THE ROLE OF MANGROVES IN MITIGATING NATURAL DISASTERS

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Abstract

Located in the monsoonal tropical region, every year Viet Nam suffers from various natural disasters coming from the ocean, causing huge personal and property damage.

Surveys in 2005 show that where there are protective mangroves, sea dykes – even those made with soil only – were not broken or eroded. In the meanwhile, hard concrete sea dykes which were not protected by mangroves suffered serious damage in storms.

The paper reports on the significant effects of mangrove belts in protecting coastal areas and minimizing damage caused by storms and tsunami in regional countries. Research in various localities of Viet Nam has revealed the impacts of mangroves in the protection of sea dykes and restriction of erosion and salt intrusion. The paper also presents some results of the research on the impacts of different types of planted mangrove forests of different composition and structure in reducing wave strength at spring tide, especially during large storms.

Several recommendations have been made to the Government and authorities concerned on the restoration and development of protective mangroves.

1. Introduction

Viet Nam has a coastline of 3260km. Located in the monsoonal tropical region, Viet Nam is struck by 5 – 8 storms annually, as well as spring tides, which result in heavy damage. In the past, thanks to protective green belts of natural and planted mangroves on the coast and at river mouths, seadykes were more stabilized, therefore, local people's lives and properties were protected. However, over previous years, increasing inland forest destruction has increased the occurrence of floods in coastal downstream regions. Landslides have also taken place in many areas; soil has been eroded, washed away and swept downriver. Moreover, destruction of mangroves for shrimp ponds, crab ponds, industrial areas, urban development and tourist sites is becoming very popular in coastal areas, which puts the coastal communities' life in increasing threat of natural disasters.

Therefore, surveys of the impacts of various types of mangroves in natural disaster control as well as research on the characteristics of protective mangroves of different composition and structure in reducing wave strength at spring tide and during large storms in 2005 have had significant practical importance.

2. Methods

1. In order to assess the damage caused by large storms during 2005, information was collected from the Internet, daily newspapers and especially from the Central Committee for Flood and Storm Control (CCFSC) for analysis. In addition, we organized field trips to take pictures and study the actual situation of sea dykes and salt intrusion in certain coastal areas after these storms.
2. Information was collated and monitored on the role of mangroves in mitigating storm damage, especially during the tsunami on 26 December 2004 in Southeast Asian and South Asian countries.
3. Coordinates of study sites were determined by Satellite Positioning Equipment (GPS-126) to place wave measurement machines. DNW-5M and Ivanov H10 equipment was coupled with Mia of the Oceanography Institute and Navy Institute to calculate the coefficients of decreased wave heights in front and behind mangrove forests at spring tide and during storms.

3. Results and discussions:

Damage caused by some natural disasters in Viet Nam

Tsunamies

Field surveys and investigations by the Institute of Physics and Earth on storm surges and tsunami in the 33 coastal sites from Mong Cai to Ca Mau Provinces have shown that tsunamies have, sometimes, occurred along the coast of Viet Nam. In 1978, tsunami is recorded to have appeared along the coast of Tra Co, Mong Cai (Quang Ninh Province). The coast of Dien Chau (Nghe An Province) witnessed tsunami as well. Additionally, in 1923, 1960, 1963, and 1991, tsunami hit some coastal areas of South Central Viet Nam and Southern Viet Nam due to the effects of Hon Tro volcano (Phu Quy archipelago), and Pinatubo volcano (the Philippines).
(Source: Institute of Physics and Earth, Viet Nam Academy of Science and Technology, cited by Thanhnien newspaper July 2006)

Storms and floods

In 1992, due to the majority of protective mangrove forests having been destroyed for shrimp ponds, the coastal area in Soc Trang province was heavily damaged by flood-tides and whirlwinds, claiming the lives of many people. The province then had to invest a great deal in forest restoration (Hong *et al.* 2006).According to official provincial disaster reports obtained from the Disaster Management Center, Ministry of Agriculture and Rural Development Viet Nam (as of October 2002), the total annual damage caused by disasters in Viet Nam in 2002 were: people killed 355, people missing 34, houses collapsed and swept away 9802, paddy areas flooded and inundated 46490ha,dyke eroded 31283 m^3,small hydraulic structures broken and washed away 462.

