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The solutions for construction of sea dike and sea embankments system as the sandy mud trap to support mangrove plants in the coastal zone of Hai Phong city, Vietnam

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Abstract
Mangrove plants play a viral role in protecting the coast, retraining erosion. Especially in areas considered the variable wave conditions, complex dynamic conditions such as the coastal region of Hai Phong city. However, due to various reasons, the development/additional planting of mangrove forests in the coastal area of Hai Phong in some locations has not achieved the desired result. This study was conducted survey measurements of mangroves, terrain, and practical experience to assess the ecological impact of certain dynamic and sedimentary conditions on mangroves. Thereby proposing several solutions to build sea dykes/embankments suitable to Hai Phong conditions, strengthen sediment traps, and create favorable conditions for developing mangrove trees in this area.

Keywords: Dynamics, mangroves, sea dike, trap sediment, Hai Phong.

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INTRODUCTION

Hai Phong is a coastal city, so it has to face many negative influences caused by nature, such as waves, wind, high tide, storms, and tropical low pressure [1]. This region is also impacted by the water discharge and sediment flux from the Red River system and the influences of land-seas interactions [2, 3]. Nowadays and in the long term, shoreline erosion in Hai Phong is an urgent and fundamental issue in mainland management.

Like other coastal locals, the coast of Hai Phong frequently appears erosion. The erosion not only occupies and lost soil, threatens human life directly in coastal areas, affects economic operations, and influences the habitat of regional fauna and flora. The erosion also causes the loss of considerable mangrove areas that carry out many alluvia, causing a fairway sedimentation phenomenon, reducing regional biodiversity [4].

Recently, Hai Phong is one of some coastal provinces with a movement of recovery and new planting mangroves. These mangrove forests have contributed significantly to protecting seashore and sea dyke systems reducing natural disasters in the locality. Areas of mangrove forests in coastal districts such as Vinh Bao, Tien Lang, Kien Thuy, Do Son, Duong Kinh,... have developed rather well, contributing to protecting and strengthening sea dyke systems [5–7].

However, during sea encroaching and dam up for planting mangroves outside of dyke, some were not suitable with the natural conditions of this area. As a result, bottom erosion still occurs in the area in front of the dike. Therefore, this makes it challenging to grow mangroves and can also threaten the safety of the sea dike system.

This paper will analyze the natural conditions, ecological conditions, and limited characteristics of the current constructing dyke. Based on these results, some lessons and experiments could be learned and applied for similar localities.

MATERIAL AND METHODS

The study area is located in the Northeast of the Do Son coastal area. A tropical monsoon climate influences this area with dry winters and wet summers [1]. Suspended sediment concentration in regional rivers changes by the season, normally about 50–70 mg/L in the dry season and 100–150 mg/L in the wet season. However, suspended sediment concentration in the study area is also influenced by hydrodynamics conditions (especially waves) and as well as other human effects as well as other human activities (dredging, dumping) [1, 4]. This area also is affected by mainly diurnal tides. Based on the tide gauge measurements at Hon Dau station (1960–2011), the tidal amplitude is about 2.6–3.6 m in spring tide and about 0.5–1.0 m in the neap tide [2].

In this study, main data used, including:

Data of species *Soneratia caseolaris* (L.) Engl) structure at two bodies of groins A and B (fig. 1) from 2005 to Dec. 2018.

Data measurement of the structure of groins A, B, and their directions.

Other references data such as flow and wind: velocity and direction.

Subjects:

Mangrove forest species *Soneratia caseolaris*, which were 10 to 14 years old at two Groins.

Mangrove forest species *Soneratia caseolaris*, were 10 to 14 years old in reference site (without groin).

Structure of groins for trapping sand and sediments from the year 2011–2012.

Methodology:

Measuring wave high and percentage (%) of wave reduction by forest

Waves were measured by the DNW-5M, wave in the forest was recorded by a measuring stake.

Velocity flow was recorded by equipment SD6000.

Topography was measured by an echo sounder.

Coefficient of wave reduction was defined following Mazda formula (1997) [8] as below:

$$r = (H_s - H_L)/H_s$$

Which of: H_s: High of waves outside of forest (in front of the forest); H_L: High of the wave inside a forest at each position with a defined distance.

