CONNECTING FRAGMENTED MANGROVE PATCHES USING BIODIVERSITY OF RANONG COASTAL LANDSCAPE, THAILAND

Puvadol Doydee and Inocencio E. Buot Jr.

Received: 12.03.2014 / Accepted: 14.08.2014

Abstract: This study has been conducted in Ranong mangrove forest ecosystem, in southern Thailand aiming to connect mangrove patches with a biodiversity corridor serving as natural bridges. Six mangrove patches have been selected based on remotely sensed data of Landsat–5 TM output derived from digital image processing technique to determine the gaps for each mangrove patch. Moreover, vegetation analysis was examined using Point Centered Quarter (PCQ) method associated with Important Value Index (IVI) for revealing the mangrove dominant species. We found six mangrove dominant species namely: *Avicennia marina*, *A. officinalis*, *Bruguiera parviflora*, *Ceriops decandra*, *Rhizophora apiculata* and *R. mucronata*. These species were recommended for planting on the identified stepping stone and linear corridors. The biodiversity corridor in Ranong satoumi plays an important role in enhancing the dispersal of organisms through habitat patches in fragmented coastal landscape and serves as routes for daily or seasonal movements.

Keywords: biodiversity corridor, coastal landscape, Landsat-5 TM, mangrove.

Introduction:

Mangroves are coastal wetland ecosystem composed of various species of trees, shrubs and herbs capable of growth and reproduction in areas inundated daily by seawater (Smith and Smith 2004; Doydee et al. 2008). This unique ecosystem is a vital habitat and very important in terms of biodiversity conservation on coastal landscape. They serve as natural bridges that link the marine and terrestrial environments (Aksornkoae et al. 1992; Doydee and Buot 2010). Also they contribute to habitat complexity and diversity of flora and fauna (Othman 1994; Lee 1998). Furthermore, they provide protection of habitats that are suitable breeding and nursery sites for shrimps, crabs and fishes (Aksornkoae et al. 1992; Sasekumar et al. 1992; Barbier and Strand 1998).

Mangroves also provide important indirect services such as shoreline stability and water quality (Buot 1994; Janssen and Padilla 1999; Anongponyoskun and Doydee 2006). Moreover, the presence of mangroves reduces the rate of coastal erosion

Puvadol Doydee:
Faculty of Natural Resources and Agricultural Industry, Department of Agro-Bioresources
University Chalemphrakiat Sakon Nakhon Province Campus
Muang District, Sakon Nakhon Province
47000, Thailand
e-mail: puvadol.d@ku.ac.th

Inocencio Buot Jr.:
Institute of Biological Sciences
College of Arts and Sciences and School of Environmental Science and Management
University of the Philippines Los Baños
Los Baños, Laguna 4031, Philippines
e-mail: iebuotjr@upou.edu.ph

(Thampanya et al. 2006; Hashim et al. 2010). However, the destruction of mangroves is common especially in the Southeast Asian countries including Thailand (Field 1996; Macintosh et al. 2002; Ashton et al. 2003).

The Ranong mangrove patches in Thailand, in fact are fragmented due to a combined effect of natural disasters and anthropogenic disturbances such as conversion of extensive tracks to fishponds, shrimp ponds and salt ponds and even to residential villages (Doydee and Buot 2011). Hence, in the 2004 tsunami, the communities and other resources in the vicinities of the mangrove ecosystem were severely damaged. Fishing villages were destroyed, innocent lives of children and adults alike were taken, and damage to properties was exceedingly high.

A healthy mangrove ecosystem could have mitigated the negative impact of tsunami commonly ravaging the coast (Hashim et al. 2010). The establishment of a biodiversity corridor is necessary to connect the fragmented mangrove patches in the matrix of fragmented coastal landscape. A biodiversity corridor is a key element in the coastal landscape ecosystem and has appealed to decision-makers for the conservation and restoration of natural resources and environments.

