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RICE CROP MAPPING AND GIS ANALYSIS FOR POLICY IMPLEMENTATION

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ABSTRACT

Thailand is a developing country that the agricultural sector plays a very important role in the economy. Among all the crops, rice is the main product for domestic use and export. Geographic Information System (GIS) is a major tool for monitoring and forecasting the rice production in the region to minimize the risk of unsuitable crop conditions. The study area focuses on the central of Thailand where higher rice production with two crops annually thanks to the irrigation water available in the region. The Office of Agricultural Economics (OAE) is the government organization for publishing statistical data on Thai agriculture. But the data is updated until the year after while water management and rice market price are required updated and near real-time data. Remote sensing is an updated data source and free of charge information that could be applied to solve this problem. Moderate Resolution Imaging Spectro-radiometer (MODIS) data is applied to classify rice crops for both major and second crops. The results of the classification are then compared to the OAE statistics data for accuracy assessment. The rice crop areas are calculated and its attribute data includes growing stages as a major and second crop with its productivity estimation.

Disciplinary: Agricultural Sciences and Technology (Crop Science), Spatial Information Science and Engineering.

1. INTRODUCTION

Thailand is one of the developing countries that the agricultural sector plays a very important role in the economy. Among all the crops, rice is the main product for domestic use and export with the value of rice traded was 174.5 billion baht in 2017 (Wipatayotin, 2018). Rice products account for nearly 12.9% of all agricultural farm products in the country. The Rice farm sector has been an engine force to drive the country's economic growth. Government policy is crucial to support the farmer to

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be wealthy but many uncertainties in a farming system such as unexpected weather conditions, floods and droughts, fluctuating prices, and rising costs that rice farmers have to face. Geographic Information System (GIS) is a tool for monitoring and forecasting the rice production in the region to minimize the risk of unsuitable crop conditions. The study area focuses on the central of Thailand where higher rice production with two crops annually thanks to the irrigation water available in the region.

Office of Agricultural Economics (OAE) is a Thai well-known organization for providing statistical data and publish research studies concern the economic reports of Thai agriculture. But the data is updated until the year after while water management and rice market price are required updated and near real-time data. Remote sensing is an updated data source and free of charge information that could be applied to solve this problem. **Moderate Resolution Imaging Spectro-radiometer (MODIS)** data is of Vegetation Indices 16-Day image Level 3 Global data 250m are used to classify rice crops for both major and second crops. The results of the classification are then compared to the OAE statistics data for accuracy assessment.

2. REVIEWS

Land use and Rice crop The absolute zone of Thailand is 514,000 square kilometers which incorporates Forest 31.9 %, Arable land 38.8%, different terrains 26.9%, Permanent harvest 8.8%, and Permanent glades and fields 1.6% (FAO 2016).

Rice in the focal of Thailand is planted into two harvests for each year relying upon the water accessibility from downpour and neighborhood water system frameworks. Agrarian primary oat crops, including rice and maize, are beginning during the blustery season. Thai Meteorological Department every year gauges that rain is beginning from May to October as called the rainy season. December is thought of as the coolest month of the year. Rice's main (rain-fed) crop is grown during the rainy season. The dry season is beginning from November to April and rice’s second (irrigated) crop is planting during the dry season. April is considered the hottest month of the year. The yield of rice profitability is unique in relation to the regions because of the nearby land, climate, and asset appropriateness during the planting to reaping stages.

Natural administration and financial development are associated with farming advancement with excellent items dependent on the idea of practical horticulture (Addeo et al. 2001). Land reasonableness investigation guarantees the ideal use of land and water assets for farming creation in a proficient manner (Ahamed et al. 2000). GIS method as appropriateness is a reason for agribusiness crop the board and common assets utilized should be assessed (Mustafa et al. 2011). Rice crop prerequisites in the area should coordinate the dirt attributes, slant slope, precipitation system, and waste information that guides as FAO rules (FAO 1967). Rice crop observing and planning is a significant wellspring of data for rural approach execution and dynamic. This investigation utilizes GIS procedures for incorporating rice crop checking for item assessment and strategy execution.

