Rice crop monitoring in Thailand using field server and satellite remote sensing

P Rakwatin[1],A Prakobya[1], T Sritarapipat[1], B Khobkhun[1], K Pannangpetch[2]; S Sobue[3], Kei Oyoshi[3], T Okumura[4], N Tomiyama[4]

[1]Geo-Informatics and Space Technology Development Agency, 120 The Government Complex, Building B 6th Floor, Chaeng Wattana Road, Lak Si, Bangkok 10210, THAILAND

[2]Department of Plant Science and Agricultural Resources, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand

[3]Earth Observation Research Center, Japan Aerospace Exploration Agency, 2-1-1, Sengen, Tsukuba, Ibaraki, 305-8505, Japan

[4]RESTEC (Remote Sensing Technology Center of Japan)TOKYU REIT Toranomon Bldg., 2F,3-17-1 Toranomon, Minato-ku, Tokyo 105-0001 Japan

E-mail: preesan@gistda.or.th

Abstract. Rice is the staple food crop consumed by more than 50% of the world population. It supplies more calorie intake in developing countries than any other food in the world. Thailand is one of the top rice exporters in the world. Rice is the most important economic crop in Thailand with 3.7 million rice farm households. It is a major income source and nutrient for rural families. Accurate monitoring and mapping of the rice crop areas are critical for regional rice cropping/water managements and estimates of rice yield [1]. Remote sensing does seem to be the most reliable measurement tool for accurate rice crop monitoring over large areas. This article presents the research activities to assess and monitor rice paddy in Thailand using Field server and satellite remote sensing.

1. Introduction

Rice is the staple food of the Thai people. It is rich in nutritional value and very important in Thai culture. Rice also plays an important role in Thai economy because Thailand has high volume of exports, Thai rice is known around the world especially, the "jasmine rice", a breed of long grain rice for its taste and fragrance. Its crop cycle is 5–6 months; most are planted in the rainy season. That is called single crop cycle per year. Since Thailand has two patterns of rice cultivation, namely, season rice and out of season rice, the latter has shorter growing period. Rice can be grown throughout the country, depending on the availability of water. Therefore, areas with irrigation have higher potential.

Change detection and classification of agricultural produce can be achieved by the use of remote sensing, which is the monitoring of the situation of the agricultural areas with a large coverage at once. It is possible to distinguish difference crops on the field. It can also be used to evaluate agricultural production as well. Principles of remote sensing systems; the use of reflection of the wave and the energy released by the object can be used for such application. The data appear as a digital number, derived from sensors mounted on aircraft or on satellites. Each orbiting track covers a wide area. The data in the form of signal spectrum, when analyzed and interpreted in the form of a map, can be used as numerical data, table or chart.

On the other hand, in-situ data is necessary for calibration and validation the production derived from satellite images. To collect the in-situ data, it is very costly and time consuming. Therefore, field server (FS) seem to answer the difficulties that we faced. FS is an Internet Field Observation Robot that consists of a set of multiple sensors, a web server, an Internet Protocol (IP) camera, as well as wireless interfaces. It is designed to provide an outdoor solution for environment monitoring.

This study aims to present recent development of rice monitoring in Thailand using field server and satellite remote sensing. The rice phenology with NDVI from 16 day MODIS data and rice crop height detection are shown here. We show the potential of using field server to measure rice crop height based on digital image processing techniques. A digital camera in field server provides photos of the rice crop field. Rice crop height can be indirectly measured by measuring marker bar height. The benefits of the method are: reducing manual works, less cost, fast computing and real time assessment The results of the study are useful to development of crop management systems, setting of Thai rice prices and insurance systems, which will affect planning and rice growing farmers, ultimately leading to better living standards for the farmers.

2. Study area

Since rice farming in Thailand spreads all over the country, this study chose an area in central part of the country, as shown in Figure 1 as a study area where it has good irrigation system; there are several major rivers to make form of agriculture that range. This area is in the river plains interspersed with hills, suited to agricultural activities. The study area is located on the tropical grasslands, near the equator, with moderate rainfall, and occasional drought. Rainy season is during May to October to make enough water to grow for rice. In dry season, irrigation systems are support to cultivation that makes the area is suitable for cultivation [2] [3]. The climate in the area, the lower part of the area is wetter than the upper part of the area.

