Time Series Analysis of SPOT VEGETATION Instrument Data for Identifying Agricultural Pattern of Irrigated and Non-irrigated Rice cultivation in Suphanburi Province, Thailand

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Abstract: In this paper, we present the different characteristics of NDVI fluctuation pattern between irrigated and non-irrigated area in Suphanburi province, in Central Thailand. For non-irrigated rice cultivation area, there is a strong correlation between NDVI fluctuation and peak rainfall, while there is a lower correlation with irrigated area. In this study, the "peak detector" classifier was developed to identify the area of non-irrigated and irrigated cropping and its cropping intensity (number of crops per year). This classifier was created based on cropping characteristics such as number of crops, time or planting period of each crop and its relationship with the peak of rainfall. The classified result showed good accuracy in identification irrigated and non-irrigated rice cultivation areas.
Keywords: Time series analysis, NDVI Time series, SPOT VEGETATION Instrument data, Agriculture pattern.

1. Introduction

The estimation of crop production for food security planning, near real-time identification of actual crop patterns such as irrigated or non-irrigated land, it is necessary to identify the number of cultivations in a year. Remote sensing has played an important role for many years in this analysis. The main objective of this study is to use multi-temporal Normalized Difference Vegetation Index (NDVI) and rainfall data to improve the estimation of actual irrigated area at a global scale. Initially, this study focuses on multi-temporal NDVI of irrigated and non-irrigated crops at local scale. Rice, the most important cereal crop in Asia, has been selected as a pilot crop. Suphanburi province in Thailand is suitable as a pilot area because the dominant of agriculture activity in this area is rice cultivation, both with and without irrigation.

2. Data and Analysis steps

The SPOT 4, currently in operation, is orbiting the earth at an altitude of 832 km, in a 26-day cycle. SPOT 4 has two kinds of sensors: Haute Resolution Visible Infra-Red (HRVIR) instrument and the VEGETATION instrument, allowing the daily observation of 2,250 km in swath width, with a resolution of 1.15 km for almost all the area, excluding some parts around the equator. As the VEGETATION instrument covers almost all of the earth everyday, therefore it is possible to obtain relatively frequent data on cloud free days [4].

In this study, 10-day composites of NDVI data, observed from January 1999 to December 2001, were analyzed. Local Maximum Fitting (LMF) was executed for the correction of 10-day composite data in order to consolidate cloud free data, while spatial resolution was retained. The LMF processing combines time series filtering with a functional fitting technique and, removes the effect of clouds, haze and other atmospheric effects from the NDVI time series data of each pixel and extracts the seasonal change pattern of the ground [3].

The areas of irrigated and non-irrigated rice were defined based on Landsat TM (08 Jan 2002) and rechecked in the field at selected sample sites. The analysis steps is shown in Figure 1

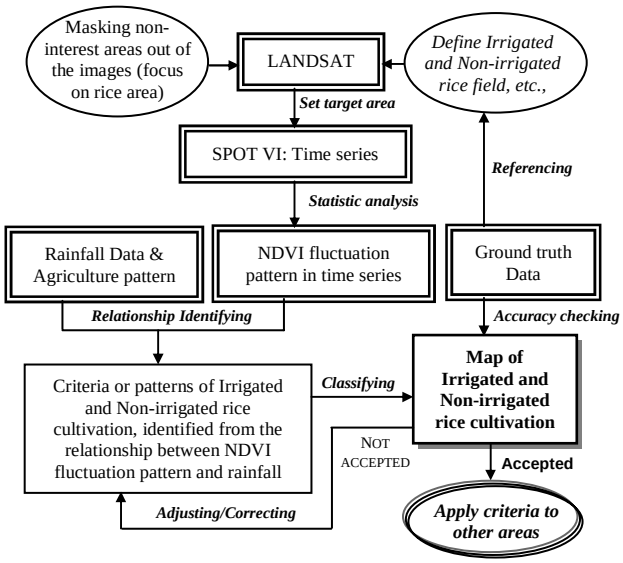

Fig. 1. Analysis steps

Crop calendar and NDVI fluctuation curves are used to select the visiting time to the ground-truth sites. In this area, dry season cropping starts in February-March. The calendar shown in Table 1 is the most common and corresponds to the "official" period of water distribution by RID (Royal Irrigation Department). Areas located at the tail end of the network will generally get water as late as the end of March, which may preclude farmers from planting dry season rice [2].

Table 1. The most common and "official" period of water distribution by RID

Zone description	Jan	Feb	Mar	Apr	May	Jun	Jul.	Aug	Sep	Oct	Nov	Dec
Common Calendar (Mae Klong/northern delta)				←	-	-	-	→	←	-	-	→

Field surveys have been conducted many times to the defined sites in different cropping seasons and stages of growth. Moreover ground truth data was used to check the accuracy of the classified image. If the classification result has low accuracy or is not acceptable, the criteria are adjusted until a satisfactory accuracy is obtained.

