# ASSESSMENT OF POSSIBILITY OF USING SENTINEL-1 DATA IN COMBINATION WITH ORYZA MODEL FOR RICE PRODUCTION ESTIMATION: A CASE STUDY IN AN GIANG PROVINCE, MEKONG DELTA

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## ABSTRACT

*Rice monitoring and rice production estimation play an important role in agricultural sector. Understanding about growth conditions such as start of season, peak of season as well as rice extent and rice production are essential. The objective of this study is to combine Sentinel-1 data and rice yield estimation model (Oryza) to monitor rice area and estimate rice production in An Giang province. The study used Sentinel-1 data with 20m spatial resolution with 12-day temporal resolution together with Oryza model for monitoring and estimating rice extent and rice production of the Summer-Autumn season in 2016 in An Giang province. The approach used in this study is based on the analysis of changes in the scattered properties (sigma nought values) of rice growth conditions from April 2016 to September 2016. In addition, other parameters for instance rice variety, soil type, fertilizer rate, irrigation are used as the inputs to Oryza model for estimating rice yield. Results showed that in the Summer-Autumn 2016 season, rice area in An Giang province was 232,970 ha, this result is compared with the official statistical data and it showed good agreement with 97%. The rice extent has also validated base on 139 ground truth points and it showed very high overall accuracy (93.5%, Kappa index is 0.87). The results of rice production estimation indicated that in this season, the average yield was 5.67 tons per hectare, which is about 1% difference from the statistical data. The research had showed there is a great potential of using remote sensing data in combination with rice yield estimation models to estimate the rice extent and its production at the provincial level, and this result provides important information for policy decisions ensuring food security and reducing vulnerability of farmers in the Mekong Delta.*

***Keywords:*** *Oryza model, rice production, rice yield, Sentinel-1.*

## 1. INTRODUCTION

Rice is an important crop for millions of people in the world (Clauss et al., 2018). Vietnam is an agricultural country, with more than 50% of its national income generated by agriculture. In particular, rice is an important crop and a strategic role in our economy. Rice not only solves the daily food problem for the people, but also is an important source of foreign exchange earnings, which is the foundation for building and developing industries (Hieu Van Nguyen, n.d.).

According to (FAO, 2004), food security of 50% of the world's population depends on the supply and distribution of rice in the world. As a result, food security has always been at the forefront in countries not only in Vietnam but also in the world, especially in the severe climatic conditions. Therefore, information about rice production plays an important role in land use planning as well as decision makers. In addition, accurate and timely information about the rice production is essential in the context of food security, trade policy, land and water management and budgetary planning (Clauss et al., 2018).

In the past, information about rice production is done by traditional methods for instance conduct a survey and statistical monitoring of productivity and output of each season, mainly based on survey data periodically from the district. This sometimes does not guarantee accuracy and requires a lot of time. For example, statistical data on rice production is released after harvesting date about 6 months and this will limit the possibility of using this for other purposes such as food security and land use planning. ,.

Today with the development of space technology especially with Sentinel data, it is capable of providing high spatial resolution data with 20 m and high temporal resolution for every 6 days. It is very important for An Giang province to monitor the status of rice cultivation as a basis for estimating rice production and yield. From the advantages of the Sentinel-1 data, and the urgency of monitoring and forecasting rice productivity to ensure food security and strengthen the rice export position of Vietnam in general and An Giang province in particular. Therefore, "Assessing applicability of Sentinel-1 data in combination with Oryza model in estimating rice yield for summer season in An Giang province" was conducted.

## 2. DATA USED AND METHODS

### 2.1 Study area

An Giang is a southwestern province of the country, is located between $10.30^0$ - $10.37^0$ N and 104.35°–105.5°E.

