

MONITORING AND DELINEATING RICE CROPPING CALENDAR IN THE MEKONG DELTA USING MODIS IMAGES

Vo Quang Minh, Huynh Thi Thu Huong, Nguyen Thi Hong Diep ⁽¹⁾

⁽¹⁾ Department of Land resources, Can Tho University,
vqminh@ctu.edu.vn

ABSTRACT

MODIS (or Moderate Resolution Imaging Spectroradiometer) is a key instrument aboard the Terra and Aqua satellites provides global maps of several land surface characteristics, including surface reflectance, albedo (the percent of total solar energy that is reflected back from the surface), land surface temperature, and vegetation indices. Vegetation indices images are available in global coverage, enables to research fluctuation of land cover with multitemporal and multispectral data. One of them, MOD13Q1 (250-m spatial resolutions, 16-day composite) was used to monitor and delineate the time of rice sowing/transplanting and cropping calendar (from 01/01/2008 to 30/09/2009) in the Mekong Delta using time series of Normalized Difference Vegetation Index (NDVI)

1. INTRODUCTION

Currently, the rice cropping calendars in The Mekong Delta are very complicated, even in the same cropping season, since it difficult to map the current state of rice-growing stages. Usually, the monitoring for cropping seasonal mainly based on surveys, reports from local staffs. Since, this does not guarantee the accuracy and require more time, funding, etc. Nowadays techniques using remote sensing images, combined with geographic information technology (GIS) has been used to delineate the distribution of natural features in many countries around the world (Burrough, P. A, 1986, Aronoff S. 1989). Interpretation of results can monitor and determine the time of sowing progress and cropping calendar in the local area which assist in assessing the current status of rice cultivation in the field as a basis to propose the solutions for rice crop management.

The study mainly uses MODIS remote sensing images combined GIS technology to delineate the rice crop progress and cropping calendar in the Mekong Delta from 2008 to 2009. The results were validated and compared with official collected and reported data.

2. RESEARCH AREA

The Mekong delta located in the region from 8°30'-11° North latitude and from 104°30'-107° East longitude, including 13 provinces of Long An, Tien Giang, Ben Tre, Dong Thap, Vinh Long, An Giang, Can Tho, Hau Giang, Soc Trang, Ca Mau, Bac Lieu, Kien Giang and Tra Vinh (Sam Le, 1996).

2. METHOD

2.1. The images collection

The images were collected from NASA (USA), code MOD13Q1, with a spatial resolution of 250m, and temporal resolution with 16-day period, total is 4800 x 4800 pixels, georectified with lat/long coordinate. The collected images taken from January 1, 2008 to September 14, 2009. Because Mekong delta is distributed on two images, since the total number of 82 images were collected.

The NDVI image was calculated to for rice crop showing stages delineation and cropping calendar determination, which Band red (Red) and near infrared (NIR) were used to calculate (Table 1).

Table 1: The spectral bands of MODIS sensors used in the calculation of vegetation indices

MODIS channel	Wavelength ($m \mu$)	Wavelength width ($m \mu$)	Resolution (m)
1	0.620 to 0.670	0.005	250
2	0.841 to 0.876	0.035	250

2.2. Creating the vegetation index image

+ Vegetation index created from combination of spectrum band of visible, near infrared, infrared and red, from which intermediate evaluation can be differentiated the characteristics of the materials such as biomass, leaf area index, and photosynthetic capacity seasonally. Those characteristics are relevant and highly dependent on the type of plant cover and weather, physiological characteristics, biochemical and pests.

+ Normalized Different Vegetation Index (NDVI) are averaged in a time series data is the basic tool to monitor changes in vegetation status, which can assist in understanding the impact of weather and climate to the biosphere. Vegetation index NDVI is calculated as follows:

$$NDVI = \frac{(NIR - R)}{(NIR + R)}$$

2.3. The relationship between NDVI values and rice growing stages

Because NDVI value of crops changing in a certain situation (ex: each soil type has different properties). Generally its value changing in the same direction. Based on research results of BR Parida et al (2008) in India's Gujarat, the proposed NDVI values as shown in the below table:

Table 2: Criteria used to classify land use (BR Parida et al, 2008)

