GTZ KIEN GIANG BIOSPHERE RESERVE PROJECT

SEA DYKE REHABILITATION

IN KIEN GIANG PROVINCE, VIETNAM

gtz

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Sea dyke rehabilitation in Kien Giang, Viet Nam

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Report on the Reconnaissance Mission from 4th to 7th December 2009

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.

The coastline of Kien Giang province is 205 km long and approximately 50% of the protective mangrove edge is eroding, thus exposing dykes and allowing sea water to break through to crop lands behind. The Province and District authorities have continually tried to grow mangroves to protect the coastline and the dykes in these areas but have failed. They have also repaired eroded sections of the dyke in the past and these continue to be breached. The Vietnam Government has a dyke reinforcement program (Decision 667 by the Prime Minister - mangrove protection and sea dyke reinforcement) and the Department of Agriculture and Rural Development (DARD) has a Department of Dyke Protection which is responsible for the construction and maintenance of dykes and planting of mangroves. The department has benefited from technical advice provided by the project but more expert advice on research, design and construction techniques is needed before a demonstration of dyke construction is implemented.

Photo 1: Visited sites in Kien Giang province

Although the Province has funds for this project, they do not have the appropriate technical skills to design a dyke that has to withstand extremes in water currents and water levels. The Province has requested the project to assist by providing technical advice on best practice construction methods.

This assignment is the second input into dyke construction for the Province and contributes to project Output 2: Land Use Management Model,.. that is being established for the key areas of the Kien Giang Province.

The overall objective is to support the Dyke Protection Department of Kien Giang province and local National experts to recommend dyke designs and/or coastal protection measures for different coastal situations and to develop research and technical guidelines on dyke construction.

The project will assist the construction of a short length of demonstration dyke as part of a land use management model that is being implemented by the project in Hon Dat District. Other components of the model include planting of mangroves and construction of silt trap fences and wave breaker fences outside the dyke to aid in its protection and planting of casuarinas and coconut trees inside the dyke for the protection of agricultural land against storms and for livelihood.

During November 2008 a first mission was conducted at Hon Dat District to inspect the eroded sea dike and to recommend measures for its rehabilitation. Following this mission the Dyke Protection Department of Kien Giang has undertaken some reconstruction works at the affected part of the sea dyke.

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

Meanwhile the GTZ Project Group in Rach Gia has discovered other areas of concern along the Province coastline. This led to the decision to call for another expert mission which

should inspect the new areas and have a look to what has been achieved at the earlier inspected area of Hon Dat district. The mission was to focus on the construction of a demonstration dyke (pilot project) which can be used as a model for future dyke rehabilitation measures.

2. Appointment of the Consultant

Beginning of December 2009, GTZ has appointed the services of Hydroprojekt Ingenieurgesellschaft mbH (HPI), consisting of the assignment of the dam expert, Mr. Michael Heiland, and Prof. Dr. Holger Schüttrumpf, coastal engineering expert at RWTH Aachen, who was integrated into the HPI team, with the general objective to support the Dyke Protection Department of Kien Giang Province.

Based on experience with other dyke protection projects it was recommended to structure the services into the following steps:

- Visit the Hon Dat District land use model and selected sections of eroded coastline with the Department of Dyke Protection.
- Identify damage (degree of erosion) and the possible cause of it.
- Develop a simple set of guidelines and necessary research needed for design of remedial works.
- Hold a technical workshop to discuss the mission's findings. The outcomes of this workshop will be an agreed design concept for a small section of demonstration dyke as a pilot project at Hon Dat District and the first step in the development of policy on dyke construction guidelines.

The input of the dyke design expert shall concentrate on design, slope protection, construction methods and maintenance, while the tasks of the coastal engineering expert shall focus on sea water level, current and wave action, stability of foreshore, dike design and construction, overtopping and influence of mangroves.

In order to support capacity development of Vietnamese professionals it was proposed that a national dyke expert would join the expatriate team during their site visit and to provide relevant technical information and support during preparation of the report.

