SEA DYKE REHABILITATION

in

Kien Giang Province

TECHNICAL REPORT

November 2008

Conservation and Development of the Kien Giang Biosphere Reserve Project

Sea dyke rehabilitation in Kien Giang Province

A report by Micheal Heiland

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1. Background

Kien Giang is a coastal province, so mangrove forest plays a very important role in the mitigation of the effects of climate change, such as increased typhoons and sea level rise. The mangrove belt is in parts very narrow and therefore has poor capacity for resilience and a limited capacity to mitigate the effects of climate change.

In Hon Dat District strong sea currents are eroding a sea dyke that is meant to protect the local people and their agricultural land from inundation during storms. The Province and District authorities have continually tried to grow mangroves in these areas but so far have failed. They have also repaired eroded sections of the dyke in the past. The Vietnamese Government has a dyke reinforcement program in place and the Province plans to repair this section of the dyke using funds from this program once the strong sea winds cease in November 2008.

Photo 1: Hon Dat District

Although the Province has funds for this project, it lacks appropriate technical skills to design a dyke capable of withstanding extremes in water currents. The Province has requested the project to assist by providing technical advice on best practice construction methods.

This assignment is part of the activities designed for Project Output 2: Land Use Management Model**.** The overall objective of the assignment is to support the Dyke Protection Department of Kien Giang province in designing a sea dyke in Hon Dat District.

The dyke will be part of a land use management model being implemented by the project. Other components include planting of mangroves outside the dyke to aid in its protection, and planting of casuarinas and coconut trees inside the dyke for protection of agricultural land against storms and for livelihood use.

Photo 2: Affected area at Hon Dat District approx. 2 km south of the channel mouth

2. Appointment of Dam Expert

On November 20th 2008 GIZ has appointed the dam expert, Mr. Michael Heiland, of *Hydroprojekt Ingenieurgesellschaft mbH*, with the general objective to support the Dyke Protection Department of Kien Giang Province in designing a sea dyke in Hon Dat District.

Based on the Terms of Reference and recommendations of the expert the assignment was divided into three sections:

A Reconnaissance Mission

Site visits of the dyke in Hon Dat District and other areas of interest, collection of technical data (e.g. hydrological data, geotechnical data), project documentation (drawings, design features) and discussion about design and construction measures with the relevant authorities (Regional and District Dyke Protection Officers).

B Study Report

Evaluation of data and information, necessary technical calculations (hydrological analysis, geotechnical calculations etc.) and basic designs, preparation of a technical report which includes cost estimate and a simple set of guidelines for dyke construction/rehabilitation.

This tasks will be realised at Hydroprojekt head office in Germany where access to other experts e.g. hydrologists, geologists, if required, is given.

C Technical Workshop

In a second mission to Vietnam the expert will hold a technical workshop where the results of data evaluation and development of designs including costs will be presented to the local authorities.

3. Site Visits

Sea Dyke at Soc Trang Province

A visit was made to Soc Trang province to familiarise the consultant with the different conditions along the South Vietnamese Coastline. The areas visited in Soc Trang are located along the coast about 50 km south of the city of Soc Trang. Because the crest of the sea dyke was not accessible by car the visit team choose transport by way of motorbike.

