ZONING FOR RAMBUTAN USING GEO-INFORMATICS IN CHANTHABURI PROVINCE, THAILAND

Yupa Limsawad[1], Chalongchai Babpraserth[1]*, Thunya Taychasinpitak[1] and Sununtha Kingpaiboon[2]

ABSTRACT

Agro-economic zoning of agricultural commodity is undertaken in accordance with the objectives of the agricultural economic act B.E. 2522. The objectives are to adjust rambutan production suitable for area potential as well as to increase efficiency of production system, processing and marketing to be in high stability, and to increase competitiveness in the world market. The methodology is to apply new technology, so called Geo-informatics, as a tool for agro-economic zoning. This technology including geographic information system-GIS, remote sensing-RS, and global positioning system-GPS has been proven and effective tool for spatial rambutan production zoning and planning. The analysis for potential level of rambutan production zoning is undertaken by integrating the map of area suitability for rambutan production obtained from land allocation suitable for production target with important economic factors effecting to production system. The factors are : commodity demand and supply, production target, production source, production cost, farm gate price, production capability, and plant location (for processing factory) at district level. Percentage of weighting and other conditions are different for each factor. The result obtained in this step is map illustrating potential level for rambutan production zoning. The potential is devided into 2 levels including production potential area level 1 and production potential area level 2.

Keywords: Zoning, Spatial Production Planning, Geo-informatics, Rambutan, Chanthaburi Province

[1] Department of Horticultural, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand. agrccb@ku.ac.th
[2]Department of Agricultural Engineering, Faculty of Engineering, Khonkaen University, Khonkaen, 40002, Thailand.

INTRODUCTION

The rambutan (*Nephelium lappaceum*) is a medium-sized tropical tree in the family Sapindaceae. The fruit produced by the tree is also known as "rambutan." It is native to Vietnam, Indonesia, the Philippines, Sri Lanka, Malaysia, and elsewhere in Southeast Asia, although its precise natural distribution is unknown. It is closely related to several other edible tropical fruits including the lychee, longan, and mamoncillo. It is believed to be native to the Malay Archipelago, from where it spread westwards to Thailand, Burma, Sri Lanka and India; eastwards to Vietnam, the Philippines and Indonesia. The name *rambutan* is derived from the Malay word *rambutan*, meaning "hairy". In Vietnam, it is called *chôm chôm* (meaning "messy hair") due to the spines covering the fruit's skin.

Thailand is the leading producer of rambutan in the Asian region with about 330,720 rai and 307,342 metric ton (2011). Production is concentrated in the provinces of Chanthaburi, Trad, Rayong, in the east and Nakhonsithammarat, Suratthani, Narathiwat, and Chumphon, in the south and Chiangrai, Nan, in the north. Peak harvest season is between May and July. In recent years, many rambutan plantings in the Chanthaburi area have been replaced by para rubber and oil palm trees due to overproduction, high postharvest costs and low return. Market and price situation in 2011 is highly trend due to continuous demand of consumption both in local and foreign market. Average price is between 14 Baht to 16 Baht /kg. Main export market is Vietnam, Cambodia, Hongkong, Singapore, and Malaysia. In 2012 expected that local consumption and export fresh rambutan fruit are more trend because of continuous increasing in production and foreign market consumption.

One of the mandates of the Office of Agricultural Economics-OAE, defined in the Agricultural Economic Act B.E. 2522, is to study, analyse factors related to agricultural production. The factors include : suitability of production source based on soil type, weather condition ; water supply ; farm type ; farmer's main income ; and domestic and external market demand. Those factors are used for agro-economic zoning of agricultural commodity, and then submit to the Committee on Agriculture and Cooperatives Policy and Development Plan.

So far, the agro-economic zoning for agricultural commodity was undertaken for 13 commodities including 12 crops and 1 livestock. They are sugarcane, oil palm, major rice, second rice, corn, cassava, pineapple, soybean, rubber, durian, longan, and coffee. However, various circumstances have been changed. The Committee therefore set up the Sub-committee on Zoning and Implementation Measure Consideration to review and renew the agro-economic zoning by using new technology so called Geo-informatics. The technology including Geographic Information System-GIS, Remote Sensing-RS, and Global Positioning System-GPS. GIS is a new technical methodology using computer for spatial data

collection, archival, and management. This method provides accurate and reliable spatial information such as position of target places. The results can therefore be effectively applied for spatial planning.