Thus, this study aimed to determine the suitable area for biodiversity corridor networks and identify appropriate types to be used as well as to investigate the dominant species of mangrove trees for planting in the biodiversity corridor.

Materials and methods:

Study area

This study was conducted in Ranong, Thailand (Fig. 1) which was severely destroyed by the tsunami on December 26, 2004. It is a biosphere reserve located on the coast of the Andaman Sea, about 568 kilometers south of Bangkok. Ranong encompasses an area of 3,298 square kilometers. The study area was situated around 9° 43' N to 9° 57' N and 98° 29' E to 98° 39' E. Geographically, in addition to sixty-two islands Ranong has long expanses of sandy beaches, unspoiled forests, waterfalls, parks, and a biodiversity sanctuary zone. Three districts were selected based on the criteria such as accessibility, size of mangrove patches and associated elements such as canals, distance. Such districts (Fig. 1) were Mueng (Ngaw [1] and Rachakrud [2]), Kapoe (Bangben [3] and Banghin [4]), and Suk Samran (Talaynog [5] and Hadsaykaow [6]). The site selection was based on the result of satellite image processing using Landsat-5 TM data.

Data collection

In each sampling site, the coordinate values were determined using a Global Positioning System (GPS) receiver with estimated accuracy of 10 m or better. To validate the coordinates, the georeferencing technique was applied to recheck the collecting localities on the map (Doydee 2005; Bantayan 2006). Remotely sensed data of Landsat-5 TM was employed to determine the mangrove fragmented patches using ER Mapper 5.5 software, then geospatial methods were used to create a biodiversity corridor using ArcGIS 9.2 software. Moreover, the Point Centered Quarter (PCQ) method of Mueller-Dombois and Ellenberg (1974) was applied to examine the dominant species of mangrove to be planted in the biodiversity corridor.

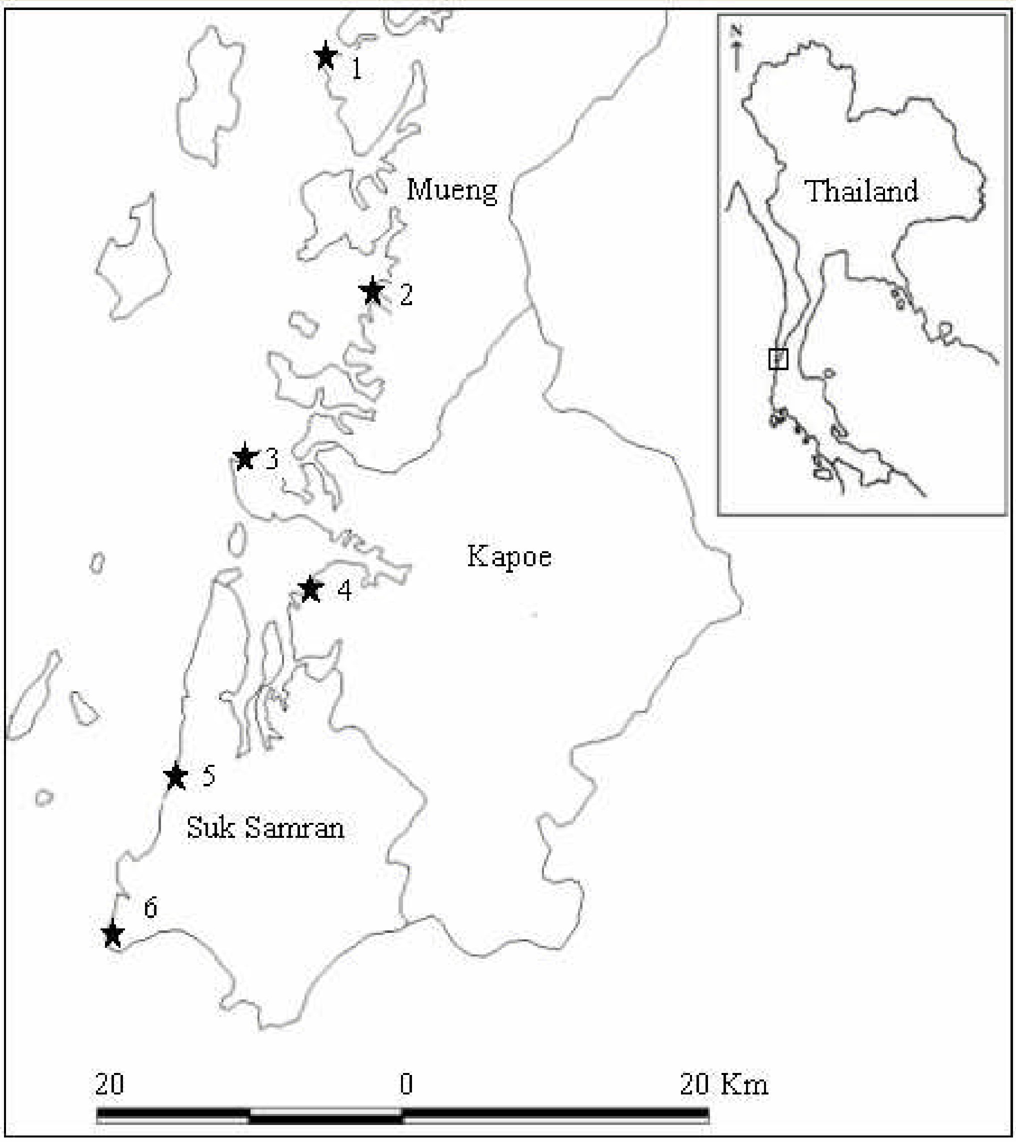
Results and discussion:

