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# The land use suitability evaluation for agricultural planning by using analysis hierarchy process (AHP) in Chachoengsao province.

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**Abstract** The results of the study using analytical hierarchy process (AHP) revealed a moderate level of the appropriateness in the development area. The y max value was 3.08 and CR value was 0.067. According to the AHP, it was found to be reliable at a high level. The analysis showed the importance for the land use suitability for agriculture in the Chachoengsao province. The suitable area (S1) was 35.55 %, the moderately suitable area (S2) was 46.96 %, and the lowly suitable area (S3) was 17.49 % of the area. Regarding a guideline for agricultural planning area, it was mostly appropriated in particularly on field crop growing such as cassava, coconut, sugar cane, and maize growing and followed by rice growing.

**Keywords:** Land use, Analysis Hierarchy Process, Water consumption

## Introduction

The rapid increase population has resulted in increase of land using and the increased of the four necessities for lives. In fact, the country needs more land space for utility. It also the needs for increased food and agriculture product. The agricultural products must be safe produce. It is in consistent with the 12th Economic Development Plan, The agricultural products safety to the international standards. Hence, there is a must for planing for using the land space for utility, the suitable to predict the ability of the land. Besides, it is important to choose the area to increase agricultural productivity, it results in efficient of resources according to Economic Development Plan 12th. (Mistry of Agriculture and Cooperatives, 2020).

The Chachoengsao province has expanded economic and increased of the population, resulting in building more industrial factories, accordingly, may

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lead to more migration of migrants from other areas to settle in this area. Resulting in demand for water in consumption increases therefore, it is not enough to do Agriculture, especially rice fields because they need a lot of water and at the same time, the amount of water is less due to seasonal rain and the problem of saltwater entering the area are causing to polluted water. (Chachoengsao province Agriculture and Cooperatives, 2020).

However, there must be a land-use plan to encourage farmers in areas that have modified agriculture, plant plots to consume less water instead of consuming much water. To solve the problem, so there is a shortage of water necessary to create a troubleshooting tool for the appropriate way. The study aimed to evaluate the suitability of land use for agricultural planning by the decision process Analytic Hierarchy Process (AHP).

## Materials and methods

### *Study area*

Chachoengsao is located in eastern, Thailand which covers an area of 535,100 hectares. The topography of Chachoengsao is a coastal plain, which has the main river flowing through it, Bang Pa Kong River basin (Chachoengsao province Agriculture and Cooperatives, 2020). It is appropriated for agricultural production. In the past, most of the population in Chachoengsao province had an occupational background in agriculture such as farming rice, crops, fruit farming, fish, and shrimp farming because Chachoengsao has a source of raw materials for food and can do it to sustain. Mostly population of 70 percent has conducted in agriculture. The study area covered 359,249 hectares of agriculture as a percentage of 69.54 % of the area. Agriculture has an average water pier for consumption to agriculture is about 7,192 million cubic meters. Chachoengsao Province has the potential to store water approximately 484.61 million cubic meters or 35.02 % of the average and there is irrigated area of 182,852 hectares for 26.05 % of the agricultural area.

### *Analysis process*

Land use planning for agricultural is analyzed by Analytic Hierarchy Process (AHP) were divided into 3 factors such as the benefit of using the land, water content and water consumption. The spatial overlay defines as forest area and allocation the land from government and suitable areas for agricultural areas as Figure 1 (Malczewski, 2004).