In addition, the establishment of the existing zones was mainly directed by the government. Even though many measures were launched to encourage farmers to produce in accordance with the production guidance in each zone such as farmer registration and provision of incentives through various projects, fewer farmers were interested to register and participate in this program. Furthermore, the supporting activities and measures provided by government and others parties were not well coordinated. This is mainly due to the lack of concrete plan that can harmonize the activities of concerned parties and provide sufficient incentives to farmers.

Thus, Zoning for rambutan using Geo-informatics in Chanthaburi Province, Thailand is the case study that can be done and used in appropriate database management both in production and market for local and export include by product in related industry. Established spatial production planning which link to development strategic plan for Thai Fruits B.E. 2010-2014. These, Thailand will be the leader of rambutan, tropical agriculture fruit crops, production and export fresh fruit and by product in the world market. Integration with spatial data and socio-economic for utmost efficiency utilization in agricultural development planning.

For the studies of land suitability for crops, Ceballo-Silva and Lopez-Blanco 2003 applied multicriteria evaluation (MCE) approach, GIS and RS to delineate suitable areas for the production of maize and potato crops in Toluca, Central Mexico. Data included in the analysis were climate, relief and soil databases, which were used to generate GIS raster coverage. Relevant criteria for crops and suitability levels were defined according to FAO standards, and criteria maps were introduced in the MCE algorithm to obtain the suitability map for each crop. Landsat TM image in 1996 were processed using supervised classification to obtain land use/land cover (LU/LC) map, which showed 13 land use/land cover types. After that, LU/LC and suitability maps were compared to identify a suitable area for maize and potato crops.

Musekawat 2004 applied remote sensing and GIS as tools for spatial data analysis toward the zoning and management of land use in tambon Bang Khunsai, Phetchaburi province, Thailand. Aerial photographs taken in 1994 and 2002 were interpolated to detect changing in land use and land cover pattern of the study area.

Srirattanatum 1988 used biophysical factors of topography, soil, vegetation, wildlife, water resources, accessibility and aesthetics to identify management zones at Tarutao National Park, Thailand by using manual overlay techniques.

Trisurat 1990 applied Linear Combination Method of multiple criteria of eight bio-physical factors to create management zones in Phu Rua National Park in northeastern part of Thailand. Each factor was ranked and weighted based on its suitability for each zone.

The objective of this research was to define and adjust agricultural production suitable for area potential. Those will lead to agro-economic zoning in Chanthaburi Province, Thailand. To increase efficiencies of production system, processing, and marketing of agricultural commodity.

MATERIALS AND METHODS

The methodology is to apply new technology, so called Geo-informatics, as a tool for agro-economic zoning. This technology including Geographic Information System-GIS, Remote Sensing-RS, and Global Positioning System-GPS has been proven and effective tool for zoning on rambutan and planning. Materials and equipments are composed of workstation, external hard disc, satellite data, color printer, and topological map 1:50,000.

The methodology for zoning on rambutan production is to study on present crop production system and land allocation suitable for production target. The step show on Figure1.