Photo 3: Area south of Soc Trang

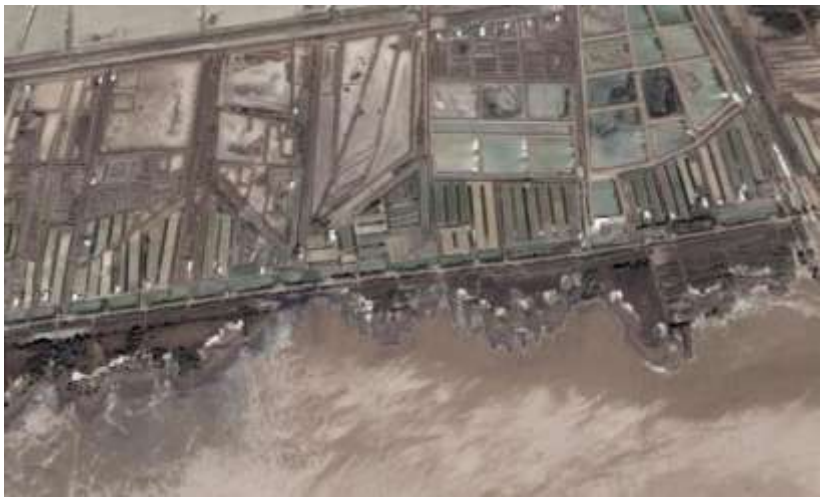


Photo 4: Eroded Foreshores

At the first site of the visited area about 200 m along the sea dyke the foreshore was eroded and in this area the former mangrove belt had completely disappeared. In some parts the erosion had also affected the toe of the dyke and in one spot overtopping of the dyke had occurred. In the area affected by erosion the dyke slopes are protected by gabion mattresses and loose rocks, whereas sand bags have been placed on the dyke crest where overtopping had occurred.

Photo 5: Eroded Foreshore, Protection with gabion mattresses

Photo 6: Eroded Foreshore

The slopes on both sides of the dyke can be estimated around 1:3, the crest width was about 5 to 6 m. The landside slope is covered with bushes, at the seaside slope small trees are growing. No signs of seepage through the dam body could be found on the landside dam slope ore toe. However, it is difficult to inspect due to the vegetation.

Photo 7: Slope protection with rip-rap

Photo 8: Landside slope of dyke

According to GIZ project manager, Dr. Klaus Schmitt, the cause of erosion could be the rapidly soaring sediments at the river mouth of the southern arm of the Mekong River, thus creating stronger deflection of the sea current running along the coastline from direction north-east to south-west. As a possible solution it was thought to construct a wave breaking barrier connecting to the land strip at the eastern end of the eroded zone in order to avoid strong currents from entering and further damaging the area. However, in order to decide on such measure an analysis of the current and its possible effects on the shore line is required.

The second site visited is located some km east of the first site. In this area the coast provides an open shore of about 300 to 400 m where the mangrove belt has completely disappeared. No sign of erosion could be found and it seems obvious that this has been caused by the extensive use of this area as access to the sea by fishermen. During the visit several boats had been placed in front of the shore and the area was covered with footprints and traces of slipping boats.

Photo 9: Area used by fishermen

The team also visited a waste disposal area which was built further west close to the shore and outside the dyke protected zone. The access to the disposal area is by means of a dam which connects to the dyke. The disposal area is surrounded by a concrete wall of approx. 1.5 m height, obviously built for protection against flooding.

Photo 10: Waste disposal Area at Soc Trang district

Sea Dyke at Hon Dat District, Kien Giang Province:

The inspected area is located about 40 km north-west of the city of Rach Giá at Hon Dat District and some two km south of the mouth of the canal which crosses the district capital. This area is also known as the “GIZ -Hon Dat Model Site”.

Photo 11: Affected area of erosion

The team approached the area from the sea by boat, thus being able to gain an impression of the condition of the mangrove belt along the shore. Some areas between the canal mouth and the inspected dyke section showed signs of the mangrove belt being already damaged and having retreated.

Photo 12: Mangroves still in good condition

Photo 13: Retreated area of mangroves

At the inspected site the sea dyke is heavily damaged over a length of about 1 km. In various parts along that stretch the mangrove belt has disappeared and new planting of

mangrove was not successful. In the areas where Mangroves do no longer exist, the seaside slopes of the dyke are deeply eroded and have in some spots completely collapsed. At one spot sea water has already penetrated the dyke.

Talking to the local people the team was informed that the dyke had been constructed about eight years ago. At that time the mangrove belt was still in good condition. However, the mangroves disappeared within three years time after dyke construction. Material for the dyke construction has been removed from the sea side of the dyke, thus creating a long trench along the seaside toe. With the disappearance of the mangrove belt in this area the sea side slope of the dam suffered continuous erosion by heavy currents and some over-topping incidents.