Biodiversity corridor network

In a mangrove ecosystem, there are many organisms like fiddler crabs, tropical lands crabs, mud skippers and other animals such as mammals, reptiles and amphibians groups (Buot 1994; Doydee and Siregar 2006). They are in need of corridor to enable movement between mangrove patches. Even mangrove vegetation would need this corridor to facilitate dispersal of propagules from one fragmented patch to the other. A biodiversity corridor has not yet been employed in the Ranong mangrove forest landscape, but this element is necessary for the efficient conservation of mangrove forest since the corridor networks contribute to the functional connectivity of a landscape (Forman 1995; Mumby et al. 2004).

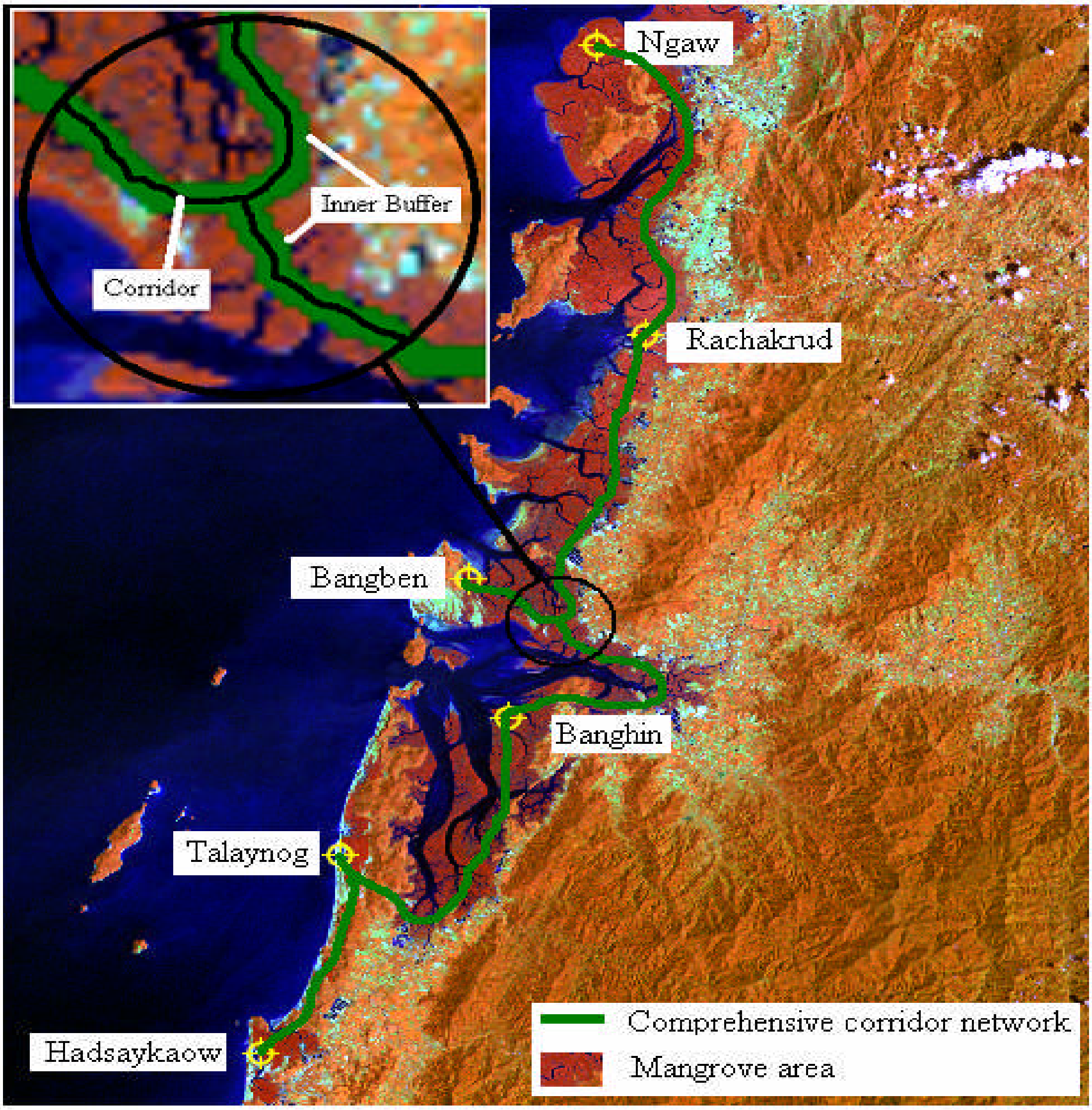
The large area of Ranong mangrove landscape was recorded from space and installed in digital image data format. The False Color Composite (FCC) technique was used to distinguish the mangrove patch from others, while comprehensive corridor network and buffer distance (Fig. 2) were performed using screen digitizing and geoprocessing methods.

Figure no. 1 The six study sites along the Andaman seacoast in mangrove landscape of Ranong, Thailand.



