Journal of Mining and Earth Sciences

Website: http://tapchi.humg.edu.vn

Monitoring progress of flood in area of different dikes in Dong Thap Province by using modis remote sensing data

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ARTICLE INFO

Article history:
Received 16th June 2018
Accepted 22th Nov. 2018
Available online 31st Dec. 2018

Keywords:
The flood in the Mekong River Delta;
Flooding of Dong Thap province;
MODIS.

ABSTRACT

This study used remote sensing data from Moderate Resolution Imaging Spectroradiometer (MODIS) to monitor the progress of flood in different areas of dikes in Dong Thap province by using the values from indices including NDVI, EVI, LSWI, and DVEL. The study results show that the time when flood occur yearly is concentrated in mid - September to mid - October, then it recede at the end of December. The results of image interpretation are verified with the collected high accuracy data and has a high degree of accuracy with a close correlation coefficient (R) of 0.66 to 0.95 for flood events through EVI, LSWI and DVEL index, thus suggesting some solutions for future applications.

1. Introduction

Currently, there are three types of dykes in Dong Thap province including closed dikes, open dikes, and semi - closed dykes. In which, a closed dike count the majority because this dike is solid and long - term, while the semi - closed dikes (dikes prevent floods around August, but the August flood overflows) this type of dike must be repaired curing after floods recede, very costly. Besides, monitoring developments and early forecasting of the flood situation in the Mekong River Delta is a pressing issue in our country, especially from the historical flood in 2011. Currently, the use of remote sensing data has many funding difficulties because remote sensing images with high spatial resolution often have high costs. However, with the development of the MODIS image system, there is a high temporal resolution and can be collected for free directly from the US NASA aerospace agency. With this image data, the spatial resolution is low (250m÷1km) but has a high time resolution (8÷16 days). According to Akm Saiful Islam, et al (2009), using MODIS image data to reflect surface forming Bangladesh flood map. Research using the MODIS / TERRA satellite image data is collected for free from the ground observation station (EOS, 2006). The product used is MODIS

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image 8 days set throughout the second period of 2004 and 2007 with a ground resolution of 500m called MODIS / TERRA SURFACE REFLECTANCE 8 - DAY L3 GLOBAL 500 M SIN GRID V005 (MOD09). The results of the flooded maps can be compared and compared with the flood maps established by interpretation results for high resolution Radarsat images along with data from the DEM elevation model (Digital Elevation Model) and hydrological data of the study area. In addition, according to Suwalak, et al (2007), from the combination of false colors bands 1, 2 and 7 (R, NIR, and SW) of MODIS. The flooding area of the whole country can be analyzed on a daily basis to track the direction of flood flow and its predictable negative effects. From the above studies, it has been shown that MODIS remote sensing images can meet the needs of the study to monitor and predict flood potential. In addition, MODIS remote sensing image is also used to identify the dyke areas in combination with the flood characteristics, to analyze and assess the role of dykes for flood characteristics in the Mekong Delta. This paper presents the monitoring of flood developments in different dyke areas in Dong Thap province with MODIS remote sensing image tool.

2. Research methods

2.1. Data collection methods

Data collected include attribute data on natural and socio - economic conditions in provincial departments and sectors.

Types of spatial data such as land use planning map of Dong Thap province by 2010 and 2020, land use status map in 2005, administrative map in 2010, the distribution map of flood protection dikes in 2012.

Annual statistics on the area of the current land use structure, calendar of yearly arrangement.

Data on the flood situation and flood peaks from 2000 to 2013 at the Hydrometeorological Center and Irrigation Department of Dong Thap province.

Collect relevant documents on remote sensing applications, guide how to use, how to image processing and map editing, research of scientists related to the application of remote sensing images in research flood, seasonal structure.

Collect MODIS images provided by the US national aerospace agency for free via the website http://www.reverb.echo.nasa.gov and download photos taken from January 2000 to December 2013 of the Mekong Delta region.

2.2. Remote sensing image processing method

MODIS remote sensing image data after being collected, processed by ENVI software according to image processing process: Cut, merge images => Geometric adjustment (image editing) => Collected images have a coordinate system degree in lat / long mode so we proceed to shape the image to bring the image to a uniform coordinate system, correct shape without distortion => Cover image => Create image sequence => Enhance image quality (Image filter: select images by Median method, increase contrast intensity by linear stretching method (Linear) => Create different index image sequence NDVI plants to interpret images, determine the current status of crop structure => Classification of objects based on different indexes of NDVI plants has been identified to interpret images, determine the current status of crop structure. image interpretation purpose for monitoring floodplains, based on EVI and LSWI values, DVEL index to determine non - flooding pixels, flood pixels, flood - free pixels, and mixed pixels and long - term flooding term

2.3. Flood maps making methods

After creating multi - time image sequences of EVI, LSWI and DVEL indexes, the objects are classified to determine the flood pixel. Inheriting the research method of Sakamoto et al. (2007) and Islam et al. (2009) to classify objects and determine flood pixels to create flood maps, with a value of Blue is 0.2 considered to be cloud pixels that will be removed from the image. If EVI> 0.3 is considered a non - flood pixel. If EVI ≤ 0.3 and DVEL 5 0.05 or EVI ≤ 0.05 and LSWI ≤ 0.0 are defined as water - related pixels. Then classify flooded pixels with EVI ≤ 0.1, mixed pixels with 0.1 <EVI ≤ 0.3 and the lake areas are separated from water - related pixels with the time flooded. 120 days.