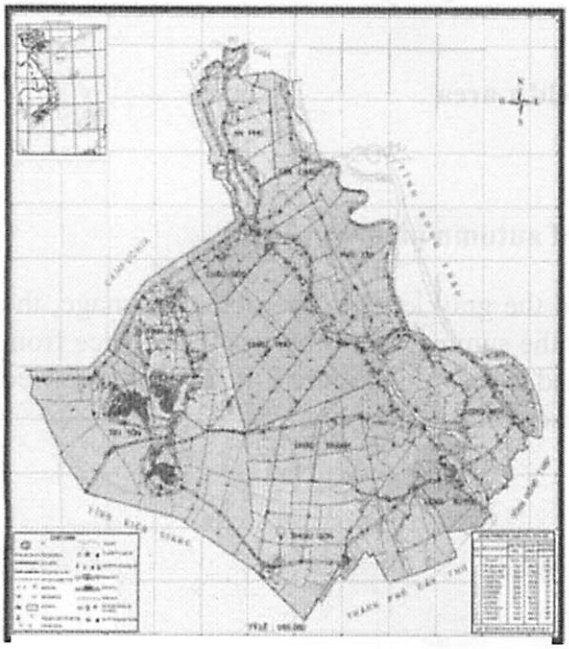

**Figure 1. Study area.**
(Source: An Giang Department of Natural Resources and Environment)

### 2.2 Data used

The satellite imagery used in this study is the Sentinel-1 provided by RIICE (Remote Sensing Based Information and Insurance for Crops in Emerging Economies). Includes 14 acquisitions from 10/4/2015 to 25/9/2016 with a revisit time of 12 days, covering up to 250 km, and spatial resolution of 20 m.

### 2.3 Data and Methodology

#### 2.3.1 *Data*

We used 14 sentinel-1 scenes acquired over An Giang province. The standard products delivered to users via the Copernicus Open Access Hub (https://scihub.copernicus.eu/) are at Level-1C processing level and are Single-Look Complex (SLC), containing amplitude and phase information, and Ground Range Detected (GRD), without phase information.

#### *2.3.2 Reference data*

The reference data have been collected at 1km grid, in total 117 field survey were conducted for An Giang province. Spatial consideration was given to the distribution of the survey points, to ensure a minimum distance between each point as well as a distribution covering all districts and rice cropping patterns in An Giang province. At each survey point the

GPS coordinate of the field edge, a close-up photo of the rice plant, showing the growing stage, and a photo in each cardinal direction, to show the surrounding land-cover, was collected.

### 2.3.3 *Rice production estimation method using Oryza model.*

According to Bounman B.A.M et al., 2001, Oryza model follows the daily calculation of the rates of dry matter production of plant organs driven by leaf photosynthesis and the rate of phenological development. In the model, the light profile within the canopy is calculated from the amount and vertical distribution of leaf surface area. There were 4 input parameters to Oryza model: weather data, variety, soil and management, together with remote sensing data (back scatter), each input parameter was collected at the local scale by using survey data.

### 2.3.4 *Method of calculating rice production*

The first variable of interest of assimilation of remote sensing data in crop yield simulation in this study is the start of season (SOS), defined as start of rice season for an individual rice field, inferred based on the lowest back scatter value, marking the agronomic flooding event. The approach of classifying LAI values and grouping yield simulation inputs into unique combinations is used prior to running the ORYZA model in order to attain processing efficiency while maintaining high resolution of the output. Then the software consolidates all inputs required to run ORYZA and run each combination of geo-referenced pixels according the LAI values derived from SAR and other spatial inputs, including weather and soil information. Then an assimilation of remote sensing data and outcomes from ORYZA model were mapped using this spatial analysis.