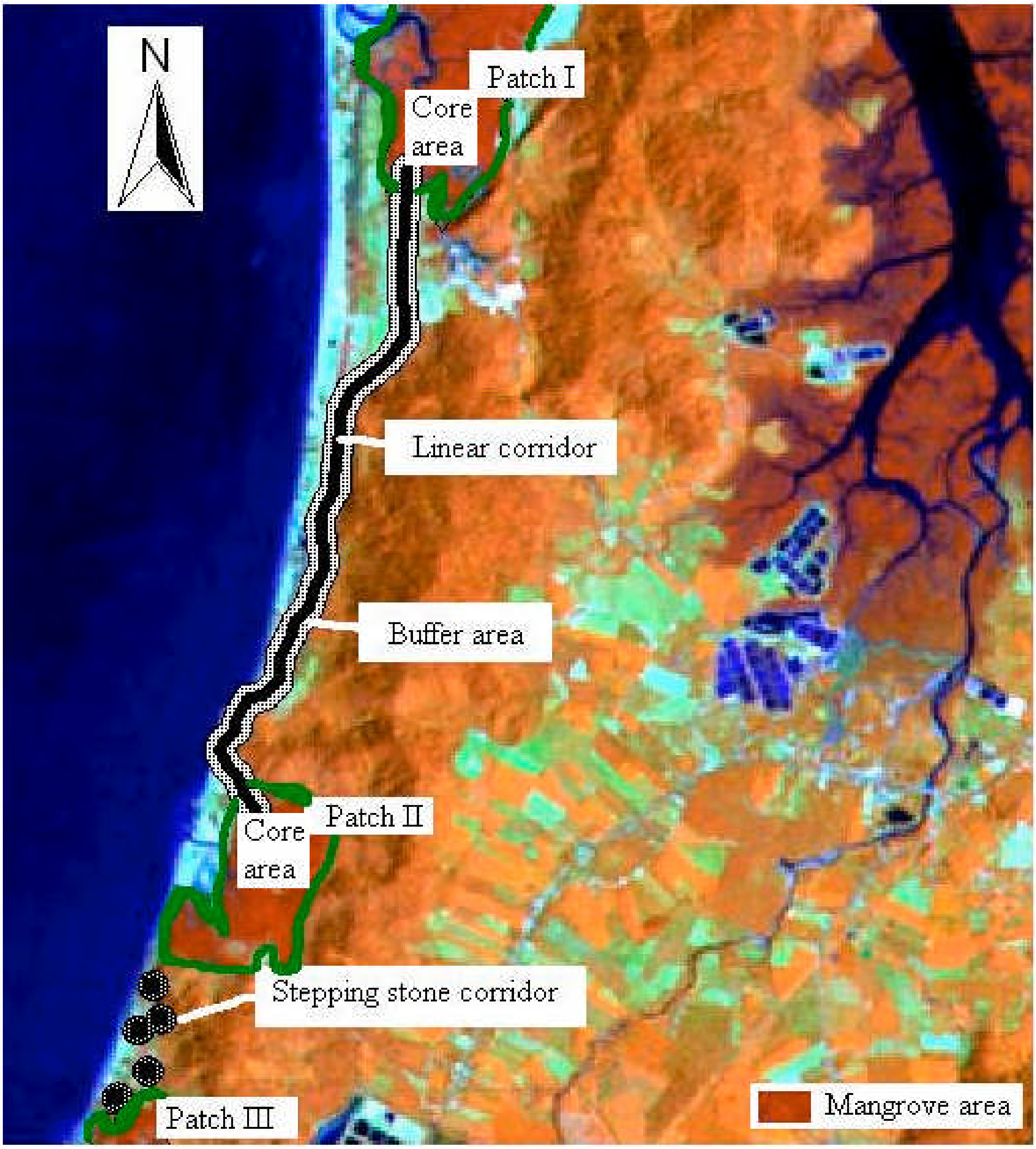
1 - Ngaw; 2 - Rachakrud; 3 - Bangben; 4- Banghin; 5- Talaynog; 6 – Hadsaykaow.

Figure no. 2 The comprehensive corridor network in Ranong mangrove landscape.



The practical types of corridor to connect the mangrove patches are the stepping stone and linear corridors (Fig. 3). It has been suggested that in order for the mangrove to effectively provide protection against waves, the width of mangrove forest should not be less than 100 m from coastal shores (Chotthong and Aksornkoae 2007). Corridors should provide habitat as well as pathway for the movement and dispersal of mangrove animals and plants respectively. They should link core areas and must be surrounded by buffer zones.

Figure no. 3 The stepping stone and linear corridor in Ranong mangrove landscape.



Habitat quality of the corridors is very important. The corridor must be sufficiently buffered against edge effect to maintain that particular habitat quality (Farina 2000). They may also present negative impacts and therefore must be carefully assessed and monitored. For example, the study of Platt (2002) reported that corridor encourages wildlife to travel toward a busy road and the study of Smith and Smith (2004) suggested that corridor provides the habitat for predators of moving species as well.

