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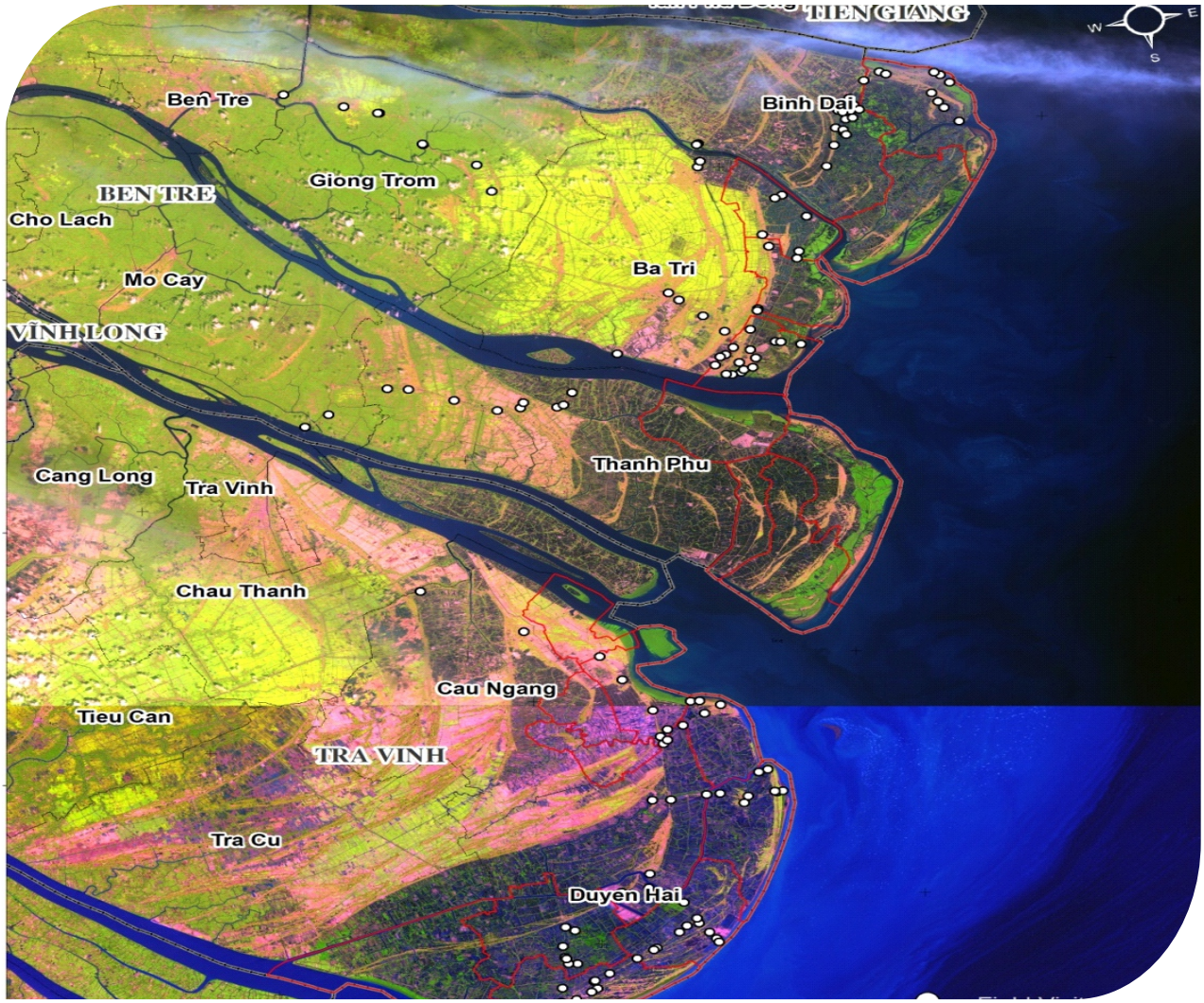
LAND COVER CHANGE ANALYSIS IN BEN TRE AND TRA VINH PROVINCES USING MULTI-TEMPORAL SPOT 5 SATELLITE IMAGES



SPACE TECHNOLOGY INSTITUTE

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1. PREFACE

Coastal communities in many parts of Asia are particularly vulnerable to the impacts of climate change, with increased severity of extreme weather events directly affecting the lives of millions of people and damaging the ecosystems and resources they rely on for everyday survival.

This report has been produced as part of the Mangroves for the Future (MFF) initiative. MFF is a unique partner-led initiative to promote investment in coastal conservation for sustainable development. Co-chaired by IUCN and UNDP, MFF works to restore the health of coastal ecosystems as a contribution to building resilience in coastal communities in Asia. The emphasis is on generating knowledge, empowering local communities and governments, and working to promote policy solutions that will support best practice in integrated coastal management.

Moving forward, MFF will increasingly focus on building resilience of coastal communities by promoting ecosystem-based approaches and by showcasing the climate change adaptation and mitigation benefits that can be achieved with healthy mangrove forests and other types of coastal vegetation.

Healthy coastal ecosystems play a major role in helping coastal communities to adapt to climate change impacts. Mangroves and other coastal vegetation support biodiversity conservation and enable improvements in livelihoods and human well-being, while also providing cost-effective risk reduction against such threats as coastal erosion, storm surges and tsunamis. Mangroves also offer potential for mitigating climate change impacts through their high carbon storage capacity, thereby contributing to the Reducing Emissions from Deforestation and Degradation (REDD+) process.

At the same time, MFF is working to improve the effectiveness of governance and management of coastal resources by promoting models of co-management, payment for ecosystem services and similar resource-sharing mechanisms that will benefit traditional coastal communities. This is particularly important given that conservation may often appear to have high opportunity costs when other uses of natural areas (notably aquaculture) are more profitable in the short term, and that the local communities most affected by natural resource decision making may not have a voice.

This report is one of many which highlight ecosystem-based approaches being developed and tested around Asia. It is being produced and shared by MFF in order to serve as a resource and learning tool for coastal management practitioners, but also to help in raising awareness of the many issues and challenges which surround the protection of Asia's coastlines and the communities they support.

2. INTRODUCTION

Ben Tre and Tra Vinh Provinces are located in the Mekong Delta, which is considered one of the world's most vulnerable areas to global sea level rise by virtue of its low elevation. Agriculture, aquaculture, transport, drinking water, and other sectors are already strongly affected by coastal erosion and salt water intrusion, which in extreme years can extend up to the Cambodian border.

Mangrove forests are an important habitat for marine life, especially small fish, crab, shrimp, and oyster, which shelter and feed among the extensive mangrove root systems. They also play a vital role in coastal protection, sediment trapping, and water filtration. The mangroves of Ben Tre and Tra Vinh have suffered successive waves of expansion and contraction since the early 1970s when they were partially defoliated during the American War.

Several internationally funded projects are working on mangrove conservation in the Mekong Delta by testing community co-management arrangements, adding value to mangrove-shrimp-crab-fish polycultures, supporting certified organic shrimp production, monitoring mangroves over time, and other interventions intended to increase the opportunity and incentives for greater public participation in mangrove conservation.

This study supports a project funded by Mangroves for the Future (MFF) to enhance community resilience in four coastal districts in Ben Tre and Tra Vinh. It builds on similar satellite-based land cover change analyses in the coastal portions of the Mekong Delta using SPOT 5 images taken in 2005, 2009 to 2012 in Ben Tre Province, Tra Vinh (2012)[1] and to 2013 in Ca Mau Province (IUCN 2013)[2].

This study's objectives are to:

- Classify land cover in Ben Tre and Tra Vinh using SPOT 5 satellite images taken in 2012.
- Validate the 2012 results, and the 2005 results for the same area, using data from field surveys.
- Map changes in land cover between 2005 and 2012 with a focus on the five coastal districts.

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[1] *IUCN (2012) Technical report on Land Cover Classification and Land Cover Change Analysis in the Mekong Delta Using Multi-temporal SPOT Satellite Images.*

[2] *IUCN (2013) Technical Report on Land Cover Classification and Land Cover Change Analysis in Ca Mau Using Multi-temporal SPOT Satellite Images.*

3. MATERIAL AND DATA PROCESSING

3.1. Data and materials

Two 10 m-resolution multi-spectral SPOT 5 satellite images (276-330 and 276-331) were used in this study. These were taken during the January-April dry season (Table 1), the same period as the images used by previous studies. The vegetation cover is therefore expected to have similar appearance and reflectance patterns, facilitating comparison over time.

Path - row	Pediod 1	Pediod 2	Pediod 3
275-330	2005-01-21	2009-03-15	N/A
275-331	2005-01-21	2009-03-15	N/A
276-330	2004-01-12	N/A	2012-02-14
276-331	2005-02-22	N/A	2012-01-02
277-330	2005-02-22	2004-01-18	N/A

Table 1. SPOT 5 images acquired for Ben Tre Tra Vinh

The project area covers nineteen communes in five coastal districts in Ben Tre and Tra Vinh (Table 2, Figure 1).