3. MATERIALS AND METHODS

3.1 THE STUDY AREA

Fifteen provinces in the central of Thailand are selected in this study because they are the provinces with high rice productivities by making two crops annually as major (rain-fed) crop and secondary (irrigated) crop. The provinces are (1) Bangkok (2) Kanchanaburi (3) Chachoengsao (4) Chonburi (5) Trad (6) Nakhon Nayok (7) Nakhon Pathom (8) Nonthaburi (9) Pathumthani (10) Chonburi (11) Lopburi (12) Samut Songkham (13) Sakaew (14) Saraburi and (15) Suphanburi.

3.2 GIS DATA AND MAPS

The provincial boundary data is in GIS standard shape format and be available at http://www.diva-gis.org/gdata

3.2.1 MODERATE RESOLUTION IMAGING SPECTRO-RADIOMETER (MODIS) DATA

The MODIS instrument has thirty-six spectral bands, seven of which are designed for the study of vegetation and land surfaces: blue band (459-479 nm), green band (545-565 nm), red band (620-670 nm), the near-infrared band (NIR1: 841-875 nm; NIR2: 1230-1250 nm), and shortwave infrared band (SWIR1: 1628-1652 nm, SWIR2: 2105-2155 nm). Daily worldwide satellite imagery is provided at spatial resolutions of 250-m (red and NIR1) and 500-m (blue, green, NIR2, SWIR1, SWIR2). The MODIS Land Science Team provides a suite of standard MODIS data products to the users, including the 16-day composite MODIS Surface Reflectance Product (MOD13Q1). The data widely used for environment application and free of charge that can be downloaded at http://e4ftl01.cr.usgs.gov/MOLT/MOD13Q1.006 .

Worldwide MODIS information type MOD13Q1 is of Vegetation Indices that comprises of 16-Day Level 3 Global information 250m. The vegetation records are helpful information sources to convey nonstop spatial data and transient checking for vegetation conditions and examination. These referenced above are utilized to create the MODIS vegetation files day by day information.

3.2.2 REFERENCE DATA

Office of Agricultural Economics (OAE) annual rice crop statistic report and harvesting area in Rai (1 Rai = 1600 square meters, 2.52929 Rai = 1 acre) is used in this study as a source of evaluating the satellite image classification of MODIS data. The statistics include two main crops such as rice major (rain-fed rice) crop and rice second (irrigated) crop. The Rice crop harvesting area in Rai and crop yield as kilogram per Rai of 15 provinces in the central of Thailand was referenced and analyzed for rice crop classification.

Google Map and Image is free information from the Google website that shows a detailed landscape of land use and cover features such as rice fields and paddy parcels, roads, and houses. With Google Map 3D function, we can see the real photo of the area of interest. This information is valuable for rice crop identification by visual interpretation of the MODIS satellite image.

3.3 METHODOLOGY

The method of general processing for Rice Crop Classification and Algorithm Development is illustrated in Figure 1. The software used for MODIS data processing and GIS data analysis is Quantum GIS (QGIS) Version 3.2.1 that is open-source and free of charge. QGIS software can be download at https://qgis.org/en/site.

3.3.1 MODIS DATA PROCESSING

MODIS 16-days in Level 3 Global data 250m (MOD13Q1) in Raster Hierarchical Data Format (HDF). This data can be downloaded from the website http://e4ftl01.cr.usgs.gov/MOLT/MOD13Q1.006 as a sinusoidal map projection. This data of the

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sinusoidal project is then transformed into the WGS84 map projection that can be the same projection of local map data for analysis (Peng et al., 2011). For saving data processing time, the data was clipped to fit into the study area of 15 provinces in the central of Thailand and ready for image classification.