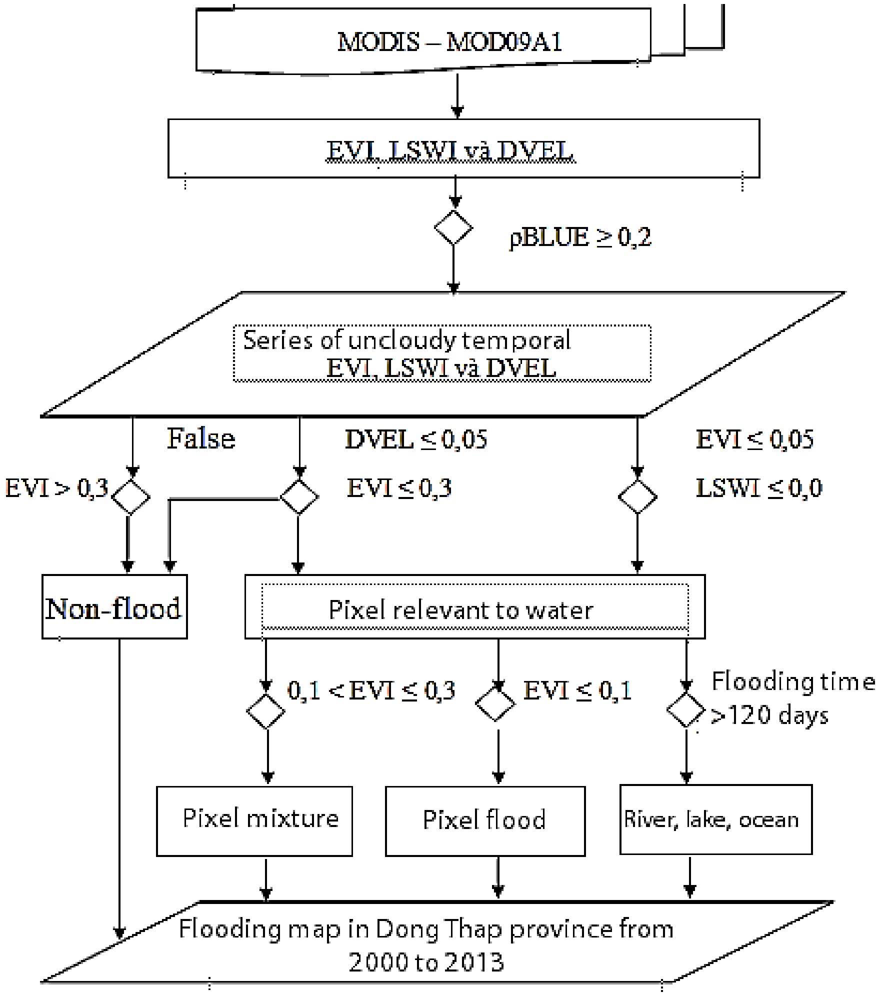


Figure 1. Flood pixel classification method based on values of EVI, LSWI and DVEL indicators (Source: Sakamoto et al., 2007; Islam et al., 2009).

2.4. Field trip investigation method

The field survey is to check the results of uncontrolled classification and as a basis for controlled classification. After classifying the subjects, selecting the representative points on the image has not been able to accurately identify the objects for field surveys (the test position is concentrated in rice - growing areas with progressive seeding) and Coordinate positioning by GPS. Record the current situation and investigate the owner of the crop structure, the situation of annual flooding in the research period. Using household survey questionnaires that are set up, investigate some indicators of crop structure in the year, type of use, seasonal calendar; investigate the situation of annual flood changes of each region in the province (such as water level, flood time, flood peak, flooded area, flood damage).

Status of flooding and dikes were investigated, collected data and maps of flood status and dikes at Dong Thap Irrigation Department.

2.5. Method of evaluating the reliability

According to Nguyen Ngoc Thach (2005), the result accuracy is calculated as follows:

Total accuracy = Total pixel classification correctly / total pixel classified.

Besides the Kappa coefficient (K) is also calculated to assess the degree of acceptance of classification results (Nguyen Ngoc Phi, 2009). Kappa coefficient = A / B

Inside:

A = number of correctly classified pixels - the number of pixels misclassified.

B = the total number of classified pixels.

