Land Cover Land Use Classification Using Multi-sensor,Multi-temporal Satellite Data; Mekong Delta, South Vietnam

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Abstract: Remote sensing data, Landsat-ETM, JERS-OPS/SAR data in Mekong River delta (Lat 10° 30'-10° 45', Lon 106° 45'-107° 00') were processed for Land-cover Land-use classification. The delta, a flood plane of Mekong River, comprises of a river network formed due to huge freshwater supply from the Mekong basin for millions years. On the other hand during dry period, low river discharge tends to back flow of ocean water due to tides (3-4 m) along the drainage system, causing salt water intrusion into upstream results salt water contamination into the environment. Therefore, the land-cover consists of salt marshes with dense Mangrove forest including other kind of brackish water flora. JERS-OPS images were processed to discriminate the Land-cover classes. Not like in the other areas, wetlands consist of both freshwater and brackish water where, Agriculture, aquaculture, salt mashes. Capability of discriminating those classes are difficult using optical sensor data, hence multi sensor and multi-temporal approaches have been made to overcome the situation to improve the results.

The processing technique adopted in this study is to identify major classes which contain similar spectral characteristics and mask out to segregate major classes. This will enhance the image seperability to perform secondary classification to each segregated major classes and avoid mixing among classes. Near Infra Red (NIR) band of optical sensors allowed to separate three major classes such as water, wetlands and vegetation. However, vegetation represents Mangrove forests, Plantations, paddy and other agricultural crops while the wetlands consist of salt marshes with sparse mangroves and other brackish water flora, mud flats, and aquaculture practices a challenge for image processing. Multi-temporal and multi sensor data allows to overcome the challenge by means of changing nature of land use pattern. Methodology and the results of this work are discussed in this paper in detail.
Key words: Mekong delta, Land-use, Remote sensing

1. Introduction

Remote sensing images are very popular for Land cover, Land-use classification around the world & Land-cover Land use are most fundamental key factors that reflect the environmental risk and main input for the land use planning. Among available space born satellite data, Optical, Thermal and Radar sensors have been demonstrated their capabilities of wide range of applications in land-use mapping. In the tropics, Radar is useful images which are independent of weather conditions and reasonably good repeat cycle for land surface monitoring. Multi-temporal SAR (Synthetic Aperture Radar) data allows monitoring changes in Land-cover using Backscatter intensity changes [3, 4]. However, the decision rules in supervised or unsupervised classification will not give satisfactory results depending on the image characteristics and mixing spectral signatures of different targets on the ground. Thus, the Land cover classification is most tricky thing that can be achieved by combination of multi-data sources including field verifications, and it's true that visual interpretation and human experience is essential. In this study we use multi-sensor and multi-temporal satellite data to discriminate the land-cover, land-use types in to satisfactory level and further development of the methodology is required to segregate some classes. Tim et al (1991) developed a new classification method in order to make the best use of remote sensing data and geographical data by likelihood calculated from remote sensing data combining with probability occurrence of each category such as elevation, inclination and soil etc. [1]. Still this is depending on the occurrence probability which is uncertain in some Land-cover categories on elevation and inclination. Therefore the usage of multi-data for the development Land cover Land use classification is essential.

2. Study area

Mekong delta in Vietnam consists of drainage network flowing out fresh water from land drainage and back flow of salt waters from the ocean cause the brackish water environment in the delta. Therefore salt marshes with mangrove forests

and intra-tidal mud flats are common. The study site falls within the Latitude 10° 30'-10° 45' and Longitude 106° 45'-107° 00' in Mekong River delta. Typical land-use patterns are human settlements, paddy fields, cultivated forest, agriculture and aquaculture practices. In addition these typical classes, Mangrove forest can be found in the south while sparse mangrove forest along river upstream.

The hydrological factors such as rainfall, drainage basin topography, and ocean tides (3-4 m) are causing seasonal flooding, saltwater intrusion during dry period. Therefore the Land-cover consists of Wetlands of salt mashes with Nipa or Palm mostly being converted to Aquaculture. In some parts paddy cultivation is taking place once a year depending on the rainy season that exist from June to October. As seen in the western part of Fig.1 wetlands mostly consist of salt mashes, Mud flats, Nipa or Palm, aquaculture practices and human settlements. In the north, settlements are high and fresh water flora can be seen indicating no salt contamination from the drainage system. Dark red in the south is Mangrove forest which also an indicator of brackish water environment.