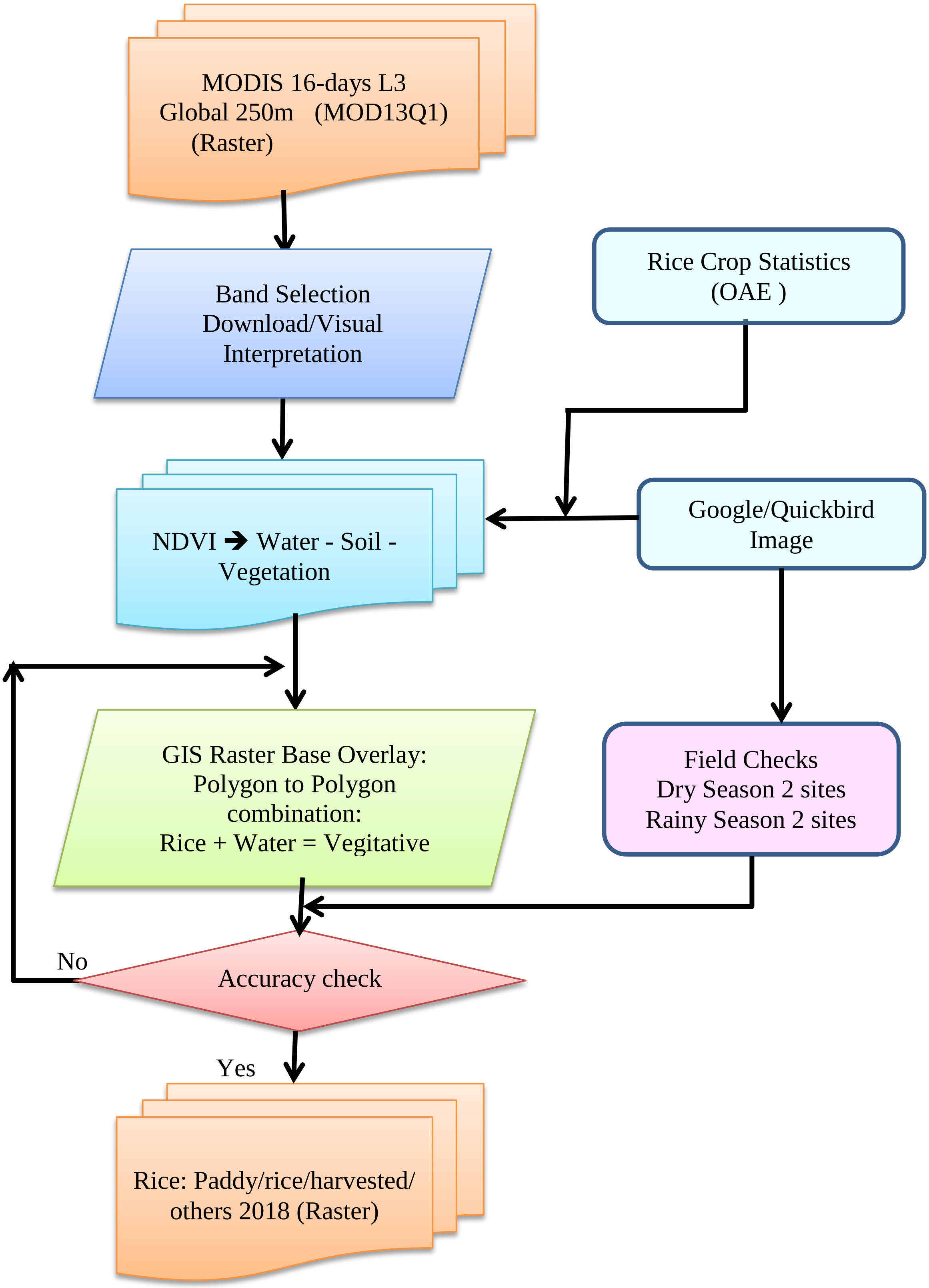

Figure 1: Methodology Rice Crop Monitoring and Mapping.

3.3.2 VISUAL INTERPRETATION AND CLASSIFICATION

The Normalized Difference Vegetation Index (NDVI) is used for visual interpretation (Xiao et al., 2006) to identify rice planting phases that are divided into three phases as vegetative, reproductive, and ripening phases (LeToan et al., 1997) as presented in Figure 2. The interpretation keys for image classification are combined referenced information and MODIS data such as rice with water, vegetation, and soil as explained in Table 1.

Table 1: Integrated reference data for visual interpretation.

INPUT		OUTPUT
Reference data (Google Map)	MODIS NDVI	Rice growing phases
Rice	Water	Vegetative
Rice	Vegetation	Reproductive
Rice	Soil	Ripening
Non-rice		Non-rice

