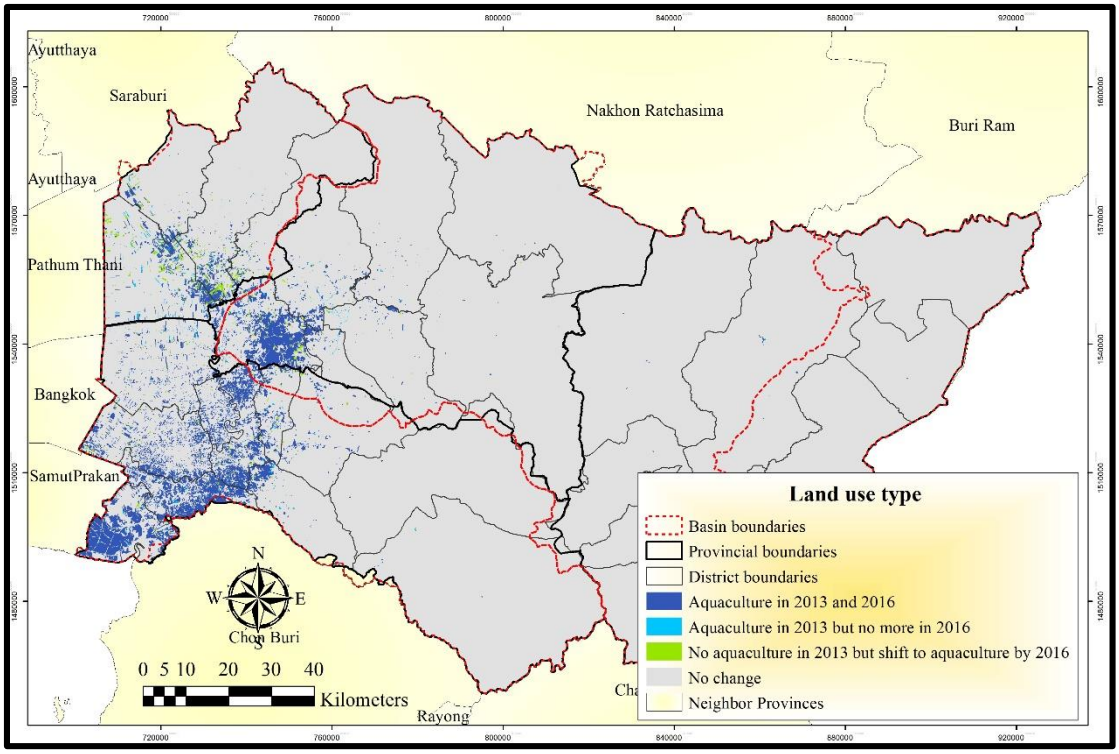


Figure 21. Expansion of aquaculture land in the study area compared between 2013 and 2016

*Other land uses*

Forest land in the study area has slightly decreased during this 14 years period. It occupied averagely 500,000 hectare in the basin or around 25% of all land use types. It did not much changed because the forest is a National Park area and it is not allowed to encroach or settle down as it is under a Conservative Forest.

Miscellaneous land in the study area occupied on average 56,000 hectare or 3% of all land use types. Miscellaneous land are classified into 9 types of land which are marsh and swamp, miscellaneous land, garbage dump, mine, pit, other miscellaneous land, rangeland and salt flat.

Urban land in the study area occupied on average 138,000 hectare or 7% of all land use types. Urban land are classified into 7 types of land which are city (included town and commercial), village, institutional land, communication and utility, industrial land, other built-up land and golf course. Village, institutional land and industrial land occupied the most proportion of urban land during 2013 to 2016. The most occupied of urban land in the study area is village. Over 60% in 2013 and 2016, village is the most proportion of urban land use following with institutional land such as school, hospital, temple or offices. Industrial land is also much occupied especially in Chachoengsao and Prachinburi province where located many industrial estate zones.

## WATER PUMPING ASSESSMENT

*Estimation of annual water pumping for all activities*

There are two types of water pumping for industrial sector. First, some industries pump water directly from rivers and secondly, they buy water from a large-scale Water Provider. There are two large-scale Water Provides in the basin. The Provincial Waterworks Authorities (PWA) and the local waterworks authorities are in charge of water supply and drinking water use. Approximately 60% of water supply and drinking water in the province is supplied by PWA and the rest by local waterworks authorities in each village.