3. Results and discussion

3.1. The result of establishing the Enhanced Vegetation Index (EVI)

The EVI index shows the plant characteristics such as biomass, leaf area index, photosynthesis ability of plants (Duong Van Mosaic et al., 2007). Therefore, by referring to the researchers, the 2 - crop rice - growing area of the EVI index fluctuates in sinusoid with two corresponding maximum points of 2 - crop rice area, EVI value fluctuates within 0.1 <EVI <1, for a river area with a stable value throughout the year, the type used is the river EVI ≤ 0.05, for the area where the EVI value forest is larger than the river use type and is stable throughout the year from above 0.2 except for the flood season.

3.2. The result of establishing surface water index of Dong Thap province (Land surface Water Index –LSWI)

The results showed that the surface water index of LSWI in the first 6 months fluctuated steadily in the range from - 0.2 to 0.4, this period the appearance of the surface layer of water is little, very little or no (exported show drought). By the middle of the beginning of July, LSWI index started to fluctuate gradually until about mid - October, this corresponds to the fact that the water appears more and more on the surface, there are some places in the province with the highest peak. specified (occurrence of flood peaks). After that, the LSWI decreased gradually until the end of December, which corresponds to the fact that surface water has gradually receded, which is the end of the one year flood period.

LSWI images presented in this study are the image selected in the months in the flood season, the time of the presence of surface water layer to easily assess the change of the surface water layer over time, flood starts time and end the flood period of the year. Therefore, the LSWI series is presented from June to December every year to conveniently assess the change of the surface water layer.

On the basis of identifying the image pixels as rice production areas of 2 crops, forests and rivers, use the Tools / Link / Geographic link in ENVI software to link the LSWI and EVI series together to determine the image pixels. corresponding to rice production areas of 2 crops, rivers and forests. The results show that the value of LSWI of rivers and lakes does not always receive the value of LSWI. 0.0. Because the influence of sediment content or suspended solids in water increases or decreases the reflectivity of water, so the river and lake areas do not always receive the LSWI value ≤ 0.0, which is consistent with the study. of Islam et., al. (2009). Because in the method of developing flooded maps from MODIS, Islam combined the EVI value ≤ 0.3 together with LSWI ≤ 0.0 to determine the area where pixel images related to water are areas with water and plants, floods and rivers.

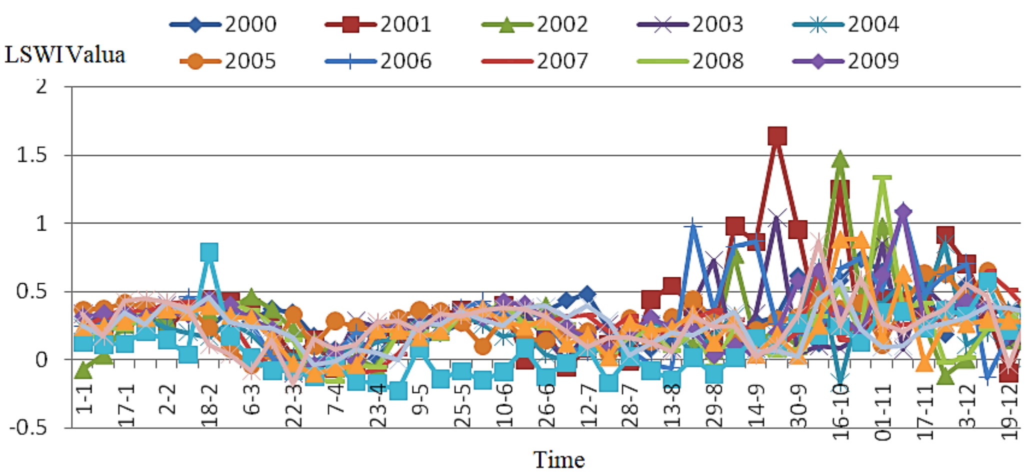


Figure 2. Chart of changes in LSWI values from 2000 to 2013.

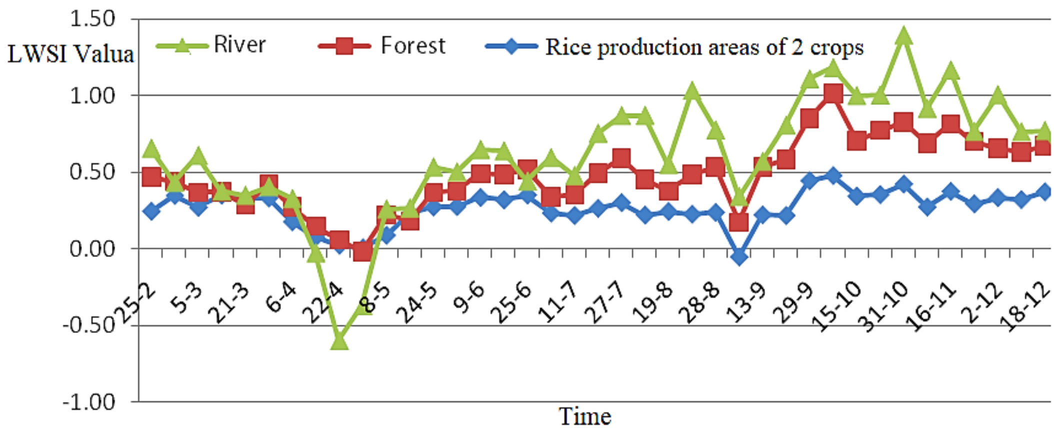


Figure 3. Diagram showing LSWI value fluctuation in 2000.