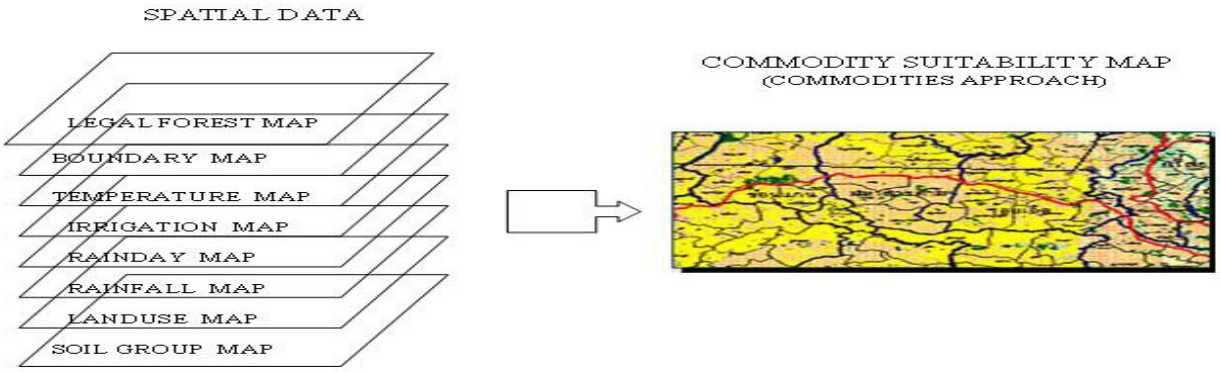

Figure 1. Show the step on using GIS to analyse potential production area**.**

Data conversion

Data conversion from the existing map into digital format by compiling such maps from relevant agencies. In case that some thematic maps are not available or obsolete, the up-to-date maps will be produced by Office of Agricultural Economics (OAE). The converted relevant maps include:

1.) Provincial soil properties map, at a scale of 1:50,000 obtained from the Land Development Department (LDD), of which comprises soil properties for the whole country.

2.) Irrigation map obtained from the Royal Irrigation Department (RID) comprises both irrigation and non-irrigation zones.

3.). Average rainfall map obtained from the Department of Meteorology of which average rainfall is ranging into 10 levels including:

(1) Rainfall of 1,000-1,100 mm.

(2) Rainfall of 1,100-1,200 mm.

(3) Rainfall of 1,200-1,400 mm.

(4) Rainfall of 1,400-1,600 mm.

(5) Rainfall of 1,600-2,000 mm.

(6) Rainfall of 2,000-2,400 mm.

(7) Rainfall of 2,400-2,800 mm.

(8) Rainfall of 2,800-3,200 mm.

(9) Rainfall of 3,200-4,400 mm.

(10)Rainfall of 4,400-5,000 mm.

4.) Forest legal boundary map, at a scale of 1:50,000 obtained from the Royal Forestry Department, of which includes both inland forest and mangrove boundaries. Inland forest is categorized into 2 zones:

- Economic forest boundary
- Conserved forest boundary

Mangrove land use is categorized into the following zones:

1. Conservation zone represents the mangrove area prohibited for any change to conserve the environment and ecosystem. The zone includes 10 categories namely:

1.1 Areas for breeding of economic plant and aqua-animal.

1.2 Areas for breeding of plant and aqua-animal.

1.3 Areas prone to destruction and soil erosion including beach, sand dune, mud flat, accreted mud flat, accreted sand, island, cave and coral reef.

1.4 Areas of history and archeology significance.

1.5 Areas of local symbol.

1.6 National park, forestry park, tourism spot, wildlife sanctuary, and hunting prohibited zone.

1.7 Forest areas reserved for fire protection.

1.8 Forest areas suitable for research.

1.9 Forest areas suitable for environment and ecosystem conservation.

1.10 Areas of the distance not less than 20 meters from river banks and not less than 75 meters from coast lines

2. Economic zone includes 2 categories namely:

2.1 Economic zone A includes the mangrove areas allowed for forestry activity especially to provide regular production. They are namely:

2.1.1 Concessioned forest area and forest under project area.

2.1.2 Unconcessioned forest area suitable for social forestry.

2.1.3 Forest plantation area for forest products of both government and private sectors.

2.2 Economic zone B includes mangrove areas allowed for other land utilize and development. However, environmental impacts are to be taken into consideration. The area includes:

2.2.1 Agricultural area for the following purposes:

2.2.1.1 Crop cultivation

2.2.1.2 Livestock

2.2.1.3 Fisheries

2.2.1.4 Salt pan

2.2.2 Industrial area includes

2.2.2.1 Mining

2.2.2.2. Industrial Factory

2.2.3 Urban area

2.2.4 Commercial area

2.2.5. Sea port

2.2.6 Others

5.) Road network map, at scales of 1:1,000,000 and 1:250,000 obtained from the Department of Highway and the Royal Thai Survey Department, includes:

5.1 Road comprises:

-Highway with number

-Provincial road with number

-Road under the Office of Accelerated Rural Development

-Dirt road, and etc.

