RICE YIELD POTENTIAL FROM SPOT-5

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ABSTRACT : Rice production areas in Phrom Phiram district had been classified from SPOT-5 images which contained four bands, B1 (NIR) in the visible, B2 (red), B3 (green) and B4 (SWIR) in the short wave infrared (1.550-1.700 µm). SPOT-5 had been supported by Geo-Informatics and Space Technology Development Agency (Public Organization), Thailand. Field survey and interview farmers for paddy field managements were done by Regional Center of Geo-Informatics and Space Technology Lower Northern Region. The off-season rice data had been sampling from 41 plots. Measurement of plant spacing, tiller diameter, tiller height, tiller number/unit area, panicle number/unit area were collected from vegetative phase, reproductive phase until ripening phase. Infoterra EADS Astrium France had supported Overland software for classified paddy field areas which base on growing stage of rice. For the rice yield potential (Y) was calculated by Multiple Regression. Variables analysis showed that the correlation of green cover fraction at heading stage (GLCV) and number of rice growing days (PLANDATE) had been calculated and showed as following equation.

$$Y = \underset{(t=2.652)}{284.396} + \underset{(t=2.910)}{335.464}\ GLCV + \underset{(t=3.692)}{3.697}\ PLANDATE$$

1. Introduction

Phitsanulok province is located on lower northern region and 377 km by road from Bangkok. Phitsanulok area was 10,815.8 square kilometers and divided into 9 districts: Muang, Bang Krathum, Bang Rakam, Chat Trakan, Nakhon Thai, Noen Maprang, Phrom Phiram, Wang Thong and Wat Bot. In 2005, rice cultivation areas in wet season rice were 225,053.12 ha, and total production was 1,052,232 tons. For the important irrigation sources for paddy field is irrigated from Naresuan Dam. Naresuan Dam had capacity to serve agriculture lands about 230,880 ha. Cause of enough water supply for whole year cultivation, most of rice production was cultivated from Phrom Phiram district.

Crop yield estimation on in many countries are based on conventional techniques of data collection for crop and yield estimation based on ground-based field visits and report. Such reports are costly, time consuming and large errors due to incomplete ground observation which leading to poor crop yield assessment and crop area estimation (Reynolds *et al*, 2000). Many empirical models have been developed to try and estimate yield before harvesting. With the development of satellites, remote sensing images provide access to spatial information at global scale; of features and phenomena on earth on an almost real-time basis. They have the potential not only in identifying crop classes but also estimating crop yield they can identify and provide information on spatial variability and permit more efficiency in field scouting (Schuler, 2002). Remote sensing could be used for crop growth monitoring and yield estimation. For example, the traditional approach of crop estimation in India involves complete enumeration for estimating crop acreage and sample surveys based on crop cutting experiments for estimating crop yield. The crop acreage and corresponding yield estimate data are used to obtain production estimates (Singh *et al*, 2002). Final production estimates based on the sampling method become available after the crops are actually harvested. Although the approach is fairly comprehensive and reliable, there is a need to reduce the cost and also to improve upon the accuracy and timeless of crop production statistics. Yield estimates predicted before actual production are required for taking various policy decisions. Hence, early assessment of crop yield is necessary, particularly in countries that depend on agriculture as their main source of economy. It enhances timely provision of information for use in food security. The launching of satellites of IRS-1A and 1 B in 1998 and 1991, respectively, and other satellites, a lot of efforts are made to use remote sensing for yield estimation. To achieve timely and accurate information on the status of crops and crop yield, there is need to have an up-to-date crop monitoring system that provides accurate information on yield estimates way before the harvesting period. The earlier and more reliable information are the greater the value (Harmer *et al*, 1996; Reynolds *et al*, 2000). Remote sensing data has the potential and the capacity to achieve this.

2. Objective of the Study :

2.1 To predict the rice yields and products from SPOT 5 by using RS and GIS in Phrom Phiram District, Phitsanulok Province.

3. Research area :

The study was conducted in Phrom Piram district in Phitsanulok province, Thailand. The district covers area of 831.57 square kilometers. Phrom Piram geography is generally flat.
The district is subdivided into 12 communes (tambon or sub-district), which are further subdivided into 119 villages. There are Phrom Phiram, Tha Chang, Wong Khong, Matum, Ho Klong, Si Phirom, Taluk Thiam, Wangwon, Nong Khaem, Matong, Thap Yai Chiang and Dong Prakham sub-districts. It is bounded by Pichai district, Uttradit province, on the North, Muang Phitsanulok district on the South, Kong Krailat district, Sukhothai province on the West and Wat Bot district on the East (Fig. 1).