Photo 14: Collapsed dyke

Photo 15: Eroded dyke

4. First Impressions and Findings

4.1 Sea Dyke at Soc Trang District

4.1.1 Erosion of the foreshore

Under normal conditions the north-east current which runs almost parallel to the cost, will continuously transport sediments. Those sediments are fed by the rivers and are taken away with the shores. At the same time the current deposits sediments with incoming waves when flow conditions allow, thus, providing a certain balance of the sediment regime along the cost. This balance may be interrupted or disturbed for various reasons, e.g.

- Extensive sediment (sand) removal from the Mekong River and drainage canals for use as construction material may create a deficit of sediment transported to the sea. This change of dynamics has led to the incoming waves carrying away sediments from the shores west of the river mouth.
- Changes of the topography along the cost, e.g. growing sandbank at the eastern edge of the mouth of the Mekong River, cause a deflection of the current turning it towards the coast. This may create erosion along the coast in flow direction of the current.

Regardless of what might have caused the erosion of the foreshore and the disappearance of the mangrove belt at the visited site, the only way to stabilize the area and to prevent further destruction of the dyke is to construct breakwater barriers along the affected area. Those barriers could reduce the strength of the current towards the shore.

Photo 16: Eroded foreshore area

However, for an appropriate design of the breakwater barriers and in order to avoid negative effects, flow model studies are strongly recommended.

The required data for such flow model are:

- bathymetric survey of the foreshore area to obtain topography of the sea bottom
- current measurements taken over a period of at least six months
- data on the sediment load of the current

For survey and current measurements a specialised enterprise will have to be appointed. However, before taking this step it is recommended to investigate existing studies in the area, e.g. the Mekong Delta. Valuable data might be obtained.

4.1.2 Protection of Sea Dyke

Although the mangrove belt does no longer exist and replanting of the mangroves is considered most unlikely due to the extensive erosion, the dyke still requires protection on its seaside slope against wave impact. The protection can either be made of rip-rap with spaces filled with concrete or with prefabricated concrete slaps (see standard design). For this reason the slopes must be cleared of trees and shrubs and re-profiled in accordance with the standard design.

4.2 Sea Dyke at Hon Dat District, Kien Giang Province

4.2.1 Erosion of the foreshore

The disappearance of the mangroves seems to be caused by severe erosion of the foreshore. The cause of erosion at the foreshore area may be distinct from that in Soc Trang Province, e. g.

- strong sea currents
- disturbance of the flow regime caused by the methods of dyke construction

Strong sea currents and rise of the water level due to climate change is a general problem which may affect the mangrove belt along the coast. The mangrove belt is vulnerable where it is narrow or already partly damaged as can be seen also in other areas of the Kien Giang coastline.

Photo 17: Eroded areas of mangroves

Besides a variety of further positive characteristics the mangrove belt forms a natural protection of the coast against strong currents; the force of incoming waves is reduced while passing the mangroves, thus lessening the danger of erosion of the terrain behind the mangroves.

Erosion may occur wherever there is a change or modification of the natural sea bed, such as the construction of a dyke.

In the case of the dyke at Hon Dat District, soil material for the dyke construction was excavated off the foreshore, thus creating a trench along the entire length of the seaward dykes toe. This trench represents a vulnerable area for erosion which can develop turbulences within the trench, due to outgoing waves. The turbulences gradually destroy the slopes and create more erosion channels in the sediment of the foreshore thus destroying the mangrove trees. Once this has happened, the erosion channels will expand and mangrove destruction will proceed rapidly. It will also affect the mangrove belt which is still in good condition as seawater turbulences enter adjacent areas through already existing trenches. This means that in the adjacent forested areas, part of the backflow will not pass through the mangroves but will be following the routes of lowest resistance and pass through the eroded areas.

Photo 18: Excavation trench along the dyke

If the natural clay cover of the foreshore has been damaged due to excavation activities in the trenches (e.g. extracting material) there might occur even more problems. This could create a seepage flow causing internal erosion while passing below the dyke towards the landside.