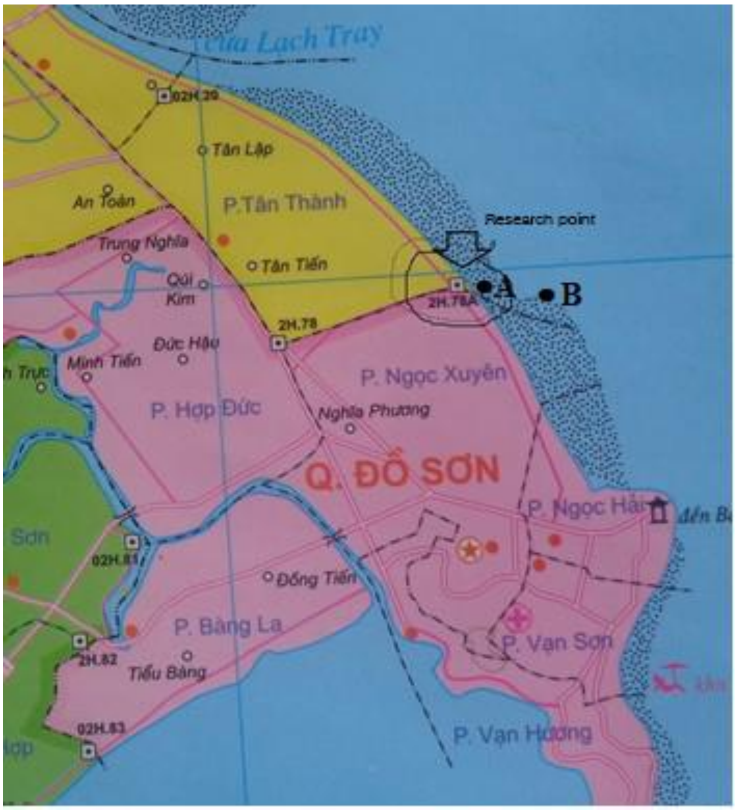

Figure 1. Maps for the research area

Forest structure was carried out by the Braun - Blanquet method [9]

All standard squares were placed along the perpendicular transect line to the sea dyke.

Mangrove forest species *Soneratia caseolaris* (L.) Engl. Measured six squares per Groins, areas of each square were about 1500m^2 (25 m × 60 m).

Control forest: measured three squares.

Measuring diameter of *Soneratia caseolaris*(L.) Engl tree far from the ground about 30 cm.

Measure wave height of the tree (from the root to top).

Determining covering of tree by the measure of 2 diameters (minimal and maximal crown canopy). Then, the cover level of the leaf canopy can be calculated by the formula $L = S/G$, *which of:* S was an area of covered ground (m^2); G was area of ground.

Data were analyzed by statistical method [10–12], and software Mapinfo Professional in the calculation of covered level.

Study on the structure of groins; and driving bamboo stake for trapping more sediment and sand

Both groins were similar in direction and structure, but they needed to survey in detail when the study was carried out.Therefore, these parameters of groins were analyzed, including construction, soaking sediment level at two sides of groins, and lines of bamboo stakes to prevent sediment at the left and right sides of each groin. In this paper, the authors showed the only structure of one Groins.

RESULTS AND DISCUSSION

Analyzing deposit alluvia characteristics at the region where have two Groins

In this study, the mangrove forest and groins belong to Zone I, subzone 3, from Cua Luc to Do Son cape (about 55 km) [13]. In this sub-zone, the topography was relatively flat with Lach Tray River, where discharge about 1.5 × 10^9 m^3 of water had come over sea annually. The river discharge in the flood season holds about 75–85% of flow, mainly in July, August, and September [5]. Due to the sediment flux of many rivers converging in this region in the rainy season had large sediment for alluvia [6]. Therefore, it was very comfortable for the development of mangrove trees and shrubs and distributed widely.

The combination of river flow and tidal flow was shown clearly in the ebb tide, thus creating a flow with a higher velocity than other tidal phases [2]. Flow direction was undoubtedly directed following river flow to the sea, mainly at the southeast with a speed of about 0.2–0.5 m/s. However, during the rainy season, the velocity reached about 0.6–0.9 m/s at low tide, and it had a large disparity of 0.2–0.4 m/s compared to high tide. At low tide, water volume moves quickly from the river to sea, but due to the limitation of water volume, the flow direction toward the sea could expand only 15–20 km, accounting from shore to sea. Thus, it may affect material fluxes from the rivers to the Hai Phong coastal area [2]. In addition, the flow of the surface layer was stronger than the bottom layer toward the sea, so the water volume from the river has only existed on the surface layer.