**Production = yield x area**

## 3. RESULTS

### 3.1 Establishment of area map planted area of autumn paddy in 2016

Based on the back scattering coefficient and the gray level of the obtained image, the results of the area interpretation were the same as the summer rice crop in the province from April 10 to May 28, divided into 5 different days and is shown in Figure 2. The results showed that on April 22, most of the farmers start their season on that period

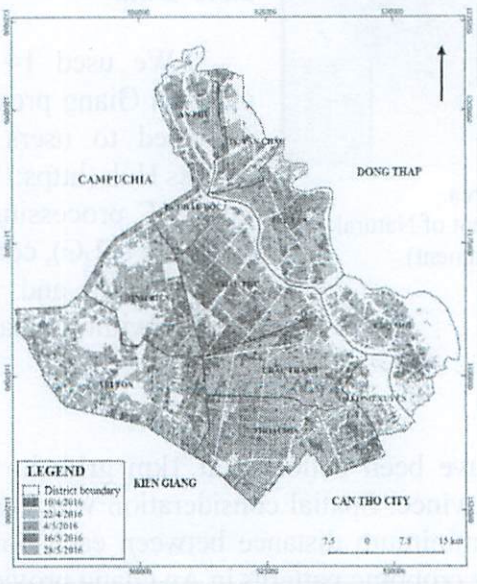


**Figure 2. Map of sowing date in autumn season in 2016.**

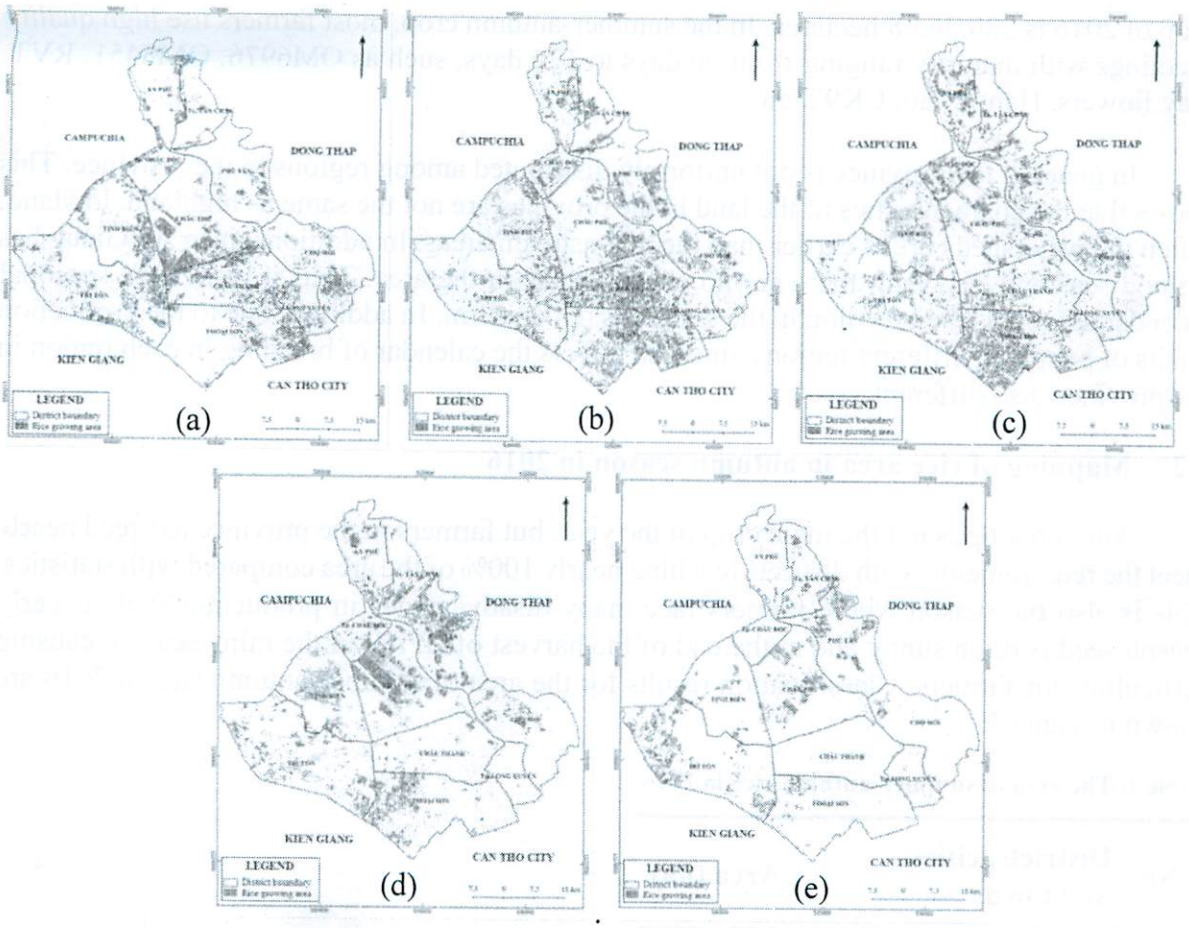


**Figure 3. Map of sowing date in autumn season in An Giang province (a) 10/4/2016;(b) 22/4/2016; (c) 4/5/2016; (d) 16/5/2016; (e) 28/5/2016.**

Sowing area of each date in the province is shown in the chart Figure 4

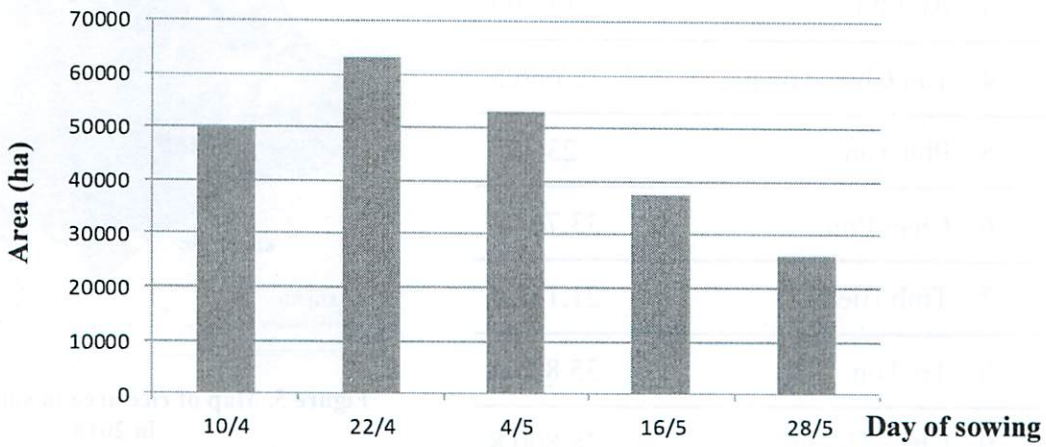


**Figure 4. Chart of sowing area from 10 April to 28 May of the province.**

From the results of the area chart down from April 10 to May 28, 2016 of the province we see. Summer-autumn crop in the province down to the seeds divided into several batches, but concentrated in early April to mid-May and coincide with the seasonal calendar to breed the focus of the Department of Agriculture and Rural Development recommended. The chart shows the most concentrated time of breeding is 22/4 specific as Chau Thanh district to breed 14,275.6 ha, Thoai Son district 11,867.5 ha. The remainder is distributed to districts, cities and towns. Results from April 10th to May 28th, the area for breeding in the whole summer-autumn

crop of 2016 is 230,363.8 hectares. In the summer-autumn crop, most farmers use high quality seedlings with maturity ranging from 90 days to 120 days, such as OM6976, OM5451, RVT, Nay flowers, Ham Chau, CK92. etc.

In general, the province is not uniformly distributed among regions in the province. This shows that the characteristics of the land in the province are not the same as highland, lowland. Often the watersheds breed earlier than the downstream areas. In addition, since An Giang has a flood season every year, there are no closed dykes in the area. Thus it makes the seasonal calendar as well as the breeding in the district is not uniform. In addition, due to the production habits of people in different regions, this also affects the calendar of breeding in each region in the province also different.