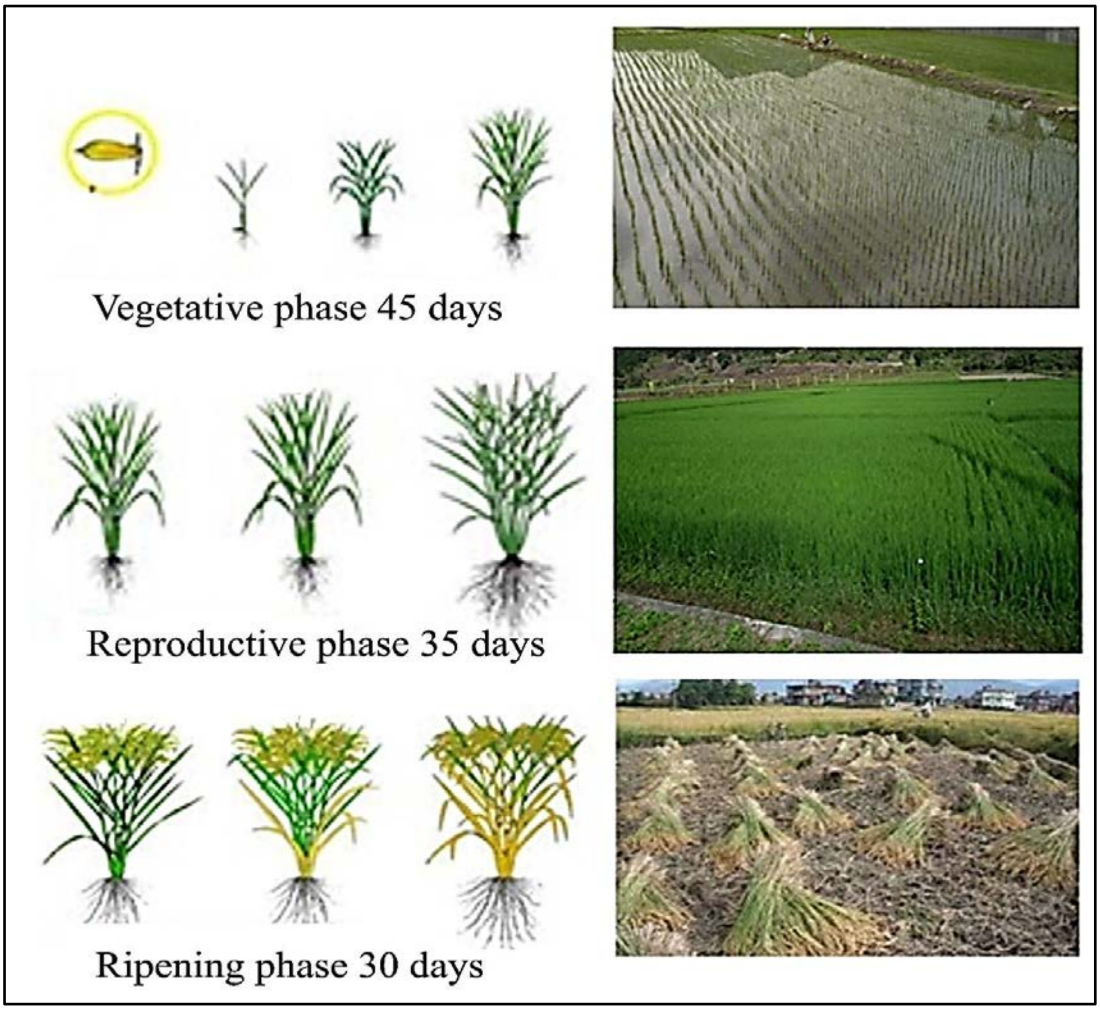

Figure 2: Rice Planting phase for visual interpretation.

3.3.3 NDVI VALUE AND CLASSIFICATION FOR RICE CROP

MODIS 16-days L3 Global 250m (MOD13Q1) with NDVI data was visualized and classified for rice crop that based on the threshold of NDVI value. The range of NDVI for ripening phase is 0.35 to 0.39 NDVI value. The range of NDVI for vegetative phase is 0.39-0.44 NDVI value. The reproductive phase can have threshold at the range of 0.45-0.49 NDVI value. The NDVI value ranges for classification of rice crop is illustrated in Figure 3.