4.2.2 Erosion of the dyke

Along the effected area over a total length of 500 to 600 m the dyke is heavily eroded and in some parts completely destroyed. The height of the dyke above natural ground can be estimated at 2 m, the crest width was 6 m. The slopes of the dyke are estimated at 1:2.5 to 1:3.

Photo 19: in-homogenous dam material

In one spot the dyke has been overtopped by seawater and has ruptured. Examination of the eroded surfaces showed that the soil material is not of homogenous quality. Traces of organic material, gravel and clay were found mixed with the soil.

5. Meeting with Department of Dyke Protection

On November 27th 2008 a meeting with the Dyke Protection Department of Kien Giang Province was held at GIZ office of Rach Giá. The participants were:

Mr. Luong Thanh Hai, GIZ Kien Giang Project Director
Dr. Sharon Brown, CTA, GIZ Kien Giang Project
Mr. Nguyen Tam Phong, Project Technical Officer
Mr. Luong Thanh Hai, Director, Department of Science and Technology (DoST)
Mr. Nguyen Xuan Niem, Vice Director, DoST
Mr. Hang, Vice Director, Department of Agriculture an Rural Development (DARD)
Mr. Van and Mr. Nam, Department of Dyke Protection
Mr. Michael Heiland, Hydroprojekt Ingenieurgesellschaft mbH

First impressions of the site visit to the dyke at Hon Dat District on November 26th 2008 were presented by M. Heiland. Thereafter, Mr. Nam of the Dyke Protection Department presented his views on the cause of the dyke erosion and the problem of replanting mangroves in the affected area. He furthermore presented some general designs to be considered for the construction of a new dyke.

The discussions following the presentations can be summarised as follows:

- For construction of sea dykes it is common practice in Vietnam to obtain material in-situ from both seaside and landside area by keeping a distance of 10 m from the dam toe.
- The excavation of trenches along the foreshore is not seen as a problem because it is assumed that the trenches will refill after some time.
- The Department of Dyke protection plans to protect the seaside slope of the dam with prefabricated concrete slaps placed on gravel which will be separated from the embankment material with a geo-textile.
- The Department will protect the toe of the dyke with concrete culverts placed vertically in line with the dyke and filled with rock. Alternatively, the toe will be protected with a double row of wooden piles.
- The Department assumed a wrong choice of species and improper plant size - rather than the erosion of the foreshore - as a possible cause for the failure experienced with replanting mangroves.

The Department has provided results of a bathymetric survey in the affected area.