Table 3 shows an approximate evaluation of water pumping for all sectors in the Bang Pakong Basin estimated by the Hydro and Agro Informatics Institute. However, data collected only enables to get broad estimation. This table shows that water is mostly pumped for irrigation and aquaculture.

Table 3. The Amount of water pumping in the basin (Source: Hydro and Agro Informatics Institute - HAII, 2012)

| **Activities** | **Amount of water pumping (Million Cubic Metre per year)** |
|---|---|
| 1. Irrigation and aquaculture | 2,720 |
| 2. Domestic use and drinking water | 70 |
| 3. Industry | 19 |
| 4. Livestock | 5 |
| 5. Tourism | 1.5 |

Data collection on water pumping in the basin is however limited. Some data are collected, directly or indirectly, in irrigation schemes areas (Table 4). However, there is a lack of follow up on the amount of water pumped outside irrigation scheme areas.

Table 4. Roles of organizations for collecting data on water pumping

| **Sector** | **Organizations involved in data collection** | |
|---|---|---|
| | **Non-irrigation scheme area** | **Irrigation Scheme area** |
| Domestic water supply | Each Provincial Waterworks Authority directly takes a responsibility in terms of water supply. They measure their water pumping daily | PWA needs to report the data on water pumping for RID. |
| Industries | Industrial Office focuses more on water quality than on water quantity. This Office does not measure the water pumping for each industry. | RID collects the data of water pumping for industries by getting data from their reports and from reports of the large Water Suppliers which pump water to distribute it to industries. |
| Agriculture | No control of water pumping | The RID calculates water requirements for irrigation crops and for aquaculture. The Agricultural Extension Offices and |

| | |
|---|---|
| | Fisheries Office have data on farm land area, but only for farmers who register to their office |

*Water requirement for irrigation and aquaculture during the dry season*

Water pumping was assessed during the dry season (November- April) for irrigated crops and aquaculture. In the dry season, only paddy field and aquaculture will be assessed its water requirement as it irrigated water while other crop activities are rainfed crops.

Water requirements are the amount of water that has to be brought to crops, either by natural rainfall or by irrigation. They were calculated using the reference evapotranspiration multiplied by cultural coefficients. The evapotranspiration was assessed using data from each provincial meteo station, measured from Meteorological Department, using climatic data of 30 years. Cultural coefficient differ between crops and along the crop production period. Rainfall was considered as limited during the dry season and was not taken into account in calculations. For aquaculture, the water requirement is basically the evapotranspiration.

**Water requirement of irrigated rice**

For paddy field, only irrigated rice is produced during the dry season. Thus, there is a need to assess the area of irrigated rice. Table 5 is separated the surface area of rice into irrigated rice and non-irrigated rice.

Table 5. Surface area of irrigated and non-irrigated rice in the basin from 2006-2016

| Year | Irrigated area (ha) | Non-irrigated area(ha) |
|---|---|---|
| 2006 | 277,000 | 251,500 |
| 2009 | 272,100 | 247,400 |
| 2013 | 258,100 | 228,700 |
| 2016 | 253,000 | 214,300 |

Figure 22 shows a map of irrigated areas. The dark brown is the irrigated zone and the light brown refers to the area outside irrigation zone where the crops in this area are rainfed crops. The irrigated area has approximately 530,200 ha from the total area 1,917,000 ha of the whole basin