The mangrove reforestation and rehabilitation have to be started at the biodiversity corridor networks of Ranong satoumi. The corridor networks will link the six study sites in Ranong mangrove forest landscape (Fig. 2). The establishment of these biodiversity corridors will be based on satellite image data of Landsat-5 TM as they are able to provide a bird's eyes view of mangrove patches patterns, other land use the cover topography, the distribution and distance between each patch. However, the criteria such as infrastructures (e.g. road, pier, building, water pipe etc.), natural limitation such river, shoreline, soil types and the like should be considered in establishing the biodiversity corridor network. Above all, of foremost consideration will be the species to be planted. Logically, the dominant species of both patches will be better reforestation species.

Mangrove dominant species

Table 1 (Annexes) presents Important Value Index (IVI) of mangrove vegetation in the study sites. There were 9 families with 19 mangrove species. The Avicenniaceae and Rhizophoraceae were the dominant mangrove families. There were 6 mangrove dominant species namely: *Avicennia marina*, *A. officinalis*, *Bruguiera parviflora*, *Ceriops decandra*, *Rhizophora apiculata* and *R. mucronata*. *Rhizophora apiculata* was the most dominant compared to other mangrove tree species with the IVI of 190.18 (Tab. 1, Annexes).

The stepping stone corridor (Fig. 3) will be appropriate in Ngaw and Rachakrud (Fig. 2) because the mangrove patches in these zones are closed and connected to each other. *Rhizophora apiculata* could be the best species for planting in Ngaw, while *Avicennia officinalis* and *A. marina* should be used for corridor establishing in and nearby Rachakrud.

The stepping stone corridor also will be used in linking between Rachakrud Bangben and Banghin (Fig. 2) since the mangrove patches in these zones are also closed and connected to each other. *Ceriops decandra* is recommended in Bangben. *Bruguiera parviflora* and *Rhizophora apiculata* are to be planted in the corridors for increasing the size of mangrove patches both inner and outer of the Banghin zone.

The stepping stone and linear corridors will be used in establishing the biodiversity corridor network from Banghin to Talaynog and from Talaynog to Hadsaykaow, respectively (Fig. 2), because these zones had more fragmented mangrove patches, varying in size, shape and arrangement. *Bruguiera parviflora*, *Rhizophora apiculata* and *R. mucronata* are recommended for planting as these are the dominant ones, hence, more adapted species in the area.

Conclusions:

The biodiversity corridor establishment is indeed important to connect fragmented mangrove ecosystem landscape. However, in doing so, there is a need to examine the dominant component of the ecosystem which should be the ideal reforestation species. In Ranong, Thailand, connecting fragmented mangrove patches should be prioritized so as to avoid the recurrence of the tragic incident in 2004 should tsunami hit the area again.

Rezumat:

CONECTAREA ZONELOR DE MANGROVE FRAGMENTATE FOLOSIND BIODIVERSITATEA DIN ZONELE DE COASTĂ RANONG

Acest studiu s-a realizat în ecosistemul de pădure din Ranong, din sudul Tailandei, cu scopul de a conecta zonele de mangrove prin intermediul unui coridor de biodiversitate folosit drept pod natural. Au fost selectate șase zone de mangrove pe baza informațiilor receptate de la distanță prin intermediul imaginilor captate de Landsat-5TM și s-a folosit tehnica de procesare a imaginilor digitale pentru a determina spațiile libere pentru fiecare zonă de mangrove. De asemenea, analiza vegetației a fost realizată utilizând metoda Point Centered Quartered (PCQ) în asociere cu Indexul de Valori Importante (IVI) pentru determinarea speciilor dominante. Am descoperit șase specii dominante cu precădere: *Avicennia marina*, *A. officinalis*, *Bruguiera parviflora*, *Ceriops decandra*, *Rhizophora apiculata* și *R. mucronata*. Aceste specii au fost recomandate pentru plantare în zona coridoarelor intermediare și liniare identificate. Coridorul de biodiversitate din ecotonul Ranong joacă un un rol important în îmbunătățirea dispersiei organismelor din habitatele zonale ale arealului de coastă fragmentat și servește drept rută de deplasare zilnică sau de sezon.

