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VIETNAM COASTAL ZONE VULNERABILITY ASSESSMENT and First Steps Towards Integrated Coastal Zone Management

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PILOT STUDY
SEA DYKE EROSION IN NAM HA PROVINCE
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1. INTRODUCTION

1. INTRODUCTION

The project "Vietnam Coastal Zone Vulnerability Assessment and First Steps Towards Integrated Coastal Zone Management" or Vietnam VA Project is being conducted from November 1994 to April 1996. During the project a full vulnerability of the coastal zone of Vietnam to the impacts and effects of accelerated sea level rise is being assessed. In the vulnerability assessment, or VA, a detailed review of the state of the coastal zone with respect to its vulnerability to flooding and erosion focuses on long term sea level change, coastal developments, coastal protection and response strategies over the coming century to cope with probable impacts. Integrated coastal zone management (ICZM) is a key instrument for meeting the challenges of not only the future threats from sea level rise but also the present threats from rapid coastal development.

To improve the understanding of the present coastal zone and its problems three pilot studies are being conducted to study and appraise the physical, socio-economic and institutional issues faced in coastal management at present in Vietnam. The three studies are :

Sea dyke erosion in Nam Ha Province (Red River Delta, north coast)
Flooding and water management in Hue Lagoon (Central coast)
Coastal management and planning in Baria-Vung Tau (South coast)

In each case joint missions and study teams with Vietnam local and ministry specialists were undertaken during a one month visit to Vietnam.

These studies aim to open up the specific problems and issues to a wide audience and to provide a framework for more in depth discussion and problem solving. Specific technical and planning issues are described and the integrated approach to problem solving is emphasised.

In this report, the first of the three Pilot Studies is described, namely Sea Dyke Erosion in Nam Ha Province.

2. PROBLEM DEFINITION, RED RIVER DELTA COAST

In this chapter the first steps are described which were made to focus on the problem definition, as it was perceived on the first VVA Workshop held on 27 February 1995, in order to define the problem definition more precisely. The perceived problem description was used as a starting point from which a sequence of start-up activities were carried out to provide a more detailed and focused definition for this first pilot study. These activities vary from the collection and study of literature, meetings with representatives of the Government and Institutes on various levels and the preparation and execution of a site visit. The findings of these activities are presented in the following paragraphs followed by an adapted and more specific problem definition on which the remainder of the study has been focused.

2.1 Outline of the perceived problem

The first Pilot Study, as was discussed during the first VVA Workshop held on 27 February 1995, concentrates on the erosion problems of the sea coast of the Red River Delta. It was perceived that, particularly within the two central provinces Nam Ha and Thai Binh, serious long term erosion problems exist resulting in significant regional socio-economic effects.

2.2 The Red River Delta

General description

The Red River takes its rise as Thao River in the Dai Ly Lake in China. In Vietnam near Viet Tri the Thao River becomes Red River and receives flow from two major other contributories: the Da River and the Lo River (figure 2.1). The Red River delta has the classical triangular form with its apex near the town of Viet Tri, about 150 km inland. East of the Red River the Tai Binh River flows onto the Red River Delta. The Red River is connected to the Tai Binh River system via the Duong (5 km north of Hanoi) and Luoc rivers. Through these in total about 32% of the Red River discharge flows into the Tai Binh River system (this is about 75% of the total Thai Binh river run-off). The Red River catchment area is about 155000 km^2. The Red River Delta embraces seven provinces in their entirety and part of three other provinces. The coastline of the delta extends from the Ninh Binh province in the south to the coal mining centre and port Hong Gai in the north. The total length of the Red River Delta coastline is about 165 km as the crow flies.