Figure 1. Study area

3. Satellite monitoring rice growth

In this study, Terra MOD13Q1 (Vegetation Indices) was used which is all about the vegetation index of the 16 days cycle at resolution of 250 meters by using index difference vegetation and NDVI. The imagery covered an eleven-year time series, from 2000 to 2010 for made to the phenology of the plant cover. In particular, the area planted with rice. Time series data is the normalized difference vegetation index (NDVI) used in the analysis area **[2]**. The MOD13Q1 is tile product, tool of mosaic and reprojection is “MODIS Reprojection Tool 4.1” to mosaic tile product and re-projected into Universal Transverse Mercator (UTM) Thailand is in zone 47-48. This tool can extract NDVI bands for MODIS data for analyze.

The MODIS time-series by Normalized Difference Vegetation Index (NDVI) data (16 days composite) have noise from inclement weather and clouds to effect the reflection of false light. The NDVI time series data of that pixel will have signal abnormalities. It is not the fact and affects the data analysis. Solution for use the time series to filtering noise signal **[3]** to obtain the time series of the NDVI accuracy by phenology of vegetation covering the area.

After filtering signal with Savitzky-Golay filter **[4]**. The signal of time-series is smoother, the acquired image data goes through a separate processing to demonstrate the characteristics of the different areas in the study area by means of the image data to the rest of the information needed to divide the area by the analysis component (PCA), which makes the rest of the information is necessary for the divided by the area of the signal in the same manner and to identify areas with a colour space that can be divided into groups.

The results are shown in Figure 2, which is noted that in each area has a signal that varies according to land use by agricultural activities. Divided by the area of water in urban areas, mountainous areas of rice fields and with other types of farming in Figure 2 is the variation of the signal varies. This area covers an area around the farm, park, hilly area, water, etc. all exhibit difference signal that is expressed in different forms. This study contents on the area planted with rice by single crop planting and multi crop pattern where signal varies. When the area is planted with multi crop, it showed different patterns that are altogether there cases: two crops per year, two to three crops per year and three crops per year depending on the natural topography of the multi crop planting area in the river basin.

4. Field server

Field server has been developed [5] [6] for monitoring environment parameters. Field server provides various sensors, cameras, communication and control units. A digital camera is a sensor that converts an optical image into an electronic signal. Communication units are used in transmission of sensor data and command data between field server and computer server. Control units are used to command system of the field server. Power supply unit supplies electric power to electrical loads. control unit was programmed to manage sensors and cameras including the system. When the sensor measures environment, observation data is acquired to stored unit and transferred to computer server. Data is collected in computer server and managed to display on webpage. Users can access data through web browser via internet. The data is separated into two display types; (1) log data for common sensor (2) image series for camera sensor.

The field server technology is useful to monitor environments or activities through sensors and cameras. Users can collect data such as rain, humidity, wind, temperature, soil moisture etc. to support planning and management. Each sensor of the field server, temperature sensor measures air temperature while humidity sensor measures air humidity. Both sensors are used in combination to reduce cost. Rain gauge tipping-bucket is an instrument to gather and measure the amount of liquid precipitation over a set period of time. An anemometer is a device for measuring wind speed, and is a common weather station instrument. The device is used to describe any airspeed measurement instrument used in meteorology or aerodynamics. Anemometers can be divided into two classes: those that measure the wind's speed, and those that measure the wind's pressure. Pyranometer is used to measure broadband solar irradiance on a planar surface and it is designed to measure the solar radiation flux density. A soil moisture sensor measure the amount of moisture found in the soil. It is most often used for agriculture. This sensor can measure moisture right near roots. DSLR (Digital single-lens reflex) Cameras are provides RGB (Red, Green, Blue) and NIR (Near infrared) images.