Based on the experience gained during a co-operation for a comparable mission for an emergency dyke rehabilitation project in Soc Trang project, Dr. Dinh Cong San, Deputy Director, Southern Institute of Water Resources Research, Ho Chi Minh City, was assigned by GTZ Rach Gia.

3. Visit Programme

For the mission the following programme was executed:

3rd November 2009 Arrival in Hoc Chi Minh City

4th November 2009	Flight to Rach Gia, Briefing at GTZ project office Site visits near Rach Gia, Hon Dat and close to T6 to inspect the actual situation of the sea dyke, accompanied by representatives of the Sub-department of Irrigation and Site Management
5th November 2009	Discussion with representatives of Sub-department of Irrigation and Dyke Management, Site visits near Ha Tien.
6th November 2009	Journey back to Rach Gia, further site visits near An Bien and An Minh, visit to the urban flood protection in Rach Gia
7th November 2009	Round-up meeting at GTZ office Rach Gia, Flight to HCM and return to Germany

4. Site Visits

4.1 Former Visit in November 2008

In November 2008 a site visit was conducted by the Chief Technical Advisor of the GTZ Coastal Zone Management Project, Dr. Sharon Brown, and Mr. Michael Heiland, dam expert of Hydroprojekt Ingenieurgesellschaft mbH of Germany. The areas visited were located along the coast around 50 km south of the city of Soc Trang where within a stretch of about 200 m along the sea dyke the foreshore was eroded and in this area the former mangrove belt completely disappeared. In some parts the erosions also affected the toe of the dyke and in one spot overtopping of the dyke has occurred. In the area affected by erosions the dyke slopes are protected by gabion mattresses and loose rocks, where overtopping has occurred sand bags have been placed on the dyke crest.

The findings and recommendations gathered during the first mission have been summarized in a reconnaissance report.

Caused by strong sea currents and erosion of the foreshore the natural mangrove belt south at Hon Dat District has been destroyed for a distance 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 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 based on stability calculations and experience a standard design profile for the rehabilitation of the damaged area and some principle guidelines for construction have been established. Regarding the mangroves it was recommended to enhance the protection against sea currents by means of traditional fencing as already used in the area (for more details see Reconnaissance Report November 2008).

This first mission focussed on the eroded dyke at Hon Dat District along a coast strip of a couple of km only. Since it could be seen during the first site visit that other areas of the mangrove belt are retreating, affected by erosion and strong sea currents it was highly recommended to undertake a survey along the coast of Kien Giang Province.

4.2 Site Visit from December 4th to December 6th 2009

4.2.1 Participants

The site visits have been attended by the following persons:

- Mr Khoa Dyke Protection Department of Kien Giang Province
- Mr Thanh Dyke Protection Department of Kien Giang Province
- Dr. Dinh Cong San, Dyke Expert, Deputy Director Southern Institute of Water Resources Research, HCM City
- Mr. Nguyen Tan Phong, Technical Officer, Kien Giang Project
- Nguyen Viet Phuong GTZ Office Rach Gia
- ...., GTZ Office Rach Gia
- Dr. Sharon Brown, Chief Technical Advisor, GTZ office Rach Gia
- Prof. Dr. Holger Schüttrumpf, Coastal Engineering Expert, Germany
- Mr. Michael Heiland, Dam Expert, HPI, Germany

4.2.2 Site 1 Vinh Quang district, Rach Gia City

The sea north of Rach Gia was visited from the sea by boat and from the landside by car.

A first boat stop was made at a waste disposal area located in the North of Rach Gia close to the coastline. The waste disposal area was covered by soil but due to currents and waves the seaward cover of the waste disposal area has been eroded and waste as well as pollutants can be washed out into the sea. Fig. 1 shows the actual situation. It is recommended to stop the wash out of waste by covering and protecting the waste disposal area as soon as possible.