3.3. Result of setting the difference index between EVI and LSWI (Difference value between EVI and LSWI - DVEL)

Differential index image creation through ENVI's Basic tools / Band math tool, then enter the DVEL formula to create single - band images at a time defined and edited on Mapinfor software through Bright - dark tone levels to easily distinguish objects. The higher the DVEL index, the higher the surface coverage, corresponding to the fact that plants thrive on dark tones, whereas the lower the DVEL index, the less the level of surface coverage, the more plants there are. little or no vegetation with bright color tone.

The classification results identify floodplains in combination with EVI, LSWI and DVEL indicators in Dong Thap province

According to research by Sakamoto et al. (2007), if DVEL ≤ 0.05 the pixel is determined to be related to the country. This was further studied by Mr. Sakamoto and his colleagues. If EVI is 5 0.05 and LSWI is ≤ 0.0, the image pixel is defined as a pixel related to water. If EVI> 0.3 is considered a non - flood pixel. So combining EVI, LSWI and DVEL indicators to detect flooded pixels is the best way.

Based on the fluctuation of EVI, LSWI, and DVEL values, it shows that the values of the indices fluctuate in the range of - 1 to +1. For the EVI index in the first 6 months> 0.2 and progress to +1 corresponding to the area with many plants, showing the surface coating thrive, around the beginning of July the EVI index decreased gradually towards - 1 corresponding to the vegetation cover on the surface as little or no vegetation, then in November the EVI index increased again, so we can determine the time when the flood appeared and ended. LSWI index shows the surface water layer, research results show that the LSWI index decreases to - 1, the surface water layer is low, plants thrive. In contrast, the LSWI index increased gradually to 1, the more water the surface layer, the less or no vegetation developed, and flood appeared. For DVEL difference index similar to EVI, in the first 6 months, the DVEL index increased gradually to +1, the surface coating is getting more and more, plants thrive, and in July, the DVEL index catches The head drops towards - 1 at which time the plants grow little or no presence of plants, the water appears on the surface increasing, this time flood appears. Then around November, the DVEL index gradually increased, indicating that the water layer on the surface gradually decreased and withdrew on the corresponding surface, the LSWI index gradually decreased, the surface coating gradually developed again.

For MODIS images with an 8 - day spatial resolution, it is difficult to determine when the flood begins and ends. Therefore, tracking the fluctuations of EVI, LSWI and DVEL indicators over time, it is easy and accurate to determine the time of flood starting and ending and at the same timeless costly Actual survey fees. Large flood time, the maximum LSWI value (flood peak), whereas the EVI value and DVEL reach the minimum, these indicators are inversely proportional to each other. Therefore the use of three EVI, LSWI and DVEL values is necessary and

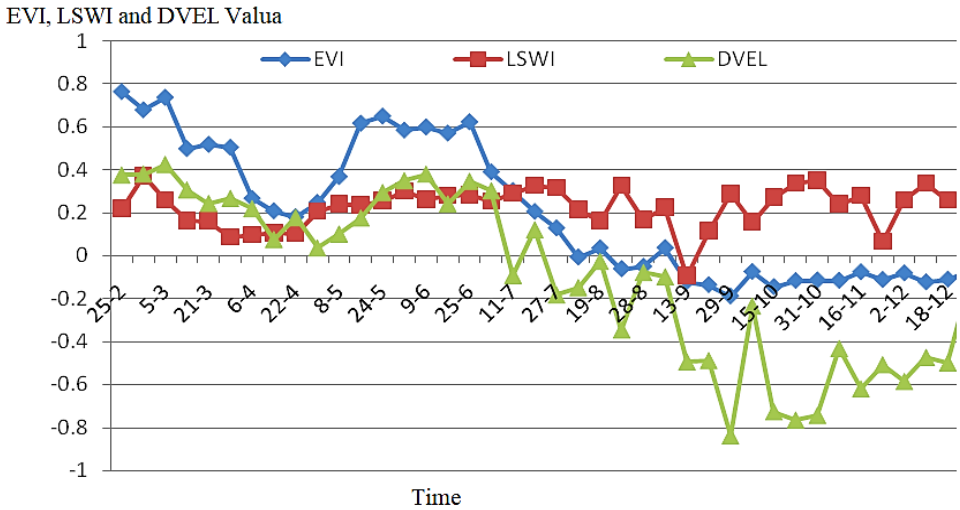


Figure 4. EVI, LSWI and DVEL value fluctuations chart in 2000.

complementary to classify objects especially flood objects.