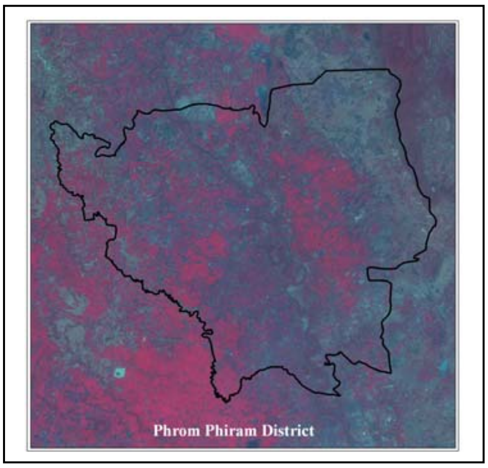

Fig. 1 Boundary of Phrom Phiram district, Phitsanulok province

4. Methodology :

4.1 Remote sensing data

Rice production areas in Phrom Phiram district had been classified from SPOT 5 images which contained four bands, B1 (NIR) in the visible, B2 (red), B3 (green), B4 (SWIR) in the short wave infrared (1.550-1.700 µm). SPOT 5 had been supported by Geo-Informatics and Space Technology Development Agency (Public Organization), Thailand. The overland software program had been supported by Infoterra, France. Satellite images used for this study had derived from SPOT 5 on 23rd January 2006, 23rd February 2006, 7th March 2006 and SPOT 2 on 14th February 2006 with multi-spectral images. Environmental data and growth stage from seedling until harvesting had been recorded in each sampling plots. Paddy field in seedling, tillering, heading and harvesting stages had been classified. Boundary of paddy fields and other areas had been digitized. From four bands of SPOT had been derived to 6 images following the overland concept on biophysical variables. Biophysical variables refer to physical or chemical characteristics of the land surface, there were soil fraction (scv), soil brightness (sb), green cover fraction (glcv), brown cover fraction (blcv), vegetation brown ratio (xsf) and Water fraction(wcv).

4.2 Field survey

The off-season rice data had been sampling from 41 plots. The consideration data were the plot locations, farm sizes, short day or long day cultivars, land preparation, sowing date, irrigations times, pesticides management, amount of seed sown, planting methods. Off-season rice was usually begun on 1st November until 30th April, in each year. Environmental factors for rice yield forecasting consisted of internal and external factors. The internal factors were plant spacing, tiller diameter, tiller height, tiller number/unit area, panicle number/unit area were collected from vegetative phase, reproductive phase until ripening phase. The external factors consisted of biotic and non-biotic factor. The biotic factors were plant diseases, insect pests and giant apple snail. The non-biotic factors were water management, relative humidity, temperature and fertilizer levels.

4.3 Remote sensing and Geo-Informatics

4.3.1   Image Geo metric correction the satellite data. Classification rice production areas in difference growth phase by 4 dates of SPOT images. Biophysical variables maps were generated in term of soil fraction (scv), soil brightness (sb), green cover fraction (glcv), brown cover fraction (blcv), vegetation brown ratio (xsf) and water fraction (wcv). Evolution of the biophysical parameters during the rice development, land preparation evolved as soil cover fraction, seedling stage evolved as soil cover fraction and green cover fraction, tillering stage evolved as green cover fraction, heading stage evolved as green cover fraction and brown cover fraction, maturing stage evolved as brown cover fraction and soil cover fraction.

4.3.2   Rice Fields Analysis. Overland software was using for rice field analysis. Image from bands of soil fraction (scv), soil brightness (sb), green cover fraction (glcv), brown cover fraction (blcv), vegetation brown ratio (xsf) and water fraction (wcv) had been analyzed for classified planting areas in each growth stage of rice. (Fig. 2)

Growth stage of rice had been classified into 5 phases

Phase 0 : Land preparation or bared land.   Phase 1 : Seedling stage

Phase 2 : Tillering stage. Phase 3 : Heading stage (reproductive stage)

Phase 4 : Maturing stage (harvesting stage)

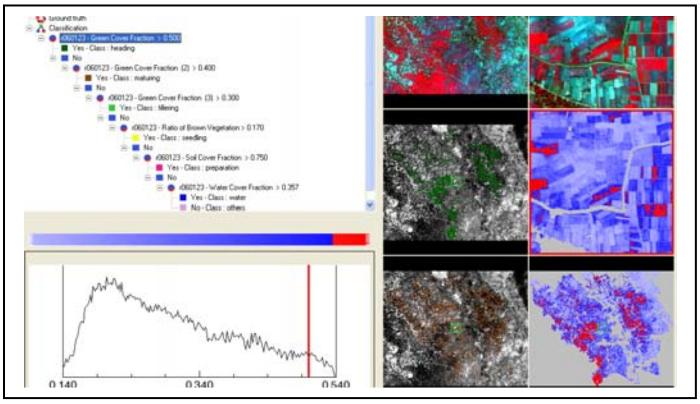

Fig. 2 Rice Fields Analysis by Overland software

4.4 Rice Yield Potential Modeling. The correlation of rice yield potential could calculate from green cover fraction at heading stage with rice growing days as following table and equation .