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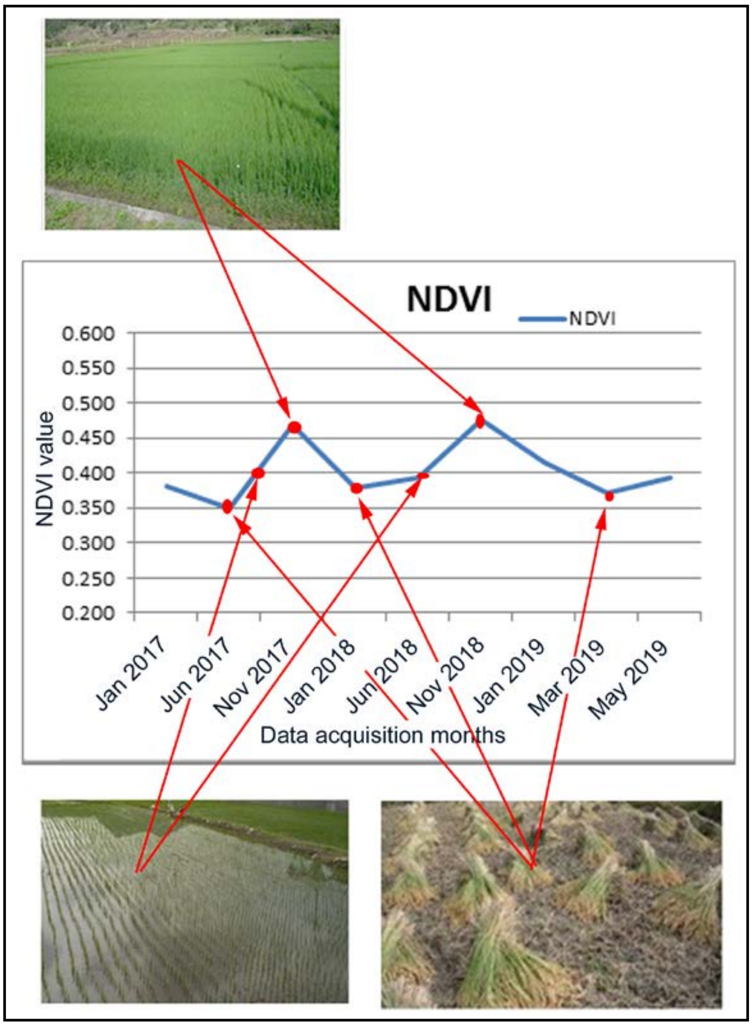

Figure 3: NDVI value and Classification for rice crop.

3.3.4 GIS DATA ANALYSIS AND OUTPUT

The results of the rice map and GIS data are export to the GIS standard ESRI Shape-file format in the map projection of WGS84 for easy to import to another GIS system. These data can be presented with the province boundary data for creating the rice crop statistic report as an area (in Rai) and yield (in kilogram per Rai) that can be collected by interviewing the farmers and compared with OAE report data for accuracy assessment.

4. RESULTS AND DISCUSSION

4.1 ACCURACY ASSESSMENT (GIS AND MODIS CLASSIFICATION)

The accuracy of the classification of MODIS data for the paddy rice map was estimated by applying the validation data obtained from Google Earth data around 2018 in the study area. The field trips were conducted in the study area in February 2018 dry season for rice's second crop and the August 2018 rainy season for rice's main crop. The total rice crop areas classified from MODIS data were compared with OAE rice statistics data for both rice's main and second crop as showed in Figures 3 and 4. The statistics Regression Model was calculated based on the linear correlation between the dependent variable (OAE data) and independent variable (MODIS data). The results of MODIS data classification is highly correlated with the OAE statistic data as the coefficient R squared as 0.9995 for the rice's main cop and as 0.9974 for the rice's second crop as depicted in Figures 5 and 6.

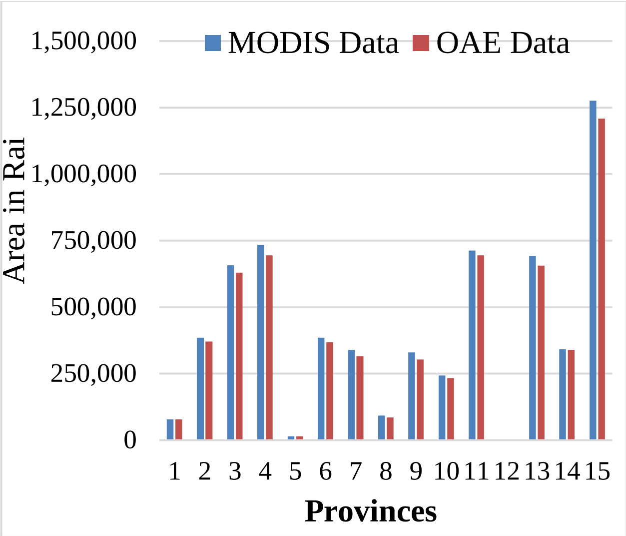

Figure 3: Area of the main-crop rice of 15 provinces for 2018.