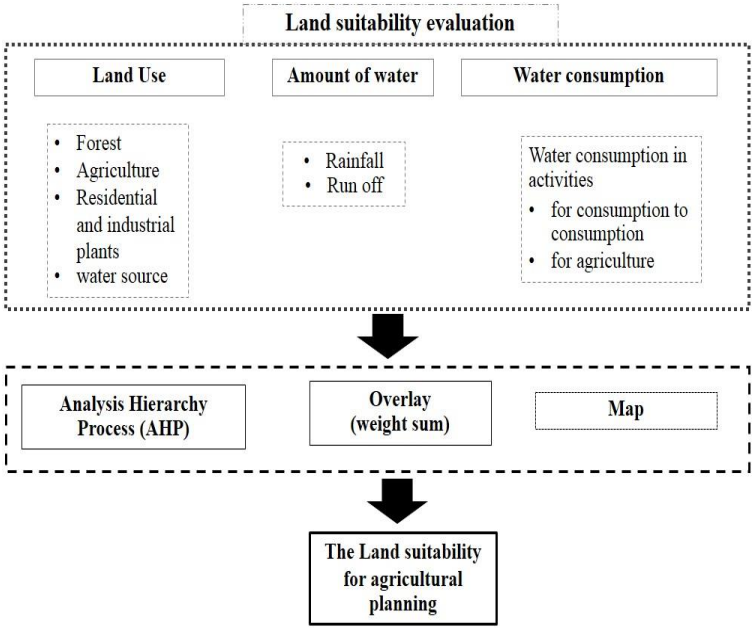


**Figure 1.** Procedure followed in land suitable evaluation for agricultural planning

### *Criteria use in the land suitability evaluation*

Land use was followed the report by FAO (1976) that obtained from land use in 2017 in the Geographic Information system (GIS) as the land use map at scale of 1:50,000. The map presented to be 5 classification. The main land use in chachoengsao province, its area coverage is agricultural production, rice field, perennial area, forest and farm area (Sys, 1991).

Amount of water was evaulated to be two criteria which were rainfall/run off covering in the area ofthis study. Rainfall/run off data were taken from interpolation of rainfall station in chachoengsao province. Water comsumption was determined for agricultural production in all activities in the study area which is provided by Open Goverment Data of Thailand (DGA), and computed the comsumption of people in area and estimating the water comsumption for agricultural production.

### *Determination of weight by Analytic Hierarchy Process (AHP)*

A nine-point scale-based (AHP) is modified from Saaty (2008) including objective, criteria, sub-criteria, and alternatives which constructed to determine the affecting factors. It was reached by the land suitability evaluation for land

use, amout of water and water consumption for agricultural planning. The expert consultation was conducted for which 5 experts for determining to fill a pairwise comparison scale of the mentioned factors and determined the relative importance of the criteria (Widiatmaka *et al*., 2016). If the score is in the range of 6-8, it is considered in the hight criteria, the sub-criteria are 0 points. Not suitable for agricuture and there were limited condition area. Finally of AHP, the weight of factors for land use suitability. The obtained weights was allocated a suitability map. The criteria is used to check accuacy of comparisons by Consistency Ratio (CR). The ratio was measured the low variation to be less than 10%.

**Table 1.** The pairwise comparison scale (Widiatmaka *et al.,* 2016)

| ***Importance levels*** | ***Priority*** |
|---|---|
| Equally Preferred | 1 |
| Equally to Moderately | 2 |
| Moderately Preferred | 3 |
| Moderately to Strongly | 4 |
| Strongly Preferred | 5 |
| Strongly to Very Strongly | 6 |
| Very Strongly Preferred | 7 |
| Very Strongly to Extremely | 8 |
| Extremely Preferred | 9 |

### *The land suitability map*

The criteria determination and subcriteria score were appointed to the related layers in ArcMAP 10.1, using the determination to analysis agricultural land suitability (FAO, 2012). The determination of the criteria were multiplied with the score of the subcriteria. This multiplication was performed in raster format on the map. The result was further reclassified using equal distance as four classes of suitability (Zhang *et al.*, 2015; Akinci *et al.*, 2013; Ghafari *et al.*, 2000; Nasrollahi *et al*., 2017).: Highly suitable(S1), Moderately suitable(S2), Lowly suitable(S3), and not suitable(N), according to the following equation (1) below :

$$LS = \sum_{i=1}^{N} Wi\ Si \quad (1)$$

Where LS is land suitability, Wi is weight of land suitability criteria, Si is a score of sub – criteria and N is a number of land suitability classes.