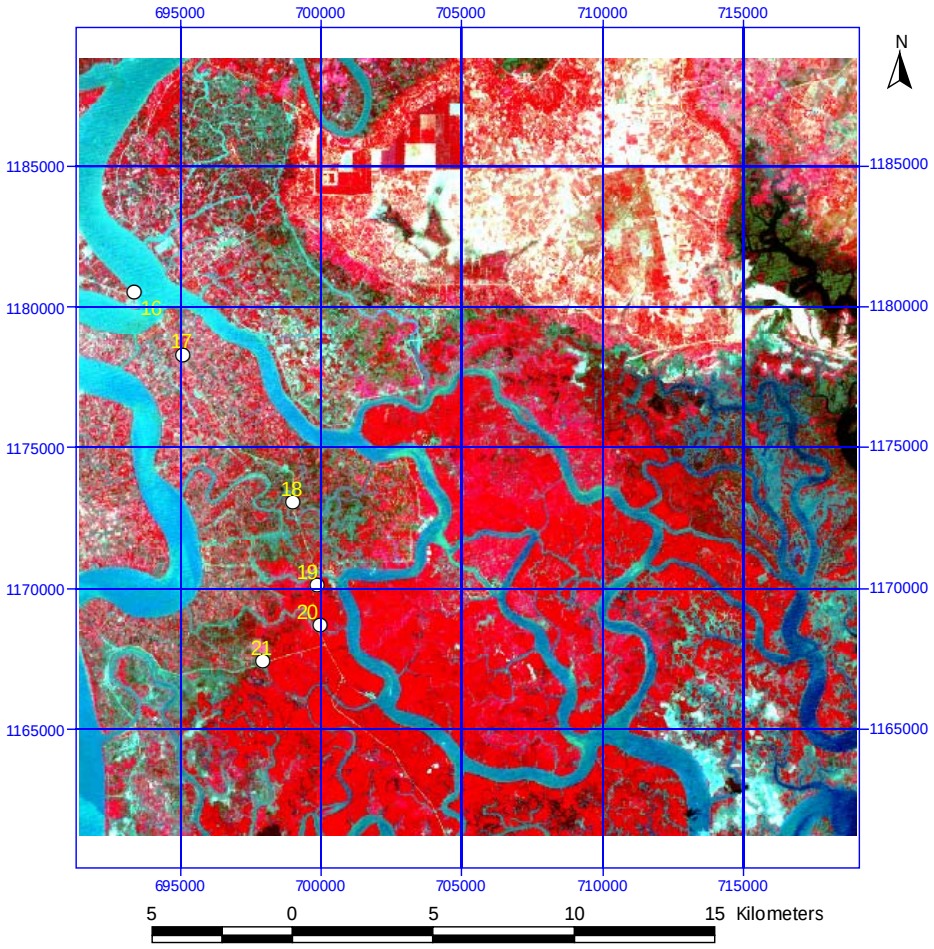

Fig.1 NIR False color composite of JERS-OPS image on 16th November 1994 (RGB:321) of the study area (Binh Phuoc) showing its field survey locations.

3. Objectives

Study area is comprised of various land cover classes including water bodies, urban areas, paddy fields, marshlands and dense mangrove forest. Some of their spectral characteristics are in Visible and Near Infrared (NIR) is very much similar, making it difficult to classify or identify. The main target of this work was to find the most appropriate method and most appropriate spectral information for classification of major Land-use classes. The objective of this study can be enumerated as below,

1. Identify spectral signatures of major Land-use classes in the study area
2. Evaluate the separarability of land use classes by satellite data
3. generate Land-use map with combinations of optical and synthetic aperture radar
4. Investigate the possibility of both Optical and SAR data for land use mapping

4. Materials and method

Two images of JERS-OPS from 1994 and 1997, 6 images of JERS-SAR from1993-1998, and Landsat-ETM data were used for Land-cover, Land-use classification. Different sensor data and multi-temporal data have been used to discriminate different Land covers which are in similar spectral characteristics in one sensor. Pixel sizes ware brought into same sizes (18 m) and all the images were geo-referenced by Image to image using a Landsat Geo-referenced image. Images were subset to fit the Binh Phuoc, local topography sheet in 1:50,000 scale. Multi-sensor and Multi-temporal data used in this study are summarized in Table 1.