In the dry season, alternation of flow field by time at can estuarine and coastal region in Hai Phong was similar to the rainy season. However, seasonal change of wind field and water volume reduction from rivers was remarkably different in the rainy season. Especially the effects of wave fields on bottom morphology change. The groins did not take into account all these influences. Therefore, so that it had not brought high effectiveness, cooperated with other reasons from a previous time, it led to some results as below:

Planted mangroves developed slowly, the ratio of survival percentage was not high (dead trees reached 65–75% of the number planted trees per time.

Although the construction of groins had improved, compared with previous groins in Cat Hai (2005), these groins still had not been suitable with the natural condition in Hai Phong.

The general feature of coastal alluvial ground in Hai Phong was flat, and the surface layer had an average silt level at almost flood land.

There were several erosional zones in the long term and eroded continuously as in Cat Hai district.

There were also alluvial zones in many years, but recently, they turned to erosional phase and reversely.

Two groins for trapping sediment and sand were constructed from 2011 to 2012 in the region where it was insufficient sediment, and the sea dyke was eroded, which had been encroached since 1980. This sea dyke elongated near Thuy Giang church (Duong Kinh district) to the old Cam Cap salinity prevention sluice (Do Son district). When encroaching at some stretches of sea dyke were constructing two Groins many barges carrying big stones were sunk in this region and became a foundation. This stretch of sea dyke up to now still had been the most important one in all systems, but it had a risk of break and landslide.

After storms happened in the year 2005, the sea dyke was rebuilt with concretion. However, in the font of the groins on the outer side, mangrove trees were still difficult to live; sea dyke was affected during storm season and high tide.

Measuring wave height in the area with and without mangrove trees

The position of wave measurement is located in the new Cam Cap sluice (no mangrove forest in the font) and the old Cam Cap sluice (with mangrove forest). These wave data were used to define the roles of mangrove forests on nearshore protection. Results showed that waves went through mangrove forest were mainly short wave with cycle less than 30 seconds. These results could not apply for wavelength with wave cycle extended from about 10 minutes to hours such as that one has destroyed coastal area in the Indian Ocean. Each tree species had a different effect of reducing other wave height.

At a distance of about 100 m in front of the forest, the wave height average measured approximately 0.30 m, but in the woods, at a distance of 100 m, it was 0.22 m, corresponding to a coefficient of wave reduction was 33% (table 2). Wave height continuously reduced at a distance of 200 m with an average value of 0.13 m and 58%. Behind the forest at position 270m inside the forest, wave height decreased only 0.07 m, and the reduced coefficient was 77%. However, at a position without forest, the average value was 0.21 m, and the coefficient was 28%.

Table 1. Number and size of the tree in Standard Square in the mangrove forest in Ngoc Hai, Do son in November 2004 and November 2011, northeast wave direction

	Age and total in the group	Criteria				
		Number of tree per ha	Maximal diameter (mm)	Average diameter (mm)	Maximal height (cm)	Average height (cm)
Year 2004	Sonneratia caselaris 5 years old	100	152	124	395	350
	Avicennia marina 5 years old	100	72	56	190	152
	Kandelia obovata 5 years old	17,700	97	76.7	185	147.9
	Total	17,900				
Year 2011	Sonneratia caselaris 12 years old	99	200	184	530	512
	Avicennia marina 12 years old	97	106	97	227	188
	Kandelia obovata 12 years old	17,600	142	116	221	184
	Total	17,796				
	Kandelia obovata regenerated closed to dyke	120,000	25	21	115	98

Table 2. Wave height and coefficient of wave reduction in areas with and without mangrove forest in November 2004 with northeast wind direction