Province	District	Commune	Province	District	Commune
Ben Tre	Ba Tri	Bao Thanh	Tra Vinh	Cau Ngang	My Long Bac
					My Long Nam
		Bao Thuan			Hiep My Đong
		An Thuy			Hiep My Tay
	Binh Đai	Thua Đuc		Duyen Hai	Hiep Thanh
		Thoi Thuan			Truong Long Hoa
	Thanh Phu	An Đien			Dan Thanh
		Giao Thanh			Long Khanh
		Thanh Hai			Đong Hai
		Thanh Phong			Long Vinh

Table 2. Communes in project area

Figure 1. SPOT 5 images of project area

3.2. Land cover classification system

In this study, special attention was paid to changes in coastal vegetation and aquaculture. For consistency, the land cover classification system used MONRE's national land cover classification scheme, which was used in the previous IUCN studies. Some land cover types that did not appear in the study area were removed and a new cover type, casuarina, a tree that is often planted along the coast as a wind break and soil stabilizer along sea dikes, was added (Table 3):

Group	Land cover code	Land cover type	Acronym
Agriculture	1	Rice field	RICE
	2	Aquaculture	AQUA
	3	Salt field	SALT
	4	Ochard/fuit garden	FRUIT
	16	Other vegetation (annual crops)	ANNUAL
Settlement	5	House and built up area	HOUSE
Forest land	6	Magrove forest	MANG
	18	Magrove (sparse,young,or scrubs)	SPARSE
	23	Casuarina stress	CAS
Water body	8	River, sea	RIV/SEA
Wetland	11	Inter tidal area	TIDAL
Other land cover	13	Sandy area (beach/dune)	SAND

Table 3: Lan cover types in Ben Tre Tra Vinh

For mangrove forest, there are several different definitions of "forest" to be considered. In this study, mangrove forest (MANG) and sparse mangrove (SPARSE) were separated using standards from the IUCN study in Ca Mau (Table 4):

Thresholds	UNFCCC	FAO	MARD	CDM	MANG	SPARSE
Minimum area (ha)	0.05-1.0	0.5	0.5	0.5	0.05	0.05
Minimum height (m)	2-5	5	5	3	2	1-2
Crown cover (%)	10-30	10	10	30	30	10-30
Strip length (m)	N/a	N/a	20	N/a	20	20

Table 4: Different definitions of "forest"

MANG refers to mangroves at least 2 m high, 30% crown cover, covering at least 0.05 hectares or strips at least 20 m long.

SPARSE refers to mangroves 1-2 m high, with 10-30% crown cover, covering at least 0.05 hectare or strips at least 20 m long.

3.3. Land cover classification approach

The two SPOT 5 scenes were rectified to the same projection as the 2005 images, which are in UTM Zone 48 North, datum WGS84.

As in the previous studies, a semi-automated classification approach was used whereby an ISODATA unsupervised classifier generated 80-100 classes. These classes were visually inspected and combined into different land cover types according to the land cover classification system. A majority filter was then used to smooth the classification result.

The classification accuracy is usually determined by comparing the classification results with reference data ("ground truthing"). In this case, a field trip was organized to collect ground truth points (GTP). The accuracy assessment focused on major land cover types such as AQUA, MANG, SPARSE, and ANNUAL.

The 2005 classification was also revised using information gathered during the field trip. Some land cover types had been misclassified. These were reclassified in order to compare with the 2012 land cover classification.

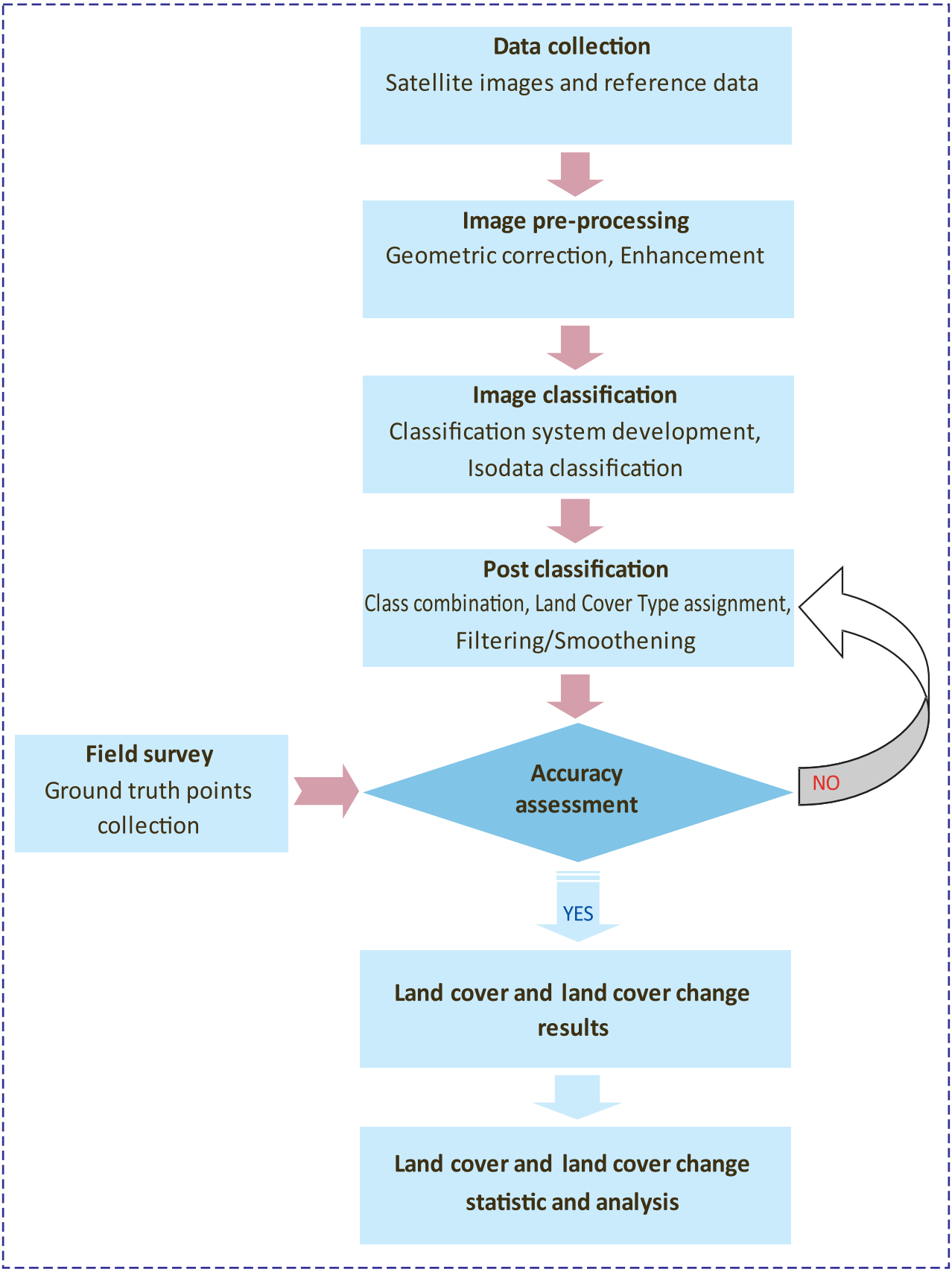

Figure 2. Images processing and land cover change analysis workflow

3.4 Land cover change assessment approach

The land cover change assessment was carried out on the overlap between the 2005 and 2012 images (Figure 3). Changes that seemed illogical (e.g., BUILT to ANNUAL) were visually inspected and corrected, as necessary. A single image was then produced that encoded the land cover type in 2005 and 2012 using the format XXYY, in which XX is the land cover code of 2005, and YY is the land cover code of 2012.

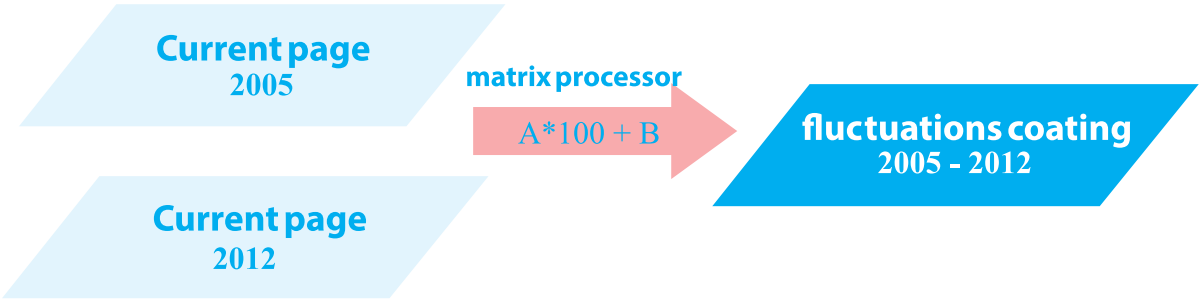

Figure 3: Change detection process

3.5 Accuracy assessment

The accuracy assessment was done using the GTPs collected during the field visit supplemented with Google Earth images and maps. A confusion matrix was used to compare the GTP results with the classification results. This matrix shows three different accuracy measures: overall accuracy, producer accuracy, and user accuracy.

Overall accuracy is calculated by counting how many GTPs were classified the same on both the satellite image and ground survey and dividing this by the total number of GTPs. It is defined as:

$$\text{Overall accuracy} = \frac{\sum_{i=1}^{k} n_{ij}}{n}$$

Where:

- k = the number of land cover types
- nij= total number of samples classified into class i (i = 1,2,…,k) on the classified image and class j (j = 1,2,…,k) on the ground
- n = total number of GTPs

The disadvantage of the overall accuracy measure is that it does not show how well individual cover types were classified. User and producer accuracy are two measures of per-class accuracy. Producer accuracy is the probability that a certain land cover of an area on the ground is classified correctly. It is defined as:

$$\text{Producer accuracy} = \frac{n_{ij}}{n_{+j}} \%$$

User accuracy is the probability that a pixel labelled as a certain land cover class on the image is in fact that class on the ground. It is defined as:

$$\text{User accuracy} = \frac{n_{ij}}{n_{i+}} \%$$

In July 2013, a 4-day field trip was conducted in Binh Dai and Ba Tri Districts in Ben Tre, and in Cau Ngang and Duyen Hai Districts in Tra Vinh. The field visits covered the whole area, allowing for a wide distribution of GTPs, and targeted sites that experienced large changes in MANG.

