

# REMOTE SENSING APPROACH FOR IDENTIFYING LANDSCAPE USE CHANGE IN MEKONG RIVER DELTA, VIETNAM

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## ABSTRACT

*Changes of landscape in Lower Mekong basin, in territories of Viet Nam could be observable by using various historical remote sensing data and up-to-date. Geographic data with various sources compose of maps, aerial photos, satellite imagery and census data. Natural ecosystems are modified to human-made systems. Flooded forest area are severely declined both in Vietnam territory. Particularly, shrimp farms of saline aquaculture occupy almost mangrove areas. As a consequence, forest cover rate drops down 5.78 % for the entire Mekong delta (Vietnam) and regarding natural forests this rate is 1.4% only. Vast marshes, swamps and flooded forests have been drained by dense system of irrigation with canals and road-dikes to block flood of Mekong River to develop rices from one to three crops per year. Typically, this is seen at two areas of Dong Thap Muoi - Plain of Reeds and Long Xuyen Quadrant. All these make a new face of Mekong delta, it is waterscape of dense canal-dike network. In some areas, natural landscape has totally changed, the others are remained a few, regarding the area extent these only occupy less than 40 percent and it is considered as semi-natural landscape.*

## 1. INTRODUCTION

With history of new land exploitation has been about three centuries, Mekong River Delta (MRD) has been a period of changing marked by spatially enormous transformations that have taken place in the landscape in order to modify the delta (Nijs, A.D. & Shannon K., 2010). This artificial prominent intervention in the MRD is to change its wild natural status, forcing the land mostly for settlement and production under the pressure of increasing population. The first cut had made into the land known as the construction of Vinh Te Canal in period of 1819-1824 (Ehlert J., 2012; Kênh Vĩnh Tế, 2014 ) stretching from Bassac river westward to Giang Thanh river running out to the Gulf of Thailand via Dong Ho swamp, connected the two towns of Chau Doc and Ha Tien. This canal is the western frontier line between Vietnam and Cambodia, a water transport, supporting people reached into the interior of the delta and it is considered as the first irrigation project in the Mekong delta (Ehlert J., 2012). Afterward, there have been drastic changes in this area that a natural, swamp and depressed area has altered to a productive agricultural land with mostly monoculture of paddy on the entire area.

There have been a large documentation and many literature reviews recored the change in the MKD both on researches as well censuses (Stewart M.A. & Peter A. C., 2011; Ehlert J., 2012; Stanturf J. *et al.*, 2012; Renaud R.G. & Kuenzer C., 2012). In addition, this modification could be observable by historcal geographic data with various sources, in particular by satellite imagery, which are changes on forest cover, cultivated lands, built-up

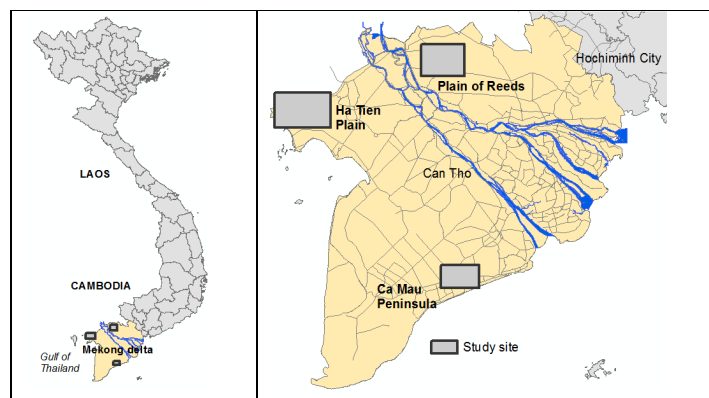
areas and others. This research will focus on three small areas using Landsat images at different dates of acquisition prior to 1990 and the latest in 2014 to examine changes over times. This will look at the landscape perspective rather than changes of forests or agriculture and urban expansion *etc.* because various studies have been already conducted on these fields by remote sensing approach. The three areas are a part of the Plain of Reeds, Ha Tien Plain, and Bac Lieu, a part of coastal area in the south where the intrusion of salt water is affected (Figure 1).