### 3.2 Mapping of rice area in autumn season in 2016

Autumn crop is not the main crop of the year, but farmers in the province to breed nearly meet the requirements, with districts reaching nearly 100% of the area compared with statistics. This is also the season where farmers face many disadvantages in production such as early season seed is often sunny and at the end of the harvest often fall in the rainy season, causing difficulties for farmers. Classification results for the area of summer-autumn rice in 2016 are shown in Table 1

**Table 1. The area of summer-autumn rice in 2016.**

| No | Districts, cities and towns | Area (ha) |
|---|---|---|
| 1 | Long Xuyen City | 4.307,8 |
| 2 | Chau Doc City | 7.066,4 |
| 3 | An Phu | 13.500 |
| 4 | Tan Chau Town | 12.666,5 |
| 5 | Phu Tan | 23.327 |
| 6 | Chau Phu | 33.767,7 |
| 7 | Tinh Bien | 21.112,9 |
| 8 | Tri Ton | 35.835,4 |
| 9 | Chau Thanh | 28.800,8 |
| 10 | Cho Moi | 13.872,2 |
| 11 | Thoai Son | 38.651,6 |
| | Total | 232.908,3 |

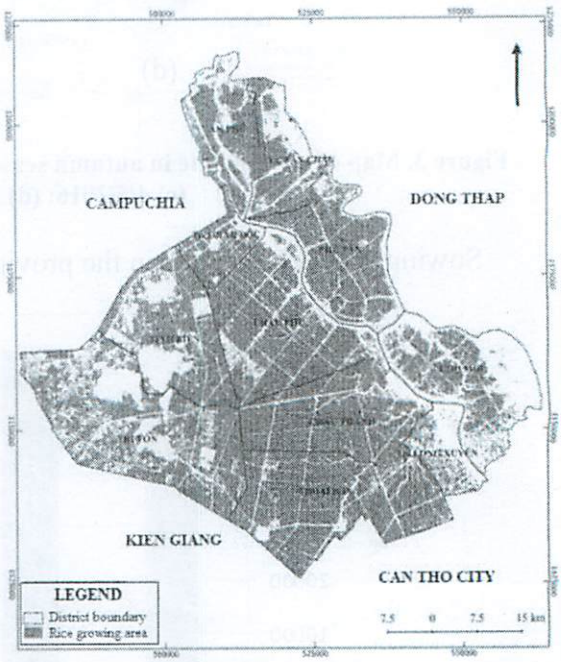


**Figure 5. Map of rice area in summer season in 2016**

### 3.3 Accuracy assessment

The results of the assessment of the accuracy of rice maps in An Giang province from Sentinel-1 have the overall accuracy and the Kappa coefficient is 93.5%, 0.87. Overall, the overall accuracy and Kappa coefficient of the study area classification image was relatively high, accepting good classification results.


**Figure 6. Map of rice production of summer-autumn in 2016.**

### 3.4 Establishment of rice productivity map

The total area of summer- autumn paddies in the province was 232,970.36 hectares (239,619 hectares). According to statistical data of the provincial statistics office, the average production in summer-autumn 2016 is 5.48 tons/ha decrease compared to 2015 (5.55 tons/ha) is 0.07 tons / ha. Due to the long-term sunshine in 2016, the growth of rice during the growing period was not as good as in previous years. As a result, productivity has decreased compared to previous years. The total output of summer rice in 2016 is estimated at 1,313,408 tons.

The average production from statistics was 5.48 tons/ha and the average production classification from remote sensing images was 5.67 tons/ha, which was higher than the statistical production of 0.19 tons/ha. The difference is about 190 kg/1000 $m^2$. The cause may be due to the fact that the collected data has not been ascertained or may be due to the limited ability of the consultant to estimate the experience, thus resulting in a disparity in the productivity of the data with data interpretation.

## 4. CONCLUSIONS

The application of the Sentinel-1 data in combination with the Oryza model to monitor the growth of rice and estimate the rice production in An Giang province results very well with a 93.5% overal accuracy, kappa index is 0.87. The results can predict rice production within 60 days after sowing, which is a favorable condition for the province to make early decision related to rice production and food security in the province. Estimation of rice production from Sentinel-1 data in combination with the Oryza model showed the potential of using radar data for such a practical purposes and it could be applied to serve decision makers in making decision for land use planning in agriculture.

## 5. REFERENCES

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