140 sites were visited. At each site, land cover and GPS location were recorded and photos were taken. This information was used to generate in the accuracy assessment
of the 399 GTPs, 330 were classified correctly (Figure 3).

Figure 4: Field sites visited in Ben Tre and Tra Vinh

4. RESULTS AND DISCUSSION

The analysis only covered the five focal districts in Ben Tre and Tra Vinh. District and commune boundaries were extracted from the national administration boundary database updated in 2008.

4.1. Land cover in 2005

4.1.1. Ben Tre

AQUA is the dominant land cover type in this area, occupying 15,871 ha or 45% of the total area (Table 5). AQUA is distributed widely but tends to decline toward the coast (Figure 4).

MANG and SPARSE cover 2,980 ha and 2,655 ha or 8.4% and 7.5% of the area, respectively. MANG located near the coast is protected forest while SPARSE surrounds MANG and AQUA. Most MANG (56%) is in Thanh Phu District while SPARSE is mostly found in Binh Dai District (Figure 4). CAS covers 11.5 ha and is found on sandy soils near the sea. SALT covers 1,050 ha or 4% of the area and is nearly all found in Ba Tri District.

Land cover	Binh Dai		Ba Tri		Thanh Phu		Total Area		
	ha	%	ha	%	ha	%	ha	%	%
RICE	0.0	0.0	794.4	100.0	0.0	0.0	794.4	100	2.2
AQUA	4,578.1	28.8	2,507.6	15.8	8,785.6	55.4	15,871.3	100	44.6
SALT	110.9	8.1	1,250.5	91.9	0.0	0.0	1,361.4	100	3.8
FRUIT	1.8	4.2	40.8	93.9	0.8	1.9	43.4	100	0.1
HOUSE	396.6	17.6	861.7	38.1	1,000.7	44.3	2,259.0	100	6.3
MANG	657.3	22.1	655.3	22.0	1,667.4	56.0	2,980.0	100	8.4
RIV/SEA	2,424.3	32.6	1,659.4	22.3	3,345.2	45.0	7,429.0	100	20.9
TIDAL	73.4	12.7	55.5	9.6	447.2	77.6	576.1	100	1.6
SAND	39.6	36.7	11.0	10.2	57.3	53.1	108.0	100	0.3
ANNUAL	448.1	29.9	277.5	18.5	773.9	51.6	1,499.4	100	4.2
SPARSE	1,372.0	51.7	449.6	16.9	833.9	31.4	2,655.5	100	7.5
CAS	11.1	96.5	0.1	0.5	0.3	3.0	11.5	100	0.0
Total area	**10,113.1**	**28.4**	**8,563.3**	**24.1**	**16,912.3**	**47.5**	**35,588.7**	**100**	**100.0**

Table 5. Land cover in focal districts in Ben Tre in 2005

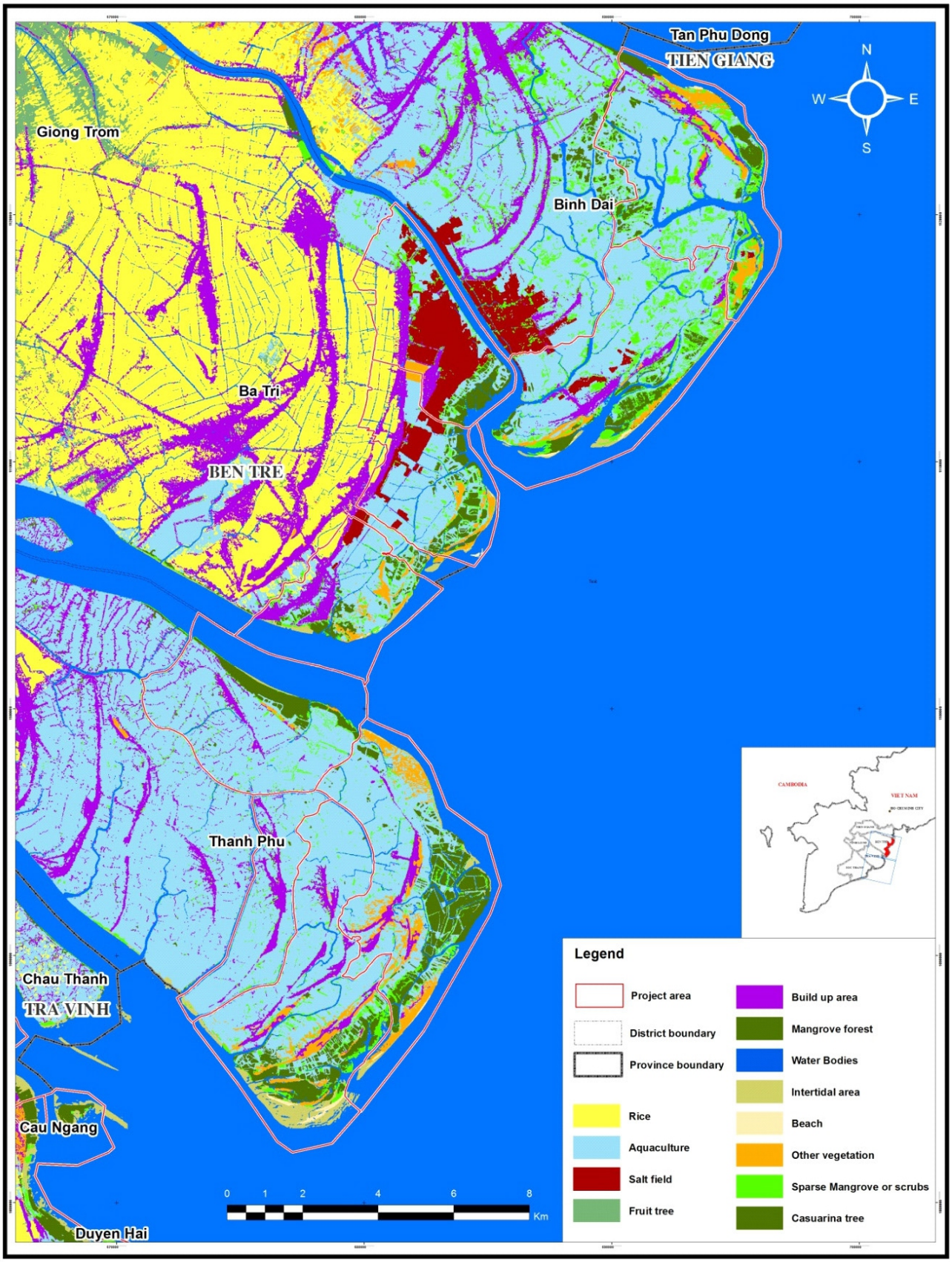

Figure 5: Land cover in project area in Ben Tre in 2005

4.1.2 Tra Vinh

AQUA is the major land cover type followed by RIV/SEA. AQUA covers 16,540 ha or 44% of the area (Table 6). The area of AQUA is much larger in Duyen Hai (86.9%) than in Cau Ngang. SPARSE is also common, covering 5,086 ha or 13.4% of the area.

MANG covers 7% of the area, much less than SPARSE. MANG is mostly found in the river mouth in My Long Bac and My Long Nam Communes in Cau Ngang District, and in Long Vinh and Dong Hai Communes in Duyen Hai District (Figure 5).

There is much more CAS in Tra Vinh than in Ben Tre. CAS covers 113 ha, mainly in Dong Hai Commune. ANNUAL covers 4.7% and is confined to the sandy areas along the shore in Hiep Thanh, Truong Long Ho, and Dong Hai Communes.

Land cover	Cau Ngang		Duyen Hai		Total		
	Ha	%	Ha	%	Ha	%	%
RICE	3,267.7	93.6	223.1	6.4	3,490.8	100	9.2
AQUA	2,170.0	13.1	14,370.8	86.9	16,540.7	100	43.4
SALT	0.0	0.0	0.0	0.0	0.0	0	0.0
FRUIT	10.2	62.7	6.1	37.3	16.2	100	0.0
HOUSE	1,171.1	52.2	1,072.2	47.8	2,243.4	100	5.9
MANG	361.0	13.9	2,235.5	86.1	2,596.5	100	6.8
RIV/SEA	1,695.1	31.8	3,628.9	68.2	5,324.0	100	14.0
TIDAL	182.9	35.3	335.6	64.7	518.5	100	1.4
SAND	0.0	0.0	354.0	100.0	354.0	100	0.9
ANNUAL	388.2	21.5	1,420.1	78.5	1,808.4	100	4.7
SPARSE	105.6	2.1	4,980.4	97.9	5,086.0	100	13.4
CAS	10.2	9.0	103.1	91.0	113.3	100	0.3
Total	**9,362.0**	**24.6**	**28,729.8**	**75.4**	**38,091.8**	**100**	**100**