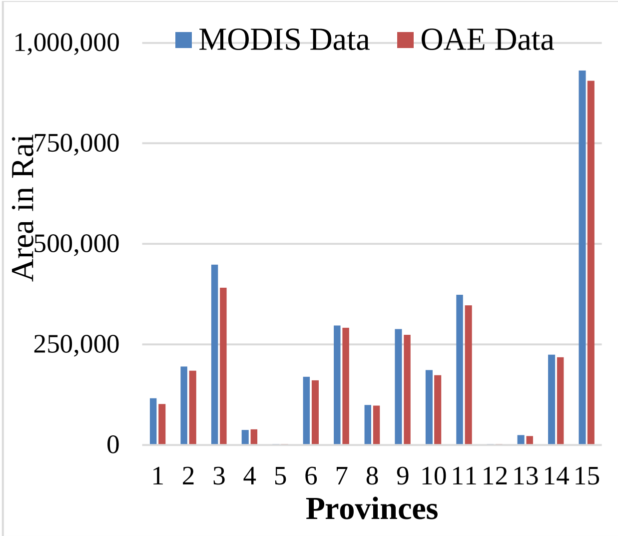

Figure 4: Area of second- crop rice for 15 provinces in 2018.

***Note:* 1 Bangkok 2 Kanchanaburi 3 Chachoengsao 4 Chonburi 5 Trad 6 Nakhon Nayok 7 Nakhon Pathom 8 Nonthaburi 9 Pathumthani 10 Chonburi 11 Lopburi 12 Samut Songkham 13 Sakaew 14 Saraburi 15 Suphanburi**

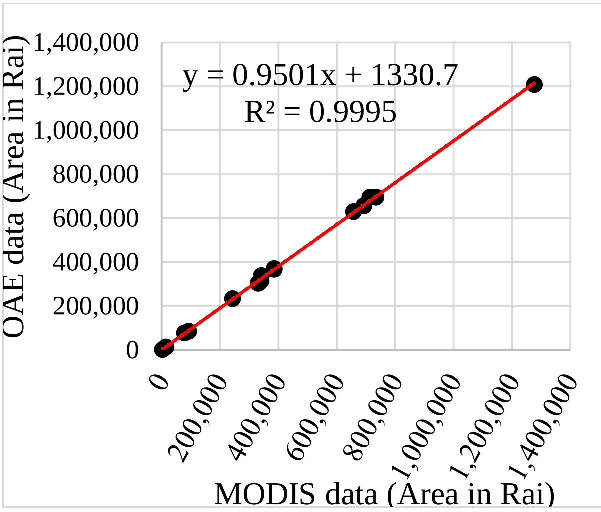

Figure 5: Area of rice main-crop MODIS data versus OAE data for 2018 (units: Rai).

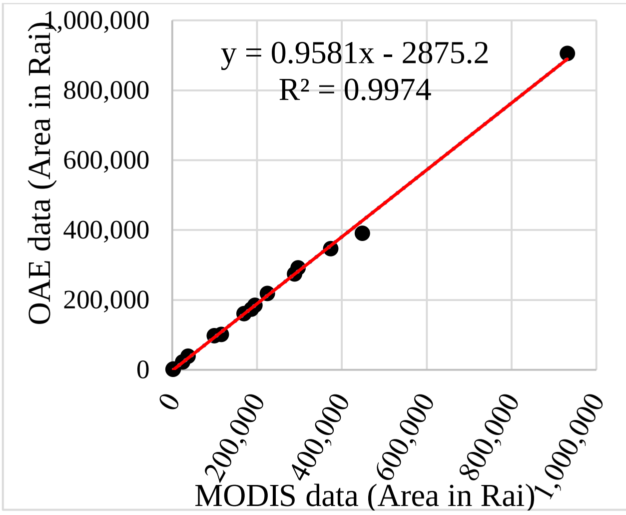

Figure 6: Area of rice second crop MODIS data versus OAE data for 2018 (units: Rai).