The year 2005 saw a great deal of large storms. Seven storms attacked Viet Nam and their destruction was also stronger and wider spread compared with those of the previous years, causing great damage to people, their properties and infrastructure. Through breached seadykes, saltwater inundated inland areas while torrential floods swept through some mountainous areas. Newspaper, radio and internet articles have cited that seadykes (the most important means of protection) could not deal with wind ranging from 118-133 km per hour. Storm No 2 attacked the Northeast coastal provinces and the North Delta on 31 July and 1August 2005 at the wind level of 9, 10 and 11 along with torrential rain and high tides. As a result, many dykes were seriously damaged in Vinh Bao, An Lao, Tien Lang (Hai Phong), Nghia Hung, Hai Hau, Giao Thuy (Nam Dinh), Bac Cua Luc, Hoanh Bo (Quang Ninh). Due to storms and high tides, the level of water rose high at 4.5 m and some dykes were broken in Cat Hai island.

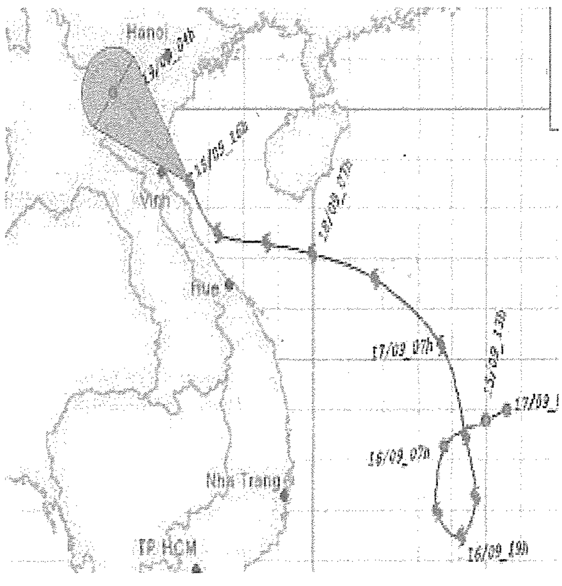


Figure 1. The storm Vincente (No. 6) attacked the country (Source: Viet Namnet 18/9/2005)

Two consecutively strong storms Vincente (No. 6) and Damrey (No. 7) attacked the Northern Viet Nam in September 2005.

The storm Vincente with a wind power of 8 and 9, combined with heavy rain and spring tides caused destruction of property, flooding areas on September 18 - 19, 2005 (fig. 1). Many sections of seadykes in Quynh Luu, Dien Chau, Nghi Loc - Nghe An province were seriously damaged. Many concrete seadykes in Cat Hai island, Hai Phong were destroyed, and thus Hai Phong city was deep under water. Many places were flooded, and roads damaged (including the Ho Chi Minh highway) by storm rains in Quang Binh and Quang Tri (Vietnam net, 9/2005).

When sections of dykes had not been recovered yet, a strong storm with a wind power level of 12(118-132km/hour) struck Nam Dinh at noon on . September 27, 2005. Three sections of Hai Hau dykes were broken and many sections of Giao Thuy, Nghia Hung dykes suffered landslides as a result.

In the afternoon of September 27, 2005, the storm Damrey broke 12km of seadykes in Ninh Phuc and Hau Loc, Thanh Hoa province, thereby enabling water to inundate other districts' seadykes. This forced thousands of people to evacuate.

According to the standing office for the Central Committee for Flood and Storm Control (CCFSC), the total material losses caused by storm Damrey were: 275 m of broken seadykes (Hai Phong: 50m, Nam Dinh: 200m, Thanh Hoa: 15m); 54,055 m of eroded seadykes (Nam Dinh: 1,250 m, Thai Binh: 3,500 m, Ninh Binh: 725 m, Thanh Hoa: 18,850 m, Nghe An: 30,000 m. The damage of properties was very severe (table 1).