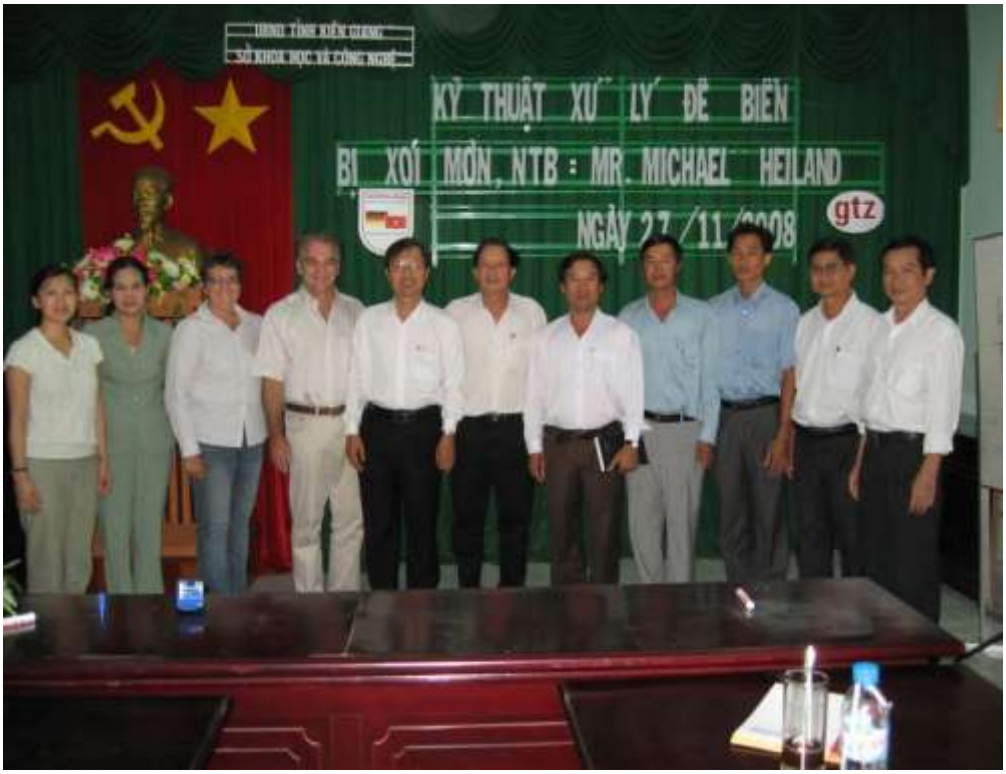


Photo 20: Meeting with Provincial Officials from DoST, DARD and Department of Dyke Protection

6. Evaluation of collected data and project information

During and after the visit the following data and documentation has been obtained from various sources:

- Volume of drawings of topographic surveys and profiles of the affected area of Hon Dat District, and typical designs and details of dyke construction
- Rainfall data and wind data of 1998 to 2007 from Hon Dat District
- Data of selected unit prices for construction materials (kindly provided by the HABITAT office of Rach Giá)
- Video and photos taken of the dyke during the November 2008 (GIZ, Rach Giá)

The data obtained during the visit is, of course, limited. No soil investigation of the collapsed dyke and / or the eroded areas was executed. Recent soil data of the dyke is not available.

The evaluation and judgement on the cause of the erosion is therefore based on experience and on what was visible during the site visit.

The proposed dam design was based on the drawings made available by the Department of Dyke Protection and discussions held with the authorities. The dyke design represents a typical section of dyke and calculates the material characteristics to achieve the required stability and safety values. The results are attached as Annex 1 of this report.

Based on the data on cost obtained on site a rough cost estimate for the construction of the dyke was conducted. The results are attached as Annex 2.

7. Summary and Conclusions

Caused by strong sea currents and erosion of the foreshore the natural mangrove belt south at Hon Dat District has been destroyed at a length of 500 to 600 m along the coast. In this area replanting of mangroves has failed and the dyke behind the mangroves is heavily eroded and in some parts completely destroyed.

The material for the dyke construction was extracted from the seaside area. This has resulted in the formation of a wide and deep trench along the seaward side of the dyke toe. This extraction of soil, combined with strong currents appears to be the cause of the erosion of the foreshore.

After evaluation of the data and documentation obtained during the site visits, and due to experience the following may be concluded:

- Before planting new mangroves a bathymetric survey of the affected foreshore area shall be executed and the area of erosion be refilled and levelled with adequate soil material
- Studies are required to investigate the adequate soil material, soil depth and the most suitable species of mangrove
- Areas of new mangrove plantation need to be protected against sea currents by means of traditional fencing as already used in the area. However, to reduce the risk of new erosions of the filled material a geo-textile shall be installed along the fences up to low tide sea level.
- The trenches along the sea side of the dyke toe shall be refilled with the remaining material of the eroded dyke and other suitable material obtained from elsewhere inland.
- Where the natural clay cover within the trench is affected it shall be replaced by adequate clay material before filling it with ordinary soils.
- The dyke must be constructed of homogeneous soil material of the characteristics specified in Annex 1.
- Embankment materials for dyke construction shall not be extracted from the foreshore area but from adequate landsite areas elsewhere.
- Before placing new embankment material the foundation area of the dyke shall be cleared of any organic and other material. Wherever required the area shall be compacted by vibrating rollers.
- Embankment material shall be placed in layers of 30 to 40 cm achieving placing layers of approx. 20 cm after compaction.
- The dyke shall be constructed according to the proposed design by slopes of 1:3 on both sides and a crest width of 6 m (standard profile see Annex 3)
- The seaside slope shall be protected by prefabricated concrete slaps placed on gravel material. Before placing the gravel a geo-textile should be installed on the slope (see Annex 3)

- Alternatively to the concrete slaps a slope protection made of rip-rap (stones) can be placed (see Annex 3)
- The dam toe may be protected with concrete culverts filled with rock or traditional wood piling as designed. However, it is recommended to investigate the use of sheet pilling with steel profiles covered by a concrete slap which could provide advantages in terms of construction time and safety (see Annex 3).