SAR images are inherently noisy, which effect mostly for the image homogeneous targets. Noise, the speckle is the main difficulty in interpreting SAR data and there are several ways in which speckle can be reduced [2]. Performance of filters is depends on the window size and number of passes. Enhanced Lee and Enhanced Frost are tested for filtering and Enhanced Lee filter preserve radiometry within the images and removes the unwanted brightness that are associated with speckle in 3 iterations. According to the results both filters show the same performance in 5x5 window size, but the Enhanced Lee filter is quite faster than the Enhanced frost. SAR images are analyzed to derive different parameters used in the classification process, such as Backscatter coefficient and Backscatter intensity change.

NIR band of OPS have been used to classify major three classes such as vegetation, wetlands and water covered areas, together with visual interpretation of Landsat and field survey data. Those classes are exported in to GIS data as shape files as shown in the flow chart (Fig.2). In these three classes, fore example vegetation includes cultivated vegetation like paddy, garden or planted forests and other agricultural plantations and Natural vegetations mangroves, nipa or Palm. Wetlands represent salt mashes, mud flats, aquaculture or stagnant water bodies with sparse vegetation including paddy fields which are land preparation stage or matured stage. The water covered areas mainly consist of rivers and fairly large flood plans fed by river water or tidal back water flows which are appeared in the images depending on the time of acquisition or season.

Training data sets from the images have been collected using the field survey data. The statistical parameters were calculated to understand the spectral characteristics of the image data which influenced by the ground condition mostly the weather and sun angle.

Table 1 Name of the Multi-sensors, observation dates of images.

JERS-OPS	JERS-SAR
	01-22NOV93
01_16NOV94	02_30JUN94
	03_05FEB95a
	04_31JUL95b
02_16JAN97	05_27DEC97
	06_08MAY98

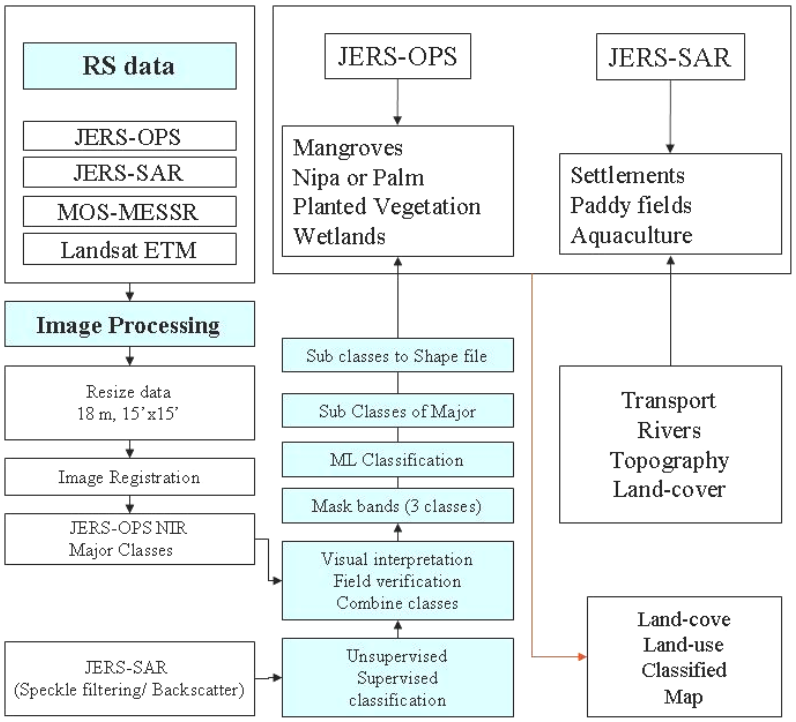

Fig.2 Flow chart showing steps of the methodology adopted for image processing

5. Results and discussion

Different approaches have been made for land-cover Land-use classifications with combinations of optical and Radar images. In optical sensors the spectral signatures are similar in all vegetations types. Thus the discrimination within the vegetation is somewhat difficult. The distribution of image data in vegetation classes Mangrove, Nipa, and Rubber in this case fall within the same ranges (Fig.3) although the intensity is different. Vegetation Reflect more energy in the NIR region and wetlands and water reflect low energy. So that the discrimination of major classes can be categorize as vegetation, wetlands and water as mentioned before. The common problem is the mixing of classes which are similar in spectral signatures. This situation can overcome by simply separating the image into major classes before subsequent detail classification. This can achieve by masking out the image in to three classes and perform decision rules for each class using training data sets separately and combine later in GIS environment.