## 2. METHODS

### 2.1 Research areas and data

Three sites are selected for Mekong delta, including Plain of Reeds (Site 1), Ha Tien Plain (Site 2) and Ca Mau Peninsula (Site 3) as on the Figure 1, which are typical for low topography, depressed areas, acid sulphat soil and coastal saline soil. The Plain of Reeds and Ha Tien plain are characterized as a depression floodplain. The first is also a depression floodplain but its extent is larger the first, located inland, left side of the Mekong River (Tien River). It is a vast wetland depression of about 13,000 km<sup>2</sup> encompassing the provinces of Dong Thap, Tien Giang, and Long An in Viet Nam, and parts of Cambodia. The second locates at the northwest of the Mekong delta, right side of the Bassac river, near the Gulf of Thailand, belonging to the Long Xuyen Quadrangle and framed by cities of Long Xuyen, Chau Doc, Ha Tien and Rach Gia, covers more than 4,000 sqkm (Ehlert, Judith, 2012). A large part of the Plain in MRD is composed of acid-sulphate soils (Mekong Wetland, 2014). The two plain lies in flat lowland regions, depressed at the middle area and subject to seasonal flooding with a depth of 1.5-3.0 m in the Plain of Reeds and around 1 m at the Quadrangle region (*ibid.*; Can N.D. and Xuan V.T., 2002). The original plains were covered in dense vegetation with small natural streams, mosaic grassland, open swamp and forest, which are still retained in nature reserves or uncultivated wetland areas (Maltby E. and Tom B., 2009).

The third site is a part of Ca Mau peninsula, a coastal region and it is in contrast to the two formers in terms of fresh water supply, subject to saline intrusion in dry season, slight inundated from 0.3 to 0.5 m because of stagnant rainwater in rainy season (Can N.D. and Xuan V.T., 2002). This area is characterized by a complexed soil of high salinity and low pH with acid sulphate potential located along coastal areas, have limited uses (Catling, H. D. , 1992; Torell M. *et al.*, 2003) and vegetation dominates by mangroves and many brackish water and saline tolerant species.



**Figure 1. Location of the Mekong delta and three study sites**

Images of Landsat 3 MSS, Landsat 4-5 TM, landsat 7 ETM+ and Landsat 8 at different dates of acquisition have been obtained from USGS – Earth Resources Observation and Science Center (EROS) via ULR <https://earthexplorer.usgs.gov> as the list below.

**Table 1. List of images used in this study**

Landsat path/ row – Date of acquisition (dd.mm.yy)	Site	Geographic extent	Area (sq.km)
125 – 53 - 25.01.1979* - 02.02.1995 - 21.01.2014	1. Plain of Reeds (Dong Thap area)	10 <sup>0</sup> 38' – 10 <sup>0</sup> 51' N 104 <sup>0</sup> 27' – 104 <sup>0</sup> 44' E	733
126 – 53 - 26.01.1979* - 01.12.1992 - 20.01.2014	2. Ha Tien Plain (Kien Giang area)	10 <sup>0</sup> 17' – 10 <sup>0</sup> 31' N 104 <sup>0</sup> 28' – 104 <sup>0</sup> 50' E	1050
125 – 54 - 25.01.1979* - 06.04.1989 - 09.12.2009	3. Bac Lieu-Ca Mau Peninsula	9 <sup>0</sup> 14' – 9 <sup>0</sup> 23' N 105 <sup>0</sup> 34' – 104 <sup>0</sup> 50 E	476

Notes: \* pixel size is 60 m, the other dates are 30 m.

Digital topographic map of 1/50,000 from 2000-2006 collected from GIS and Remote sensing Research Center (GIRS); Old topographic maps during 1968-1975, scale 1/50,000 and statistic census from the General Statistics Office (gso.gov.vn).

## 2.1 Method

Identification of main cover types as forests, grass land, water bodies, cultivated land and aquaculture, which are applied supervised classification approach for all images. Samples for training data were adopted from recent field surveys during 2010-2012 for land cover mapping research of GIRS. Classification results were grouped regarding to property of natural, semi-natural or artificial landscapes that are based on distribution pattern and its nature shapes of classified objects. Changes are analyzed with statistical census and other ground observation that are used as illustrations along with observation from satellite images.

## 3. RESULTS

There are large changes to be observable in the MRD after 1980s from natural/ semi-natural to artificial landscape. The former is identified as forests (seasonal flooded forests – Melaleuca forests and mangroves, water bodies), swamp/ marshes with seasonal grasses and the later is defined as cultivated surfaces, water bodies of aquaculture, built-up areas.

### 3.1 Sites

- Plain of Reeds with total area of 733 sqkm.

**Table 2. Percentage of landscape use in the Plain of Reeds during 1979-2014**

	1979	1995	2014
Nature	99.14	51.42	24.07
-Forests (Melaleuca)	29.69	29.98	14.00
-Swamp, seasonal grassland	69.46	21.44	10.07

Artificial	0.86	48.58	75.93
- Agriculture	0.86	48.58	75.93

The wild landscape was kept as its original condition till prior to 1980s. Seasonal flooded forest, shrubs of Melaleuca and grassland were indentified as heterogenous shapes, size and distribution in the area in 1979 image, which occupied 99 percent in this area. In 2014, system of canals with high density is observed, which indicated as the most change and a vast natural land became area of paddy relying heavily on the canal system. This covers more than ¾ the total area (Table 2).

- Ha Tien Plain with total area of 1,050 sqkm.