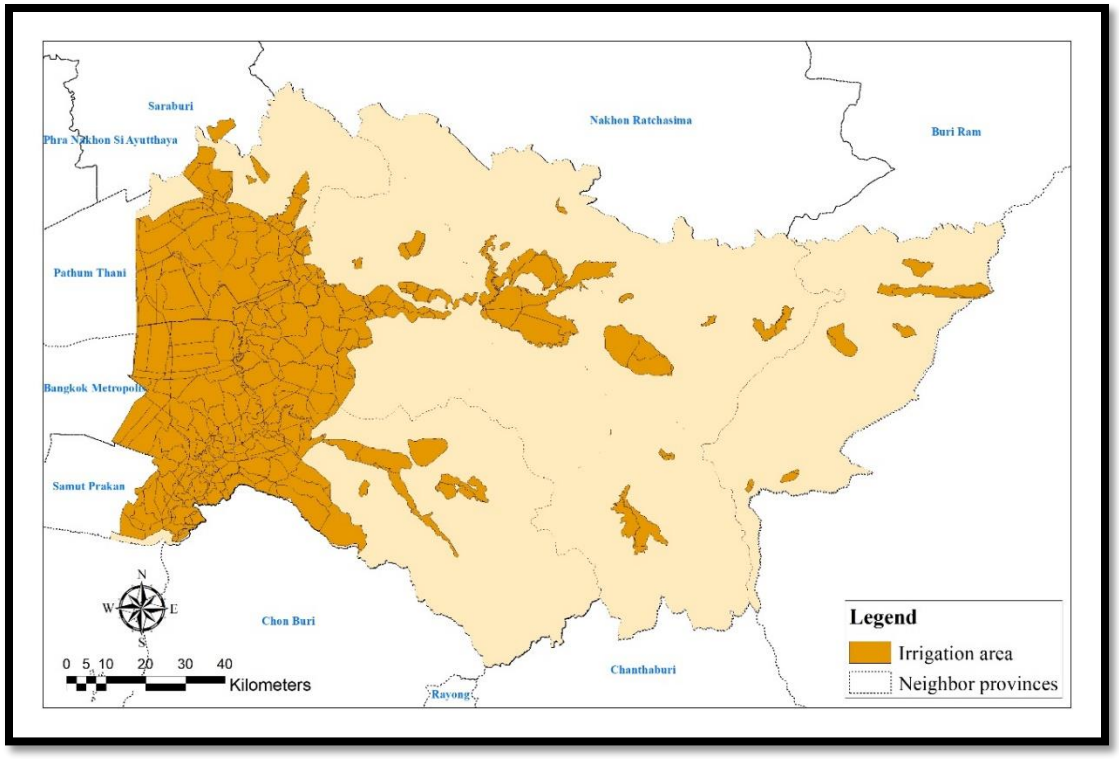


Figure 22. Irrigated boundaries in Bang Pakong river basin.

Figure 23 shows the evolution of cropped irrigated rice from 2006 to 2016. The surface area of irrigated rice has slightly decreased from approximately 277,000 ha to 253,000 ha. Rainfed rice also has decreased from approximately 251,500 ha to 214,000 ha (Figure 24).

Based on crop water requirement calculation, dry season rice needs approximately 5,500 m3 of water per hectare. Table 5 shows the water requirement of irrigated rice relevant to its surface area from 2006 till 2016.

Table 5. Water requirement for irrigated rice from 2006 to 2016

| Year | Irrigated area (ha) | Water requirement for irrigated rice (million m3) |
|---|---|---|
| 2006 | 277,000 | 1,520 |
| 2009 | 272,000 | 1,497 |
| 2013 | 258,000 | 1,420 |
| 2016 | 253,000 | 1,391 |