Time	Wave height (m)					Coefficient of wave reduction (%)			
	In front of the forest	100 m inside of the forest	200 m inside of the forest	Behind forest	In front of seashore without mangrove forest	100 m inside of the forest	200 m inside of the forest	Behind forest	In front of seashore without mangrove forest
3	0.25	0.18	0.10	0.05	0.20	28	60	80	20
7 h 30’	0.30	0.15	0.15	0.06	0.20	50	50	80	33
7 h 45’	0.30	0.20	0.12	0.08	0.20	33	60	73	33
8 h 00’	0.30	0.18	0.12	0.08	0.19	40	60	73	37
8 h 15’	0.30	0.20	0.10	0.05	0.20	33	67	83	33
8 h 30’	0.30	0.20	0.10	0.05	0.21	33	67	83	30
8 h 45’	0.25	0.18	0.10	0.06	0.20	28	60	76	20
9 h 00’	0.30	0.22	0.14	0.07	0.25	27	53	77	17
9 h 15’	0.35	0.25	0.18	0.09	0.25	29	49	74	29
9 h 30’	0.30	0.22	0.15	0.08	0.23	27	50	73	23
Average	0.30	0.22	0.13	0.07	0.21	33	58	77	28

Measurement and calculation results of wave height in the mangrove forest in Ngoc Hai, Do Son, and other locations with scattered development of mangrove trees. Trees concentrated only near the foot of dyke; so they may be considered as there were not mangrove forests because it did not reduce wave height due to trees dispersedly between new Cam cap sluice and old Cam cap sluice (Do Son).

Wave measured location at the seaside was far from new-planted (*Sonneratia caselaris* (L.) Engl) forest about 100 m, the average value of wave height was 0.38 m. When the wave went through the forest at

250 m, wave high was 0.24 m, corresponding to a coefficient of wave reduction of 39%. Went to the end of 440 m forest, wave high was 0.06 m, corresponding to a coefficient of wave reduction was 83%.

Thus, although the regenerated tree layer was closed to the foot of dyke, (*Kandelia obovata* Shuen, Lui& Young) was still small. Still, the tree layer was thick up to 20 m, creating a specific barrier that reduced the influence of waves to shore.

The area where had a survival rate of the tree was only 20% concentrating near the foot of dyke and tree was scattered so it could not prevent wave as well as reduce wave height; in detail, the average of wave height closed to shore was 0.24 and the coefficient average was 38%.

Table 3. Wave height and coefficient of wave altitude reduction in area with mangrove forest length 440 m

Time	Wave height (m)					Coefficient of wave reduction (%)			
	Front of the forest	250 m inside the forest	350 m inside forest	Behind the forest	In front the seashore without mangrove forest	250 m inside the forest	350 m inside the forest	Behind the forest	In front of seashore without mangrove forest
6 h 00	0.36	0.22	0.13	0.06	0.23	39	64	83	36
6 h 15’	0.37	0.22	0.12	0.07	0.22	41	68	81	41
6 h 30’	0.39	0.24	0.14	0.07	0.24	38	64	82	38
6 h 45’	0.42	0.27	0.16	0.08	0.26	36	62	81	38
7 h 00’	0.42	0.27	0.15	0.07	0.28	36	64	83	33
7 h 15’	0.41	0.25	0.15	0.08	0.26	39	63	80	37
7 h 30’	0.40	0.24	0.16	0.06	0.25	40	65	85	38
7 h 45’	0.38	0.23	0.13	0.06	0.23	39	66	84	39
8 h 00’	0.37	0.23	0.14	0.06	0.23	38	62	84	38
8 h 15’	0.36	0.22	0.13	0.05	0.22	39	64	86	39
8 h 45’	0.35	0.21	0.12	0.05	0.22	40	66	86	37
Average	0.38	0.24	0.14	0.06	0.24	39	64	83	38

Notes: Location measure is one (forest 270 m) shown in table 1, but more 150 m (*Sonneratia caselaris* (L.) Engl) forest under growing at the seaside and 20 meters generated (*Kandelia obovata* Shuen, Lui& Young) forest, closed to shore. Time for collecting data in November 2011, wave direction was Northeast.

Structure of groins

Two groins constructed in the areas were similar to each other

Body of the groins was perpendicular to the sea dyke.The body of groins towards the seaside was divided into two parts attaching the main body of groins and parallel with the sea dyke.

Groin A (near to new Cam cap sluice):

Length of the main body of groin A from dyke to main body of groin at the seaside was 264 m.

The stretch of the breakwater at the seaside was 151.8 m.

Head closed to dyke: 20°44’18.12’’N - 106°47’13.19’’E - Groin - head at sea: 22°44’20.32’’N - 106°47’11.56’’E.

Groin B (near to Do son direction)

The length of the main body of groin B from dyke to main body of groin at the seaside was 264 m.