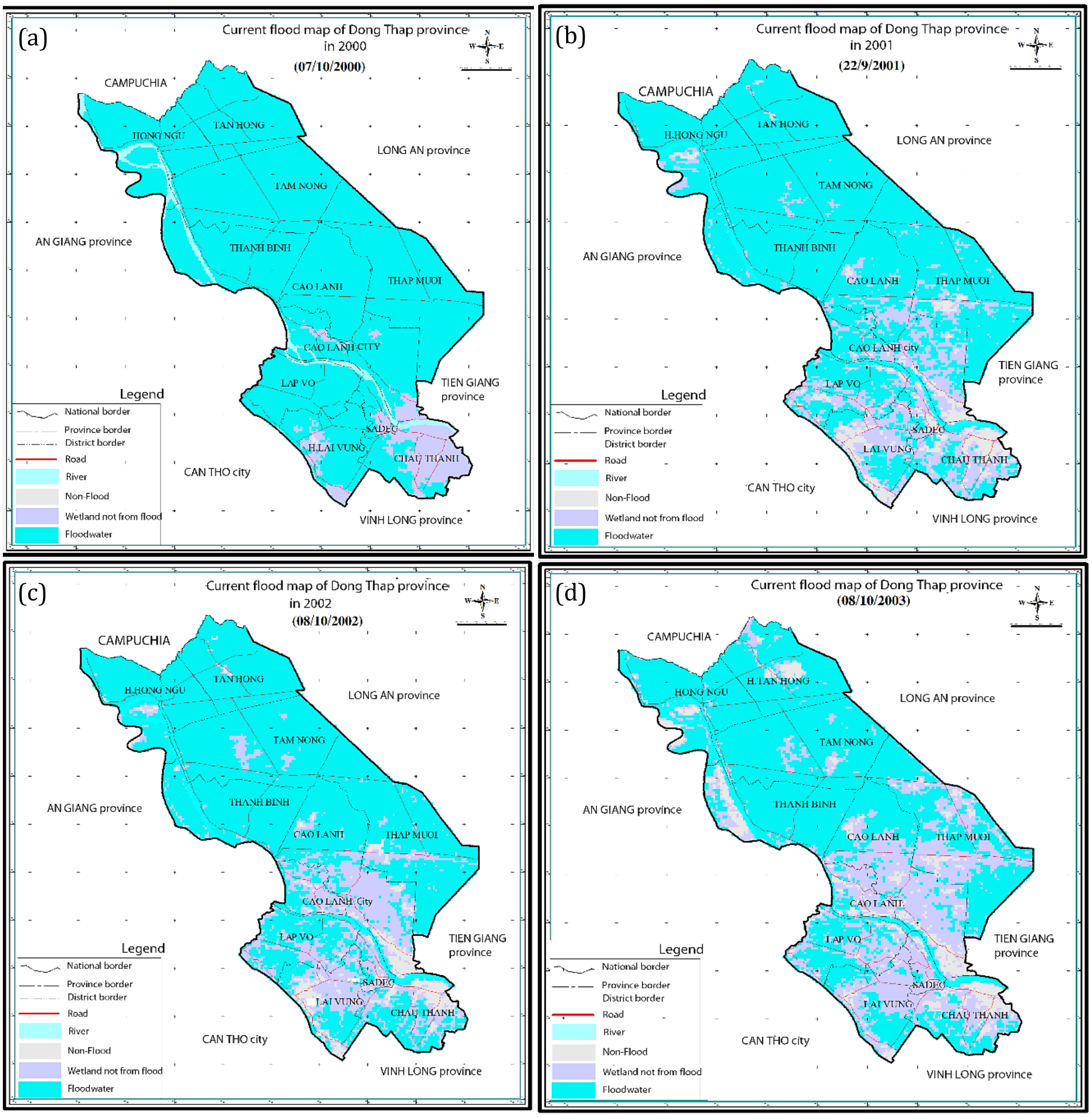
In early July when the EVI value decreased, the LSWI index increased. This shows that plants at this time decrease, surface water increases, this period is defined as the period when floods appear. At this time, the differential index DVEL EVI and LSWI decreased, indicating that the surface vegetation also decreased and therefore assessed the existence of surface water. In contrast, when EVI and DVEL increased gradually, plants developed strongly, at this time, the LSWI index gradually decreased, indicating that this time the flood began to end.