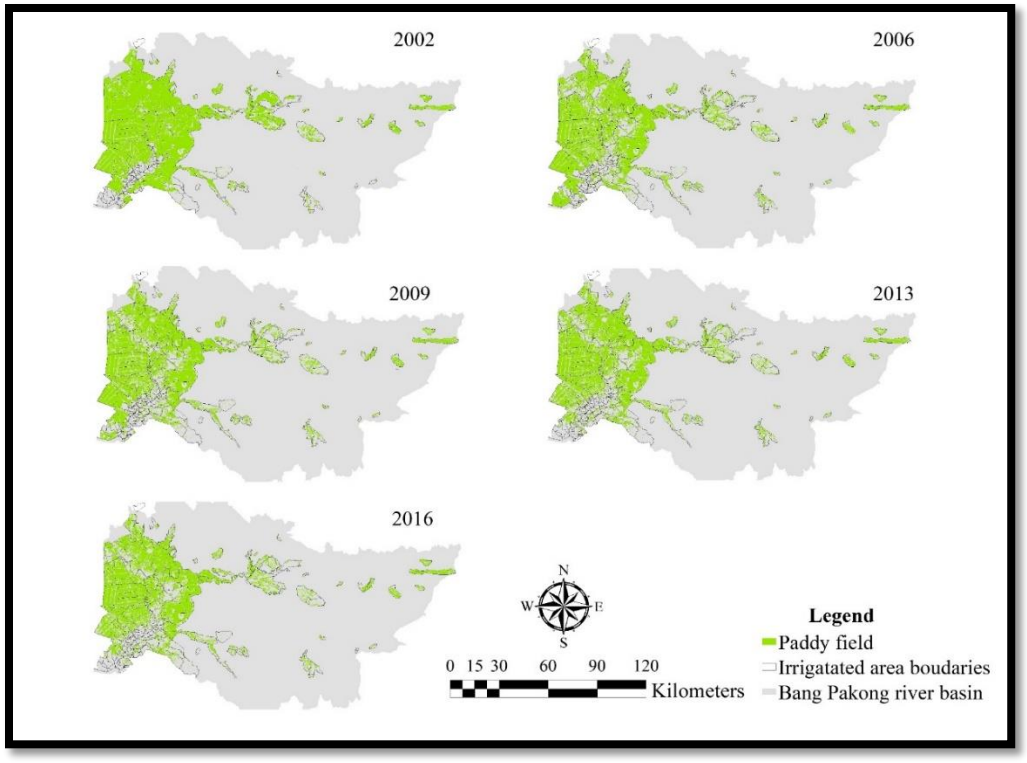


Figure 23. Irrigated rice in Bang Pakong basin from 2002 to 2016

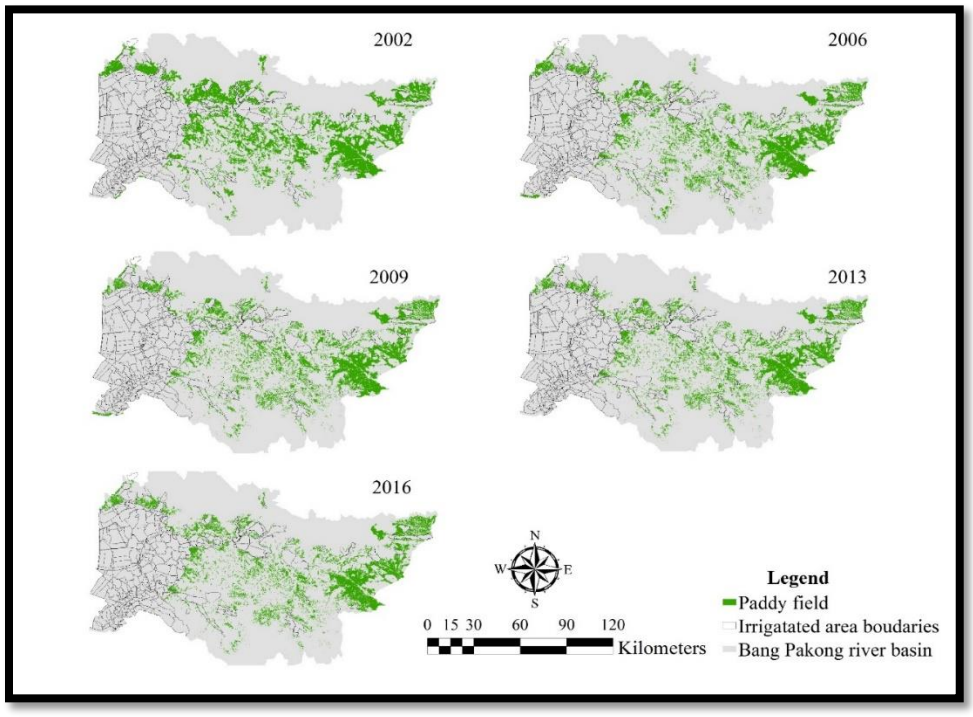


Figure 24. Rainfed rice in Bang Pakong basin from 2002 to 2016

**Water requirement of fish and shrimp farming**

Fish and shrimp farmers will produce during the whole year. Production mainly takes place in Chacheongsao Province (Table 6). Table 7 shows an estimation of water requirements during the dry season. As a result, the water requirement of fish and shrimp farming based on the calculation is approximately 7,180 $m^3$/hectare. According to the table 7 and the figure 26, the water requirement for fish and shrimp has been increased from 2006 until 2016.