Fig.1: Waste disposal area close to Rach Gia City

A second boat stop was made to visit the mangrove forest north of Rach Gia (Fig. 2). The mangrove belt is about 20m wide. The influence of this mangrove belt on waves and currents will not be significant during storm surge events. Anyway, no erosion from the seaside was

observed but the inner side of this mangrove area is used for agriculture and housing. Fig. 2 and Fig. 3 show the same site, Fig. 2 from the seaside and Fig. 3 from the landside.

Fig.2: Mangrove forest north of sea bridge No 1, Rach Gia City

Fig. 3 shows the coastal defence dyke in the North of Rach Gia. The dyke has been built as a military defence road and became a coastal defence dyke in recent years. The dyke has a crest level of about 1.6m above MSL and a crest width of about 6m. The slopes with a gradient of about 1:2 are covered by grass on both sides. No dike protection like a revetment or an overflow protection is applied at this site.

Fig.3: National defence dyke, Vinh Quang , Rach Gia City

4.2.3 Site 2 Vam Ray Commune, Hon Dat District

The second stop of the site visit was in Hon Dat district. In Hon Dat district, in some areas the coastal mangrove belt shows no erosion (Fig. 4) and seems to be in a very good condition in these areas. The mangrove belt consists of different mangrove species. The width of the mangrove belt is estimated to be around 100m.

Fig.4: Mangrove forest without erosion in Hon Dat district

In other areas in Hon Dat district, severe erosion of the coastline resulting in a retreat of the mangrove belt occurred (Fig. 5). In parts, no mangroves are protecting the coastal dyke anymore. No explanation for this retreat of the mangrove belt was given by the local authorities. The collapse of the mangrove belt resulted in dyke failures and dyke breaks already observed during the last mission in November 2008.

Fig.5: Mangrove forest with erosion in Hon Dat district

The collapsed dyke without any mangrove protection is shown in Fig. 6. It is obvious that the material for the dyke construction was taken from the seaward side of the dyke resulting in the excavation of a canal being parallel to the dyke. In addition, canals were built to connect the sea with the dyke in these areas. Therefore, the tides and storm surge currents are able to enter the canals resulting in high currents at the toe of the dyke. Since the clay material of the dyke can be easily eroded, the dyke has no residual strength and fails.

Wooden fences were built along these mangrove retreat areas to reduce the incoming currents and waves, to initiate and to support siltation and to create areas for mangrove rehabilitation (Fig. 7).

In addition, parts of the dyke were rebuilt as a pitched slope revetment in between the mission in November 2008 and the present mission in December 2009. The crest level height is estimated to be only 2.0m above MSL, the slope is 1:3 and the width of the crest is 6.0m. The revetment is built out of placed prefabricated concrete slaps on a geotextile. However, deviating from the recommendations placing of a filter zone of gravel material has been omitted. It was reported that a special foot protection consisting of concrete culverts filled with rock material is installed according to the recommendations but cannot be proven whether this has been applied to the whole section of dyke reconstruction.

Fig.6: Eroded dyke with emergency repair in Hon Dat district

Fig.7: Protection of eroded area by wooden fences

Fig.8: New coastal dyke in Hon Dat district

4.2.4 Site 3 Close to T 6 canal, Binh Giang Commune, Hon Dat District

Site 3 is located south of the canal T6. Here, the present condition of the mangrove forest was visited by boat. As can be seen from Fig. 9, the mangrove forest is strongly eroding. No measures were undertaken up to now to reduce this erosion. In some areas, the erosion of the mangrove forest has already reached the dyke toe.

Dyke construction works were ongoing at this site during the site visit (Fig. 10). As can be seen from Fig. 10, the dyke construction material is taken from the seaward side. This results in a new dyke parallel canal which will have the same negative effects on the dyke safety as already mentioned for the dyke in the Hon Dat district in Fig. 6.