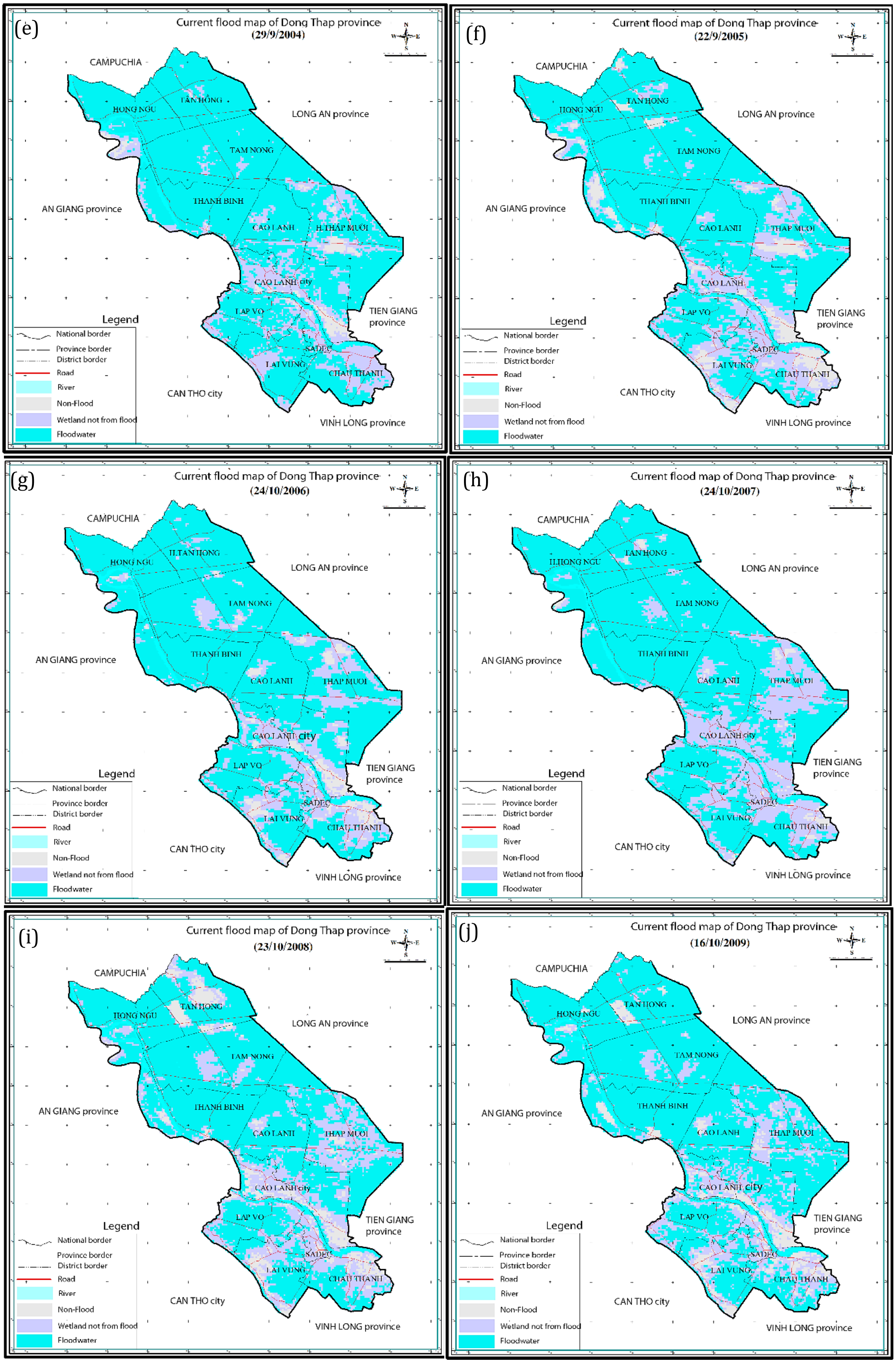
Classifying objects and determining flood pixels, after identifying water - related pixels, continue to classify flood pixels with EVI ≤ 0.1, mixed pixels with 0.1 <EVI ≤ 0.3 and rivers and lakes areas are separated from water - related pixels with a flood duration of over 180 days. To facilitate the separation of objects, the project uses Basic tools / Region of Interest / Band Threshold to ROI of ENVI software, resulting in flooding status of Dong Thap province from 2000 to 2013 , maps presented in the period from July to December each year to determine the time of flood occurrence and ending the flood cycle with 2 main objects: green is the presence of flood, the object is gray White is not flooded.

3.4. The results of the flood mapping, flooding of Dong Thap province from 2000 to 2013

The results of the mapping of flooding status from 2000 to 2013 were verified by the method of flood mapping of Islam in 2009 and based on the calculation of EVI, LSWI, and DVEL indicators. The map of the current status of flood each year is built on the image with the area to explain the biggest flood. The objects on the flood map of each year are shown as follows: the flooded objects are defined as dark green (submerged with a long period and ending), light green is the object flooded but not flooded (flooding due to high tide, flooding due to rain, storms), white gray is the object identified as not flooded and blue is a separate river object to be easily distinguished. At the same time, through the data on the flooded area that has been interpreted, draw a diagram of each year 's evolutions to easily distinguish and identify the flood period that began to appear, the flood reached the highest peak in the period and period. the end of the flood cycle. Since then assess the annual flood evolutions.