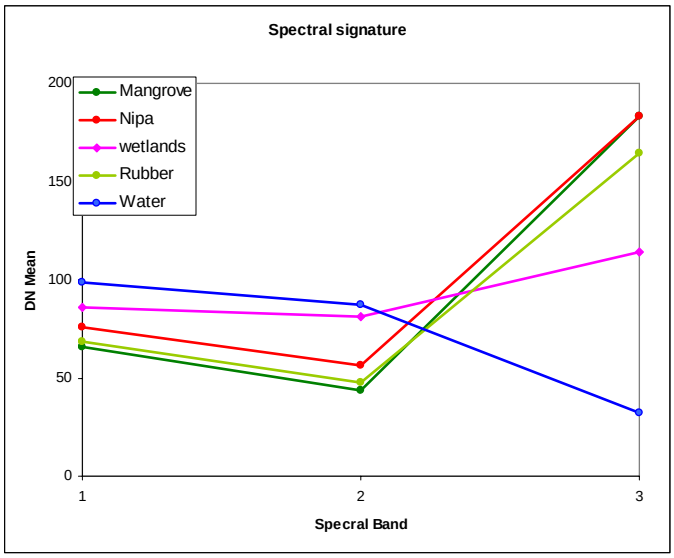

Fig.3 Spectral signatures of training data sets of JERS-OPS image

Multi-temporal satellite data can be used to discriminate some of the seasonal vegetations such as paddy. The spectral signatures of garden-vegetation, nipa and mangrove are very close in all 3 bands in the image (Fig.3, Fig 5). However, the spectral signatures of all categories of vegetation, wetlands and water are separable in NIR, the band 3 (Fig.3) show that some pixels may still be mixed and appeared in each class but can be merged after secondary classification.

Most challenging part of this study is to discriminate the classes within the wetlands which include mash lands, paddy fields, cleared Nipa fields and aquaculture ponds. Although these are appeared as same in satellite images, the changing parameters can be utilized for discriminating these classes. For example, paddy fields have different stages from their land preparation to harvesting period which can be detected from the multi temporal SAR backscatter intensity changes. Thus, the SAR data allows to extract the paddy field. Separating the marsh lands and aquaculture can
be achieved by the geometric shape of the aquaculture ponds the mashes have an irregular shape. The backscatter from surrounding dykes allows the recognition and separation of shrimp ponds from all other water-covered surfaces [5].

Fig.4 is a multi temporal JERS-SAR image of the study area. This was created using 4 JERS-SAR images acquired on 1993 November, 1994 June, 1995 Feb and 1995 July in order to enhance the changes in backscatter between different data, ratio images were used in the composite. That is the RGB composite of 1993/94, 1994/95 and 1995/15 respectively.

Darker tone of the western part is mostly the wetlands of mash, paddy and aquaculture. North part which appeared in light-radish color are areas of land covers are being changed by the human activities and discolored areas are human settlements which are not been changing during short time periods. Similarly, in the south part also represent as discolored which are mangrove forest (see fig.6) also less temporal changes. However, settlements and mangroves can be discriminate from their backscatter coefficients also.

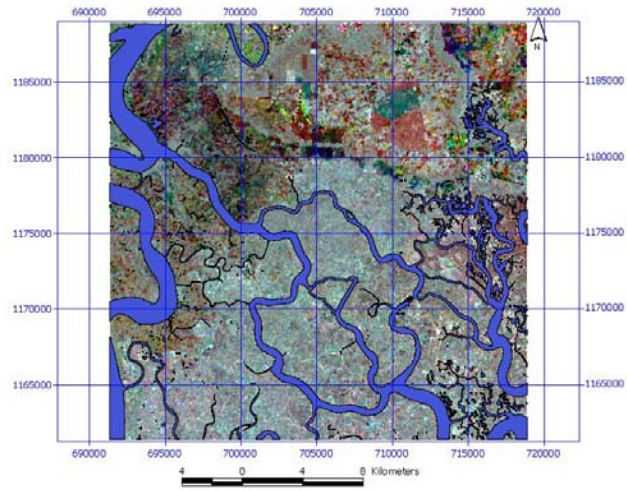

Fig.4 JERS-SAR showing wetlands (paddy, salt mashes, mud flats, Aquaculture) in dark tone on the left and uniform Radish in the south is Mangrove.