Fig.9: Erosion of dyke mangrove forest close to T6 canal

Fig.10: Dyke construction works close to T6 canal

4.2.5 Site 4 south of Ha Tien Town

In the south of Ha Tien, the road connecting Rach Gia and Ha Tien is protected by a coastal revetment with a single rubble mound layer (slope of 1:1). A number of weak points were identified during the site visit:

- Trees in the revetment (Fig. 11)
- Break outs in the seaward slope (Fig. 12)
- Missing geotextile
- Missing foot protection
- Missing stability due to bad concrete
- Roots under the cover layer

These weak points are points of initiation for further erosion, stability lost and breaching of the revetment.

Fig.11: Coastal revetment south of Ha Tien Town

Fig.12: Coastal Revetment south of Ha Tien Town

4.2.6 Site 5 An Bien District

Site 5 – An Bien was reported by the local authorities as an erosion site. The mangrove belt at this site has a width of more than 100m and a very shallow foreshore. No signs of erosion were detected during the site visit (Fig. 13). This site was observed by boat.

Fig.13: Mangrove forest without coastal erosion at An Bien

4.2.7 Site 6 An Minh District

A severe retreat of the mangrove forest was observed at site 6 – An Minh (Fig. 14). This site was also visited by boat.

Shrimp farms were built in the mangrove forests in the past and connected by canals with the sea. The canals eroded and a breaching of the shoreline occurred due to currents and waves. Therefore, the water can enter this site and erode the clayey soil. The soil is eroded in between the roots of the mangroves and thus, the mangroves lose their stability and fall into the water. This process is very fast resulting in a retreat of the mangroves from about 10 to 20 m/year. Fig. 15 shows a detail of the eroded coastline. The coastal erosion could even be observed during the site visit. Small clayey aggregates felt into the water.

Fig.14: Retreat of mangroves at An Minh District

Fig.15: Detail of coastal Erosion of a Mangrove forest at An Minh District

4.2.8 Site 7 Rach Gia City

The urban flood protection at Rach Gia was visited at the end of the mission. The urban flood protection consists of concrete seawalls with a wave return wall at the top. Figs. 16 and 17 show two examples in the new land reclamation area of Rach Gia. It has to be mentioned that other parts of the city of Rach Gia are not protected by seawalls.

Fig.16: Seawall in Rach Gia City

Fig.17: Seawall in Rach Gia City

5. Recommendations and required Investigations

5.1 General Remarks

For more than 1,000 years, the inhabitants of coastal regions and the shoreline zones of estuaries have protected themselves against the destructive forces of the sea by means of artificial dwelling mounds, dykes and other coastal protection structures. While in very early times people were only concerned about protecting their dwellings from flooding, later they also began to protect their agricultural land by means of dykes.

Nowadays typical coastal protection measures consist of

- wave barriers
- groynes
- dykes
- mangroves

Groynes and barriers are measures against coastal erosions and retreat of the coast line. With wave barriers placed offshore strong currents and breaking waves can be mitigated before hitting the coastline. The installation of groynes along the coast in relation to current direction will allow certain control of sediment balance along the shore. For a proper design of wave barriers and groynes, long term measurements of the sea current, wind direction and speed, wave action and sediment loads are required. The results will form basic data for computer model simulation studies.

Sea dykes are built for flood protection and to allow cultivation of land behind the dyke. The embankment material is usually abstracted from the area but should never be taken from the immediate foreshore because it might provoke erosions. Geotechnical investigations on the material and the foundation area are mandatory for dyke construction as well as stability

analysis of dam body and underground. Protection of the slopes and dam toe to avoid erosions and undermining and the control of seepage by filter drains are very important. However, dykes need permanent maintenance by skilled staff with adequate equipment and a protection strip of 5 m at least along the dyke toes should be kept free of any construction and plantation.

In tropical and sub-tropical regions natural mangrove belts along the shore provide excellent coastal protection and their preservation is very sensitive. Through their ability to reduce strong sea currents mangroves may also protect dykes. However, it is very important that the dykes are being built in a certain distance to the mangroves, minimum 20 m, and the mangrove regime by no means is disturbed by the dyke construction or its maintenance. On the contrary dyke construction may also cause the retreat of the mangrove belt.