To see more clearly the evolution of the annual flood and compare the time of flood occurrence sooner or later. On the basis of the map of identified flood status, we arrange them in order of each month of the year (from July to December) to easily distinguish the early or late floods from years to years. Clearly, in 2000, 2001, 2002 floods appeared early in mid - July, but all ended later than other years; for 2005, 2008, 2010 and 2012 floods occur late between late July and early August but the flooding rate peaks quickly and then gradually withdraws to the end of December for 20052008, particularly in 2010 and 2012 then withdraw earlier than in late November; In the remaining years, the flood appeared in the middle to the end of July, the speed was slow and gradually withdrawn from the middle to the end of December was the end. The results of the map of flooding situation from 2000 to 2013 were established from the results of MODIS image interpretation, showing that every year, floods are distributed in a large area, floods often appear in the beginning to the end of July, flood peaks usually concentrated in mid - September to mid - October, then gradually withdrawn until the end of December. Especially the upstream area and the area of Dong Thap Muoi flood often appear early and withdraw later than the South of Tien River, some The area in the province is not flooded due to the construction of a solid dike system to ensure that the third crop and fruit orchards are concentrated in some areas of most districts and towns in the province and in the center. towns and townships of districts, towns, and cities. The flooded area tends to decrease over the years from 2000 (the flooded area is 303,204.9 ha) and in 2013 (the flooded area is 206,688.2 ha), so over 13 years, the area is flooded. 96,516.7 ha. However, it is necessary to combine with the current distribution map of the dike to see if the dike affects the variation of the flooded area as above.




(e)
Current flood map of Dong Thap province
(29/9/2004)
CAMPUCHIA
HONG NGU
TAN HONG
LONG AN province
TAM NONG
AN GIANG province
THANH BINH
CAO LANH
THAP MUOI
CAO LANH city
LAP VO
TIEN GIANG province
SADEC
LAI VUNG
CHAU THANH
CAN THO city
VINH LONG province
Legend
National border
Province border
District border
Road
River
Non-Flood
Wetland not from flood
Floodwater
(f)
Current flood map of Dong Thap province
(22/9/2005)
(g)
Current flood map of Dong Thap province
(24/10/2006)
(h)
Current flood map of Dong Thap province
(24/10/2007)
(i)
Current flood map of Dong Thap province
(23/10/2008)
(j)
Current flood map of Dong Thap province
(16/10/2009)