Table 6. Surface area of fish and shrimp farming in the basin in 2002-2006

| Province | Year (ha) | | | | |
|---|---|---|---|---|---|
| | **2002** | **2006** | **2009** | **2013** | **2016** |
| Prachinburi | 5,600 | 14,900 | 15,500 | 17,400 | 17,700 |
| Chacheongsao | 26,800 | 42,700 | 50,400 | 55,200 | 57,600 |
| Sakaew | - | 143 | 160 | 158 | 144 |
| Nakhon Nayok | 4,200 | 9,800 | 10,300 | 10,500 | 12,400 |
| **Total** | **36,600** | **67,543** | **76,360** | **83,258** | **87,844** |

Table 7. Water requirement for fish and shrimp farming in Bang Pakong basin from 2006 to 2016

| Agriculture activity | Year | | | |
|---|---|---|---|---|
| | **2006** | **2009** | **2013** | **2016** |
| Surface of fish and shrimp farming (ha) | 67,600 | 76,300 | 83,300 | 87,800 |
| Water for fish and shrimp farming (million m3) | 486 | 547 | 598 | 631 |

# LAND USE AND WATER USE IN A BUSINESS AS USUAL SCENARIO

The scenario is projected under a business-as-usual scenario to estimate the trend of land and water use in Bang Pakong river basin in the future in order to plan for water management in the study area. Past trends were prolonged till 2028.

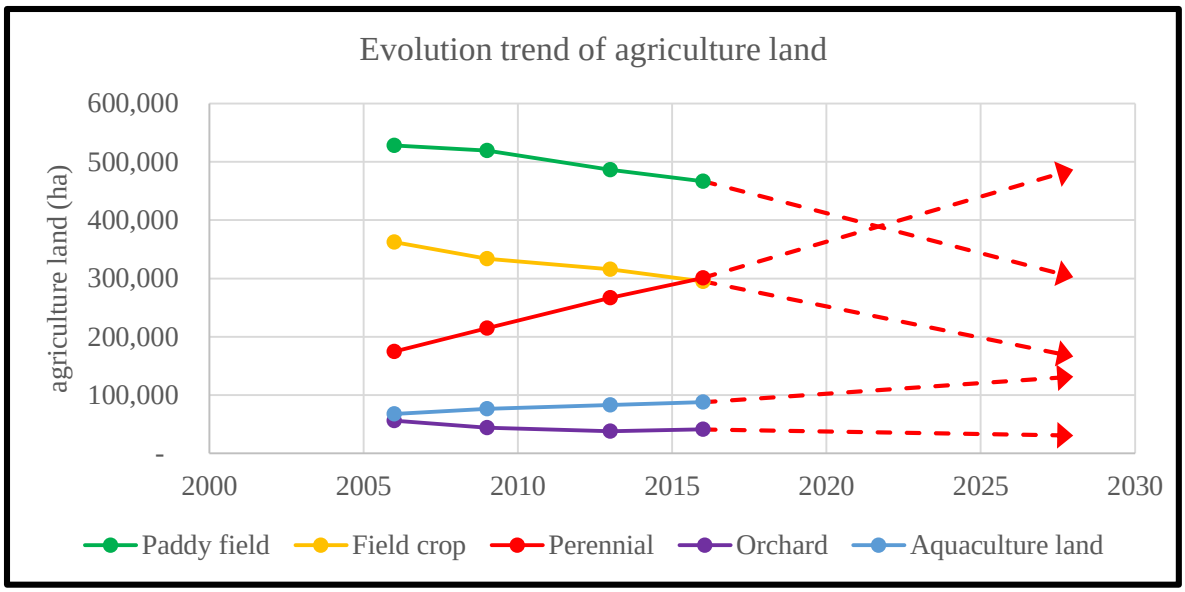


Figure 27. Agriculture crop area evolution in 2028

The figure 27 shows the agriculture land projection with the base line since in the year 2002 – 2016 and project the evolution of agriculture activities in 2028 as agriculture land is the most changed land in the study area and it is going to effect a lot for water resources in the basin. The evolution in 2028 shows that perennial crops and aquaculture land tend to increase in the future while other types of agriculture tend to decrease.

Figure 28 shows that, in a business as usual scenario, requirements of rice will decrease and water requirement for fish and shrimp will increase. But irrigated rice will still remain the most water consuming crop.