Table 6. Land cover in focal districts in Tra Vinh in 2005

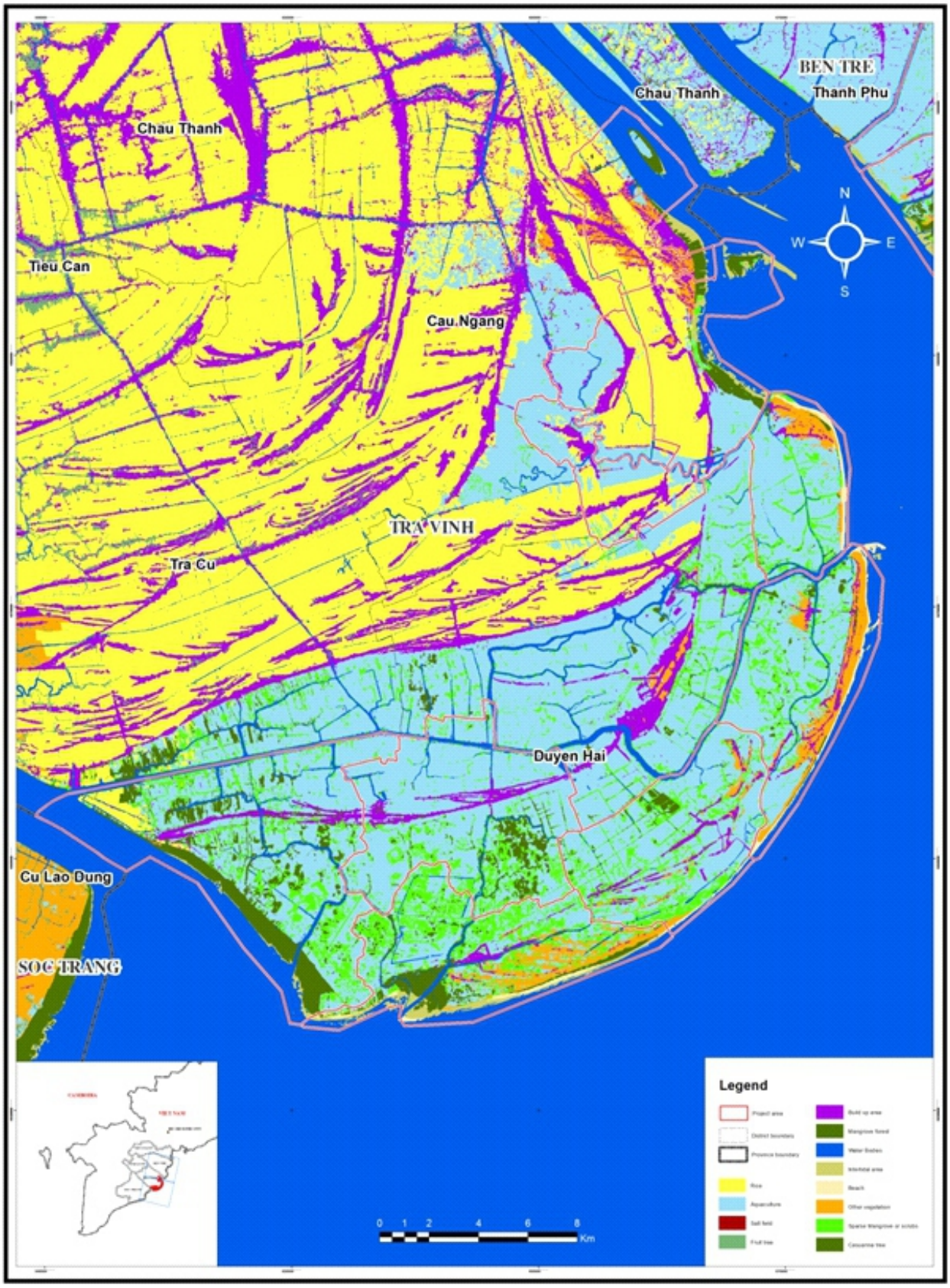

Figure 6: Land cover in project area in Tra Vinh in 2005

4.2 Land cover in 2012

4.2.1 Ben Tre

AQUA remains the dominant land cover type, covering 44.5% of the area (Table 7). Between 2005 and 2012, only 39 ha of AQUA changed to other land cover types. RIV/SEA is the second largest.

Land cover	Binh Dai		Ba Tri		Thanh Phu		Total		
	Ha	%	Ha	%	Ha	%	Ha	%	%
RICE	0.0	0.0	683.0	100.0	0.0	0.0	683.0	100.0	1.9
AQUA	4,075.7	25.7	2,867.3	18.1	8,889.1	56.1	15,832.1	100.0	44.5
SALT	443.3	27.9	1,144.2	72.1	0.0	0.0	1,587.5	100.0	4.5
FRUIT	0.1	0.1	95.4	99.9	0.0	0.0	95.5	100.0	0.3
HOUSE	423.5	18.1	889.4	37.9	1,031.4	44.0	2,344.3	100.0	6.6
MANG	729.7	22.0	627.9	18.9	1,966.0	59.2	3,323.5	100.0	9.3
RIV/SEA	1,910.7	28.8	1,425.9	21.5	3,308.1	49.8	6,644.6	100.0	18.7
TIDAL	235.8	35.5	159.1	24.0	268.6	40.5	663.4	100.0	1.9
SAND	171.3	84.2	7.4	3.6	24.8	12.2	203.5	100.0	0.6
ANNUAL	433.9	31.1	195.0	14.0	764.4	54.9	1,393.4	100.0	3.9
SPARSE	1,677.0	60.4	467.4	16.8	631.7	22.8	2,776.1	100.0	7.8
CAS	12.2	29.2	1.3	3.1	28.3	67.8	41.7	100.0	0.1
Total	**10,113.1**	**28.4**	**8,563.3**	**24.1**	**16,912.3**	**47.5**	**35,588.7**	**100.0**	**100.0**

Table 7. Land cover in focal districts in Ben Tre

Between 2005 and 2012, MANG and SPARSE increased slightly to 9.3% and 7.8% respectively. Most MANG is located in Thanh Phu District (Figure 6). MANG declined by 27.4 ha in Ba Tri District and increased in Binh Dai (72.4 ha) and Thanh Phu (298.6 ha) Districts. CAS increased (28 ha) sharply in Thanh Phu Districts .

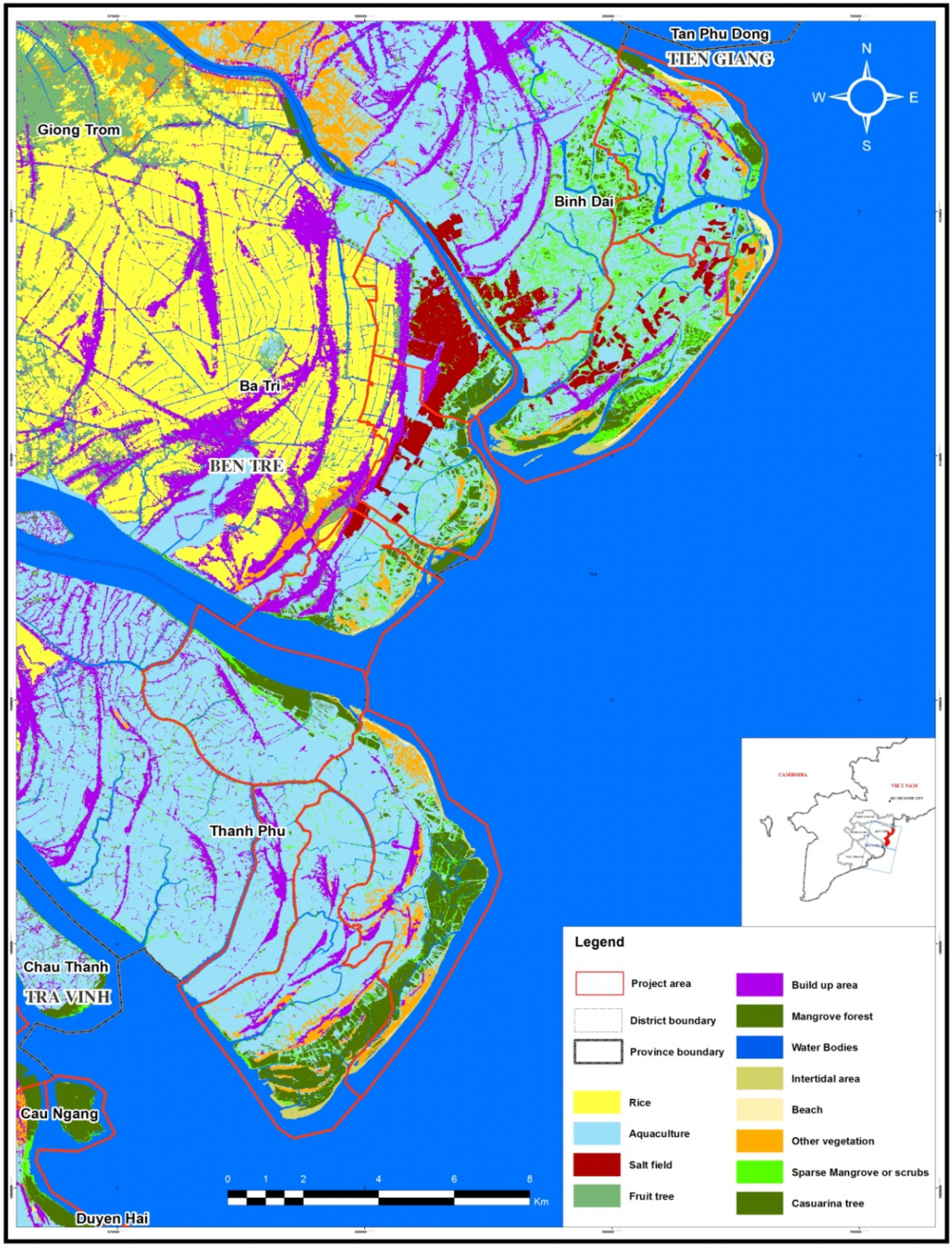

Figure 7. Land cover in project area in Ben Tre in 2012

4.2.2 Tra Vinh

AQUA, the largest land cover type, increased from 43.4% in 2005 to 46.5% in 2012, mainly at the expense of RICE and SPARSE (Table 8).