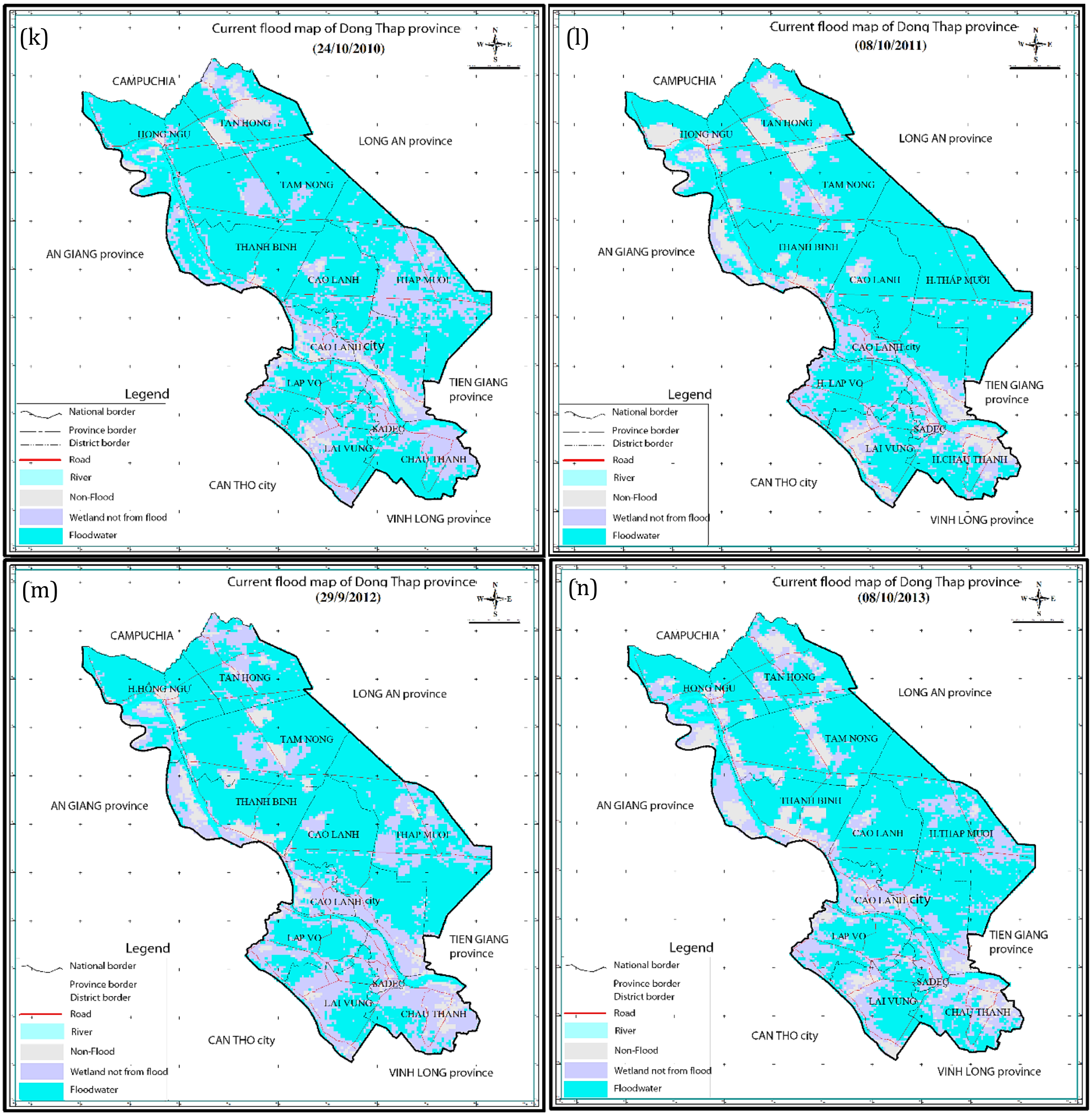


Figure 5. Map of the flooded state of Dong Thap province from 2000 to 2013.

3.5. Results of the mapping of the dike areas in Dong Thap province in 2000 - 2013

Based on the results of the interpretation of flooded areas and non - flooded areas, from the non - flooded areas, we exclude linear objects such as roads, residential roads over flooding, etc., to remain in areas without flooding in closed areas, which are areas flood protection. Results of the image interpretation area map with MODIS image 09A1.

Conclusion

By studying the application of multi - resolution MODIS remote sensing images to evaluate flood evolution in the dyke areas of Dong Thap province, the results were achieved:

- The result has built a flood status map, assessing the fluctuation of floods from 2000 to 2013 in Dong Thap province. In general, flood developments are always complicated. Floods often appear early in the North of Tien River and

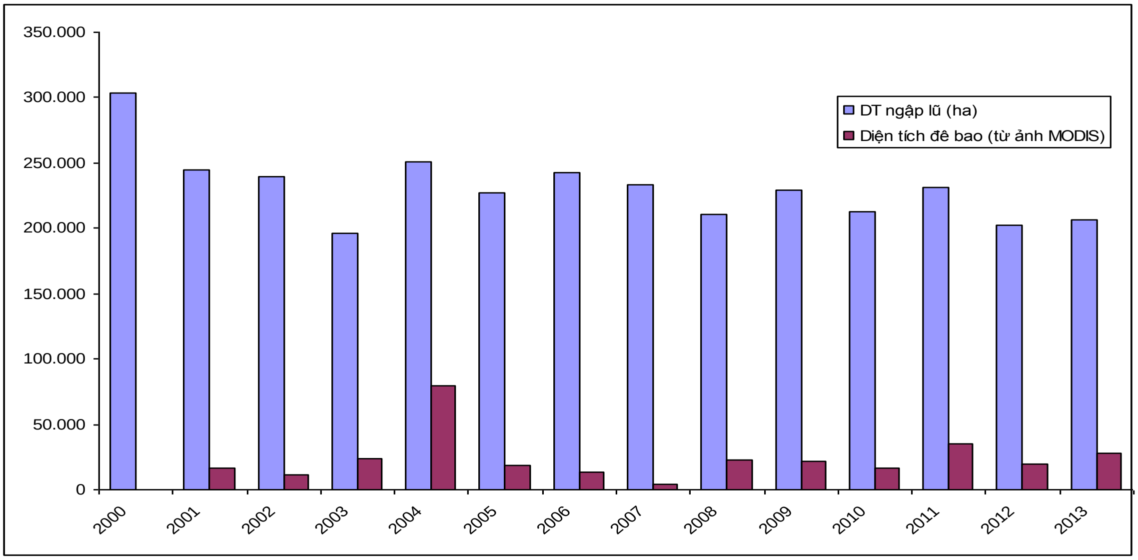


Figure 6. Chart of changes in the area of dikes and flooded area of Dong Thap province.

with draw more slowly than the South of Tien River. Flood peaks often appear in the middle of September to mid - October every year. In the big flood years, it caused many losses, mainly the rural infrastructure works, the area of rice, fruit trees lost,...

- Determining the fluctuation of the area of the dike in Dong Thap province from 2000 to 2013.

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