Rice Yield Potential = f (green cover fraction, rice growing days)

Correlations

		Rice yield potential	Green cover fraction at Heading stage	rice growing days
Rice yield potential	Pearson Correlation	1	.228*	.317**
	Sig. (2-tailed)		.031	.002
	N	90	90	90
Green cover fraction at Heading stage	Pearson Correlation	.228*	1	-.161
	Sig. (2-tailed)	.031		.129
	N	90	90	90
rice growing days	Pearson Correlation	.317**	-.161	1
	Sig. (2-tailed)	.002	.129	
	N	90	90	90

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

5. Results

5.1 Classification of rice area using from SPOT images.The SPOT images dated on 23rd January 2006, 23rd February 2006, 7th March 2006 and SPOT 2 on 14th February 2006 with multi-spectral images had been using for classification the paddy field areas. Satellite images showed different of color tones in different growing stages (Fig. 3-6).

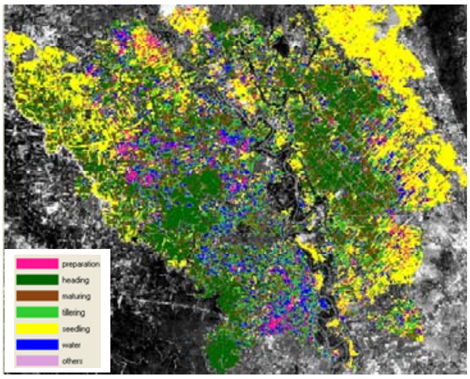

Fig 3 Growth stage of rice on Phrom Phiram, Phitsanulok, Thailand, on 23rd January 2006

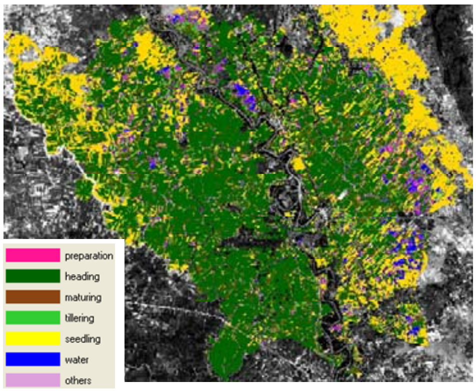

Fig 4 Growth stage of rice on Phrom Phiram, Phitsanulok, Thailand, on 14th February 2006

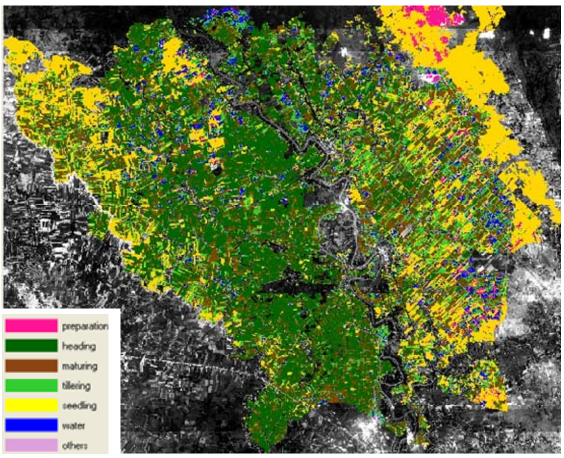

Fig 5 Growth stage of rice on Phrom Phiram, Phitsanulok, Thailand, on 23rd February 2006

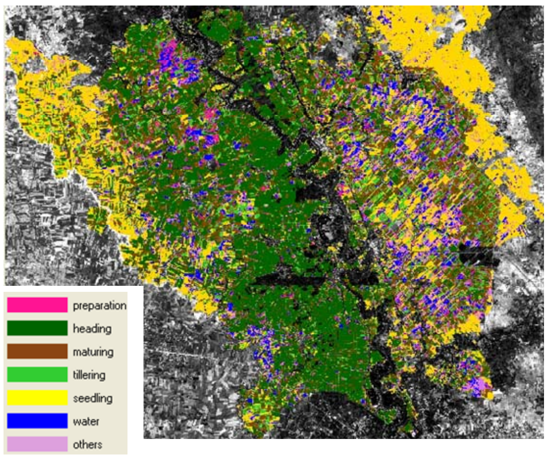

Fig 6 Growth stage of rice on Phrom Phiram, Phitsanulok, Thailand, on 7th March 2006