In Vietnam the deforestation of mangrove forests is leading to the loss of natural coastal protection in the Mekong Delta, increasing the danger of flooding. One reason for the destruction is also the spread of shrimp farming.

Whatever coastal protection measures against storm surges are applied the gathering of correct design data is required, such as wind data, wind speed and direction, and water levels, tides, storm surges, mean sea water level.

Furthermore when damages or a dyke failure has occurred a detailed research with respect to the cause of the failure is decisive to understand what has happened in order to adopt the correct measure and to prevent future damages.

During the site visits conducted within this mission different kinds of damage and erosion have been observed where the causes are still uncertain. This led to the conclusion that in order to be able to develop a pilot project which should serve as a demonstration dyke various investigations are required, including

- sea current modelling
- sedimentation studies
- geotechnical investigations
- bathymetric and topographic surveys

Furthermore economical aspects will have to be taken into account, whether there are sufficient funds to allow for construction of a dyke line at a crest level which avoids overtopping (i.e. built to design water level with a return period of 20 years as usual practise in Vietnam). On contrary if the dykes are to be constructed below design water level, due to economical constraints, the dyke will have to be designed resistant to overtopping.

Based on this approach the recommendations and required investigations are classified in the following areas of concern:

- Mangroves
- Dyke design
- Dyke construction
- Dyke maintenance

5.2 Mangroves

The health and diversity of mangroves in Kiang Giang province are in different conditions. During the site visits, mangroves in good condition but also mangroves in a very bad condition were found. Unfortunately, no data (satellite information, currents, water levels, salinity, pollution, human activities, etc.) are available to analyse the reasons for the present evolution. Therefore, it is very difficult to identify the causes of mangrove retreat at all sites. In some areas human activities like the construction of dykes or shrimp farms can be made responsible for mangrove erosion but in other parts the cause remains unclear. This is the reason, why mangrove rehabilitation in Kiang Giang district according to a trial and error philosophy is applied with different success.

The following recommendations are made to better understand the processes and to avoid further retreat of the mangroves with a long term perspective:

(a) understand processes

- It is recommended to **set-up a database** including the actual situation of the mangroves and former situations in past years based on satellite data and field survey data and to analyse the evolution.
- A **numerical current model** should be set-up based on field measurements of currents, water levels and bathymetry to understand the processes resulting in mangrove retreat and to explore and to identify adequate countermeasures.

(b) avoid further retreat of mangroves

- Make use of the numerical model to identify efficient **counter measures** to reduce mangrove erosion (to avoid a trial and error approach).
- Before planting new mangroves a **bathymetric survey** of the affected foreshore area shall be executed and the area of erosion refilled and levelled with adequate soil material.
- The area with new planted mangroves shall be protected by wooden fences to avoid new erosions. It is also recommended to reduce the currents in the canals behind the dykes by **dyke normal fences**.
- **Avoid shrimp farms** in the mangroves which decrease the efficiency of the mangrove forest and which are initiation points for coastal erosion.

5.3 Dyke Design

Dyke design in Kiang Giang province in based on the existing national guidelines, experience from the past and the available budget.

Vietnam has very comprehensive guidelines concerning the design of coastal structures such as revetments, breakwaters, seawalls, sea dykes and other coastal structures. The guidelines cover recommendations concerning the hydraulic design of these structures as well as recommendations for constructional aspects such as examples for the construction of the toe of sloped coastal structures. In addition, Vietnamese guidelines give also very detailed recommendations on the functional design of groynes and offshore breakwaters, the determination of a design wave and a design water level, the calculation of filter criteria, wave transmission, wave run-up, uplift and impact pressures, sliding and finally stability analysis. Therefore, these guidelines can be regarded as a very valuable tool for coastal designers in Vietnam.