The stretch of the breakwater at the seaside was 167.1 m, perpendicular to the sea dyke.

Groin - head closed to dyke: 22°44’6.28’’N - 106°47’6.16’’E; Groin - head at sea: 20°44’8.66’’N; 106°47’15.19’’E.

Structure of groin trapping sand and sediment

Characteristics of the context of the groin area

When the city constructed a ready and concreted full dyke system, the stretch of dyke where existing groins still were weak from 1980 to 2005. The sustainable dyke was built in 2005 after three continuous storms (location of groins afterward) was the weakest of the full system. It was treated entirely because it lost stretch of footing, reasons originated from previous works. After that, the dyke was rebuilt with a concrete cover. It was wide 5–6 m, divided into two lanes and the lorry could go on this dyke. Elevation was higher than 50 cm, so the total height of dyke was 5.5 m in Cam Cap and Bang La - Dai Hop.

The real height of a body of groins was higher than then the toe, about 1 m. The width of a body of groins except freestone with a stainless net at two sides was 8.4 m. The width of groins took account of freestone, and the stainless net was 15.4 m.

Groins trapped sand and sediment at the seaside

The location of the groins was perpendicular to the main body of dyke. The main body of dyke was a middle point for dividing the length of groins into two equal parts.

Structure of body of groins:

Those were solid stainless pipes with $2r$ = 1.2 m. Two tubes were arranged parallel to lines, which were parallel to dyke. Two sides of the back of the groins were blocks of square reinforced concrete and matched together.

After-action reviews of learning from experience and improving groins construction outside the dyke in Cat Hai, Hai Phong, this groins for sand and sediment trapping for mangrove forest could grow well outside dyke; this groins might be the most modern and biggest whole nation.

Structure of mangrove forest after construction of two groins for sand and sediment trapping from the year 2012 to the middle year of 2015

Studying from papers connected events from the year 2005 to the beginning of 2012 and from 2012 to the middle of 2015 showed that:

* At the area of groins A (near new Cam Cap sluice)

Mangrove forest was unique, only (*Sonneratia caselaris* (L.) Engl) species.

Trees planted from 2005 to 2006 until the beginning of 2012 was an average high of about 1.9 m, and the average diameter was 2.0 cm. The covering level was from 20–27%.

The important thing was trees in this stretch needed to replant every year, so it caused loss of labor and expenditure but brought back low effectiveness.

The forest in this stretch, after the appearance of groins A, still needed to replant. Still the rate of the tree was lower, meaning decreasing dead trees, and the rated of the tree had bigger diameter increased rapidly; at the same time, the rate of covering level was also higher. However, the covering level at two sides (left and right) of groins was much different. On the left side (toward the sea), the covering level was 40%, but it was only 25–27% on the right side. On the left side, the tree's height from 2012 to the middle of 2015 was 3–3.5 m, and its diameter was 15–21 cm. The tree was 2.0 m high with only 8–13 cm on the right side.

Rate of alluvia at the two sides of the groins was much different.

The level of alluvia on the left side was thicker from 2–3 times compared to the right side.

The number of breath roots (*Sonneratia caselaris* (L.) Engl) at the left side was much more than at the right side about two times, although length and diameter of root were similar, l = 10–20 cm, $2r$ of root = 0.6 cm, respectively.

* At the area of groins B (toward Do Son)

(*Sonneratia caselaris* (L.) Engl) the forest also increased clearly.

From 2005 to the beginning of 2012: from 2005 to the beginning of 2015, the average height of the tree was 1.9 m (figure 2).

From 2012–2015:

Diameter of the tree ranged from 12–20 cm, height was 2.9–3.2 m, and there were only (*Sonneratia caselaris* (L.) Engl) tree grew near the foot of dyke having breath roots with 10 cm long, but it was smaller than the left side of groins.

Diameter of the tree ranged from 10–13 cm, height was 2.0–2.3 m but these trees concentrated near to the foot of dyke at the right side.

General, when groins appeared, the survival rate of trees increased, growth of tree was more rapid than the period of 2005 - beginning of 2012 including height and diameter of tree body, so that the covering level improved and kept sand and sand sediment in the area (figure 2).

Groins in the period of 2012–2015 | Trees grew in 2014 at left and right sides of groins A and B (growing in mass near to the foot of dyke) | Trees grew on the right sides of two groins in 2017

Figure 2. Groins and tree grew in the study area in 2012–2017

It proved that there was a better way shown in finishing groin construction work, but it did not research carefully in the calculation so that it needed following treatments in the right way, but it was not such a suitable manner.