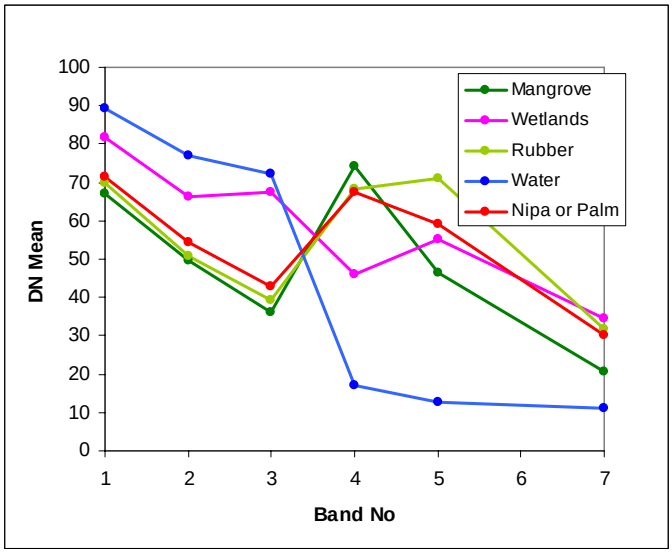

Fig.5 Spectral signatures of training data sets of Landsat TM+ image

Landsat ETM+ image was also processed for the similar way to classify the land cove land use pattern to compare the results. NIR, the band 4 (0.76-0.9 μm) with similar spectral range of JERS-OPS (0.76-0.86 μm) is enables to separate the area into 3 classes as in the JERS-OPS data. Classification results (Fig.6) is more generalized and appropriate for large area mapping for Land cover Land use. The spatial resolution of JERS-OPS is 18 m which is higher (~3/5) compare to the Landsat revealed that the detailed classification is requiring higher spatial resolution depending on the objectives.

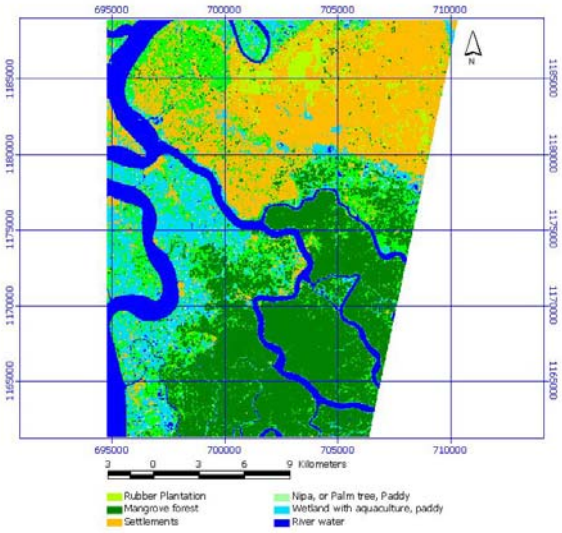

Fig.6 Land cover Land use map of Binh Phuoc classified into five classes from Landsat TM+ image data

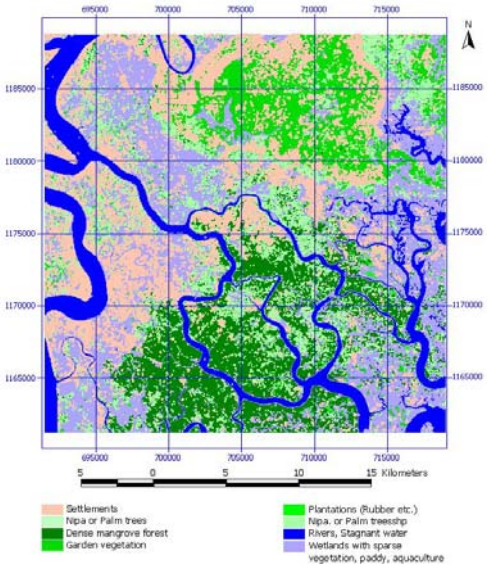

Fig.7 Land cover Land use map of Binh Phuoc classified into six classes from JERS-OPS image data

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