The total average annual discharge through the branches in the Red River delta is estimated at 137 $* 10^9$ m^3/year carrying a sediment load of about 72 $* 10^6$ tn/year [lit 1]. The highest recorded discharge was 37.000 m^3/s measured in 1971. Based on measurements is was estimated that 12% of the sediment load is sand, 59% clay and the remaining 29% is classified as aleuritic (silt) [lit 2]. This enormous amount of sediment in general leads to sedimentation in the coastal areas for which the Red River Delta itself is the most outstanding proof and example. However, despite of the fact that every year a huge amount of sediment is transported into the Gulf of Tongking and coastal areas there are pieces of coast on which serious erosion problems are reported. Two provinces where erosion problems exist are the Thai Binh and Nam Ha provinces (figure 2.2). Surprisingly both provinces are directly located at the mouth of the main branch of the Delta, the Red River itself (Cua Ba Lat).

Land use and socio economics in the Red River Delta [lit 4,5]

Vietnam has transitioned its tightly controlled centralized economy towards a market economy. Its legislative system and its fiscal regime is designed to encourage foreign investment. Despite the fact that Vietnam is receiving the highest rate of foreign investment in Asia, that the inflation is reasonably under control, that the export is growing 20 % a year and that the GNP has averaged about 5 % growth over the last few years, Vietnam is still one of the poorest countries of the world with a per capita GNP which is smaller US$ 200,- per year.

Agriculture is still the main sector of economy in Vietnam, accounting for more than one third of the GDP. 75% of the national employment is found in agriculture.

The country is densely populated with over 1,000 inhabitants per square kilometre of cultivated land. Within Vietnam the Red River Delta (16,000 km^2) is the most densely populated region with 1,700 inhabitants per square kilometre. This is also the highest population density on arable land in the world (1992). As a result, the Red River Delta is characterized by a chronic food deficit and a high degree of food insecurity.

A UNDP/FAO study for the World Bank describes the coastal region in Vietnam as the most significant locus of poverty and malnutrition. According to a survey conducted by the Ministry of Health, 45% of the population have a daily energy intake which is lower than the acceptable minimum requirement.

The Red River Delta is characterised as low lying with a enormous network of river dykes and sea defences. Most of the sea dykes are built over the centuries mostly on local initiatives. The sea dykes have generally an inadequate design and are poorly constructed. Due to this state of the dykes a significant part of the yearly funds has to be allocated to repairs and maintenance. In the coastal area overtopping of the sea defences causes salt intrusion which decreases the agricultural productivity. Further the constant risk of flooding discourages farmers to adopt new technology or to invest in other income-generating activities.

In the coastal provinces about 65 to 70% of the land is in use for rice production; about 2 % for other annual crops and about 20% of the land is in use as, what can be described as, rural area (villages etc).

Governmental organization

At the national level the government is organized[1] according to the schematized tree diagram in figure 2.3. The country is being led by the governmental council in which Ministers and Vice Ministers are seated. Each minister has the responsibility over his ministry or equivalent organization (like SPC).

The same organization structure as on the national level is also implemented on the lower levels (figure 2.4). These are the provincial level, the district level and the commune level (a cluster of

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1 Just before the submittal of this report the government has been reorganized into a new structure. The former Ministry of Water Resources falls under the new Ministry of Agriculture and Rural Development. The reorganization has taken place on ministerial level only. The changes on the lower levels will be implemented in the coming months and years. For the time being the 'old' structure of the old Ministry of Water Resources is still operational.

villages). The administration of these levels is called the Peoples Committee of the province, district or commune. At the province and district level there are representatives of all the ministries and equivalent organizations as presented in figure 2.3. Each department or representative has the responsibility to report to the higher level. So it is the task of the Representative of the Water Resources Department in the commune to report the condition of the dykes to the district level. In its turn the district will report to the province and the province to the ministry.

Parallel to the People Committees there is also the structure of the Communist Party which has its national, provincial, district and commune departments and representatives as well. On each level the Party Committee plays an important role in all the important decisions. The chairman and people on key positions in the Peoples Committees are usually also seated in the Party Committee. Decisions are therefore made in good agreement between the Party Committee and the Peoples Committee. In general it can be stated that the Peoples Committees are responsible for the daily administration while the Party Committees control the outline of the policy.