NDVI ranges	Land uses
NDVI > 0.74	Forest
0.74 > NDVI > 0.46	Irrigated crops
0.46 > NDVI > 0.20	Rainfed crops
0.20 > NDVI > 0.15	Fallow land
0.15 > NDVI > 0.05	Bare Soils
0.05 > NDVI > 0.001	Salt pans
NDVI < -0.001	Water

2.4. Monitoring the progress of rice sowing and delineating the rice cropping calendar map

From the results of image processing, the time series NDVI values of the Mekong Delta were calculated and delineated. The combination with the rice growing states to find out the actual relationship between NDVI indexes for the rice growing stages. On the basis of the theory that low NDVI value at the early stage, then increased gradually and peaked at tiling stage, and decreased when rice began mature and harvested (Figure 1)

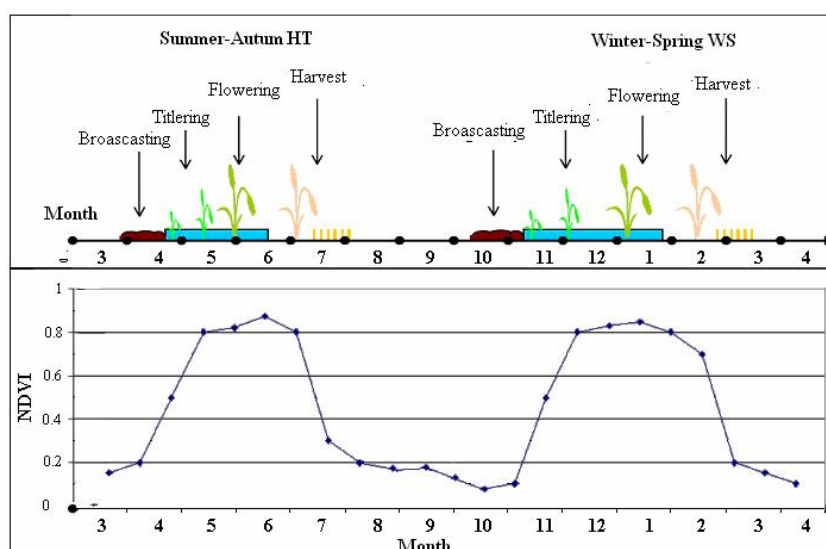


Figure 1: Changing of NDVI at different rice growing stages of winter-spring WS - summer-autumn SA cropping seasons