3. NDVI Time series analysis and Agricultural practice

An NDVI time series over 3 years (1999-2001) was analyzed continuously. The fluctuations of NDVI value over irrigated and non-irrigated areas were defined through field survey. The fluctuation pattern was compared to the rainfall pattern, which has its peak at the beginning of September and also with surveyed crop pattern. The fluctuation patterns of irrigated and non-irrigated rice cultivation are summarized in 3.1 and 3.2.

3.1) Non-irrigated Rice

Non-irrigated rice is planted only one time a year, starting around the middle to the end of August until the end of December to the middle of January. After harvesting in January, farmers always leave their field bare or change to pasture and will cultivate rice again in the next August (see Figure 2).

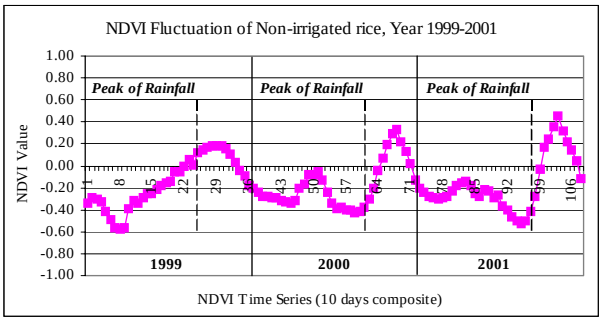

Fig. 2. Fluctuation pattern of Non-irrigated rice

3.2) Irrigated Rice

The observed sites with irrigated rice have different planting patterns, including with number of crops planting per year (2-3 crops per year) and cultivation pattern (homogeneous or heterogeneous fields). In large homogeneous rice areas, with two crops per year, the second crop always has lower density compared to that in the first half of year (see Figure 3).

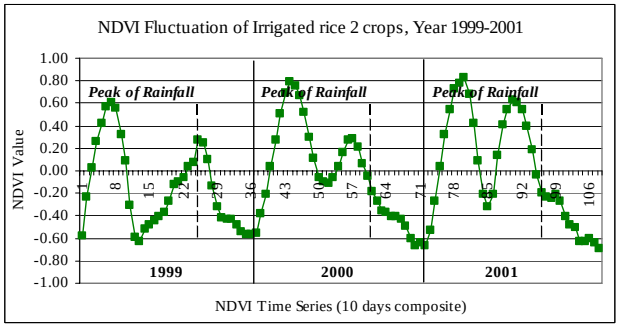

Fig. 3. Fluctuation pattern of Irrigated rice 2 crops/year

Figure 4 shows irrigated rice cultivation with 3 seasons per year in northern Suphanburi. With a good irrigation system in this area, farmers can continue planting 3 times per year.

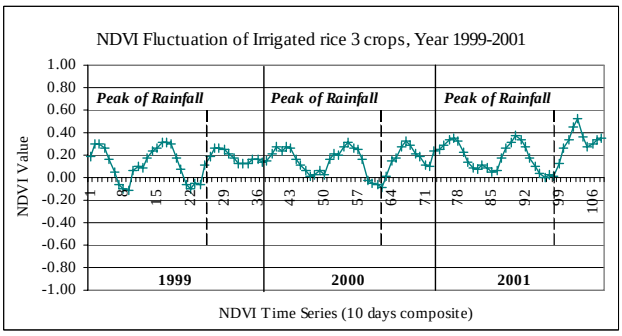

Fig. 4. Fluctuation pattern of Irrigated rice 3 crops/year

Figure 5 shows NDVI fluctuation pattern of irrigated rice cultivation 2.5 crop per year or 5 crops in two year.

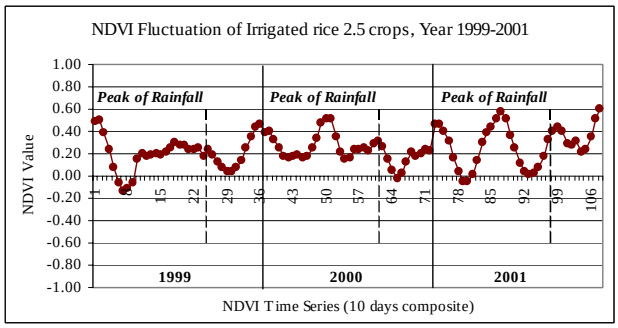

Fig. 5. Fluctuation pattern of Irrigated rice 2.5 crops/year

The result of NDVI fluctuation shows clear differences between irrigated and non-irrigated area.