MANG increased from 6.8% in 2005 to 10.3% in 2012 while the area of SPARSE did not change much. MANG and SPARSE are mainly found in Long Khanh, Long Vinh, and Dong Hai Communes (Figure 7). The area of CAS more than doubled from 0.3% in 2005 to 0.8% in 2012.

TIDAL decreased sharply from 1.4% in 2005 to 0.3% in 2012. This could be due to coastal erosion or changes in tide height between dates.

Land cover	Cau Ngang		Duyen Hai		Total area		%
	Ha	%	Ha	%	Ha	%	
RICE	1,201.2	86.9	180.6	13.1	1,381.8	100.0	3.6
AQUA	4,059.6	22.9	13,650.1	77.1	17,709.7	100.0	46.5
SALT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FRUIT	36.1	93.1	2.7	6.9	38.8	100.0	0.1
HOUSE	1,175.8	50.6	1,147.9	49.4	2,323.8	100.0	6.1
MANG	727.8	18.5	3,207.6	81.5	3,935.4	100.0	10.3
RIV/SEA	1,482.7	27.7	3,864.3	72.3	5,347.0	100.0	14.0
TIDAL	7.4	9.6	69.8	90.4	77.2	100.0	0.2
SAND	0.0	0.0	377.6	100.0	377.6	100.0	1.0
ANNUAL	454.6	29.0	1,114.1	71.0	1,568.7	100.0	4.1
SPARSE	206.4	4.1	4,809.3	95.9	5,015.7	100.0	13.2
CAS	10.3	3.3	305.9	96.7	316.2	100.0	0.8
Total	**9,362.0**	**24.6**	**28,729.8**	**75.4**	**38,091.8**	**100.0**	**100.0**

Table 8. Land cover in focal districts in Tra Vinh in 2012

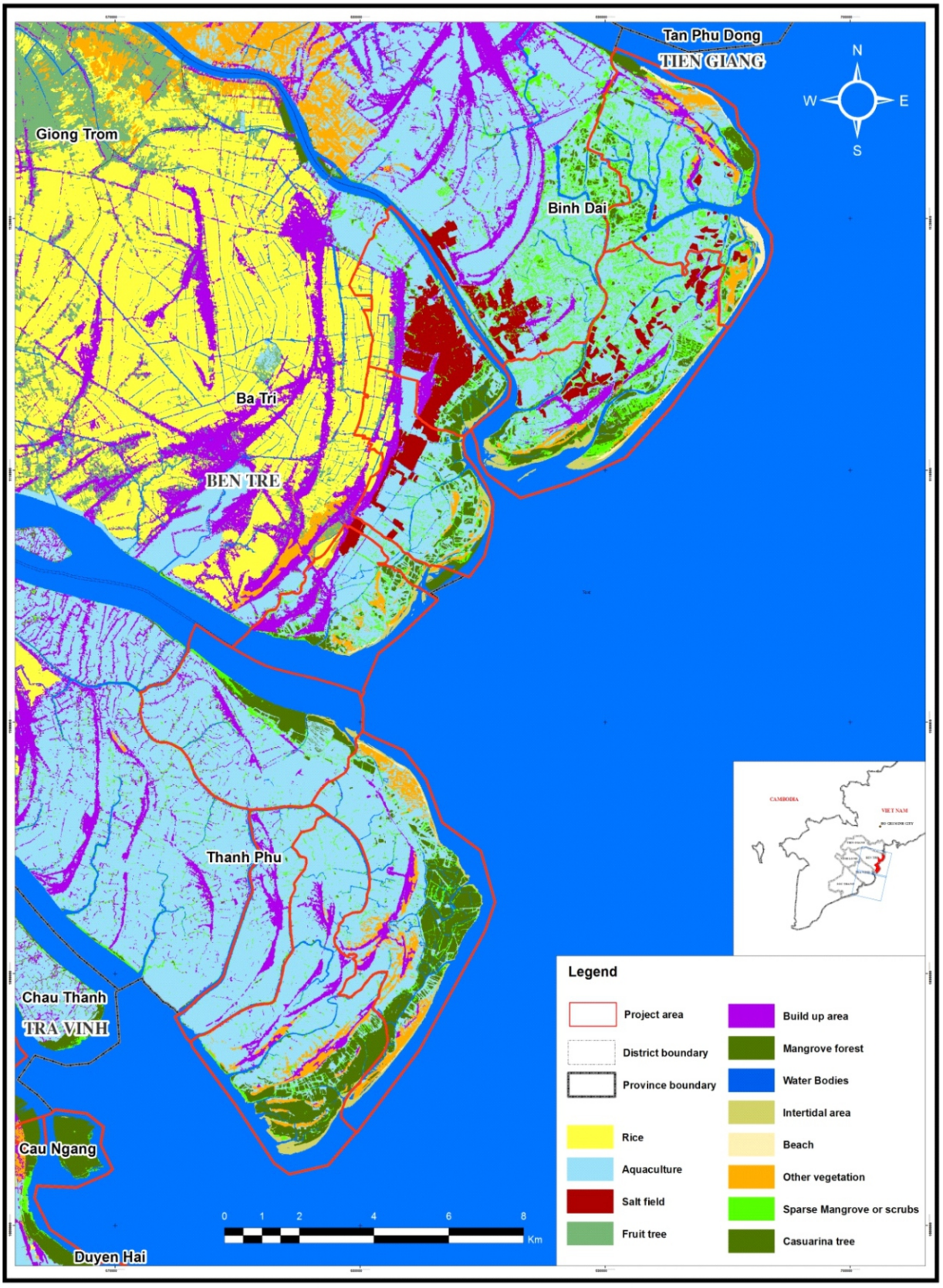

Figure 8. Land cover in project area in Tra Vinh in 2012

4.3 Land cover change analysis

4.3.1 Ben Tre

MANG increased from 3,029 ha in 2005 to 3,330 ha in 2012 (Table 9). 2,322 ha of the original 3,029 ha (70%) stayed as MANG. The remaining 30% came mostly from conversion from SPARSE (372 ha), AQUA (279 ha), RIV/SEA (236 ha), and TIDAL (118 ha). MANG loss was due mainly to conversion to SPARSE (305 ha) and AQUA (274 ha). As a result of coastal erosion, especially in Thanh Hai Commune, 80 ha of MANG were converted to RIV/SEA and 31 ha to TIDAL (Figure 9).

SPARSE increased from 2,617 ha in 2005 to 2,772 ha in 2012 of which 1,093 ha (39%) persisted from 2005. Of the SPARSE lost, 931 ha resulted from conversion to AQUA, particularly in Thua Duc and Thoi Thuan Communes (Figure 9). Moving in the other direction, 1,056 ha of AQUA, 305 ha of MANG, and 223 ha of RIV/SEA changed to SPARSE (Table 9).

AQUA remained the dominant land cover, covering 44.7% of the area, or 15,891 ha, in 2005 and 44.5% or 15,834 ha in 2012 (Figure 8). The conversion of other land covers to AQUA is shown in Figure 10. The matrix shows that there was substantial inter-conversion between AQUA, MANG, and SPARSE during this period reflecting a rapid land cover "turn-over".

		Land cover 2012 (ha)													
	Land cover	RICE	AQUA	SALT	FRUIT	HOUSE	MANG	RIV/SEA	TIDAL	SAND	ANNUAL	SPARSE	CAS	TOTAL AREA	%
Land cover 2005 (ha)	RICE	686.9	23.8	0.0	72.3	4.9	0.0	0.0	0.0	0.0	10.8	0.0	0.0	798.6	2.2
	AQUA	0.0	14,193.9	324.5	0.0	17.6	279.0	8.5	3.3	0.0	8.8	1,055.8	0.0	15,891.3	44.7
	SALT	0.0	115.4	1,218.5	0.0	2.6	0.6	0.0	0.0	0.0	0.0	26.6	0.0	1,363.7	3.8
	FRUIT	0.1	7.0	0.0	22.8	10.5	0.0	0.0	0.0	0.0	2.5	0.0	0.0	42.9	0.1
	HOUSE	0.0	0.0	0.0	0.0	2,261.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,261.5	6.4
	MANG	0.0	273.9	0.0	0.0	2.1	2,321.8	80.0	30.8	0.7	14.5	305.4	0.0	3,029.0	8.5
	RIV/SEA	0.0	98.3	0.0	0.0	0.0	235.7	6,265.3	422.1	136.8	0.2	223.3	2.2	7,384.0	20.7
	TIDAL	0.0	24.5	0.0	0.0	0.0	118.0	194.6	129.0	23.4	37.3	50.9	0.0	577.7	1.6
	SAND	0.0	3.4	0.0	0.0	0.0	1.7	22.2	13.6	18.6	14.6	1.0	34.2	109.3	0.3
	ANNUAL	0.0	163.0	0.0	0.1	15.5	1.5	0.0	14.6	4.9	1,286.2	15.7	0.0	1,501.6	4.2
	SPARSE	0.0	930.6	46.2	0.0	33.2	371.7	62.2	44.2	11.5	24.4	1,093.1	0.0	2,617.0	7.4
	CAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	5.1	12.6	0.0
	Total area (ha)	**686.9**	**15,833.8**	**1,589.1**	**95.1**	**2,347.9**	**3,330.0**	**6,632.7**	**657.6**	**203.3**	**1,399.2**	**2,771.8**	**41.5**	**35,589.0**	**100.0**
	Total in %	**1.9**	**44.5**	**4.5**	**0.3**	**6.6**	**9.4**	**18.6**	**1.8**	**0.6**	**3.9**	**7.8**	**0.1**	**100.0**	