Table 1. Damages caused by storms in September 2005

Loss category	Item	Unit	Storm Vincente (No.6)	Storm Damrey (No.7)
Human life	No. of people killed	person	14	59
	No. of people missing	person	6	16
	No. of households evacuated	No	1,867	32,442
Shelter	No. of houses collapsed and swept away	No	68	4,746
	No. of houses damaged and submerged	No		113,523
	No. of class rooms collapsed	No	60	157
	Hospitals and health care station affected	No		197
Agriculture	Area of rice submerged and damaged	ha	109,433	240,174
	Area of subsidies crops submerged and damaged	ha	22,678	77,761
Irrigation works	Volume of soil and rock eroded and swept away	m3	328,200	1,574,930
	Volume of rock and concrete damaged	m3	1,800	253,365
	Sea dyke broken	m		1,160
	Sea dyke eroded and affected	m		76,681
	Canal eroded	m		6,420
	Under dyke sluices collapsed and damaged	No	15	18
Transportation	Area of road surface eroded	m2		62,240
	Length of roads damaged and submerged	Km	40	268
	Bridge, sluice damaged and swept away	No		156
Fisheries	Area of aquaculture farming submerged and affected	ha		21,984
	Fishing boats broken and sunk	No		65
	Fishery dyke eroded	m3		75,000

Source: Damage situation report of CCFSC on September 22nd and October 2nd 2005

Great damage brought by storms or waves (breaking or collapsing seadykes) often occurs in places which experience regular erosion, such as the coastal areas in Hai Hau and Nam Dinh districts. These include places where mangroves may or may not be planted. No planting of mangroves has taken place yet, as they are reserved for shrimp farming by local authorities. (Hau Loc – Hoang Hoa, Tinh Gia – Thanh Hoa). Additionally, local residents destroyed mangroves to create aquaculture ponds (communes in Cat Hai district - Hai Phong city, Kim Son district – Ninh Binh province).

After Damrey storm, some government members upon inspecting some heavily damaged coastal areas made the observation that the lack of protective mangrove belt was the cause of erosion or break of seadykes. Where mangrove was still in existence, no or little damage was caused. Therefore, it was suggested that localities should have plans to restore and develop mangroves.

In the first half of 2006, the State of Viet Nam spent over 200 billion dong to repair sea dykes, but this amount has been sufficient to cover only the most strategic parts with concrete (Fig. 2).

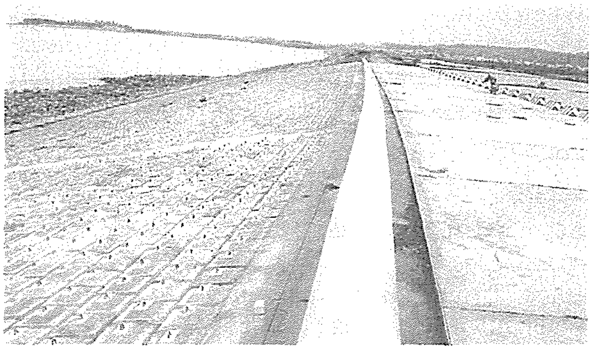


Figure 2. A section of seadyke in Hai Phong destroyed by the 2005 storms has just been consolidated with the cost of nearly 20 billion VND (1,250 million USD)
(Photo Vu Doan Thai taken on 14 July 2006)

The role of mangroves in coastal area protection

Some information on the effects of healthy mangrove stands in mitigating the natural disasters

A Japanese disaster impact reduction study has found a dense 100 meter wide mangrove forest could reduce a tidal wave's height by 50% and the wave's destructive power by 90% (Samabuddhi 2005).

In Bangladesh, in October 1999, mangrove forests reduced impacts of a super cyclone that struck Orissa on India's east coast, killing at least 10,000 people and making 7.5 million homeless. Those human settlements located behind healthy mangrove stands suffered little, if any, losses (Ricardo 2004).

There is evidence of mangrove importance from the Indian Ocean tsunami on December 26th 2004 that hit countries in South and Southeast Asia, and Eastern Africa.

Many other such reports have reaffirmed this fact that fewer losses of life and property occurred in mangrove zones, which were more intact. In many places where the devastation was greatest, mangroves were gone.

An initial press from Tamil Nadu's Point Calimere Wildlife and Bird Sanctuary – a Ramsar site of international importance for migratory water birds – indicates that the natural configuration of the bay and mangroves may have helped to reduce the impact on the site, although the area was inundated (IUCN 2005a).