Field server shown in Figure 3 is installed for monitoring rice crop field. As sensor of field server, a digital camera is used as the sensor to provide photos of rice crop field. The height of rice crop can be measured form the photos. Since rice height is hard to directly measure because its stalk is quite small and there are so many rice plants in any particular field. Rice crop height can be indirectly measured by measuring marker bar height. The images compose of rice plants and the marker bar. The marker is focused and detected for measuring while the other things such as rice field, soil, cloud, and sky are defined as background. The proposed method gives an average height of rice crop in the field. Figure 3 shows Field server at a rice crop field in Suphan-buri province, Thailand. The product image of this field server is also shown in Figure 4

The marker is detected for indirect measuring of rice crop height. For digital image processing techniques, feature selection method is used to remove redundant features. Feature extraction module extracts more differential features between the marker bar and the others. Image segmentation is applied to separate the marker bar and the others. The marker bar is detected and compared with initial marker bar for measuring rice crop height. The flowchart of this method is shown in Figure 4 and the detail is described in four topics of feature selection, feature extraction, image segmentation and measuring [7].

The rice crop height can be reliably measured by human evaluation of the image. Therefore, the results of this method is set as the reference and compared with the results of our proposed method. Relative error index is selected to verify accuracy of our experimental result. The experimental result is shown in Figure 5. For single crop per year, the corresponding NDVI signature show two peaks a year, but the smaller peak of NDVI represents the grass growth at the start of the rainy season (or natural re-growth on residual moisture). For two or more crop per year, farmers start planting whenever water is available and vary the number of crops per year, and thus it is very difficult to define an exact crop calendar of this area. In this area, rice is grown from one to three times per year.