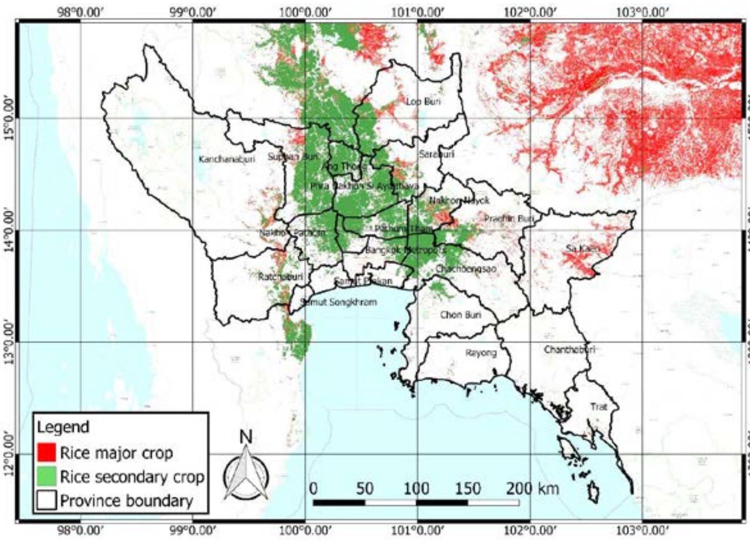

Figure 7: Rice Crop map processed from MODIS data.

4.2 GIS ANALYSIS AND RICE CROP MAPPING

The rice crop areas are calculated in Rai and its attribute data includes different crops as a main and second crop with its productivity estimation as illustrated in Figure 7. The attribute data will include the yield of the total crop area. Because yields are typically represented in the unit of kg/Rai (kilograms of granule per Rai) that were collected by interviewing the farmers and also referring to reports released in OAE agricultural crop data as shown in Table 2.

Table 2: Rice productivity estimation from MODIS data

Provinces	Yield (kg/Rai)	Major crop 2018		Secondary crop 2018		Total Productivity 2018 (Ton)
		MODIS data area (Rai)	Productivity (Ton)	MODIS data area (Rai)	Productivity (Ton)	
Bangkok	640	78,251	50,081	115,734	74,070	124,151
Kanchanaburi	743	385,282	286,265	194,954	144,851	431,116
Chachoengsao	718	656,893	471,649	448,463	321,996	793,646
Chonburi	659	733,918	483,652	37,533	24,734	508,386
Trad	566	14,347	8,120	2,383	1,349	9,469
Nakhon Nayok	678	385,330	261,254	169,625	115,006	376,259
Nakhon Pathom	777	339,809	264,032	297,108	230,853	494,885
Nonthaburi	710	92,149	65,426	99,525	70,663	136,089
Pathumthani	732	329,955	241,527	288,346	211,069	452,596
Chonburi	736	242,409	178,413	186,377	137,173	315,586
Lopburi	660	712,840	470,474	373,545	246,540	717,014
Samut Songkham	698	2,033	1,419	1,901	1,327	2,746
Sakaew	571	692,343	395,328	24,484	13,980	409,308
Saraburi	657	341,498	224,364	224,341	147,392	371,756
Suphanburi	719	1,276,610	917,883	931,338	669,632	1,587,515

5. CONCLUSION

The updated information for agricultural crops especially for rice crops is very important for policy decision making and socio-economic development. However, official statistical data will be available next year. Satellite image as MODIS data is widely used for environmental applications and free of charge that can be downloaded from the internet. This study uses updated MODIS data for rice crop classification to produce spatial mapping and statistical data for rice crop monitoring. The results are then compared with the government statistic AOE data for accuracy assessment. The linear regression models for rice in main and second crops are calculated for predicting the crop planting area and yield for rice productivity. The results of MODIS data classification is highly correlated with the OAE statistic data as the coefficient R squared as 0.9995 for the rice's main cop and as 0.9974 for the rice's second crop. Rice crop monitoring and mapping estimate rice-planting time of the fifteen provinces in central Thailand for the year 2018 is conducted in this study. The results clearly represented the spatial identification of rice planted in road accessed areas and water supply sources. As MODIS data has a limitation of low spatial resolution as 250m x 250m, further research may used alternative data for investigations and applies for slope map and microwave remote sensing data.

6. AVAILABILITY OF DATA AND MATERIAL

Data can be made available by contacting the corresponding author.

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