5.2 The field survey had begun from January to March 2005. Primary data on land and land use for irrigated rice or off-season was collected from the farmers through interviews. The interviews were conducted on farmer fields. Paddy fields data were collected from 41 sampling plots. The rice data on seedling, tillering, heading and maturing stages were collected on 23rd January 2006, 23rd February 2006, 7th March 2006 and 14th February 2006. The analyzed field survey and satellite image showed that the rice population or planting area is highest in January which calculated as 48.36% of the total paddy field areas and no rice production in April. Cause of Phrom Phiram district was located in irrigated areas, therefore paddy field could be continuous planting and harvesting. The harvesting time had also begun from January until June. Most of rice grains were harvested in April, which the rice yield was calculated as 49.12% of total paddy field area (Fig.7 and Table 1).

Table 1 Off season Rice planting and harvesting areas during November 2005 until June 2006, in Phrom Phiram District

Month/year	Planting area (%)	Harvesting area (%)
November 2005	9.85	-
December 2005	22.65	-
January 2006	48.36	-
February 2006	11.93	4.60
March 2006	7.22	14.22
April 2006	-	49.12
May 2006	-	20.68
June 2006	-	11.38

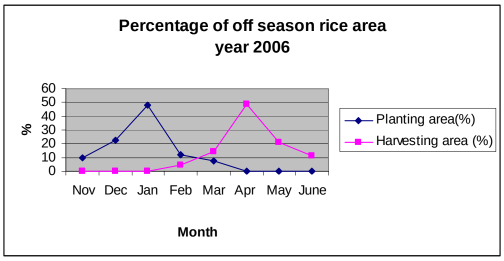

Fig7 of planting and harvesting areas of irrigated paddy fields in Phrom Phiram District during November 2005 until June 2006.

5.3 Remote sensing and Geo-Informatics

Remote sensing technique was using to generate set of biophysical variables. Biophysical variable maps were analysis. Main biophysical variable are vegetation, soil and water. Vegetation fraction in this research had concerned on green cover fraction (glcv), Brown cover fraction (blcv) and vegetation brown ratio (xsf). Soil cover fraction had concerned on soil brightness (sb) and soil fraction (scv). Water cover fraction had concerned on water fraction (wcv) and water height (mwh). From satellite images showed that the most of land preparation done in January (Table 2).

Table 2 Four dates of SPOT images in difference growth stage of rice.

Stage	Planting Area (ha.) / SPOT images			
	23-Jan-06	14-Feb-06	23-Feb-06	7-Mar-06
Land preparation	1,503	642	1,195	892
Seedling	13,562	5,117	2,614	2,551
Tillering	16,103	17,658	13,902	11,379
Heading	5,234	11,128	16,493	17,197
Maturing	2,462	4,319	4,660	6,845
Total	38,864	38,864	38,864	38,864

5.4 Rice Yield Potential Modeling

The correlation of green cover fraction at heading stage and rice yield potential had been calculated and showed as following equation:

$$Y = 594.337 + 266.850\ GLCV \ldots\ldots(1)\ ;\ R^2 = 0.052,\ F = 4.812,\ Sig.=0.031$$
$$(t=8.333) \qquad (t=2.194)$$

From above equation and the value of R^2 about 0.052 with an F value of say 4.812 at .05 level of significant. The effect of green cover fraction at heading stage to rice yield potential was 5.2% of the total factors. Another of the variation in rice yield potential is effect to by factors other than accumulation of green cover fraction at heading stage.

The correlation of green cover fraction at heading stage and number of rice growing days had been calculated and showed as following equation

$$Y = 284.396 + 335.464\ GLCV + 3.697\ PLANDATE \ldots(2);\ R^2 = 0.18,\ F = 9.566,\ Sig.=0.000$$

(t=2.652) (t=2.910) (t=3.692)

From equation (2) and the value of R^2 about 0.18 with an F value of say 9.566 at .01 level of significant. The effect of green cover fraction at heading stage and number of rice growing days to rice yield potential was 18% of the total factors. Another of the variation in rice yield potential is effect to by factors other than accumulation of green cover fraction at heading stage. The results from both equation showed that green cover fraction at heading stage and land management ware main factors to rice yield potential.

6. Conclusion and Recommendations:

From linear regression of this research showed that the effect of green cover fraction at heading stage to rice yield potential was only 5.2% of total factor. In addition, if consideration green cover fraction at heading stage and rice growing days to rice yield potential was 18% of the total factors. For the future research should be consideration other factors such as pest and land management. The satellite image for rice yield estimation should be derived from the same satellite.

7. Acknowledgement:

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8. Literature Reviews

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