It is the mangrove belt and coral reefs that mitigate damage and defend thousands of human lives. Friends of the Earth state that protecting such natural buffers is a primary solution to sheltering coastal residents from tidal waves and other threats. Initial recent reports by an IUCN survey team upon tsunami influenced areas show that the coastal zones covered by dense mangroves, protective tree belt (casuarinas) or other vegetative plantations (coconuts) saw much less loss in terms of human life and assets compared with the areas where coastal ecosystems had suffered from degradation or conversion to other use purposes such as shrimp farming or tourism (IUCN 2005b).

In the south of the tsunami- ravaged Kedash state of Malaysia, communities living behind the country's most pristine protected mangrove forests, Matang, were completely untouched by the waves while the nearby areas were badly hit, said Malaysian environmentalist Suzana Mohkeri (cited by K. Samabuddhi 2005).

According to a report from India, "When the tsunami struck India's southern state of Tamil Nadu on 26 December areas in Pichavaram and Muthupet with dense mangroves suffered fewer human casualties and less damage to property compared to areas without mangroves…" (Ricardo 2004)

Effects of planted mangrove belts in protecting sea dykes in Viet Nam

From early last century, local residents planted some mangrove species such as *Kandelia obovata* and *Sonneratia caseolaris* in order to protect seadykes and estuarine areas in Northern coastal regions. In this period, even though seadykes were not constructed of concrete and embanked with stone, many of them suffered no damage when hit by moderate storms (level 6-8). Mangroves, thick grass cover and a liana layer on the sides of seadykes, protected them from erosion (Hong *et al.*, 2006).

In some localities, seadykes and fields have been well protected due to serious implementation of the reforestation program "327" of Government and Non-government Organizations. In 2001, a strong storm struck Thach Ha district, Ha Tinh province. However, the dyke systems of the Nghen river were not damaged because of the presence of the mangroves planted in 9 coastal communes. According to people in Ha Tinh province, Dong Mon seadykes might have been broken had it not been for the SCF-UK assistance project in planting mangroves.

When storm No 2 attacked Thai Thuy district, Thai Binh province in 1996, the protective green belt of mangroves, protected pond embankments. In Tien Hai district (nearby area) many mangroves had been destroyed. As a result of the storm, most pond embankments were damaged.

In the storm Damrey on 27 and 28 September 2005, high waves crashed down over a 650m seadyke in Tan Boi village, Thai Do Commune (Thai Binh Province) (fig. 3) where no mangrove was present. At the same time many other sections of the seadyke in the commune suffered no collapse due to the protective green belt of mangroves decreasing wave intensity (fig. 4).

Figure 3. 650m of central seadyke in Tan Boi village, Thai Do commune, Thai Thuy district, Thai Binh province eroded due to storm Damrey (No 7) as a result of mangrove absence
(Photo: Phan Hong Anh taken on 10/10/2005)

Figure 4. 5km of seadyke protected by mangroves in Thai Do commune and therefore, not eroded in presence of the storm Damrey
(Photo: Phan Hong Anh taken on 10/10/2005)

During the first quarter of 2006, the State had to spend 1.3 billion VND (equivalent to USD 81,200) to repair the above seadyke, which is equal to the total cost of planting and protecting a mangrove belt along this seadyke during many years.

Mangrove forests' roles in protecting alluvial soils, preventing erosion and hindering salt intrusion

Expanding alluvial soils and restricting soil erosion

Except for some special cases, the growth of mangroves and the expansion of alluvial soils' areas always happen concurrently. In general, mangrove species could grow in mud flats with favorable edaphic features and climate and good seed sources.

Mangroves in coastal areas and river mouths play a very vital role in protecting and expanding mud flats, minimizing erosion, and decreasing wind power, strength of waves and currents on the coastal seadykes and at the river mouths.

Floral mangrove roots, especially pioneer floral populations, are able to push up the sediment deposition. They not only effectively disperse the strength of waves toward the seashores, but also speed up the process of sedimentation. In addition, mangroves are really useful in terms of erosion restriction and seashore intrusion.

A typical example is found in Can Gio District, Ho Chi Minh City. After the mangroves were destroyed by warring herbicides, most local river banks were eroded due to strong tidal currents and high tidal amplitude (3-3.5m). However, after only 5 years of replanting (from 1978 to 1983), Dong Tranh river bank was no longer eroded. Alluvium rapidly accreted, facilitating the regeneration of various species and creating a mixed vegetation (Hong 2004).