In the non-irrigated area, the fluctuation pattern is rather similar throughout the study area. The pattern agrees with actual conditions on the ground, such as one high peak for cultivation and another low peak that indicates grass growth after harvesting. The NDVI fluctuation pattern in irrigated area varies from place to place, due to the influence of the unit size of cultivation (large continuous or patchy field) and water availability and position in the irrigation system. Homogeneous areas show a few big peaks. Fluctuation patterns in patchy fields show several low peaks, due to mixed crop calendars at each unit of cultivation.

4. Peak detector algorithm

The pattern of NDVI fluctuation in time series in various types of rice cultivation and its relationship with rainfall was summarized and developed into a set of criteria for the next step of classification. The details of the criteria are:

- The peak is the highest value among 9 neighbor values (we should find one peak only for 3 months)
- The peak value must be higher than 0.2
- If there are 2 or more peaks per year, it is irrigated rice.
- If there is only a peak per year and appears within 50-60 days after peak of rainfall (beginning of September), it is rain fed rice

This criterion was developed and assigned in IDL (the Interactive Data Language) for mapping actual irrigated and rain fed rice cultivation in the study area. Before the classification process, the unique areas of rice cultivation were extracted from a Landuse map (GIS coverage, 2000) from Office of Agricultural Economics (OAE).

5. Results and Discussion

In this paper, we present 3 years data that was classified into two classes: irrigated and non-irrigated area of rice cultivation by using peak detector algorithm. The verification was done in 2 methods.

First, the verification was done using ground truth data and the accuracy of the classified result was higher than 90%. Second, we overlaid vector data of irrigated zone in Suphanburi onto the classified results and the result was visually verified.

Figure 6 shows results of classification year by year (1999, 2000 and 2001) that were overlaid with vector data from the irrigation zone in Suphanburi. After visual verification, the overlaid vectors cover quite exactly the classes mapped as irrigated area. On the other hand, another class of non-irrigated rice is clearly located outside the vector of irrigation zone.

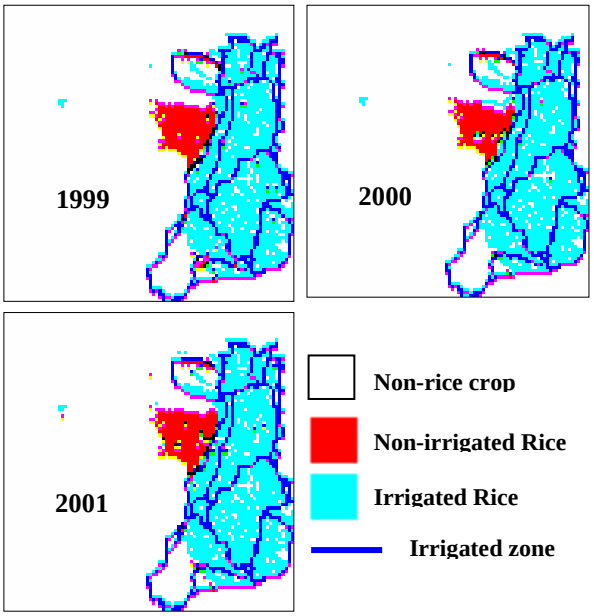

Fig. 6. Results of Irrigated area mapping

The classified results show high accuracy, however the algorithm for identifying irrigated and non-irrigated rice areas should be tested in other and/or larger rice areas. We are now trying to develop the peak detector algorithm to identify different practices of irrigated rice cultivation within the study area. In a future study, the pattern of other crops will also be observed. Finally, a reliable model, which relies on more general parameters (NDVI and Rainfall), is expected to result in irrigated area mapping capability at a global scale.

Acknowledgement

This research is funded by the Comprehensive Assessment, a programme of the International Water Management Institute (IWMI). We also wish to thank Dr. Supan Karnchanasutham from Office of Agricultural Economics (OAE) for supplying data for this research.

References

[1] Mark E. Jakubauskas, David R. Legates, and Jude H. Kastens, 2001. Harmonic analysis of time-series AVHRR NDVI data. *Photogrammetric Engineering & Remote Sensing* Vol. 67, No.4, pp. 461-470

[2] Kasetsart University, ORSTOM, 1996. Agricultural and irrigation patterns in the Central Plain of Thailand: Preliminary analysis and prospects for agricultural research and development. Bangkok, Thailand; DORAS Project, 224 pp.

[3] **URL:** LMF ALGORITHM, ANDES homepage. Available at http://www.affrc.go.jp/ANDES

[4] **URL:** SPOTSYSTEM, homepage. Available at http://www.spotimage.fr/home/system/introsat/payload/vegetati/welcome.htm