3. RESULTS AND DISCUSSION

3.1. Temporal NDVI image interpretation

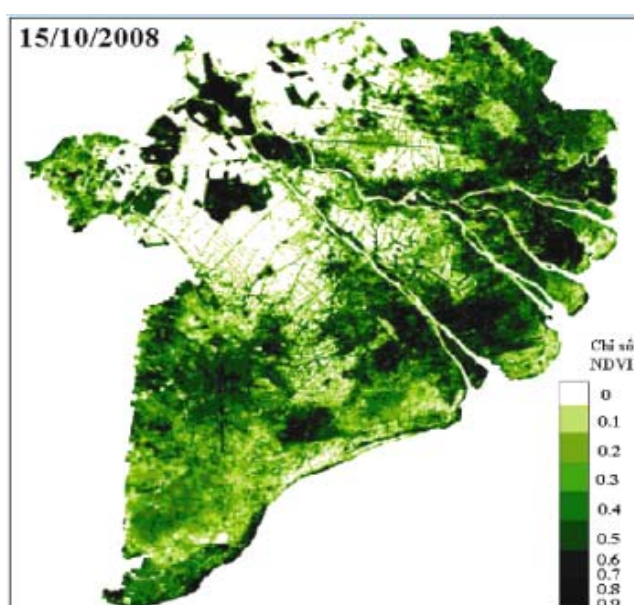


Figure 2: NDVI index image day 15/10/2008

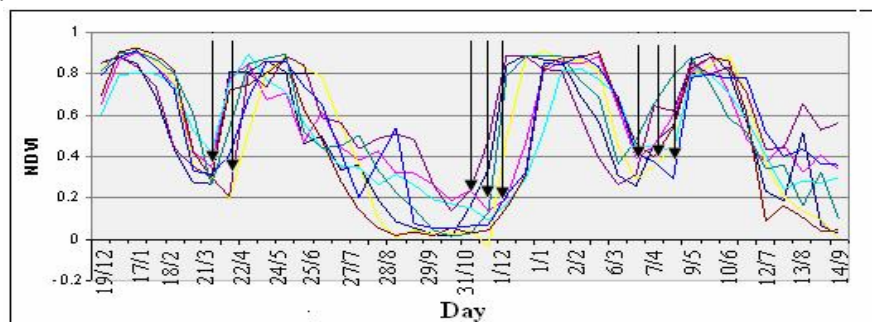
Each NDVI images allow us to monitor changes in vegetation status, represented by the difference of NDVI index at a certain time, corresponding to level of light and dark values. Through analysis of NDVI images in 2008, a few images where homogenous tone (light or dark) throughout the year, remaining changes over time. From six months of 2008 showed that the coastal areas and Ca Mau peninsula have very low NDVI indices (brightness color) and not significantly changed during the year. In contrast, in An Giang, Dong Thap, Can Tho, Hau Giang have high NDVI value in January, February and decreased in March, April, and increased again in May, June. In last 6 months of 2008, in Ca Mau peninsula and the coastal area, the NDVI values colors tend to dark over time (decreasing of

NDVI). In contrast, the NDVI value decreased in the September, October and November in An Giang, Dong Thap and Kien Giang provinces. The results in 2009 also showed a similar variation.

3.2 Analysis of variation in NDVI values

Usually, if the NDVI index peaks (from 0.5 to 0.9) are the regions with well-developed, rice is in tiling/maturing/flowering or industrial crops/fruit trees/forests. If value < 0.5, the region is no or poor plant growth, specialized areas such as shrimp, salt, water logging or

sowing rice, or starting of tiling. The NDVI values of uncultivated or no crop are often stably throughout the year. The NDVI values of objects which not high fluctuations over time will be split into a separate object. For rice cultivation in the Mekong Delta region, according to figure 3, the changes in NDVI sinusoidal shape, reaching maximum values at about 0.8 to 1.0 corresponds to stage the maximum growing stage and decreased to about 0 - 0.4 when the season ends, this value then continues to increase as a rule on when starting a new season.



Note: ↓ Time of starting sowing

Figure 3 : Example of changing of NDVI index for 2 crops areas (Main DX-Early HT)

3.3 Time of rice sowing

Based on the temporal variation of NDVI values in the Mekong Delta, showing that the time of rice sowing of each rice crop as in table 3:

Table 3: Rice sowing area (ha) interpreted from MODIS images in May and June/ 2009 at different districts

From	To	An Giang	Lieu	Ben Tre	Ca Mau	Tho	Dong Thap	Hau Giang
01/05	08/05	30,712	850	87	56	21,412	67,468	26,106
09/05	16/05	78,262	12,456	618	237	7750	29,912	14,187
17/05	24/05	166,600	10,600	18,156	5518	5050	74,500	29,343
25/05	01/06	650	3231	1331	550	6,250	406	1450
02/06	09/06	2356	35,856	6550	2537	37	37	400
10/06	17/06		156					
18/06	25/06		4131	68	9431	400	4012	168
26/06	03/07							

From	To	Soc trang	TGiang	Tra Vinh	KGiang	Long An	V Long	Total
01/05	08/05	7093	2543	1468	77,843	20,506	10,531	14,543
09/05	16/05	20,075	5643	3512	15,050	26,431	50	9206
17/05	24/05	52,768	45,418	38,337	105,862	135,131	5543	8930
25/05	01/06	6318	1006	11,375	1662	23,737	31	12,412
02/06	09/06	17,400	6500	4375	9243	17,287	6	10,881
10/06	17/06	868						
18/06	25/06	39,868	1106	943	18,625	225	175	2225
26/06	03/07	243	206			25		206

3.4. Accuracy assessment:

The results was correlated with official reported data (Southern Center for Crop protection, Ministry of Agricultural and Reraul development), which showed very close

correlation ($r = 0.752^{**}$, $n = 481$, $df = 479$). Since, it shows that the interpretation of results is quite reliable and can be used in monitoring the status of rice cropping stages. (Figure 4)

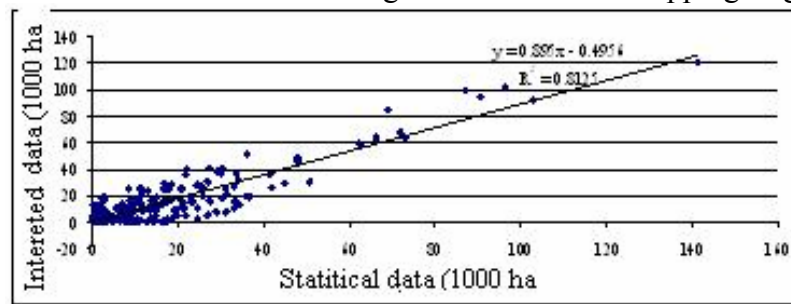


Figure 4: The correlation between the plated area in statistics and data interpretation.