The coastal defence system in Vietnam is in principle the responsibility of the Ministry of Water Resources (MWR). The Ministry is organized according to figure 2.5. In this schedule the Department of Dyke Management and Flood Control (DDMFC, figure 2.6) is in charge of the monitoring, maintenance, improvement, design and funding of projects on the river and sea dykes. The DDMFC manages 5,000 km of river dykes and 3,000 km of coastal and estuarine dykes throughout the whole country. In practise, the Ministry has especially a funding, controlling, managing and supportive function towards the local (province and district level) representatives. The institutional structure for combatting the annual effects of floods and typhoons is presented in figure 2.7 [lit 6].

The DDMFC (figure 2.7) also runs the Secretariats of the Central Committee for Flood and Storm Control (CCFSC) and the Vietnam National Committee for the International Decade for Natural Disaster Reduction (VNCIDNDR). The CCFSC is responsible for the emergency responses just before (forecasting and warning), during (coordination) and after the onset of the disastrous event. The VNCIDNDR is responsible for preparing the community and the responsible authorities in cooperation with international organisations (public awareness, emergency preparedness) [lit 6].

General hydraulic and meteorological conditions

The hydraulic and meteorological conditions [lit 7,...,11, 15](figure 2.8) at the coast of the Red River Delta can clearly be split into a South West summer monsoon period (wind force about 3 Beaufort) and a North East winter monsoon period (wind force about 4 Beaufort). The wave conditions at the coast also follow this pattern as these are mainly generated by the monsoon winds. The average deep water wave height in the summer months is about 1.5 m (coming from SW directions) whereas the average wave height in the winter is about 2 m (coming from NE directions). The characteristic range (HHWS - LLWS) of the diurnal tide is about 3.1 m. Currents along the coast are mainly tidally driven with a significant (seasonal) influence of wind and waves. The highest activity of typhoons occurs during the months July and August. On average 6 typhoons hit the Vietnamese coast on a yearly basis of which about 35 % hit the northern part of the country. Surges may develop during storm or typhoon activity. Measurements show that during the last 30 years water levels (astronomic tide plus wind set-up) up to 2.35 m above MSL have been reported at Hon Dau station.

2.3 Thai Binh province

The Thai Binh province lies between the Red River (Nam Ha province), the Luoc River (Hai Hung province), and the Hai Phong province (fig 2.2 and 2.9). The province is divided into 8 districts of which three are located at the coast. Thai Thuy District covers the northern part, Dong Hung District the middle part and Tien Hai District the southern part (joined by the Red River). The total coast length is approximately 40 km as the crow flies, facing east. This coastline is divided into four sections of about 10 km length separated by five branches of the Red River system discharging into the Gulf of Tongking. Going from to north to south (fig 2.9), the river names (and mouth names between brackets) are:

- Thai Binh River . . . . (Cua Thai Binh)
- Song Diem . . . . (Cua Diem Dien)
- Tra Ly . . . . (Cua Tra Ly)
- Song Lan . . . . (Cua Lan)
- Red River . . . . (Cua Ba Lat)

Of these, the Cua Diem Dien and the Cua Lan have drainage sluices (in Cua Lan a second sluice is now under construction) to increase the drainage and discharge capacity and to decrease salt intrusion.

The development of the coastline in all three coastal districts has been investigated based on various reports [lit 12,13,14] and on inspections and meetings held with the local authorities during the first site visit of this 1st Pilot Study.

The coastline in these districts is curved as a result of developments over decades. The land is protected by sea dykes, on some points also by mangroves and on one location in combination with a groin system. The crest level of the dykes is irregular but on average 3.7 m above Mean Sea Level. The High Water level reaches to the toe of the dyke. The outer slopes of the dykes are protected by a rock revetment (figure 2.10). In front of the dykes is in general a very gentle sloped beach (1:500) which consists of very fine sand in the higher parts (grainsize estimated on 100 μm) and more muddy in the lower parts (Low Water line). Close to the river mouths very active shoals develop along the coast. These shoals change continuously in size, height and position. This means that the wave protection of the coast by these natural offshore breakwaters is changing continuously.