By studying the construction of strong groins from the beginning of 2012 to the middle of 2015, the authors believed the groin construction was stable at the suitable erosive sites when it was urgently in need.

Thus, the above parts showed that errors of dyke embanking from 1980 to 1981, next to the construction of direction of groins and setup of groins was not suitable. So the effectiveness of sediment trapping was low. The process of alluvia was slow, costly, and wasted time. It also affected to whole dyke system due to existing depressed sites and had to consolidate by groins.

Next step of repair, bamboo stakes were driven into many lines and rows but had to be parallel to dyke and straight fence to join two ends of groins A &B at the seaside. Until the end of 2018, it needed to consolidate many lines of bamboo stakes to encroach outside of groins (figure 3).

Trees grew in some sites near two right sides of groins in 2018 | Trees grew near to two left sides of groins in 2018 | Bamboo stakes drove in sites of two groins in 2018

Figure 3. Groins and tree grew in the study area in 2017–2018

Consolidate by bamboo stakes at sea from the middle of 2015 to the end of 2018 for sediment trapping.

* Structure of forest in the area without erosion near groins B and forest at left and ri ght close to a body of groins B. Time of data

collection: 16 h 30' on 18th December 2018 (figure 3).

Forest near to erosive area toward Do Son: mix species forest interposed each other near to old Cam Cap sluice:

(*Sonneratia caselaris* (L.) Engl) trees were 5,5–6,0 m high; leaf canopy was 3–4 m wide;

Regenerated (*Kandelia obovata* Shuen, Lui& Young) tree floated closer to shore and developed densely, becoming a belt (*Kandelia obovata* Shuen, Lui& Young) 2.5–3.0 m with a canopy level was 98%.

(*Avicennia marina* (Forssk) Veich) was outside belt, 2.0–3.0 m high, the canopy was 2–2.5 m wide, covering level reached 90–95%.

Height of (*Sonneratia caselaris* (L.) Engl) reduced gradually toward groins B: from 6 m to 4 m to 3 m close to the groins, and the forest was the only species (*Sonneratia caselaris* (L.) Engl).

At the right side of groin B, the tree had developed slowly, with a rate of covering level was 60%, but it took only 20%. Near the foot of the national dyke, trees were high, about 2 m, 2.5 m and 3 m. Near the end of groins at the seaside, trees grew sparsely; the rate of covering level reached 15–20%.

At the left side of groins B near the foot of the national dyke, (*Sonneratia caselaris* (L.) Engl) was 4–4.5 m high. Out of 40 m along the body from the dam to the end of groins (*Sonneratia caselaris* (L.) Engl) was about 1.5–2.4 m high. Many breath roots, about under 100 roots/m^2 around the foot, there was no regenerated tree layer, only sparsely the number of trees (*Kandelia obovata* Shuen, Lui & Young) closed to the foot of groins. The covering level near the body of groins was 65%, with the length was no longer than 60 m.

* Structure of forest at the area without erosion was planted only (*Sonneratia caselaris* (L.) Engl) near new Cam Cap sluice toward Duong Kinh district similarly to time to grow (*Sonneratia caselaris* (L.) Engl) at the area of the left and right of groins A. The time of data collection was on 19th Dec 2019.

Trees at the new Cam Cap sluice's left edge toward Duong Kinh were planted only (*Sonneratia caselaris* (L.) Engl), but the trees did not grow after two years, 2005–2007. The trees were dry and turned to black grey (we did not know why); after that, the trees recovered and grew. At the time of data collection, all trees were 6.5–7.0 m high, the diameter of the body was 25–30 cm. There were many regenerated trees as (*Kandelia obovata* Shuen, Lui& Young), (*Avicennia marina* (Forssk) interposed closely to the foot of dyke. The forest was at the right side of groin A was long, about more than 40 m, the diameter of the body was from 10–18 cm, and breath root around the body was 60 roots per m^2. Near to the body of the groin at the seaside, trees were small and the rate of dead trees was high, covering level was 15% in 2018, and new trees were planted every year.