5.2 Railway

5.3 Road along irrigation canal

6.) Administrative boundary map, at a scale of 1:50,000 obtained from the National Statistical Office, and the Royal Thai Survey Department includes:

6.1 Province boundary

6.2 District boundary

6.3 Sub-district boundary

6.4 Locations of province, district and sub-district offices

7.) Present land use map, at a scale of 1:50,000 obtained from 2005 satellite image interpretation by OAE, includes the following categories:

Land use Type	Code
1. Paddy field	Ri
2. Paddy under trees (agro forest)	Ri /Tr
3. Field crops	Up
3.1 Single crops	
Cassava	Ca

Sugarcane	Su
Corn	Co
Pineapple	Pi
3.2 Mixed crops	Up
4. Horticultural crops	
4.1 Special Orchard	
Rubber	Ru
Oil palm	Pa
Coconut	Ce
Coffee	Cf
Orchard	Or
4.2 Mixed orchard	
Mixed orchard	Or
Resident orchard	Or/ Ur
5. Tree crops (Standing trees)	
5.1 Trees along the road or riverene trees	Tr
5.2 Standing trees in the village	Tr
6. Forest	
6.1 Inland forest	Fo
6.2 Mangrove	Ma
6.3 Swamp forest / bog	Fs
6.4 Forest plantation (Pine, Eucalyptus, Teak)	Fp
6.5 Idle land	Id
7. Pasture	
7.1 Grass land	Gs
7.2 Swamp grass	Sw
8. City, Village	Ur
9. Other land uses	
9.1 Shrimp farm	Sh
9.2 Salt pan	Sa
9.3 Fish pond	Fi
9.4 Others	Ot
10. Water body	Wa
11. Barren land	Ba

Data Analysis

Data analysis was carried out by using GIS and oracle software under WINDOW NT operating system the steps are follows:

1) Project construction and database establishment to integrate spatial information, obtained from digital map, and attribute information so called topology.

2) Data analysis was undertaken by overlaying of multi-layer spatial information. The data includes:

2.1 Soil series were categorized, in accordance with suitability condition, into 3 levels namely:

1.represents high suitability for rambutan cultivation

2.represents moderate suitability for rambutan cultivation

3.represents unsuitability for rambutan cultivation

2.2 Rainfall map was categorized into 4 levels namely:

1. The rainfall of high suitability for rambutan.
2. The rainfall of moderate suitability for rambutan.
3. The rainfall of marginal suitability for rambutan.
4. The rainfall of unsuitability for rambutan.

2.3.Overlaid the rainfall map onto the irrigation zone and soil series maps to obtain the map of suitability area for rambutan including: The map of suitability area for rambutan was then overlaid onto the present land use map and forest legal boundary map to remove the undesirable areas including conserved forest, water body, and others.

2.4.Calculate the suitability area for rambutan in Chanthaburi Province and district , Thailand

Suitability analysis

The results comprise 2 types of information: map and level of rambutan suitability area which was ranged into 7 levels. They are:

1. High suitability area
2. Moderate suitability area
3. Unsuitability area
4. Existing forest area
5. Deteriorated forest area
6. Water body
7. Residential, city, and other built up areas.

Agro-economic zoning analysis

Section 1.01 To analyze rambutan agro-economic zoning using main data as follow:

Spatial data

GIS was applied for the analysis of rambutan suitability area in Thailand by overlaying of soil map, rainfall map, and irrigation map. By such a procedure, The undesirable areas such as conserved forest, urban area, water body and etc. were removed. Rambutan suitability areas were then categorized, based on the boundary of Chanthaburi Province, into 3 levels: high, moderate and unsuitable. Administrative boundary of Chanthaburi Province, district and sub-district, and communication network were also overlaid onto the rambutan suitability area map in both paper print at a scale of 1:50,000 and digital formats.

Socio-economic data

-Study and analyze demand and supply of rambutan both of domestic and foreign market include factory production needed.

-Analyzing and forecasting rambutan production and price level, cost, transportation expenditures and income return from farmer to factory.

-Rambutan production data in 1 years (2011) by district or Amphoe.

-Rambutan canned factory and quantity were located with GPS show about latitude-longitude to the earth.

-Production and trade policy data of rambutan and canned factory between Thailand and relevant organization. Figure 2.