Table 9. Land cover change matrix in project area in Ben Tre

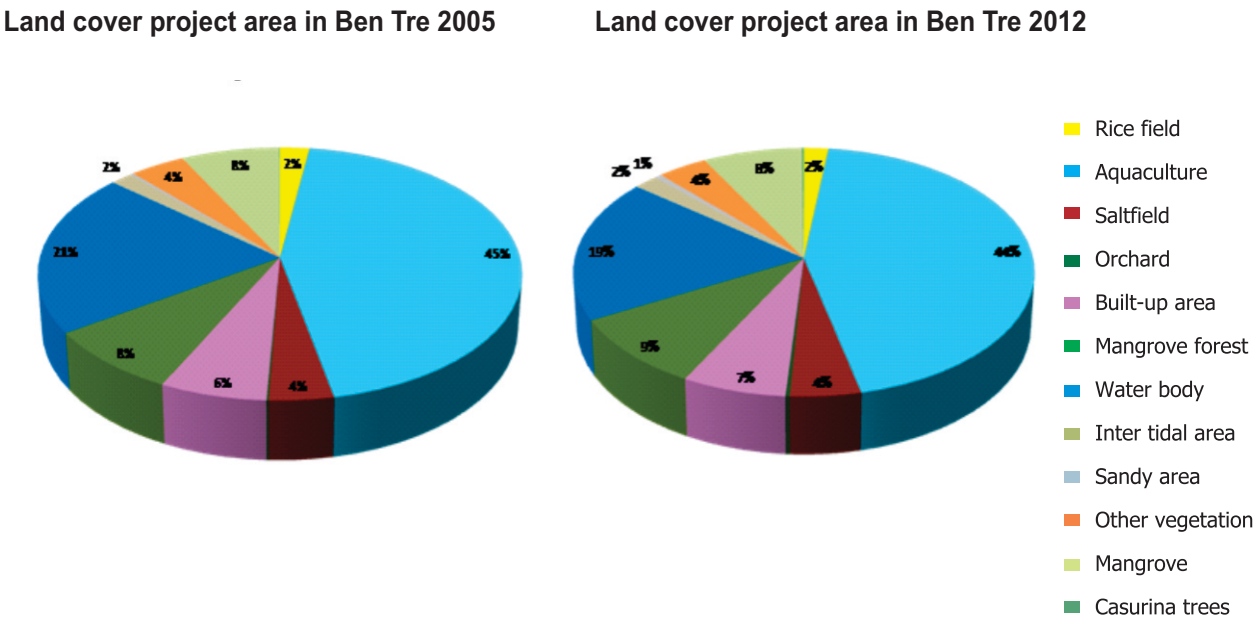

Figure 9. Contribution of different land cover classes in project area in Ben Tre