Mangrove forest at the left side of groin A was more than 50 m long; and the tree was 6–6.5 m high. The rate of covering took about 40%, level of covering reached 60%. Far the foot of dyke toward end of groins, trees were 2–2.7m high, rate of covering was 60–63%, took 20% of the surrounding area. At the left side of groin B, there were regenerated (*Kandelia obovata* Shuen, Lui & Young) interposed with modest height.

Table of sediment analysis at the same area. Strengthened to treat sediment trapping by rows of bamboo stakes drove parallel to shore, both inside and outside of groins at the seaside.

Table 4 of the sediment analysis results showed that the entire right sides of two groins had a high sand and mud distribution; the low and medium mud distribution rate took a high percentage.

Practical measurement of the thickness of mud sediment showed that the thickness of sedimentation of small and medium mud powder at the left side of groins was higher than groins B (folded three times). The thickness of medium and big mud powder sediment at the right side of groins was higher than groins B (folded two times).

Table 4. Results of grand sediment size at some point in the study area

STT	Point	Grand size distribution (%) of sediment (μm)																Parameters			
		2,000	1,000	710	500	400	250	200	125	100	63	31	16	8	4	2	1	Md (μm)	S0	Sk	Type
1	A1	0,00	0,48	0,20	0,26	0,22	1,07	0,62	3,04	3,29	6,91	16,73	9,07	8,00	5,52	8,90	35,69	7,7	6,573	0,025	Fine silt
2	A2	0,00	1,93	0,69	0,63	0,46	1,34	0,54	1,19	0,90	3,60	12,04	8,93	12,90	11,86	12,11	30,88	6,7	6,490	0,162	Fine silt
3	A1’	0,00	0,77	0,44	0,54	0,69	6,13	5,40	17,15	2,68	1,72	3,13	8,37	8,90	4,43	13,04	26,61	14,0	9,201	0,052	Medium silt
4	A2’	0,00	2,98	0,47	0,58	0,37	1,45	1,04	3,24	1,86	6,74	17,81	13,57	13,94	7,99	8,36	19,60	12,4	6,705	-0,109	Medium silt
5	B1	0,00	0,41	0,16	0,15	0,16	1,45	1,42	4,04	4,63	16,77	16,41	6,57	8,06	7,14	11,77	20,85	13,8	6,486	-0,242	Medium silt
6	B2	0,00	0,00	0,00	0,00	0,14	0,91	1,15	3,56	4,47	19,10	20,07	7,46	7,58	10,03	8,05	17,49	16,6	5,838	-0,425	Coarse silt
7	B1’	0,00	0,56	0,14	0,13	0,09	0,38	0,48	2,58	13,08	34,54	6,55	5,55	6,22	3,00	4,99	21,71	21,0	6,436	-0,768	Coarse silt
8	B2’	1,54	2,15	4,10	8,25	11,18	14,15	16,54	20,30	15,12	5,07	1,60	0,00	0,00	0,00	0,00	0,00	233,9	2,062	0,145	Fine sand

[*Source:* The sample was analyzed in Dep. of environmental Geography - Institute of Marine environment and resources]

Notes:

A1, A2: Left side along groins A belongs to Duong Kinh district, along the main body of groins from inside to outside of groins.

A’1, A’2: Right side along groins A belongs to Duong Kinh district, along the main body of groins from inside to outside of groins.

B1, B2: Left side along groins B belongs to Do Son district, along the main body of groins from inside to outside of groins.

B’1, B’2: Right side along groins B belongs to Do Son district, along the main body of groins from inside to outside of groins.

CONCLUSION

Studying on mangrove trees, which was suitable with practical sites, has not been appropriated at the beginning time.

Land for planting and groins construction later was laid in deficient sediment area was right, but groins did not research in detail, so it caused waste.

The solution of repair at the deficient sediment area was to take the plump of (*Sonneratia caselaris* (L.) Engl) tree and put it into it. Still, the tree could not be alive for more than two years because the sand soil foundation was not stable and lacked sediment. They were keeping sand and sediment in this area needed to treat in another way.

Cooperation of hard and soft solutions to protect the sustainability of dyke was not harmonious, so it caused waste of economy and time; durability of work did not last long in some weak sites, affecting the whole dyke system.

Land reclamation has spent a very arduous, hardworking period, and it has not gained success overnight. On the other hand, it has to go through many management steps, so there must be a closed combination, and data must be stored in one place. When it is necessary to look up, it is easy to find the cause of further handling if there are defects.

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