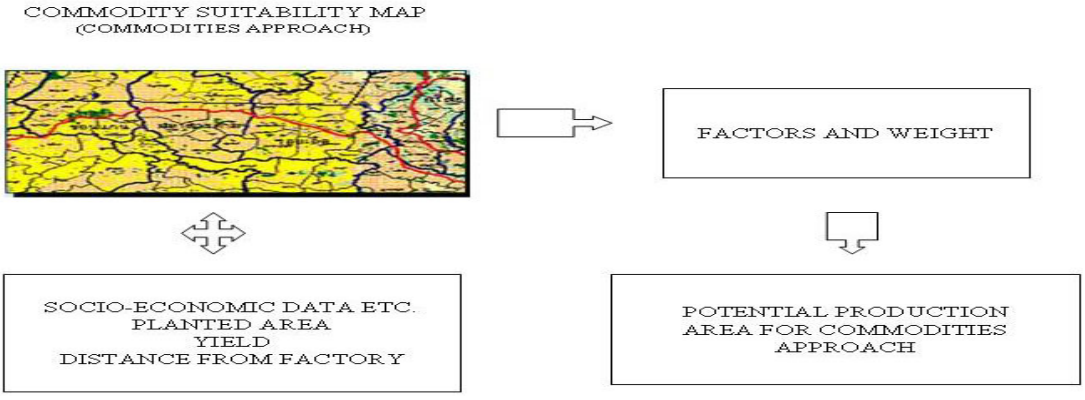

Figure 2. Show the step on using GIS to analyse spatial data for rambutan zoning.

RESULTS AND DISCUSSION

Analysis of area suitability the spatial data map are analysed on area plysical suitability for crop planting based on the boundary of Chanthaburi Province, Thailand. Area calculation and production of area physical suitability map is undertaken by overlaying administrative boundary on to the suitability map. Area for each suitability level can then be obtained and analysed to define agro-economic zone for rambutan in this step. The items to be studied are such as production source, production quantity, market demand both domestic and external markets, market future trend, and production target suitable for rambutan such as production target defined in agricultural commodity strategic plan.

The analysis for potential level of rambutan production zoning is undertaken by integrating the map of area suitability for rambutan production obtained from land allocation suitable for production target with important economic factors effecting to production system. The factors are : commodity demand and supply, production target, production source, production cost, farm gate price, production capability, and plant location (for processing factory) at district level. Percentage of weighting and other conditions are different for each factor.

The results of analysis for rambutan zoning in Chanthaburi Province, Thailand show that correlation analysis of physical factor and economic factor with 3 variables such as: suitable area, existing planted area and product yield. The result obtained in this step is map illustrating potential level for rambutan production zoning. The potential is devided into 2 levels including production potential area level 1 and production potential area level 2. Production potential area level 1 or zone1 refers to suitable area more than 10,000 rai , Existing area more than 5,000 rai , Yield more than 1,000 kilogram per rai. Production potential area level 2 or zone 2 refers to suitable area more than 1,000-9,999 rai , Existing area between 1,000-4,999 rai , Yield between 500-999 kilogram per rai. Weight analyse for zoning among suitable area : existing area : yield related to ratio 30 : 40 : 30 respectively as show on table 1.

Table 1. Correlation Analysis of Physical Factor and Economic Factor

Potential Production	Suitable Area (rai)	Existing Planted Area (rai)	Product Yield (kg. / rai)
level 1	suitable>10,000	>5,000	>1,000
level 2	suitable>1,000-9,999	1,000-4,999	500-999
weight (%)	30%	40%	30%

From the results map of land suitability for rambutan in Chanthaburi province which define and group into 5 levels, namely, highly suitable, moderately suitable, unsuitable, forest, and water as show on

figure 3. These will lead to map of zoning for rambutan in Chanthaburi province when analyse with socio-economic data via weight and score for each variable by overlaying technique. The results map of zoning for rambutan in Chanthaburi province show production potential area level 1 or zone1 by principal and condition as laid out in 8 amphoe which respect to highly suitable area and exiting planted area include yield. They are Mueang Chanthaburi, Kaeng Hang Maeo, Laem Sing, King Amphoe Khao Khitchakut, Khlung, Tha Mai, Na Yai Am, Makham, except 2 amphoe of Pong Nam Ron, and Soi Dao that state on production potential area level 2 or zone2 as show on figure 4 and table 2.