3.5. Some rice cropping calendars in the Mekong Delta in 2008 - 2009 interpreted from MODIS images

Based on the relationship between NDVI values with the rice cropping stages over time, determine the start time and end of each cropping season, which can assist in developing the major rice cropping calendars for the study area.

❖ Mono rice crop (traditional rice)

The Mono rice crop s usually distributed along the coast from Long An, Ben Tre, Tra Vinh and Soc Trang, Bac Lieu and Ca Mau. Time of transplanting period ranging from August to middle of September (rice have been sown from June, July). This cropping calendar can be shown in Figure 5.

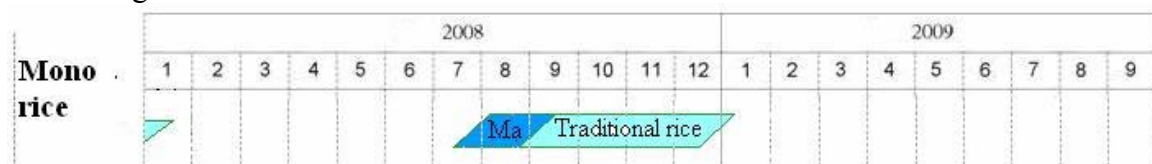
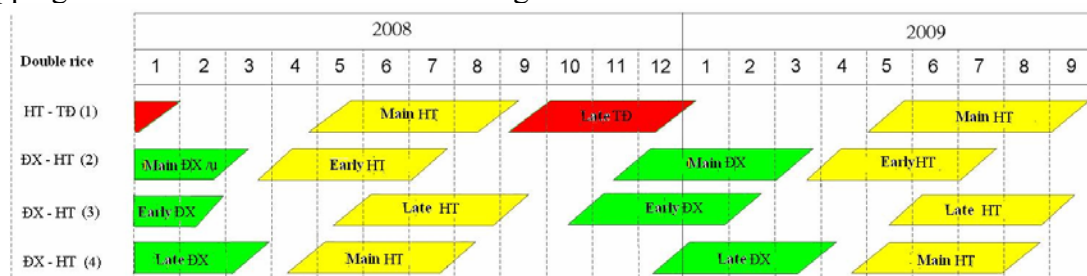


Figure 5: Typical mono rice cropping calendar

❖ Double rice crops

This rice cropping calendar is most popular in the Mekong Delta (in the freshwater and slightly saline areas). The image interpretation showing that NDVI index reached its maximum twice a year at different intervals depending on the time of sowing. The rice cropping calendar can be shown in below figure 6.



Notes: (1): Summer Autumn - Autumn Winter (2): Main Winter Spring - Early Summer Autumn (3): Early Winter Spring - late Summer Autumn (4): late Winter Spring - Main Summer Autumn

Figure 6: Some typical double rice cropping calendars

- Summer Autumn- Autumn Winter: The cropping calendar is less popular in the Mekong Delta, where scattered in the coastal areas. The Autumn-Winter starting date of rice sowing around middle of September of previous year (2007) and ended at end of January of year after (2008). Then, soil will be fallowed for 3 months (may be due to soil salinity, or water) and start sowing Summer-Autumn rice crop in early to May. At the end of this cropping season, land will start a new cropping season. Which distributed concentrated in Gia Rai (Bac Lieu); Thanh Tri, My Xuyen and Long Phu (Soc Trang).

- Main Winter Spring - Early Summer-Autumn: Winter-Spring cropping season started in November of previous year, after the end of Winter-Spring, time of starting rice sowing from 21/3 to 6/4. The soil is left fallow from early of August to end of October, and will begin Winter Spring cropping season of 2009. Concentrated mainly in Can Tho, Dong Thap, An Giang, Vinh Long, and scatered in Kien Giang province.