## Results

### *Land use map*

From analyzing land use data and making land use maps by using geographic information system using Arc GIS program to examine land use change in 2008, it was found that most of the land use in Chachoengsao were agricultural areas 392,374 hectares divided into 148,631 hectares of rice 69,679 hectares of farm plants and 34,736 hectares of horticulture. It is a forest area 87,540 hectares and a residential area 31,080 hectares as shown in (Figure 2) From analyzing land use data and making land use by using maps using geographic information system, using Arc GIS program to examine land use changed in 2017 found that the land use was change most of the area is an agricultural area 378,815 hectares divided into rice farming 126,579 hectares, farm plants 53,696 hectares, horticulture 405 hectares. It is a forest area 87,035 hectares and a residential area 36,057 hectares. The decline in forest and agriculture areas from 2008 to 2017 was due to the increased expansion of living space. Originally, forest and agriculture area has 87,540 hectares and 392,374 hectares in 2008. Then, there was a reduction of forest agriculture areas to 378,815 hectares and 87,035 hectares in 2016. For residential are from the original area of 31,080 hectares, there has been increased the residential area to 36,057 hectares.

### *Amout of water*

The analysis of water content in Chavhoengsao for the past 10 years from 2008 to 2017 from Meteorological Department of Thailand and Ministry of Natural Resources and Environment is rainfall data and runoff data. The average rainfall for the past 10 years from 2008 to 2017 found that an average of rainfall of 2008 to 2012 was increased. The average of rainfall was 1,885.4 mm in 2012. Later in 2012 to 2017, the amount of rain tended to decrease, the average rainfall is 1377.4 mm in 2013, which from 2008 to 2017. Graph of average rainfall is tended to increase by 496.2 mm as shown in Figure 3.

The average run-off of the past 10 years from 2008-2017 with the SCS-CN method found that the amount of runoff in 2008-2012, the amount of runoff tended to increase. The average runoff was 9,909 million cubic meters in 2012 and later in 2012-2017 average running water tended to decrease the average runoff is 7,192 million cubic meters. In 2013, from 2008-2017 the average runoff graph tended to increase qual to 2,758,761,560 million cubic meters as shown in in Figure 4.