This expertise focusses on the eroded dyke at Hon Dat District along a coast strip of a couple of kilometers only. Since it could be seen during the site visit that other areas of the mangrove belt affected by erosion and strong sea currents are retreating it is highly recommended to conduct a survey along the south cost of Vietnam. For the first attempt this survey could be supported by aerial-photos to be taken during the dry season.

Annex 1. Sea Dyke Rehabilitation Vietnam

Stability Analysis

Based on information obtained during the site visits and discussions with the authorities a preliminary stability analysis for standard profile of the sea dyke was carried out.

The following conditions were assumed:

- Slopes 1:3 (seaside and landside)
- Height of the dyke 2.00 m
- Crest width 6.00 m
- Design Load on crest 10 kN/m²

The load case flood water level at crest level has been considered with a draw down time of 2 days from crest to dam toe. Because of non-availability of soil data the following soil characteristics were assumed:

- Friction angle $\varphi' = 28°$
- Cohesion $c' = 0$ kN/m²
- Specific weight $\gamma = 20$ kN/m³

For permeability the following values were varied:

- subsoil $k_f = 10^{-5}$ m/s
- dyke material $k_f = 10^{-3}$, 10^{-5}, 10^{-7}, 10^{-9} m/s
- toe drain $k_f = 10^{-3}$, 10^{-4} m/s

Under these criteria the seepage line with corresponding potential lines were calculated. In the computer model the seepage line was assumed as direct pore pressure for calculation of the slope stabilities.

The analyses were carried out with SS-Flow 2D and Stability of GGU.

The following results have been gained:

1. For permeability of the dyke material higher as or equal to the subsoil the slopes are not stable. The seepage line exit point is within the landside slope of the dyke, stability of the slope is below 1
2. For permeability of the dyke material lower than the subsoil the seepage line exit point is at the dam toe, but safety value of 1.3 for extraordinary load case is not achieved
3. For flood water level the stability of the seaside slope is given. Rapid drawdown will result in a delayed seepage line, but slope stability for the assumed conditions is not at risk.
4. It is recommended to arrange a toe drain of gravel material along the landside slope to guarantee a controlled exit point of the seepage line. The permeability of the embankment material shall be around $k_f = 10^{-7}$

The above preliminary assumptions will not substitute proper stability analysis, erosion and suffusion analyses for the final design of the dyke. For these analyses it is required to investigate the actual underground conditions and characteristics of the materials to be used. Furthermore, wave impact as well as seismic loads will have to be considered.