Anyway, it is recommended to add some more recent information concerning sea dyke design by taking into account the aspect of high overtopping discharges. Wave overtopping

is one important parameter for the design of coastal and flood protection structures and of very high importance for Vietnamese dykes. The knowledge on wave overtopping has been significantly improved within the last years based on a number of national and international projects. Therefore, it was important to extend and adapt existing guidelines and recommendations in Europe as well as in the US. This approach resulted in the new European overtopping manual (www.overtopping-manual.com). It is recommended to adapt this Overtopping manual for the special situation in Vietnam. In addition, more recent research concerning the resistance of sea dykes against wave and current attack is available and should be considered.

According to Dr. Dinh Cong San the expected design crest level should be 3.5m above MSL. The actual crest level is only approximately 2.0m in Kiang Giang Province. This difference in height between the expected and the actual crest level will result in severe wave overtopping and overflow during typhoon storm surge conditions. Therefore, the following recommendations are made:

- Design the coastal dyke according to the international guidelines based on a design water level and a tolerable wave overtopping rate by taking into account country specific aspects. Since it is financially impossible to increase the crest level of all dykes in Kiang Giang province up to 3.5m above MSL over a length of more than 200 km, a **dyke resistant to overtopping** is required which is able to withstand even high overtopping rates without breaching. Research is needed to design such a type of dyke taking the hydraulic loads, geotechnical aspects as well as other local aspects into account.
- Undertake **geotechnical investigations** by means of core drillings/open pits and laboratory test to determine soil parameters as base for stability calculations to international standards.
- Where dykes are constructed, it is recommended to **use adequate homogenous material** which should be covered by grass or gravel to avoid cracks in the clay and a loose of stability.
- Development and construction of an overtopping resistant **demonstration dyke** which can be compared to other dyke sections under storm surge conditions.
- Adaptation of Vietnamese guidelines on sea dyke design to consider new international developments.
- Consider the effects of climate change (especially sea level rise and increase of storminess) in sea dyke design

5.4 Dyke Construction

A number of recommendations were derived for dyke construction aspects:

- Use dyke construction material from the landward side and not from the seaward side.
- Before placing new embankment or revetment material the foundation area shall be cleared of any organic or other material. Wherever required the area shall be compacted by vibrating rollers.
- Trees, roots, houses or other items in the dyke should be removed before constructing the dyke.
- Special attention should be paid to the intersections between seaward slope and crest to avoid backward erosion.

- The construction works should be supervised by geotechnical engineers experienced in dyke construction

5.5 Dyke Maintenance

No dyke maintenance exists in Kien Giang province. As a result, coastal dykes and other coastal structures are only repaired when they fail. Such a no maintenance philosophy results in many dyke failures, inundated areas and extremely high costs. Therefore, it is strongly recommended to apply a dyke maintenance programme for the coastal defence structures in Kien Giang province. The following aspects have to be considered in such a maintenance programme:

First step of maintenance programme:

- Definition of rules and guidelines for Dyke maintenance programme
- Set-up of a database with existing structures (incl. geometry, soil conditions and other information (e.g. width of the mangrove forest))
- Identification of the actual condition of these structures with regard to geometrical, hydraulic, geotechnical and other aspects
- Prioritisation of repair
- Update of information in database

Second step of maintenance programme

- Yearly observation of all existing structures after the monsoon season
- Identification of new weak points in coastal defence structures and in the flood defence line
- Immediate repair of coastal defence structures before the next monsoon season
- Update of information in database

For bathymetric surveys and current measurements a specialised company, preferably a national institution of Vietnam, will have to be appointed. However, before undertaking such a campaign it is recommended to investigate about existing studies in the area, e.g. the Mekong Delta, from which valuable data could eventually be obtained.

6 Summary and Conclusions

The existing damages of the sea dykes along the coast of Kien Giang province may have different causes:

- Erosions on the foreshore and disappearance of the mangrove belt, thus making the dyke vulnerable to strong sea currents and wave attacks
- Low crest level of the dyke allowing its overtopping during the wet season without being designed for it
- Inadequate design of the dam (such as insufficient slope stability due to inadequate material characteristics, missing toe protection causing undermining, no slope protection against wave action, no protection of landside slope etc.)