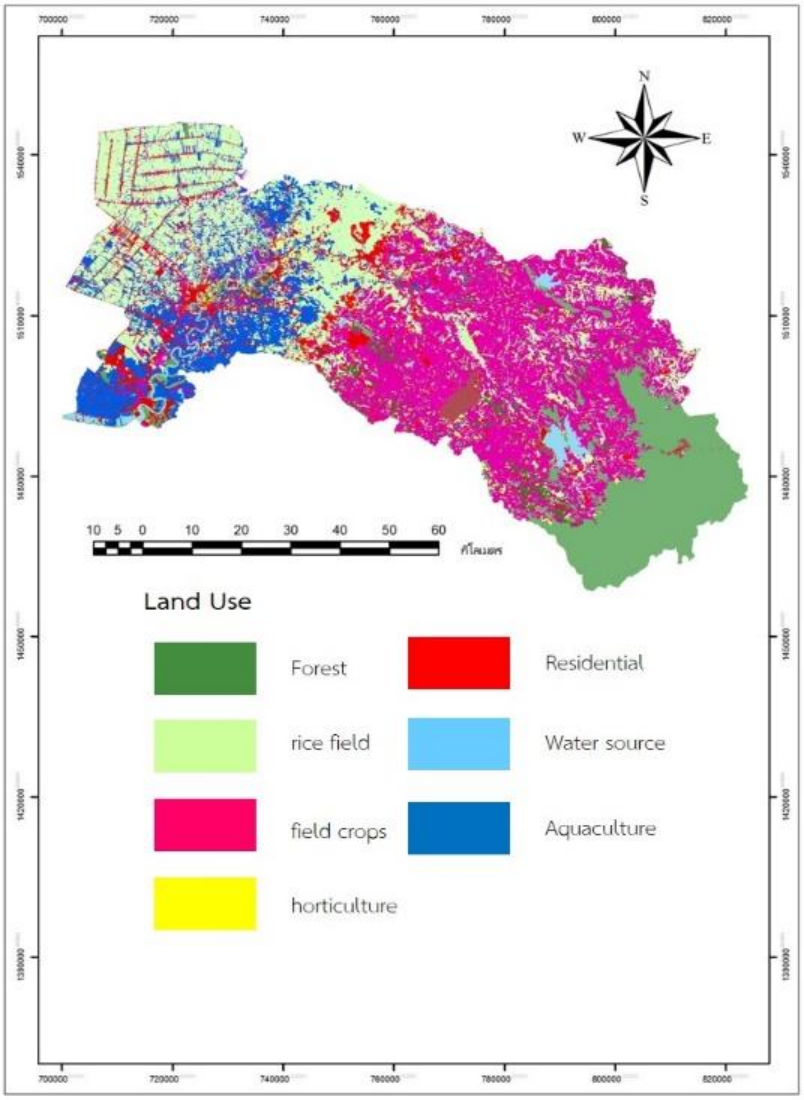


**Figure 2.** Land use map in Chachoengsao province

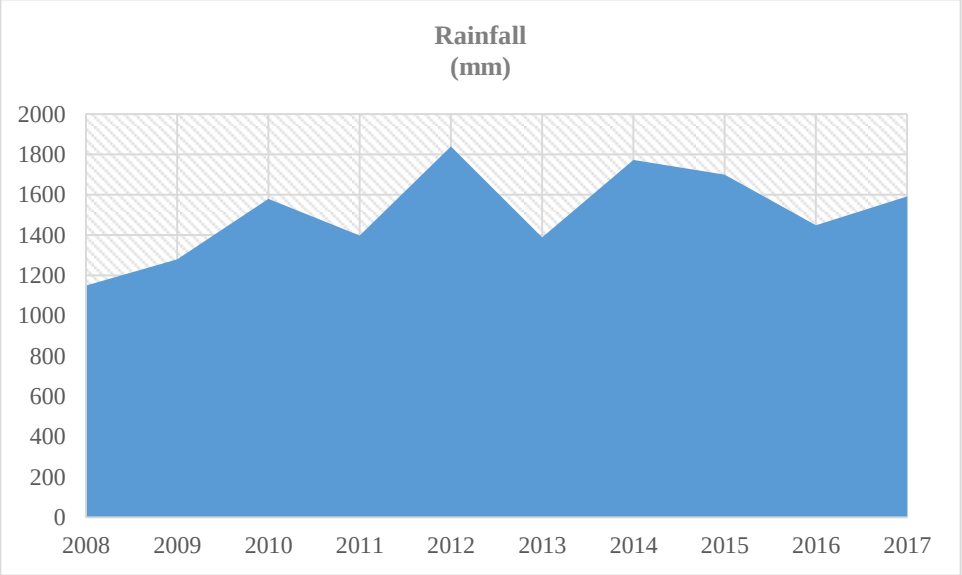


**Figure 3.** Rainfall

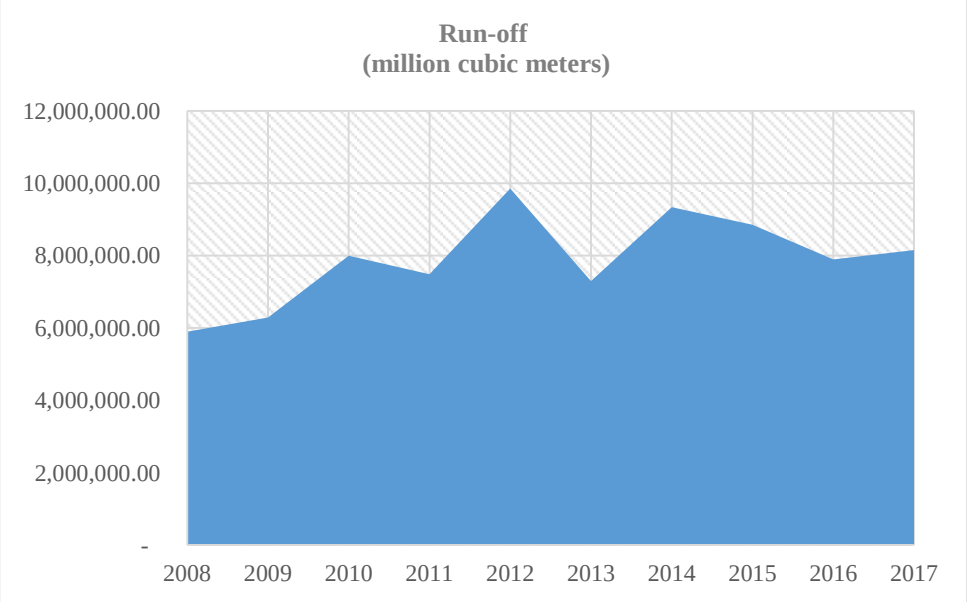


**Figure 4.** Run-off

***Water consumption***

Water consumption data in Chachoengsao the study of Chachoengsao irrigation office is concerned in agricultureal water use data and water consumption data. Analysis of agricultural water consumption data in Chachoengsao for the past 10 years, from 2008 to 2017 found that in 2008, the total agricultural water consumption was 13,462,174 $m^3$ divided into 3 factors rice field 9,336,980 $m^3$, field crops 3,003,201 $m^3$ and horticulture 1,121,993 $m^3$. In 2017, agriculture water consumption was reduced to 11,130,552 $m^3$ divided into rice fields 8,126,425 $m^3$, field crops 2,314,318 $m^3$ and horticulture 689,809 $m^3$ from 2008 to 2017, the graph of agricultural water consumption tended to decrease by 2,331,622 $m^3$ as shown in Table 2.

**Table 2.** Agriculture water consumption in Chachoengsao province

| **Land Use** | **Agriculture water consumption ($m^3$)** | |
|---|---|---|
| | **2008** | **2017** |
| **Rice field** | 9,336,980 | 8,126,425 |
| **Field crops** | 3,003,201 | 2,314,318 |
| **Horticulture** | 1,121,993 | 689,809 |
| **Total** | 13,462,174 | 11,130,552 |

The water consumption data in the past 10 years since 2008 to 2017 was shown. In 2008, there was a total water consumption of 33,241.5 $m^3$/day late, in 2017 the consumption rate of water increased to 35,494.5 $m^3$/day and from 2008-2017, the consumption of water is tended to increase to 2,253 $m^3$/day as shown in Table 3.

**Table 3.** The water consumption in Chachoengsao province

| **Year** | **The water consumption ($m^3$ /day)** | **The increase of water consumption** |
|---|---|---|
| 2008 | 33,241.5 | - |
| 2009 | 33,467.3 | 0.68 |
| 2010 | 33,696.7 | 0.69 |
| 2011 | 33,968.5 | 0.93 |
| 2012 | 34,286.1 | 0.66 |
| 2013 | 34,511.3 | 0.76 |
| 2014 | 34,773.9 | 0.78 |
| 2015 | 35,045.1 | 0.57 |