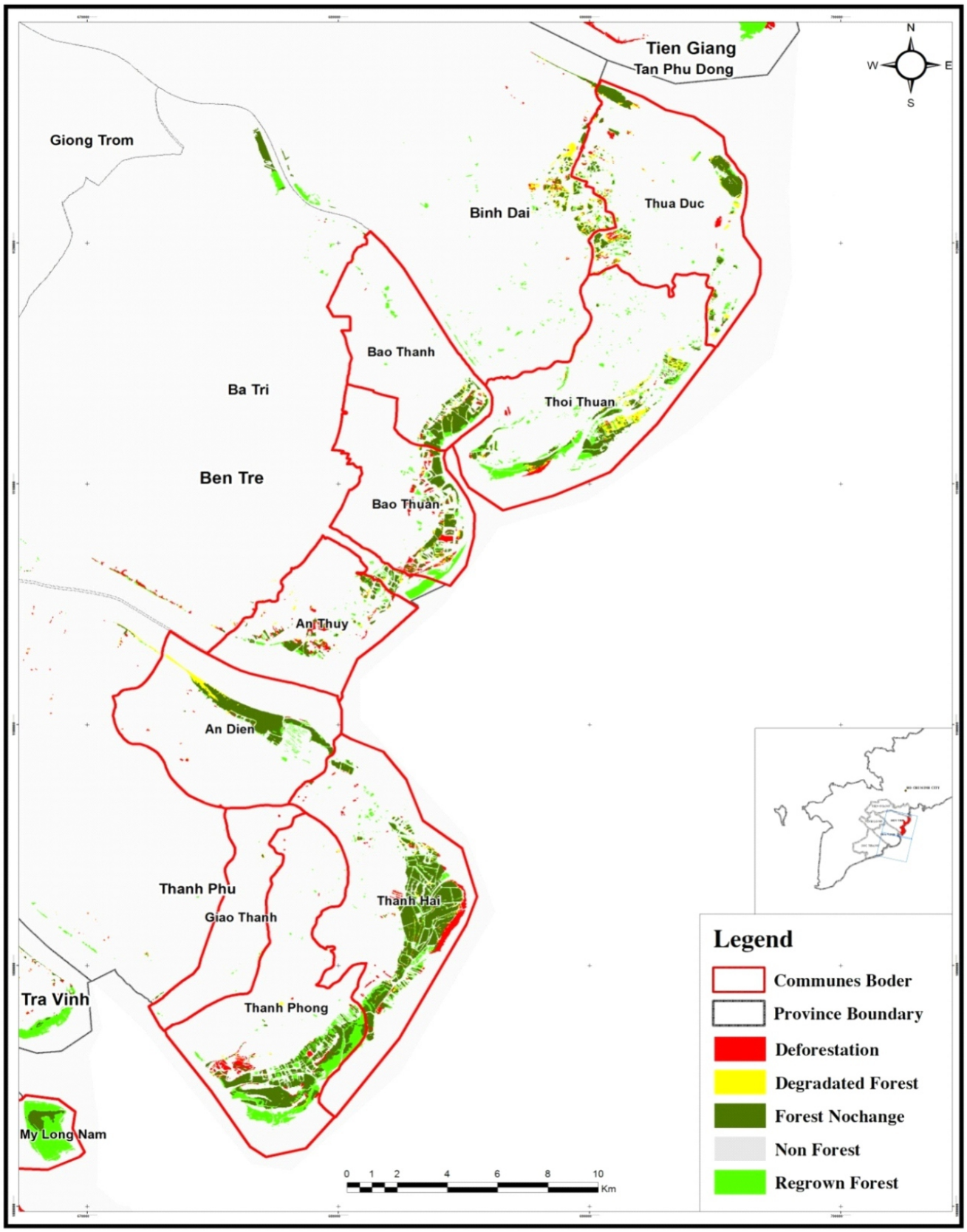

Figure10. Mangrove forest changes in project area in Ben Tre

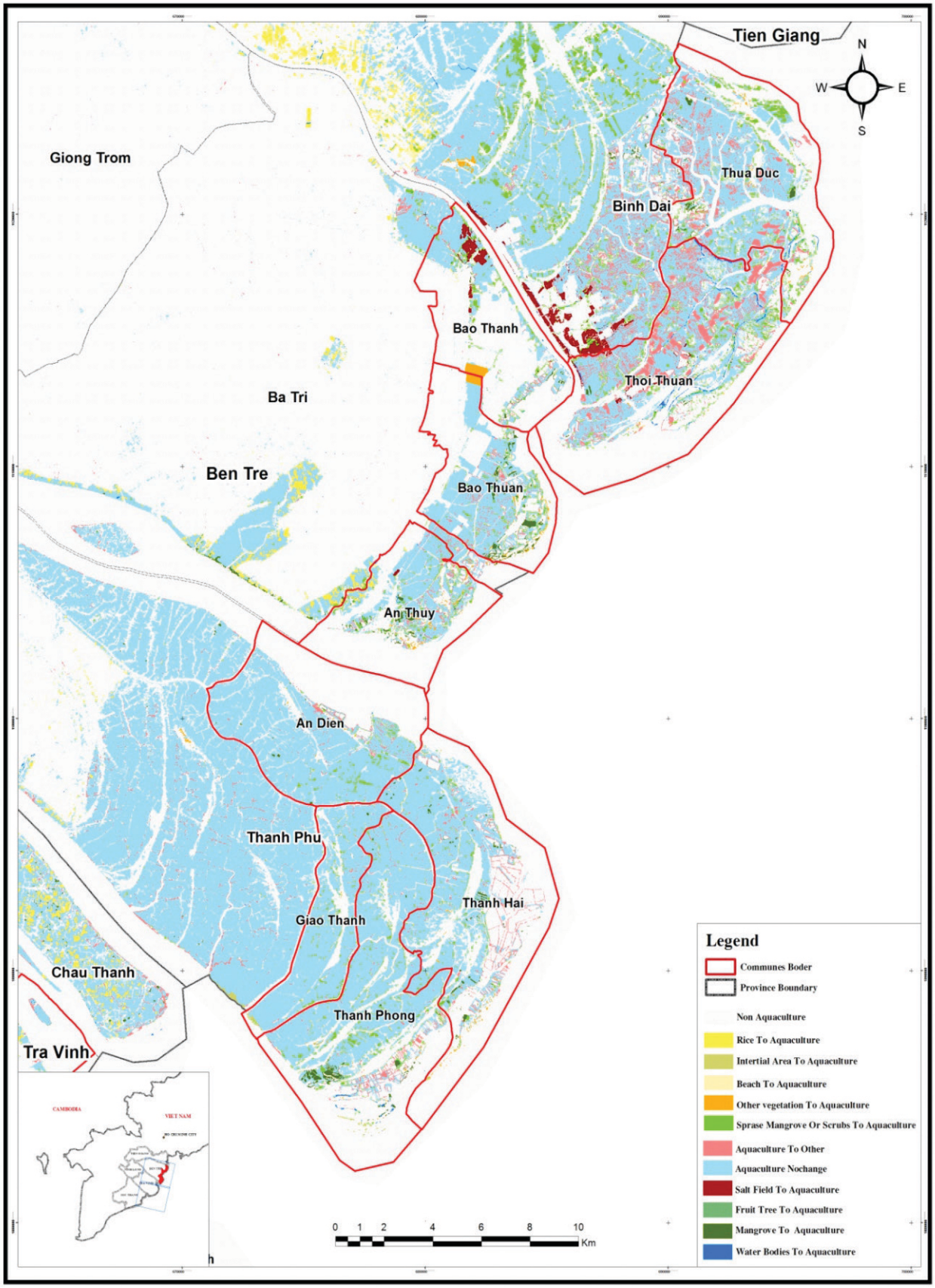

Figure 11: Aquaculture changed in project area in Ben Tre 2005-2012

4.3.2 Tra Vinh

Between 2005 and 2012, MANG increased by 33% from 2,620 ha to 3,935 ha (Table 10). However, only 51% of the 2005 MANG survived until 2012. The 49% difference mainly resulted from conversion to MANG from SPARSE (843 ha) and AQUA (649 ha) with small contributions from RIV/SEA (272 ha) and TIDAL (154 ha). Figure 11 shows that most of the new MANG is located in My Long Nam, Long Khanh, Long Vinh, and Dong Hai Communes. Between 2005 and 2012, the net MANG loss was much less than the net MANG gain. Only 234 ha of MANG changed to AQUA, 325 ha to SPARSE, and 34 ha to RIV/SEA. MANG loss was concentrated in Truong Long Ho and Long Vinh Communes.

SPARSE did not change much: it covered 5,069 in 2005 and 5,019 in 2012. But of the original 5,069 ha, only 1,898 ha (38%) existed in the same location in 2012. The 62% difference resulted from the conversion to SPARSE from AQUA (2,709 ha), MANG (325 ha), RIV/SEA (43 ha), and TIDAL (41 ha). MANG and SPARSE loss was greatest in Long Khanh and Long Vinh Communes (Figure 11). Between 2005 and 2012, 3,171 ha of SPARSE (63%) were converted to other land cover types.

Between 2005 and 2012, AQUA increased by 1,156 ha, mostly as a result of conversion to AQUA from RICE and SPARSE (Figure 12). As shown in Table 10, 2065 ha (12%) of AQUA in 2012 came from SPARSE conversion. At the same time, 2,709 ha of AQUA changed to SPARSE and 649 ha to MANG. CAS expanded from 112 ha in 2005 to 318 ha in 2012, mostly from ANNUAL.

		Land cover 2012 (ha)													
	Land cover	RICE	AQUA	SALT	FRUIT	HOUSE	MANG	RIV/SEA	TIDAL	SAND	ANNUAL	SPARSE	CAS	Total area	Total in %
Land cover 2005 (ha)	RICE	1,378.6	2,017.6	0.0	31.5	2.7	0.0	0.0	0.0	0.0	65.2	0.0	0.0	3,495.5	9.2
	AQUA	0.0	13,117.5	0.0	0.0	47.0	649.1	12.7	1.7	8.8	6.4	2,709.2	0.0	16,552.4	43.5
	SALT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	FRUIT	0.0	1.4	0.0	6.7	4.6	0.0	0.0	0.0	0.0	3.0	0.0	0.0	15.7	0.0
	HOUSE	0.0	0.0	0.0	0.0	2,239.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,239.3	5.9
	MANG	2.8	234.4	0.0	0.0	6.0	2,016.7	34.2	0.0	1.0	0.0	324.8	0.0	2,619.8	6.9
	RIV/SEA	0.0	92.0	0.0	0.0	0.0	271.7	4,758.7	45.4	88.2	0.0	43.3	0.3	5,299.6	13.9
	TIDAL	0.0	13.4	0.0	0.0	0.0	153.5	136.4	14.1	139.4	1.2	41.4	18.6	518.1	1.4
	SAND	0.0	6.8	0.0	0.0	0.0	0.6	174.3	1.7	94.4	5.3	0.1	77.7	360.9	0.9
	ANNUAL	0.9	161.2	0.0	0.2	0.7	0.3	10.6	0.9	33.1	1,486.8	2.5	113.4	1,810.6	4.8
	SPARSE	0.0	2,064.7	0.0	0.0	19.8	843.2	221.0	11.2	1.9	1.0	1,897.9	8.7	5,069.4	13.3
	CAS	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	9.2	0.5	0.0	98.9	111.7	0.3
	Total area (ha)	**1,382.3**	**17,708.8**	**0.0**	**38.3**	**2,320.1**	**3,935.2**	**5,350.9**	**75.1**	**376.0**	**1,569.4**	**5,019.2**	**317.6**	**38,092.9**	**100.0**
	Total in %	**3.6**	**46.5**	**0.0**	**0.1**	**6.1**	**10.3**	**14.0**	**0.2**	**1.0**	**4.1**	**13.2**	**0.8**	**100.0**	

Table 10. Land cover change matrix project area in Tra Vinh

		GTPs													
		RICE	AQUA	SALT	FRUIT	HOUSE	MANG	RIV/SEA	TIDAL	SAND	ANNUAL	SPARSE	CAS	Total points	User accuracy (%)
Land cover in 2012	RICE	**11**	0	0	0	1	0	0	0	0	0	0	0	12	**91.67**
	AQUA	2	**103**	2	0	1	0	0	0	0	4	4	1	117	**88.03**
	SALT	0	2	**8**	0	0	0	0	0	0	0	0	0	10	**80.00**
	FRUIT	0	0	0	**15**	1	1	0	0	0	0	1	0	18	**83.33**
	HOUSE	0	0	0	3	**53**	1	0	0	0	6	4	0	67	**79.10**
	MANG	0	2	0	0	0	**70**	0	0	0	0	3	0	73	**95.89**
	RIV/SEA	0	3	0	0	0	1	**5**	0	0	1	1	0	11	**45.45**
	TIDAL	0	0	0	0	0	1	0	**3**	0	0	0	0	4	**75.00**
	SAND	0	0	0	0	0	0	0	0	**5**	0	0	0	5	**100.00**
	ANNUAL	1	0	0	0	0	0	0	0	0	**19**	2	0	22	**86.36**
	SPARSE	0	0	0	1	0	16	0	0	0	1	**31**	2	53	**58.49**
	CAS	0	0	0	0	0	0	0	0	0	0	0	**7**	7	**100.00**
	Total points	14	110	10	19	56	90	5	3	5	31	46	10	**399**	
	Producer accuracy (%)	**78.57**	**93.64**	**80.00**	**78.95**	**94.64**	**77.78**	**100.00**	**100.00**	**100.00**	**61.29**	**67.39**	**70.00**		
Correct classification points															**330**
Overall accuracy															**82.7%**