Annex 2

Sea Dyke Construction Vietnam

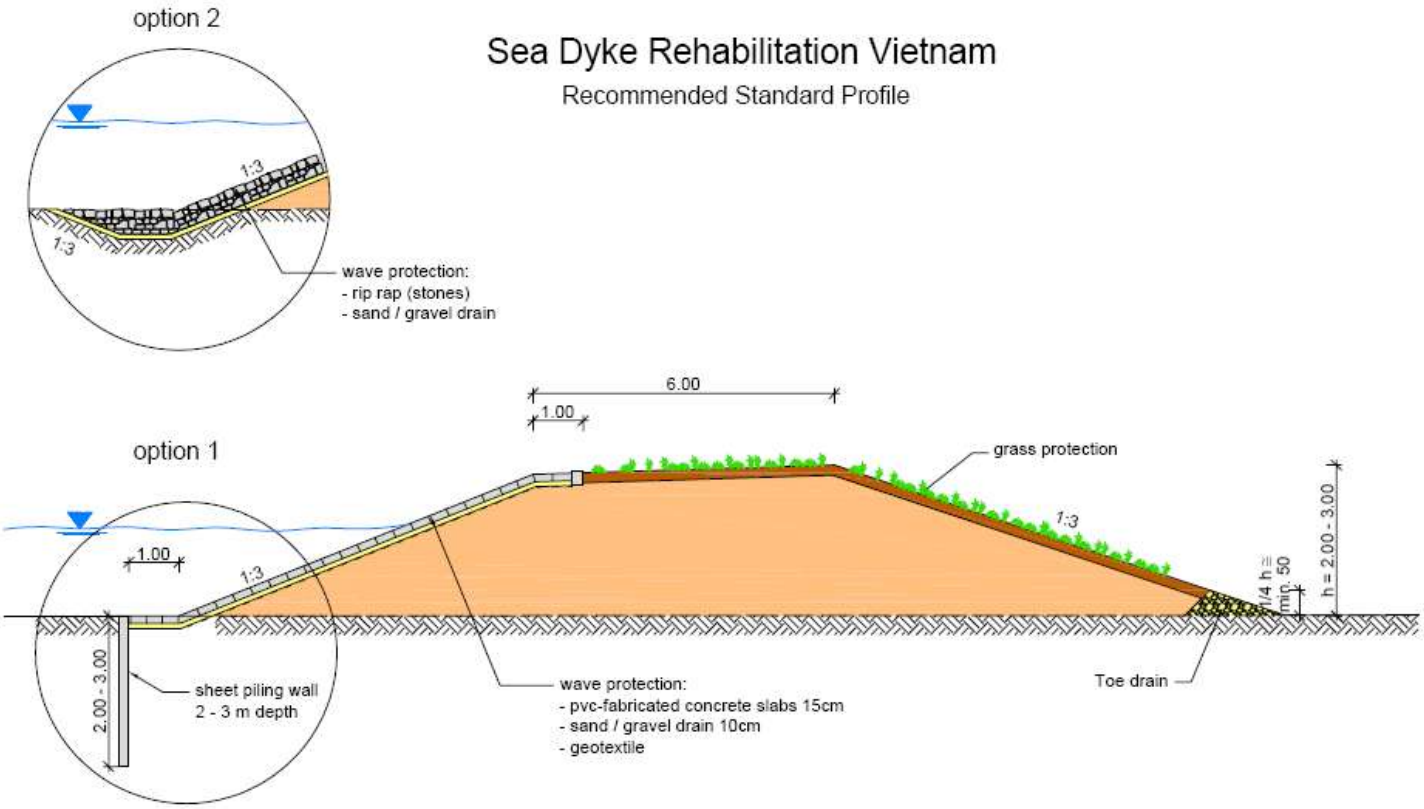
Preliminary Cost Estimate

With the kind support of HABITAT office of Rach Giá the following local unit prices have been obtained:

	Unit	USD
1. excavation, transport, filling and compaction of soil material (haulage distance up to 1 km)	m^3	4
2. wave protection on dyke slope by reinforced concrete slaps 15 cm (pre-fabricated)	m^2	29
3. sand/gravel layer on dyke slope	m^3	12
4. grass cover on dyke slope	m^2	5
5. lean concrete	m^3	54
6. structural reinforced concrete	m^3	275
7. geo-textile	m^2	4
8. sheet piling	m^2	85

Based on the above unit prices the total construction cost for a dyke of 2 m height (average height) can be put at about 650 USD per meter. Inclusive of filling the trench on the foreshore total cost will be approx. 1 Million USD

Annex 3


option 2
Sea Dyke Rehabilitation Vietnam
Recommended Standard Profile
1:3
1:3
wave protection:
- rip rap (stones)
- sand / gravel drain
6.00
1.00
option 1
grass protection
1:3
1.00
1:3
h = 2.00 - 3.00
1/4 h ≥ min. 50
2.00 - 3.00
sheet piling wall
2 - 3 m depth
wave protection:
- pvc-fabricated concrete slabs 15cm
- sand / gravel drain 10cm
- geotextile
Toe drain