Hindering salt intrusion

When mangroves were not destroyed on a large scale, salt intrusion took place slowly and in a very narrow scope. The reason was that when tides were high, water inundated large mangroves; however, tidal water, then, was weakened by systems of dense roots and trees' stems and the wind power was hampered by canopies of leaves.

Yet, for the past years, because most of the mangroves in the coastal areas have been logged to give land for agriculture, especially shrimp ponds, the scope of distribution of the coastal estuarine tidal water has been narrowed. Thus, encouraged by monsoons, saltwater in high tides flows very strongly along the rivers deep into the mainland.

This results in erosion on the river banks and at the foot of seadykes. Moreover, saltwater penetrates through the body of seadykes into fields, decreasing productivity. The shortage of freshwater also affects the production and daily life (Hong (ed.) 1997).

Some preliminary results of research on mangroves' capability in decreasing wave intensity

The protection a mangrove forest provides is dependent on their width, structure and leaf canopy. The wider a forest is, the stronger its ability to reduce the force and the height of waves. The effect in reducing the intensity of waves also depends on the topography and wind directions.

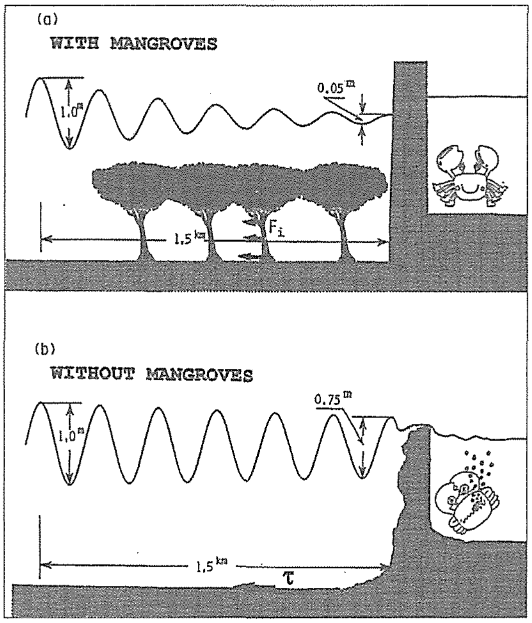
Effects of mangrove forest types in mitigating the strength of waves at the storm-free time

Measurement of the strength of waves was taken in three sites:

1. Pure planted Kandelia obovata forest

Measurement of wave height in places with and without mangroves at the storm free time (when there was no storm) in the mangroves of Thuy Hai – Thai Thuy – Thai Binh from 17th to 21st November 1994. This was conducted under the management of Professor Yoshihiro Mazda.

Thuy Hai has planted *Kandelia obovata* forests of 1.5km width, with various ages. These types of forest have been newly planted; the trees are still small and sparse. Therefore, they would have little effect on reducing the strength of waves. The strength of waves is decreased only by friction with the substrate. Meanwhile, inside the forests, trees of over 2m high and their thick canopies of leaves and root systems under the tidal water (fig. 5) effectively reduce wave strength (fig. 6).



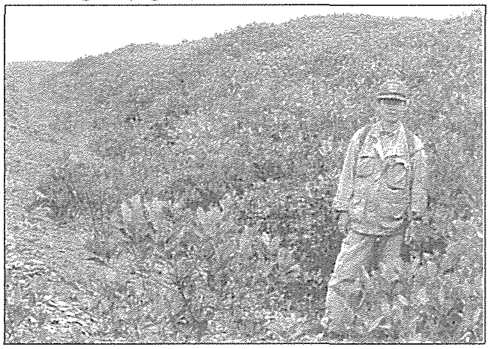


Photo 6. Mangroves in Thuy Hai, Thai Thuy, Thai Binh (Photo: Le Xuan Tuan)
- The highest trees (close to the bank): 3.00m
- The trees of medium height (200m far from the bank): 2.5m
- The trees near sea water edge (newly planted): 0.3m

Figure 5. Wave decrease difference between mangrove (a) and non – mangrove areas (b) in Thuy Hai, Thai Binh
- The waves of 1m high from the bare flat that pass through the 1.5km wide mangroves are reduced in height to 0.05m when reaching crab ponds
- In the non-mangrove area, with the same wave movement distance, the wave height at crab ponds is 0.75m and the pond embankment is eroded.
(Souce: Mazda *et al.* 1997)

2. Pure planted Sonneratia caseolaris forest

Measurement of wave height and calculation of their Decrease Coefficient when these waves passed planted *Sonneratia caseolaris* forests aged 8-9 years in Vinh Quang commune, Tien Lang district (Hai Phong city) , at the time of high tides on 17th January 2004.