Table 11. Confusion matrix

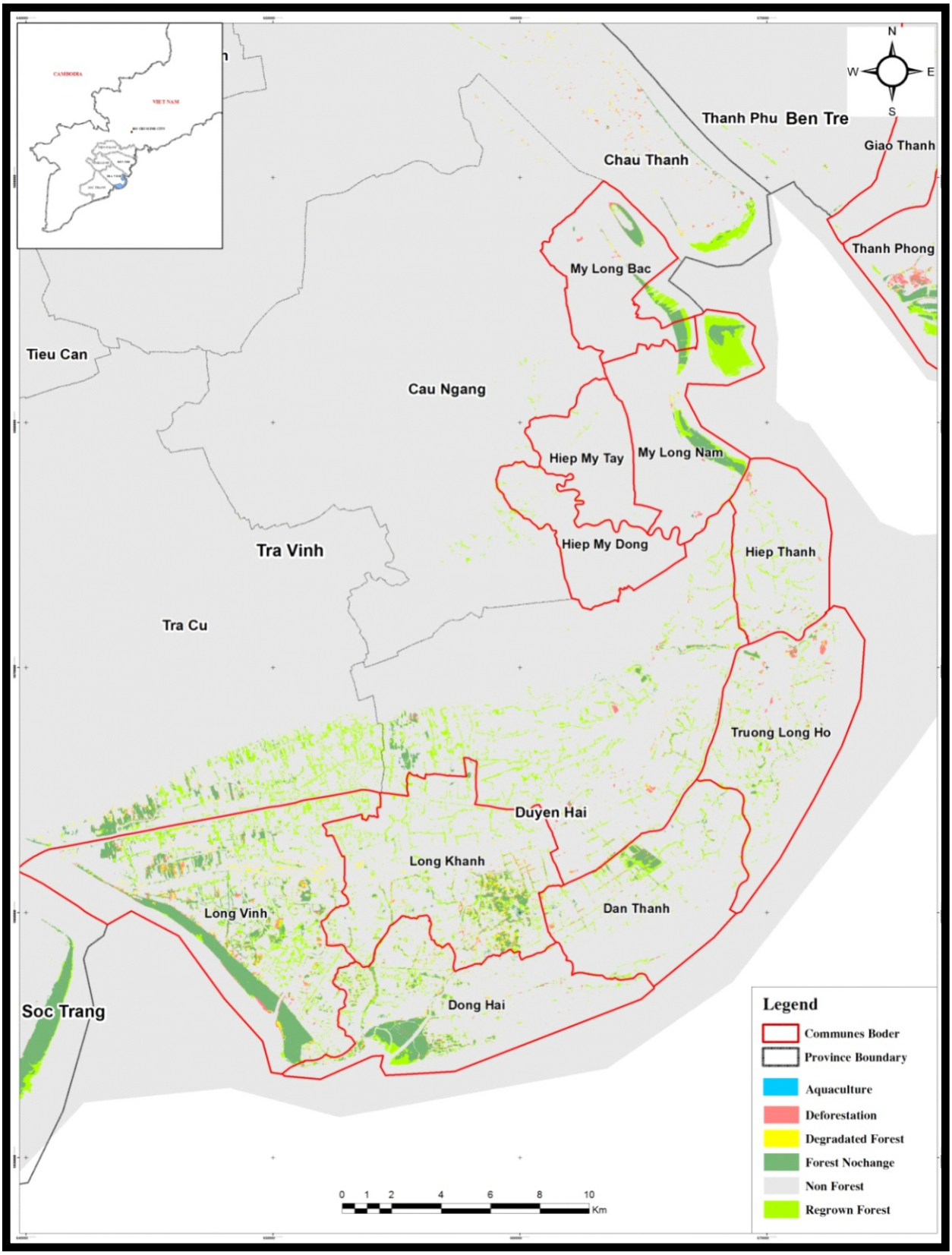

Figure 12. Mangrove forest change in project area in Tra Vinh

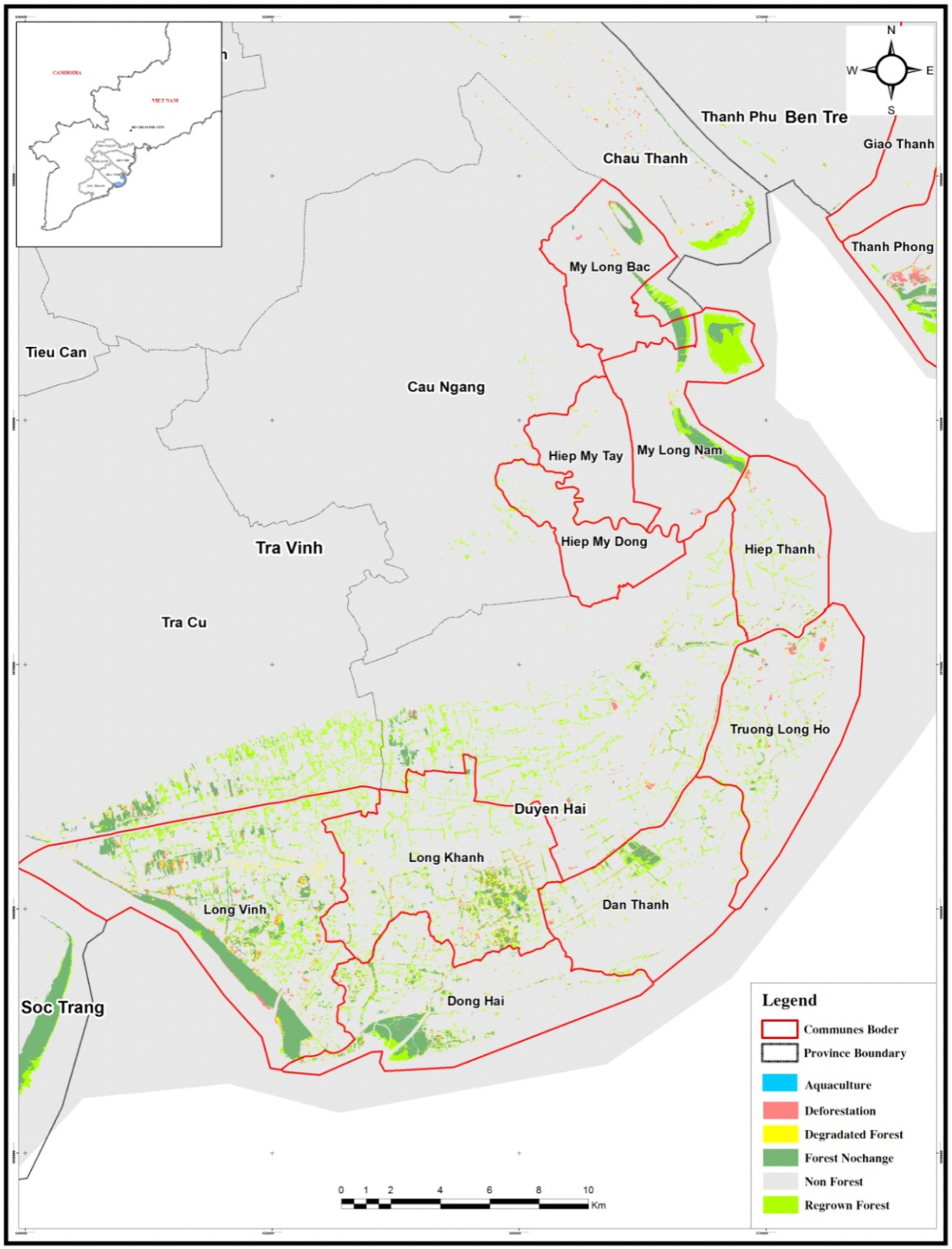

Figure 13. Aquaculture changes in project area in Tra Vinh 2005-2012

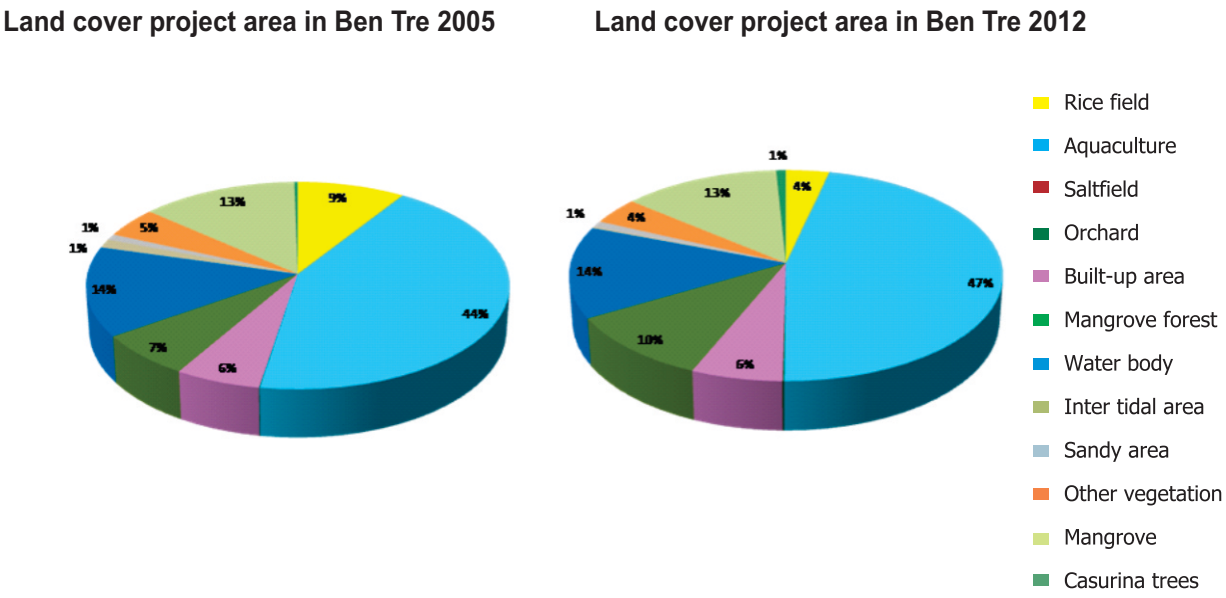

Figure 14. Contribution of different land cover in project area in Tra Vinh, 2005 and 2012

Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS
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Mangroves for the Future (MFF) is a unique partner-led initiative to promote investment in coastal ecosystem conservation for sustainabl e development. Co-chaired by IUCN and UNDP, MFF provides a platform for collaboration among the many different agencies, sectors and countries which are addressing challenges to coastal ecosystem and livelihood issues. The goal is to promote an integrated ocean-wide approach to coastal management and to building the resilience of ecosystem-dependent coastal communities.

MFF builds on a history of coastal management interventions before and after the 2004 Indian Ocean tsunami. It initially focused on the countries that were worst affected by the tsunami – India, Indonesia, Maldives, Seychelles, Sri Lanka and Thailand. More recently it has expanded to include Bangladesh, Cambodia, Pakistan and Viet Nam.

Mangroves are the flagship of the initiative, but MFF is inclusive of all types of coastal ecosystem, such as coral reefs, estuaries, lagoons, sandy beaches, sea grasses and wetlands.

The MFF grants facility offers small, medium and la rge grants to support initiatives that provide practical, hands-on demonstrations of effective coastal management in action. Each country manages its own MFF programme through a National Coordinating Body which includes representation from government, NGOs and the private sector.

MFF addresses priorities for long-term sust ainable coastal ecosystem management which include, among others: climate change adaptation and mitigation, disaster risk reduction, promotion of ecosystem health, development of sustainable livelihoods, and active engagement of the private sector in developing sustainable business practices. The emphasis is on generating knowledge, empowering local communities and advocating for policy solutions that will support best practice in integrated coastal management.

Moving forward, MFF will increasingly focus on building resilience of ecosystem-dependent coastal communities by promoting nature based solutions and by showcasing the climate change adaptation and mitigation benefits that can be achieved with healthy mangrove forests and other types of coastal vegetation.

MFF is funded by Danida, Norad and Sida

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