Acknowledgments:

The authors are grateful for the support of Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) in Los Banos, Laguna, Philippines for providing research funds.

References:

AKSORNKOAE S., MAXELL G.S., HAVANOND S., PANICHSUKO S. (1992), *Plants in Mangroves*, Chalongrat co., ltd. Bangkok, Thailand, 119 p.

ANONGPONYOSKUN M, DOYDEE P. (2006), The changed coastline in Loi Island, Chonburi Province during 1997 to 2004, *Kasetsart J. (Nat. Sci.)*, 40: 249-253.

ASHTON E.C., MACINTOSH D.J. and HOGARTH P.J. (2003), A baseline study of the diversity and community ecology of crab and molluscan macrofauna in the Sematan mangrove forest, Sarawak, Malaysia, *Journal of Tropical Ecology* 19:127–142.

BANTAYAN N.C. (2006), *GIS in the Philippines-Principles and Application in Forestry and Natural Resources*, PARRFI and AKECU, Los Banos, 173 p.

BARBIER E.B., STRAND I. (1998), Valuing mangrove-fishery linkages, *Environmental Resource Economic*, 12: 151-166.

BUOT I.E. Jr. (1994) The True Mangroves Along San Remigio Bay, Cebu, Philippines, *The Philippine Scientist*, 31: 105-120.

CHOTTHONG B., AKSORNKOAE S. (2007), *Sustainable Community-based Mangrove Rehabilitation in Thailand*, Thailand Environmental Institute, Nonthaburi, Thailand, 12 p.

DOYDEE P. (2005), Coastal landuse change detection using remote sensing technique: Case study in Banten Bay, West Java Island, Indonesia. *Kasetsart J. (Nat. Sci.)* 39: 159-164.

DOYDEE P., SIREGAR V. (2006), Assessment of coastal land use changes in Banten bay, Indonesia using different change detection methods, *Biotropica*, Vol 13, No. 2: 122-131.

DOYDEE P., KAMWACHIRAPITAK P., BUOT I.E. Jr. (2008), Species composition of Mangrove ecosystem in Ranong, Thailand, *The Thailand Natural History Museum Journal* 3:51-58.

DOYDEE P., BUOT I.E. Jr. (2010), Mangrove Habitat Restoration and Management in Ranong Province, Thailand, *Proceeding of Coastal Zone Asia-Pacific Conference and World Small-Scale Fisheries Congress*, Bangkok, Thailand, October 17-22.

DOYDEE P., BUOT I.E. Jr. (2011), Mangrove Vegetation Zones in Ranong Coastal Wetland Ecosystem, Thailand, *Kasetsart University Fisheries Research Bulletin* 35(1): 14-28.

FARINA A. (2000), *Landscape Ecology in Action*, Kluwer Academic Publishers, The Netherlands, 317 p.

FIELD C.D. (1996), *Restoration of Mangrove Ecosystems*, International Society for Mangrove Ecosystems, Okinawa, Japan, 250 p.

FORMAN R.T.T. (1995) *Land mosaics: the ecology of landscapes and regions*, Cambridge University press, Cambridge, England, 632 p.

HASHIM R., KAMALI B., TAMIN N.M., ZAKARIA R. (2010), An integrated approach to coastal rehabilitation: Mangrove restoration in Sungai Haji Dorani, Malaysia, *Estuarine, Coastal and Shelf Science*, 86: 118-124.

JANSSEN R., PADILLA J.E. (1999), Preservation or conservation? Valuation and evaluation of a mangrove forest in the Philippines, *Environmental and Resource Economics* 14: 297-331.

LEE S. Y. (1998), The ecological role of grapsid crabs in mangrove ecosystems: implications for conservation, *Marine and Freshwater Research* 49: 335–343.

MACINTOSH D.J., ASHTON E.C., TANSAKUL V. (2002), *Utilisation and Knowledge of Biodiversity in the Ranong Biosphere Reserve*, Thailand, ITCZM Monograph No. 7, Series 2002, 29 p.