| 2016 | 35,129.9 | 1.04 |
| 2017 | 35,494.5 | 1.03 |

### *The weights of criteria and score*

The criteria for the level of importance of self-determination of the appropriate level of land-use land development was done by analyzing hierarchy process (AHP). It is the process for acceptable and widely used. There are detected and eliminated of prejudice or bias.The criteria for the analysis were waiver to score the level of importance of the weighting criteria as shown in Table 1. The value of 1-9 showed that the line had significantly shown to be less importance than the column (Table 4).

The analysis hierarchy process (AHP) was shown by the criteria or factors from hierarchical chart to make a matrix table and diagnosed to compare the factors at each level of pair, and established a criteria for level of importance to develop area in Chachoengsao as shown in Table 4. It was found that the most important determination for land use was 0.578, the value of water was 0.263, and water consumption was 0.159.

**Table 4.** Comparison of the importance of the criteria used for Chachoengsao province

| Criteria | LU | AW | WC | Level of weight score |
|---|---|---|---|---|
| LU | **1** | 4 | 2 | **0.578** |
| AW | 1/4 | **1** | 3 | **0.263** |
| WC | 1/2 | 1/3 | **1** | **0.159** |

Note* LU: land use; AW: Amount of water; WC: Water consumption. Max eigenvalue ($\varphi$max)=5.38; n = 3; consistency index (Ci) = 0.083; consistency ratio (CR) =0.067

### *The land suitability for Agriculture planning*

The priorities of 3 factors were land use, water content and water consumption. Data analysis found that the land use area is moderately found to be suitable for development by the area most suitable for development (s1). The area was 127,269 hectares or approximately 35.55 %. Medium suitable area (s2) was 163,882 hectares or approximately 46.96 %. Less suitable areas (s3) was 68,097 hectares or 17.49 % as shown in Table 3 and a map of agricultural management practices in Chachoengsao is shown in Figure 5.