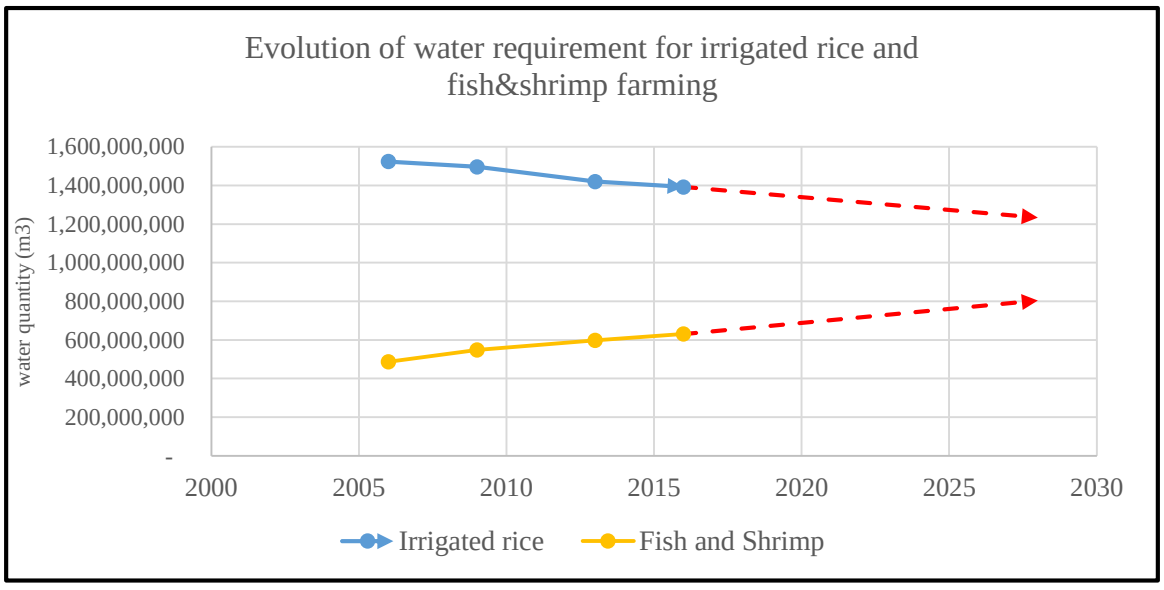


Figure 28. Water requirement for irrigated rice and fish and shrimp evolution.

Meanwhile, Royal Irrigation Office has a near future plan to expand more irrigation scheme in many parts of the basin, especially for the new reservoir projects which are not yet have its own irrigation scheme such as Huay Samong Dam and Phra Phrong reservoir in the upper part of the basin.

Apart from the evolution trend of agriculture crops in the next 10 years, increase of industries is also one of the main factors that may impact water use in the basin. The confirmed up-coming projects of Eastern Economic Corridor in Eastern region of Thailand may be a driver of land use change in Bang Pakong river basin. The Eastern Economic Corridor is planned to become a "World-Class Economic Zone", support an industrial investment in the future and also several economic activities such as transportation of ASEAN and distribution center (BOI, 2017).

Those incoming projects will focus on industrialization, it is obviously that the water needs for industries are going to impact the water resources in the basin as nowadays, Rayong and Chonburi provinces are the most developed provinces in terms of industrial sector and also use the most amount of water resources.

The main concept of EEC is 3+2: 3 means Chonburi, Rayong and Chacheongsao provinces while two means Prachinburi and Samutprakan provinces. Firstly, in 2016-2022, the development is planned to focus in those 3 provinces. After that another 2 provinces will be developed next. For Chacheongsao province, the purpose in Eastern Economic Corridor project is not about industrial development instead, it will be focused on residential purpose. In this case, water use for domestic will increase in the future. Moreover, the upper part of Chacheongsao Province, which is urbanized, needs to pump water from the canals and often faces lack of water during the dry season. As a result, RID plans to connect to pump water from reservoirs located in the lower part of the province and provide it to the upper part. For Prachinburi Province, the Eastern Economic Corridor context will not lead to an expansion of the industrial zone but some agricultural land should be changed to urban land.

# CONCLUSION

Perennial crops and aquaculture land are the agricultural activities that increased the most in this case while paddy field, field crop and orchard decreased in the past 10 years. During the dry season, rice is the crop with most water requirement (approximately 1,400 million m3) in 2018 followed by fish and shrimp (approximately 630 million m3). There is an opportunity for increased coordination between public organizations in the basin who works relevant to land and water resources in terms of coordination for sharing data on land and water use.

In a main business-as-usual scenario, rainfed rice will keep on decreasing while perennial crop will be increasing in the next 10 years. Rice and fish and shrimp will likely remain the activities requiring more water. However, main changes in terms of water requirements will probably come from the non-agricultural sector in the future.

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