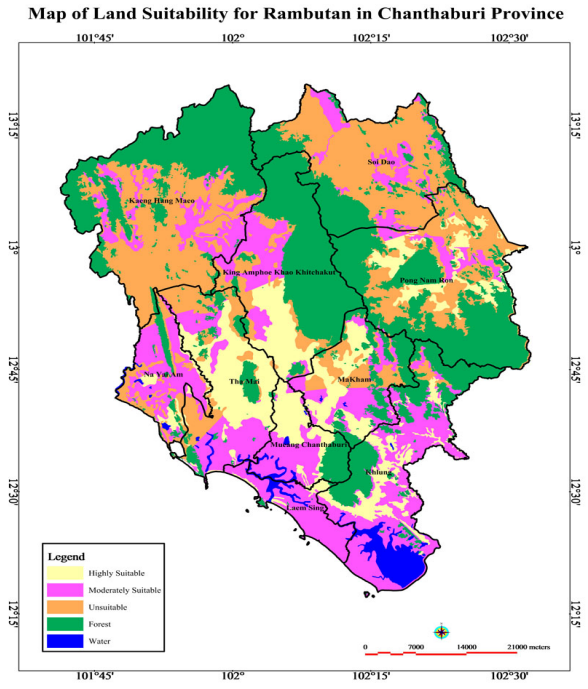

Figure 3. Map of land suitability for rambutan in Chanthaburi province

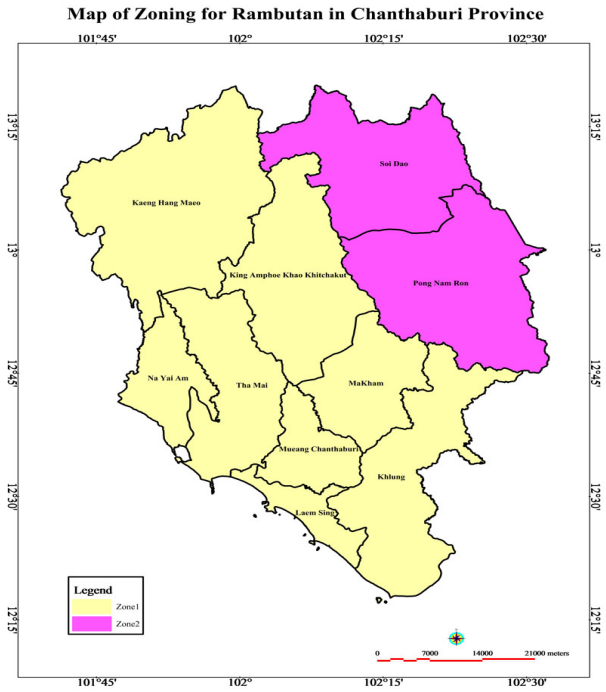

Figure 4. Map of zoning for rambutan in Chanthaburi provinc

ACKNOWLEDGEMENTS

The researcher would like to thank Department of horticulture, Faculty of agriculture, Bangkhen campus, Kasetsart University, and Office of agricultural economics for funding and providing materials with equipment in this research.

Table 2. Zoning For Rambutan in Chanthaburi Province

Province /Amphoe	Suitable Area (rai)		Existing Planted Area	Yield	Zone	Analyse Zoning Area						Existing Planted Area (rai)		
						Highly Suitable			Moderately Suitable					
	Highly	Moderately	(rai)	(kg./ra)		level 1	level 2	level 0	level 1	level 2	level 0	level 1	level 2	level 0
Mueang Chanthaburi	29,591	11,281	5,790	1,042	1	29,591			11,281			5,790		
Kaeng Hang Maeo	0	77,981	24,659	627	1	0			77,981			24,659		
Laem Sing	58	12,439	30,709	1,526	1	58			12,439			30,709		
Pong Nam Ron	66,643	18,518	850	443	2		66,643			18,518			850	
King Amphoe Khao Khitchakut	77,145	30,235	16,283	1,263	1	77,145			30,235			16,283		
Khlung	38,682	64,439	860	1,473	1	38,682			64,439			860		
Tha Mai	118,813	16,283	624	741	1	118,813			16,283			624		
Na Yai Am	11,414	55,545	2,886	1,769	1	11,414			55,545			2,886		
Makham	39,253	65,352	4,938	1,257	1	39,253			65,352			4,938		
Soi Dao	0	12,233	24,309	1,589	2		0			12,233			24,309	
Chanthaburi Total	381,599	364,306	111,908	262		314,957	66,643	0	333,555	30,751	0	86,749	25,159	0

Remark

Rambutan 30 : 40 : 30 Weight analyse For Zoning among Suitable Area:Existing area :Yield related to ratio 30 : 40 : 30 by order.