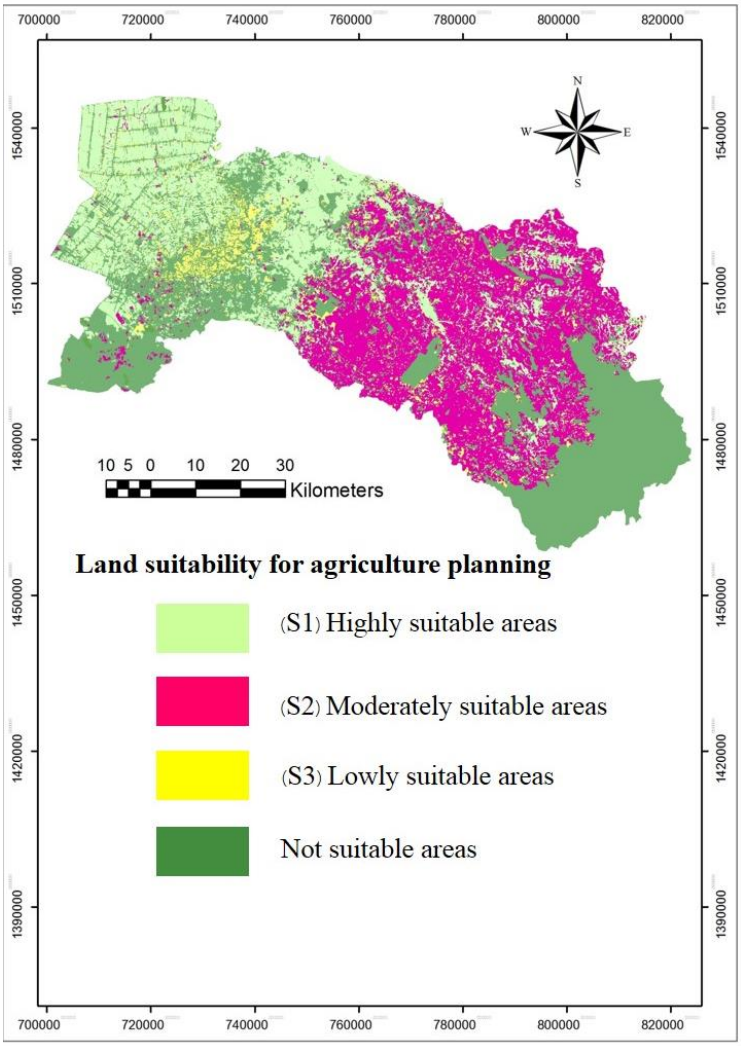


**Figure 5.** Land suitability for agriculture planning in Chachoengsao province

## Discussion

The pairwise comparisons were shown so that the value of 9 indicates (Cengiz and Akbulak2009) that the line was relatively more important than the column, while the value (Malczewski, 2004; Saaty, 1977) of 1-9 showed that the line was significantly less important than the column. The results indicated that the consistency ratio (CR) was 0.067. The ratio of consistency ratio being equal to or less than 0.10.

The result revealed 3 factors for the development in Chachoengsao with regarding to 3 criteria as land use, amount of water and water consumption, it was found that the suitable planning development area had a moderate level of the development (Liu *et al.*, 2007). However, the most suitable area for the development (S1) covered an area of 127,269 hectares or 35.55 percent of the total area. A moderately suitable area (S2) covered an area of 163,882 hectares (46.96%); and lowly suitable area (S3) covered an area of 68,097 hectares (17.49%). There are some limitations to the plausibility of this study which should be noted. Firstly, from the methodology, the suitable analysis depended on the AHP result, which is highly dependent on experts' opinions. The second limitation to the validity of this suitability analysis lies on how the parameter and criteria are viewed upon.

However, there are many other aspects which should also be considered, such as soil order, topography, land availability and social aspects. One of the obstacles to integrate more social aspects in this type of study is the difficulty in which to integrate social aspects into spatial representation. Consequently, other aspects that are not explored during this study should be further considered.

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