Figure 7. Planted *Sonneratia caseolaris* forest to protect sea dyke at Vinh Quang Com. (Source: Vu Doan Thai)

Forests of pure *Sonneratia caseolaris* in Cong Roc area of Vinh Quang commune planted in 1995* are about 920m in width, 8-9m in height and with diameters of 15-18cm (fig. 7). Machines of DNW – 5M and Ivanop H10 coupled with Mia were used in some specific sites (Thai 2005) to calculate coefficients of decreasing height of waves. The results showed that: At the times of highest tides combined with the wind directions into forests, the average height of waves in the shallow water, 180m away from forests, was 0.43m; however, the wave level decreased to 6.8cm behind *Sonneratia caseolaris* forests of 920m wide. Wave height and its average decreasing coefficient at each range of forests are: 0.39m and 31%, respectively, after the first 100m; 0.19m and 57% after 300m; 13cm and 69% after 500m; 9.8cm and 77% after 700m; .6.8cm. and 84%, correspondingly, after 920m.

3. Mixed planted Kandelia obovata and Sonneratia caseolaris forest

Kandelia obovata has been planted since 1997 in Bang La. *Sonneratia caseolaris*** has been inter-planted since 1999. Average height of *Kandelia obovata* is 1.72m (5 year old) and 1.95m (6 year olds). Average height of *Sonneratia caseolaris* is 3.8m. Leaf canopy is about 350 m in width.

Measurement of wave height was implemented on the day of strong tides on 17th August 2005. Calculations and analyses pointed out that: average height of waves in the shallow water, 150m away from forests, was 0.42m at the times of highest tides and direct wind directions. Yet, at the foot of *Kandelia obovata* forests of 650m wide, the figure was only 2.5cm. At every forest section, the height and average decreasing coefficient of waves are: .19.5cm and 53.7% after the first 150m; 9.4cm and 77.7% after 250m; 5.4cm and 87.4% after 350m; 4.9cm and 88.4% after 450m; 4.3cm and 89.9% after 550m; 3.5cm and 94.1% after 650m, correspondingly.

Effects of mangrove forest types in mitigating the strength of waves during storms

Main features of the storms

The Vincent storm (18 September 2005) landed in the coast of Hai Phong during spring tide (2.8-2.9m) with the wind direction almost unchanged, mainly eastern. The storm occurred during an extended period, from 14:00 to 19:00. The highest wave offshore was 3.4m, with the highest water level of 4.0m at 16:55 (at the Hydrology station on Hon Dau island)

The Damrey storm (27 and 28 September 2005) landed in the coast of Hai Phong with the wind direction being mainly eastern – south-eastern. The highest wave offshore was 3.6m, with the highest water level reaching 4.18m at 13:00 (at the Hon Dau Hydrology Station).

* The planted *Sonneratia caseolaris* forest supported by ACTMANG (Japan)
** The mangroves in Bang La have been planted with the sponsorship of Japanese Red Cross; the Red Cross of Hai Phong City is responsible for management

Measurements and calculations in Bang La mangrove area (Do Son)

During Vincent storm, the height of waves decreased as they reached the large shallow mudflat close to shore wave measured at 17:30 at a point of 150 meters in front of the *Kandelia obovata* forest was 1.1m. Behind the forest of 650 meters wide, waves were only 0.09m, giving a Decrease Coefficient of 92% (fig. 8).

The highest During the Damrey storm, close to shore (in a shallow zone), the waves reduced in height. The highest wave measured at 12:30 at a point of 150 meters in front of the forest was 1.4m. Behind the *Kandelia obovata* forest of 650 meters wide, waves were only 0.2m, giving a Decrease Coefficient of 86%.