Suitable area Calculated from spatial map by Office of Agricultural Economics.

Existing area From Department of Agricultural Extension by Amphoe.

Yield From Department of Agricultural Extension by Amphoe.

Zone 1 refers to suitable area more than 10,000 rai , Existing area more than 5,000 rai , Yield more than 1,000 kilogram per rai.

Zone 2 refers to suitable area more than 1,000-9,999 rai , Existing area between 1,000-4,999 rai , Yield between 500-999 kilogram per rai.

Zone 0 No potential for zoning because lower than lever zone 2.

REFERENCE:

Aronoff, S. (1990). Geographic Information System : A Management Perspective, WDL Publications.Ottawa Canada.

Boonyanuphap, J., W. Det, and S. Kasutoshi (2004). GIS-Based Land Suitability Assessment for Musa (ABBgroup) Plantation. Retrieve from http:// www.horticultureworld.net/Jaruntorn.pdf.

Burrough, P.A. (1986). Principles of Geographic Information System for Land Resources Assessment, Clarendon Press. Oxford 193 pp.

Ceballos-Silva, A. and J. Lopez-Blanco (2003). Delineation of Suitable Areas for Crops Using a Multi-Criteria Evaluation Approach and Land Use/Cover Mapping : A Case Study in Central Mexico. Retrieve from http://www.sciencedirect.com

Charuppate, T. (2002). Land Use Change Detection, Land Evaluation and Land Use Planning in Lam Pha Phloeng watershed. Ph.D. Dissertation, Khon Kaen University, Thailand.

Corbett, J.H. (1996). Dynamic Crop Environment Classification Using Interpolated Climate Surfaces. GIS and Environmental Modeling: Progress Research Issues. GIS World book, Fort Collins.

FAO (1996). Agro-ecological Zoning Guidelines. FAO Soil Bulletin. N. 76. FAO, Rome.

Ghaffari, A.A., H.F. Cook, and H.C. Lee (2000). Integrating Climate, Soil and Crop Information: A Land Suitability Study Using GIS. 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4),September 2-8, Alberta, Canada.

Haeze, D.D., J., Deckers, D., Raes, T.A., Phong, and H.V., Loi (2005). Environmental and Socio-economic Impacts of Institutional Reforms on the Agricultural Sector of Vietnam Land Suitability Assessment for Robusta Coffee in the Dak Gan Region.

Kalogirou, S. (2002). Expert system and GIS : An Application of Land Suitability Evaluation.

Musekawat, U. (2004). RS/GIS Aided Land Use Zoning for Natural Resources Management in Bang Khunsai, Phetchaburi, Thailand. Master's Degree thesis. Asian Institute of Technology, Bangkok, Thailand.

Saha, S.K. and L.M. Pande, (1996). Agro-ecological Zoning Using Satellite Remote Sensing and GIS based on Integrated Approach - a case study of Doon Valley, India. Proc. INDO- US Symposium - Workshop on Remote Sensing and its Applications, IIT, Mumbai.

Srirattanatum, M. (1988). Application of biophysical factors in identification and classification of management zones at Tarutao National Park. Master's Degree thesis. Kasetsart University. Thailand.

Trisurat, Y. (1990). Management plan for Phu Rua National Park, Thailand including Remote Sensing and GIS techniques. Master's Degree Thesis. Asian Institute of Technology. Bangkok, Thailand.

Turner, B.L., D., Skole, S., Sanderson, G., Fisher, L.Fresco, and R.Leemans, (1995). Land-Use and Land-Cover Change Science/Research Plan. Available: http://www.ihdp.uni-bonn.de/html/publications/reports/report07/luccsp.htm

Venkatachalam, P., C.V.S.S.B.R., Murthy, S.Chowdhury, and L.N. Sharma, (1991).Groundwater Potential Zone Mapping Using GIS approach. AsianPacific RS Journal, 4,(1), 75-78.

Xu, W. (1997). Agricultural Land Use Change in Relation to Agro-ecosystem Health. Ph.D. Dissertation, University of Guelph, Canada.