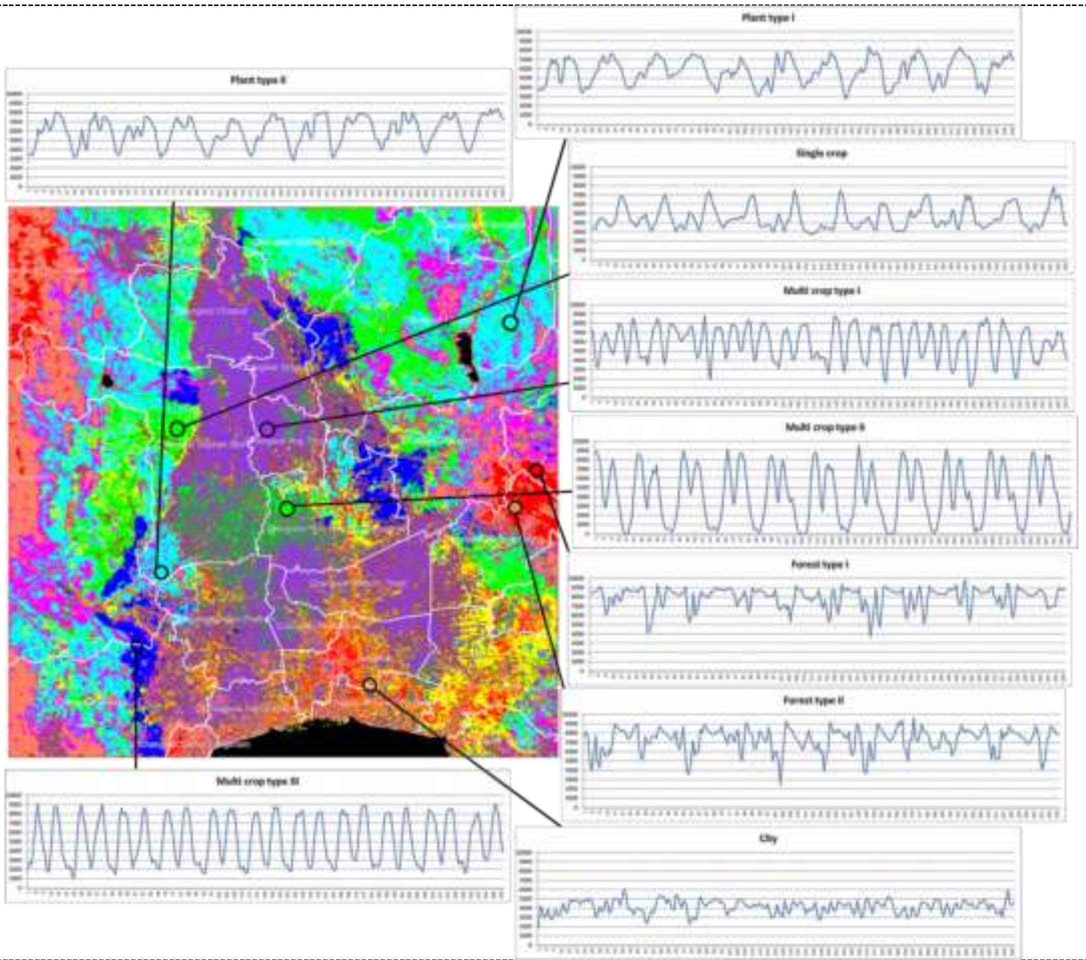

Figure 2. Area grouping based on NDVI

Figure 3. The field server at a rice crop field in Supanburi province, Thailand

Figure 4. Photo showing rice crop height monitoring at a rice crop field in Suphanburi province, Thailand

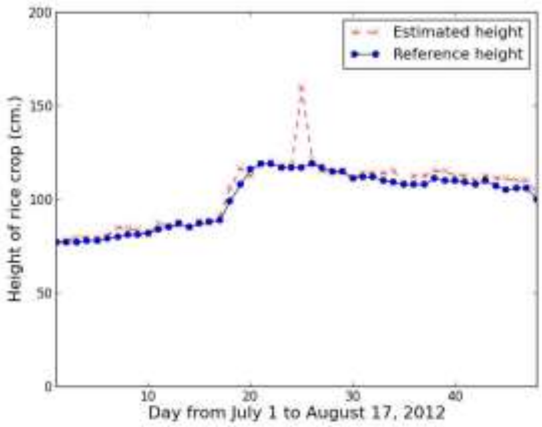

Figure 5. Rice crop height series from date of July 1 to August 17, 2012 using automatic height detection algorithm

5. Conclusion

This study aims to present recent development of rice monitoring in Thailand using field server and Terra MODIS images. The results of research by NDVI time series indicated that the areas in the study area have some form of agricultural activity with a lot of varieties. The study area covers an area around the farm. Farm land, park, hilly area, water, etc. all exhibit difference signal that is expressed in different forms. This study contents on the area planted with rice by single crop planting and multi crop pattern where signal varies. When the area is planted with multi crop, it showed different patterns that are altogether there cases: two crops per year, two to three crops per year and three crops per year depending on the natural topography of the multi crop planting area in the river basin. This paper also presents a method for measurement of rice crop height using filed server and image processing technique. The proposed method can measure rice crop height effectively. This method can be adapted for the feature of the marker bar which depends on designation. The advantages of the method are four fold: replacing human evaluation, less cost, speedy operation and real time system.

6. References

[1] A. Bridhikitti and T. Overcamp, "Estimation of Southeast Asian rice paddy areas with different ecosystems from moderate-resolution satellite imagery," *Agirculture, Ecosystems, and Environment,* pp. 113-120, 2012.

[2] M. Boschetti, D. Stroppiana and e. al., "Multi-year monitoring of rice crop phenology through time series analysis of MODIS images," *International Journal of Remote Sensing,* vol. 30, pp. 4643-4662, 2009.

[3] Y. Julien and J. Sobrino, "Comparison of cloud-reconstruction methods for time series of composite NDVI data. Remote Sensing of Environment," vol. 114, pp. 618-625, 2010.

[4] A. Savitzky and M. Golay, "Smoothing and differentiation of data by simple least squares procedures.," *Analytical Chemistry,* vol. 36, pp. 1627-1639, 1964.

[5] T. Fukatsu and M. Hirafuji, "Field monitoring using sensor-nodes with a Web server," *Journal of Robotics and Mechatronics,* vol. 17, p. 164–172, 2005.

[6] T. Fukatsu, M. Hirafuji and T. Kiura, "An agent system for operating web-based sensor nodes via the internet," *Journal of Robotics and Mechatronics,* vol. 18, p. 186– 194, 2006.

[7] R. Gonzales and R. Woods, Digital image processing (second edition), Prentice Hall, 2008.