- Early Winter Spring - Late Summer-Autumn: The Winter Spring starting date of rice sowing is within October. Soil will be fallowed after this cropping season for two months before the start of Summer-Autumn cropping season from 8/5 to 24/5. After the Summer-Autumn rice cropping seasons, the soil will be also fallowed for one month and it starts Winter-Spring cropping season of 2009. This rice cropping season concentrated in the coastal province of Tra Vinh, Kien Giang, Ca Mau, Bac Lieu.

- Late Winter Spring – Main Summer-Autumn of services: The starting time of rice sowing for Winter Spring (2008) within December; and The Main Summer Autumn starting from 21/3-6/4. In 2009, the Summer Autumn rice sowing relatively later than in 2008 (middle to end of April). Distribution of Hon Dat, Tan Hiep, Rach Gia (Kien Giang province).

❖ *Triple rice crops*

Triple rice cropping season is most popular and almost year round in freshwater alluvial soil ecosystem. Based on the time of rice sowing calendar, it is divided into Early Winter-Spring, Main Winter-Spring and Late Winter Spring rice cropping. The rice cropping calendars can be shown in below Figure 7.

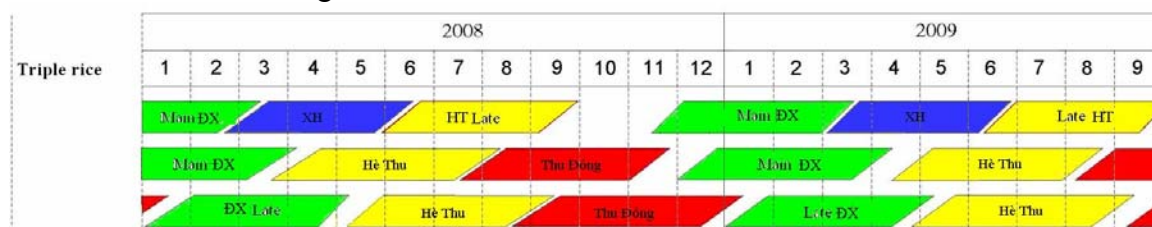


Figure 7: Some of triple rice cropping calendars

- Winter Spring - Spring Summer – Late Summer Autumn : At the end of Summer-Autumn crop land is left fallow for 1 or 2 months before starting Winter-Spring rice crop of next year. Sowing time for the three cropping season can be listed as follows: Winter-Spring - starting from end of november to beginning of December, second rice crop starting from middle of March (5/3 to 21/3), third rice crop starting from beginning of June. This cropping calendar most populated in Cai Be, Cai Lay (Tiengiang), Thap Muoi (Dong Thap).

- Main Winter Spring – Summer Autumn - Autumn Winter: Winter-Spring crop sowing time starting at beginning of December, the Summer Autumn starting from 6/ April to 22/April, Autumn-Winter sowing from end of July to first half of August. When for Autumn-Winter rice crop harvested in 2008, soil will be left fallowed for a month before the start of Winter-Spring crop of 2009. This rice cropping calendar distributed in An Giang, Hau Giang, Ben Tre, Long An provinces.