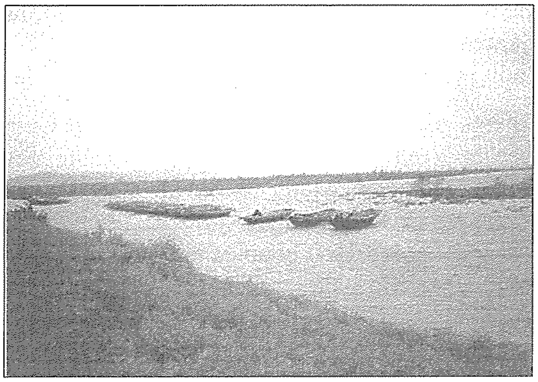


Figure 8. Planted *Kandelia obovata* reduce wave height at Bang La Com in Vincente storm (Photo Vu Doan Thai taken on 18 September 2005)

The above calculations show that *Kandelia obovata* forests of 650m wide, with a density of 182 plants/100m^2, with branches growing 45-50cm from the ground level, thick canopy, 90-95% coverage have the effect of reducing up to 80-88% the height of waves during storms.

Measurements and calculations in Vinh Quang area (Tien Lang)

Measurements and calculations of decrease coefficients of waves in front of and behind *Sonneratia caseolaris* forests of 920m wide and in areas of mangrove in Vinh Quang (Tien Lang) in the above two storms.

During the Vincent storm, the highest wave measured at 17:30 at a point of 100 meters in front of the *Sonneratia caseolaris* forest was 1.2m. Behind the *Sonneratia caseolaris* forest of 920m wide, the wave height was respectively 0.25m. The decrease coefficient of wave height for the forest of 920m wide is 79%.

During the Damrey storm, the highest wave measured at 12:30 at a point of 100 meters in front of the *Sonneratia caseolaris* forest was 1.5m. Behind the *Sonneratia caseolaris* forest of 920m wide, the wave height was 0.35m. The decrease coefficient of wave height for the forest of 920m wide is 77%.

For *Sonneratia caseolaris* forest of 8-9 years of 920m wide, with a density of 203 plants per standard plot (1,500m^2), branches growing 100-150cm from ground level, 92-96% coverage have the effect of reducing 78-81% of wave height during storms.

4. Conclusions:

The results of surveys carried out by scientists of both other regional countries and Viet Nam agree that mangroves play a very important role in mitigating damage caused by natural disasters such as floods, storms, tsunamis, etc. Protective mangroves have significant impacts in reducing wave strength at spring tide and during storms. Thanks to them, sea dykes are protected and in turn safeguard the life and property of coastal communities. Therefore, it is urgent and essential that protective mangroves be protected and developed in accordance with careful plans.

5. Recommendations

-. It is suggested that the Government issue some legal documents stipulating measures for protection of wave buffering mangrove forests, coastal wind buffering forests. The Ministry of Natural Resources and Environment should cooperate with the Ministry of Fisheries and the Ministry of Agriculture and Rural Development to recover the abandoned or ineffective shrimp pond land which used to be mangroves on which mangroves should be rehabilitated.

-. The Government should soon issue legal documents covering the stipulated size of the mangrove belt for protection of river banks, coast and seadykes from erosion (due to rain, storms, land slides, high tides, storm surges and boat/ship plying).

(It is suggested that the green belt along the brackish water river and the coast be 30 – 50m and 500 - 1000m respectively).

-. It is recommended that the Government stipulate mangrove belts to be an important part of seadyke systems and spend an appropriate amount of funds for seadyke maintenance and restoration and conservation of the green belts. The Ministry of Agriculture and Rural Development should provide guideline documents on establishment of mangrove belts.

-. Evaluate economic and environmental values of mangrove f ecosystems and compare with other economic activities in coastal and estuarine wetlands to call for appropriate investment from decision makers.

-. There should be awareness raising programmes for governmental agencies, leaders and managers from central to local levels and the local communities about the role of mangroves and other coastal ecosystems in sustainable development on economic and environmental aspects.

-. It is necessary to involve community in greenbelt protection through micro-credit program for local livelihood, mangrove and other coastal forest rehabilitation and protection (in stead of interest payments).

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