**Table 3. Percentage of landscape use in the Ha Tien Plain 1979-2014**

	1979	1996	2014
Nature	83.58	82.46	40.57
-Forests - Melaleuca	28.64	26.76	12.89
-Forests - Mangroves	0.57	1.41	0.93
-Swamp, seasonal grassland	45.79	45.57	9.79
-Upland forests	3.67	1.16	10.01
-Water body (lake, river, sea)	4.91	7.56	6.95
Artificial	16.42	17.54	59.39
- Agriculture	5.23	13.75	45.76
- Bare land (built up...)	11.19	3.79	1.30
- Aquaculture			12.33

Situation of the Ha Tien Plain is similar to the Plain of Reeds, which is a depressed area, subjected seasonal flooded from Mekong River in rainy season. In addition, this region locates adjoining the Gulf of Thailand via Dong Ho swamp and Giang Thanh river that is favorite for natural mangroves growing. In 1979, about 80 percent of the land was covered by seasonal flooded forest and swanp and a small patch of mangrove along GiangThanh river and around Dong Ho swamp. Cultivated land at that time was only about 5 percent and it has been raised up 45 percent in 2014, addition 12 percent of aquacultural land. Percentage of natural and man-made landscape in 2014 are 40 percent and 60 percent respectively (Table 3).

- Bac Lieu - Ca Mau Peninsula with total area of 476 sqkm.

**Table 4. Percentage of landscape use in Bac Lieu - Ca Mau Peninsula during 1979-2009**

	1979	1996	2009
Nature	25.93	11.18	6.29
-Forests - mangroves	25.22	10.39	5.53
-Water bodies	0.71	0.79	0.76
Artificial	74.07	88.82	93.71
-Agriculture	69.65	76.52	43.39
-Built-up	0.03	1.34	5.09
-Bare	4.39		
-Parennials		6.61	14.22
- Aquaculture		4.35	31.01

This area is not suffered seasonal flood I rainy season so land has been cultivated for a long time ago. The land was covered by paddy in rainy season with type of deep water rice and a long period of fallow during dry season, at which land exposed as observable on the satellite images as type of dry saline and acid sulphate soils. In 1979 25 percent of the area remained as natural land featured by mangroves and the rest as semi-natural area as

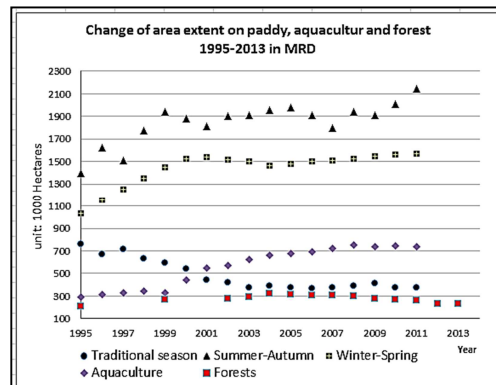
cultivation only in rainy season but in 2009 mangrove extent has been declined, covering only 6 percent of the total land area, aquaculture has strongly developed and it reached up 31 percent. At the present, 93 percent of the land is considered as modified landscape. Agriculture area of paddy was reduced but crop rotation has raised up two crops per year based on canal system too.

### 3.2 Mekong River Delta

Considering the whole MRD with the three sites a typical samples of change in landscape. The most change in the MRD is the conversion of natural land into agricultural land through strong development of canal system that has been called a a long period of canalization in this area.

Before 1980s, density of canal system of the MRD area was less than 1km/sqkm. Based on topographic map of 1/50,000 published during 2000 - 2006 for the MRD, canals were extracted and canal density was computed, of which outcomes shows that canal density increased more than 2 km/sqkm. In the Plain of Reeds, canal system is of the highest density with more than 4 km/sqkm. In the site 1, average density is 3.1 km/sqkm, site 2 is 1.7 km/sqkm and site 3 is 2.8 km/sqkm. This canal system is observable on landsat image with 30 m spatial resolution for wide canals.

In general, statistic census also disclosed that during period 1995 until now, there have been changes in land cover that are in paddy, aquaculture and forest (Figure 2).



**Figure 2: Area extent of paddy, aquaculture and forest during 1995-2013**

**Soucre data: GSO Vietnam**

Paddy cultivation with three crops per year has increased area of Summer-Autum and Winter-Spring whilst traditional season (cultivated in rainy season) has decreased significantly. This illustrates changes in landscape coinciding with observation and identification by Landsat images in this period. The increase of the two paddy crops indicates that land area has been strongly canalization along with raising density of canal system. In addition, water bodies for aquaculture has increased and forest cover decreased, which are also evidences of ground census for space observation.

## 4. CONCLUSIONS

Landsat 3-MSS images acquired in 1979 are limited in low spatial resolution and spectral bands so that small objects were not detectable but these gave enough information to differentiate the two defined status for three study sites. Landsat TM, ETM and Landsat 8 fully give information for landscape observation. The main conversion for all is from nature to agriculture, mostly for paddy. The natural remains are also modified as semi-nature

## 5. ACKNOWLEDGMENTS

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