MUELLER-DOMBOID D., ELLENBERG H. (1974), *Aims and Methods of Vegetation Ecology*, John Wiley and Sons, New York, 547 p.

MUMBY P.J., EDWARDS A.J., ARIAS-GONZALEZ J.E., LINDEMAN K.C., BLACKWELL P.G., GALL A., GORCZYNSKA M.I., HARBORNE A.R., PESCOD C.L., RENKEN H., WABNITZ C.C.C, LLEWELLYN G. (2004), Mangroves enhance the biomass of coral reef fish communities in the Caribbean, *Nature* 427: 533-536.

OTHMAN M.A. (1994), Value of mangroves in coastal protection, *Hydrobiologia* 285: 277-282.

PLATT S.J. (2002), *How to Plan Wildlife Landscapes: a guide for community organisations*, Department of Natural Resources and Environment, Melbourne, 64 p.

SASEKUMAR A., CHONG V.C., LEH M.U., R. CRUZ D. (1992), Mangroves as habitat for fish prawns, *Hydrobiologia* 247: 195-207.

SMITH R.L., SMITH T.M. (2004), *Elements of ecology*, Pearson education, Benjamin Cummings, San Francisco. 682 p.

THAMPANYA U., VERMAAT J.E., SINSAKUL S., PANAPITUKKUL N. (2006), Coastal erosion and mangrove progradation of Southern Thailand, *Estuarine, Coastal and Shelf Science* 68: 75–85.

Annexes:

Table no. 1 Importance Value Index (IVI) of mangrove species in 6 coastal sites in Ranong, Thailand.

Name of species (Family)	Mangrove Forest Sites											
	Ngaw		Rachakrud		Bangben		Banghin		Talaynog		Hadsaykaow	
	A	B	A	B	A	B	A	B	A	B	A	B
Aegiceras corniculatum (Myrsinaceae)	5.12			9.15								
Avicennia alba (Avicenniaceae)		11.91	3.74	23.98								
Avicennia marina (Avicenniaceae)			102.14	60.61	3.82	31.90						
Avicennia officinalis (Avicenniaceae)	18.44	46.95	8.38	87.55					23.43	15.87	17.22	14.31
Bruguiera cylindrica (Rhizophoraceae)	17.51	8.42	8.87	6.33		4.02	4.19					8.21
Bruguiera gymnorrhiza (Rhizophoraceae)			3.69									
Bruguiera parviflora (Rhizophoraceae)	30.97	56.76	48.85	26.03		13.51	77.35	4.07	103.13	67.59	37.80	18.31
Ceriops decandra (Rhizophoraceae)	8.74	20.67			98.53	104.82					4.11	4.54
Ceriops tagal (Rhizophoraceae)	4.64	11.45					75.00	29.31	22.36	18.39	3.56	
Excoecaria agallocha (Euphorbiaceae)				3.45	10.65	4.33						
Heritiera littoralis (Sterculiaceae)					3.92							
Lumnitzera littorea (Combretaceae)				5.30	16.97							
Lumnitzera racemosa (Combretaceae)					26.85							
Rhizophora apiculata (Rhizophoraceae)	190.18	111.59	61.75	19.01	80.47	102.41	64.16	107.05	72.83	78.52	119.81	176.51
Rhizophora mucronata (Rhizophoraceae)		18.23	4.84			13.59	4.87	44.97	66.85	119.63	106.46	74.14
Scyphiphora hydrophyllacea (Rubiaceae)					27.55							
Sonneratia alba (Sonneratiaceae)			21.92	43.07			5.70	44.24				
Xylocarpus granatum (Meliaceae)	24.40		10.32	15.53	31.25	25.43	68.73	70.36	4.61			3.97
Xylocarpus moluccensis (Meliaceae)		14.03	30.51						6.79		11.05	

Note: A = PCQ perpendicular to the channel and B = PCQ parallel with the channel.