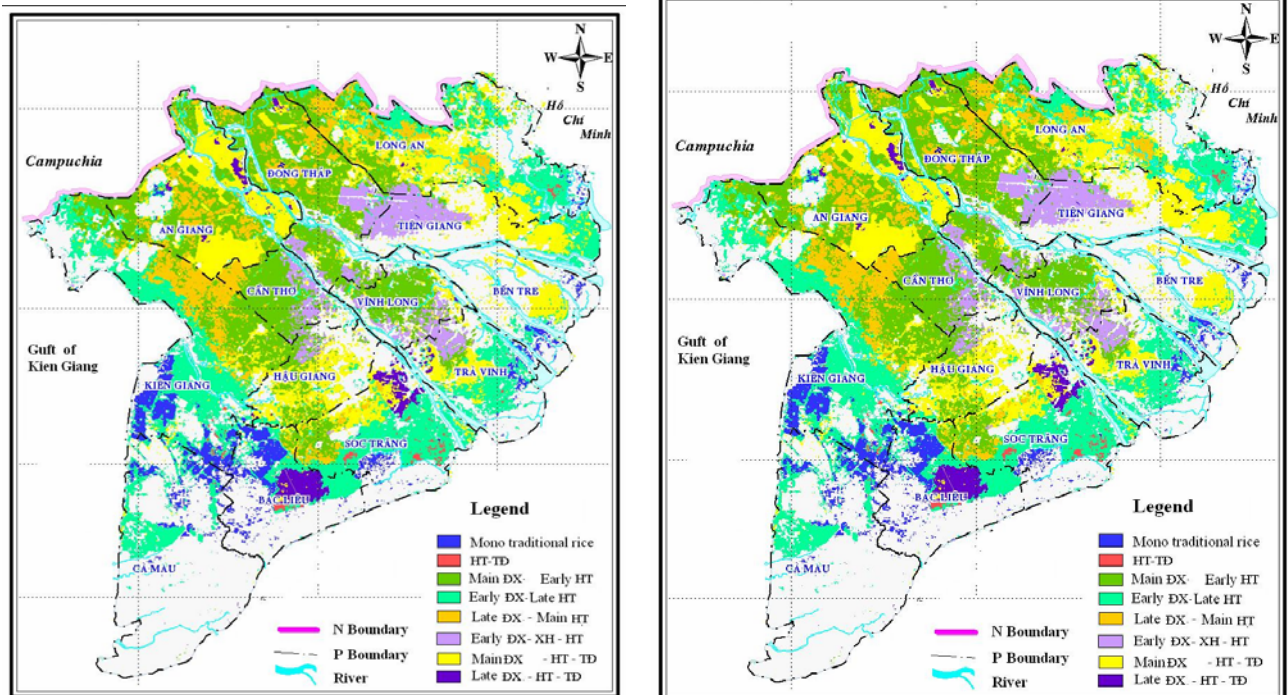


Figure 8: Distribution of rice cropping seasons and tiem of rice sowing in the Mekongh delta in 2008-2009

Note: DX: Đông Xuân (Winter-Spring); XH: Xuân Hè (Spring-Summer); HT: Hè Thu (Summer-Autumn); TD: Thu Đông (Autumn-Spring); N National; P Provincial

- Late Winter Spring - Summer Collection - Autumn Winter: Winter-Spring crop sowing from end of January to beginning of February, the Summer Autumn crop starting in end of May, and Autumn Winter starting from middle of September (Figure).

Which distributed in Hong Dan, Gia Rai and Phuoc Long district of Bac Lieu province; and in Ke Sach, My Tu, Long Phu, Soc Trang province?

Figure 8 shows that The double rice crops dominate in the area (> 63.8%) followed by tripple rice crop (30.7%) and finally mono rice crop for only about 5.5%. In which the double rice crops of Early Winter Spring – Summer Autumn cropping season occupied most popular (>27.9%), followed by the main Spring Summer – Early Summer Autumn (> 25.5%). Thirdly is triple rice crop (Main Winter Spring – Summer Autumn – Autumn Winter (22.0%). Lostest is double rice crops of Summer Autum – Autum Winter (0.6%)

Although a total of eight major rice cropping calendar representing in the Mekong Delta but the double and triple rice crops dominated, which account for about three quarters of the total area. The remaining rice cropping calendar occupy negligible

4. CONCLUSION

Monitoring the date of starting rice sowing based on temporal variation of NDVI is very effective, and useful, for determining the current state of rice evolution and rice sowing stages then rice cropping calendar, which did not depend on human subjectivity. Multispectral and Temporal Remote Sensing Data, MODIS most suitable for research at regional or national level. Which can provide quick and low cost information for managers and decision maker to select the suitable best strategys for crop management.

Cloud and low spatial resolution impaired the acuracy of the results, since it needs for further studies and more fields validation is also needs to enhance the accuracy.

REFERENCES

- Casadesus, J., Tambussi, E., Royo, C. and Araus, JL (2000), "Growth assessment of individual plants by an adapted remote sensing technique," *Durum Wheat Improvement in the Mediterranean Region: New challenges*, pp.129-132. Options Mediterranennes, Zaragoza
- Jiang, ZY, Huete, AR, Chen, J., Chen, YH, Li, J., Yan, GJ, & Zhang, XY (2006), "Analysis of NDVI and scaled difference vegetation index retrievals of vegetation fraction", *Remote Sensing of the Environment*, 101(3), pp. 366-378.
- Nguyễn Ngọc Thạch, Nguyễn Đình Hòa, Trần Văn Thụy, Uông Đình Khanh, Lại Vĩnh Cẩm . (1997) .
Viễn Thám trong nghiên cứu tài nguyên và môi trường, NXB Khoa Học và Kỹ Thuật, Hà Nội.