- Inadequate construction methods (such as soil material not placed in recommended layers and properly compacted, soil material abstracted from foreshore and placed with too high moisture content, no treatment of dyke foundation area before placing of material, no cover of the clay resulting in deep cracks, inadequate supervision during construction)
- Lack of maintenance i.e. no periodic inspections as recommended at least once a year but only action when dyke failure has occurred.

Based on the experience gained during the site visits and during earlier missions to Kien Giang Province and Soc Trang Province in order to develop a pilot project consisting of the design and construction of a demonstration dyke which shall serve for future dyke construction and rehabilitation measures the following steps are recommended:

- Set-up a data base for the mangroves
- Establish a numerical current model
- Bathymetric surveys
- Install wooden traditional wooden fences where required
- Take actions to eliminate and avoid shrimp farming in the mangrove areas and on the foreshore
- **Detailed design and Tender documents for demonstration dyke (pilot project)**

Based on experience the preparatory services for a demonstration dyke shall include the following tasks:

- Geotechnical investigations of foundation area and construction materials
- Stability calculations and design of dyke resistant to overtopping according to international standards
- Technical specification for dyke construction
- Pre-qualification on capability of contractors
- Supervision during construction
- Establish dyke maintenance programme

A model Terms of Reference for further consultancy and expert services is attached as Annex A

Weimar, 14th November 2009

Hydroprojekt Ingenieurgesellschaft mbH

Michael Heiland
Dam Expert

Prof. Dr. Holger Schüttrumpf
Coastal Engineering Expert

Sea Dyke Rehabilitation Kien Giang Province

Model Terms of Reference

A Site Investigations

In order to achieve a professional judgement it is required to evaluate

- available hydrological data of typhoons, wind speed and wave motion, currents, normal min/max water levels, influence of tides etc.
- design features of existing dyke, dam profile, dimensions/slopes, filter zones, materials used (friction angle, kf-value etc.)
- topographic data, layout of the dyke and the whole flood protection system including the mangrove belt, restrictions regarding land use (e.g. possibility of widening the dyke which could affect agricultural area)
- extension of the erosions and the affected portions of the dyke

B Numerical current model

Based on the aforementioned investigations the consultant will specify, set-up, calibrate and operate a numerical current model which enables the local dyke authorities to understand the processes resulting in mangrove and dyke erosion and to specify and optimize dyke rehabilitation works as well as mangrove planting. This numerical current model is required and strongly recommended to change from a trial and error philosophy to a physically based solution finding.

C Design and Specifications

Based on the site visit the collected data will be evaluated, necessary technical calculations (hydrogeological analysis, geotechnical calculations etc.) will be undertaken and a design for the dyke protection works will be carried out. The design report will also include a cost estimation.

Technical Specifications and a Bill of Quantities will be prepared and drawings in sufficient detail to allow the Contractor to bid for the rehabilitation works.

D Construction Supervision

Throughout the implementation of the construction works the consultant shall provide technical supervision, i.e. among other

- Check, control and approve the construction documentation produced by contractor
- Check, control and approve that the construction methods applied are in accordance to the technical specifications
- Check that the daily construction activities are carried out properly in accordance to quality requirement
- Check and approve possible design changes due to unforeseen topographical and/or geological conditions and design improvements during construction
- Verify that the progress of contractors activities is proceeding according to schedule and check that the respective payments correspond to the works already executed

- Verify by innovative field tests that the resistance to wave overtopping and overflow of this new dyke is much higher than for the traditional type of dyke.
- Report on the above matters to the Authorities

E Maintenance

The Consultant shall prepare a typical maintenance manual describing the following topics:

- yearly visual inspections
- checking erosions and settlements
- checking failures in the dyke section
- checking cracks or displacements of the revetment
- checking vegetation cover of landside slope
- yearly visual dyke inspections
- yearly visual mangrove inspections

> Rehabilitation/repair works as required

- Maintenance training
- Detection and evaluation of damages
- Documentation of damages
- Organisation of required repair works
- Control of success
- Training courses in the field
- Training tours to Germany (if desired)