Damage to the coastal protection usually occurs in winter when the waves of the NE monsoon (figure 2.8) attack the dyke face (the area is well sheltered from the SW monsoon waves, which are usually also smaller in size). Also typhoons may cause damage to the coastal defence. Due to the shallow foreshore the wave attack on the dyke is seriously reduced. A point of concern is the overtopping of the dykes under typhoon conditions. Due to the low crest level of the dykes the volume of water passing the dyke as overtopping can be significant. For instance, in 1986 3000 ha of land was impacted by salinity (on average a strip of 750 m along the entire Provincial coastline), and it took many years before the original crop yield could be reproduced. In that year typhoon Wayne hit the coast at the Red River mouth on the 3rd of September causing 400 casualties [lit 15]. The waterlevel reached up to 3.9 m, the wind speed exceeded 40 m/s and (offshore) wave heights of 7 m where recorded.

Based on historical maps, bathymetric surveys (eg. Environmental and Marine Research Programs, 1981- 1990) , air photography and satellite images an assessment of progression rates has been made [lit 12]. These show in general high accretion figures over the last century. The highest accretion rates (40 m/yr and more) are found near the Cue Ba Lat, Cue Tra Ly and

Cue Thai Binh. Also the shoals in front of the coast have been investigated. Results show very high rates (up to 160 m/yr accretion and up to 100 m/yr erosion) indicating the high dynamic character of the area.

In these two provinces erosion has only been reported for small pieces of coast. On one site, just south of the Cua Lan, groins have been built as additional protection. On another site (just south of Cua Tra Ly) remains of old sluices can be observed on the beach some 200 m from the dyke in the sea. In another case, small dykes built for protection of newly reclaimed lands have been destroyed in storms, leading to erosion of the new lands. The erosion in all these cases seems to be very local and can be related to a shift in the channel systems of the nearby river branches or to the dynamic development of the delta formation.

In general it can be stated that the development of the coastline of the two coastal districts of the Thai Binh province can be characterized as a dynamically accreting coastline. 'Dynamically accreting' in this context means that on average the coastline is accreting but that the coastline is also continuously changing in response to the seasonal wave and current conditions and bathymetry in adjacent areas. About 80 % of the annual sediment transport through the rivers occurs in the period June to October (wet season). In this period, which coincides with the SW monsoon and the typhoon season, typically massive accretion takes place. During the rest of the year (NE monsoon) and also during typhoons in the 'wet season' the accreted material is redistributed in the area. Erosion might take place very locally or under specific conditions (eg typhoons) but averaged in time the coastal development trend for Thai Binh Province is accretion.

2.4 Nam Ha province

Just south of Thai Binh, across the Red River, lies the Nam Ha province which is bound by the Red River (north) and by the Day River (south). The coast length is about 60 km as the crow flies, facing SE (figures 2.2 and 2.9). The province is divided into 11 districts of which 3 are coastal; Xuan Thuy (north), Hai Hau and Nghia Hung district (south). These districts are separated by branches of the Red River. Going from north to south these are: (see figure 2.11)

- Red River . . . . (Cua Ba Lat)
- Song Nho Dong (dammed in 1955) . . . . . . (Cua Ha Lan)
- Song Ninh Co . . . . (Cua Lach Giang)
- Song Day . . . . (Cua Day)

With respect to the coastline development special attention has been paid to the Hai Hau district. In a very early stage it became clear that in this district a serious consistent and widespread erosion problem exists. From the other districts no indications were received (either from meetings with authorities nor from several reports) that coastal erosion problems in the other Nam Ha districts exist. Xuan Thuy and Nghia Hung are both districts with a generally *accreting coastline. Therefore the efforts were focused on the Hai Hau district.* The development of the coastline of Hai Hau district has been investigated for this analysis based on various reports [lit 2,3,14] and meetings in Hanoi and on inspections and meetings held with the local authorities during the first and second site visit of this 1st Pilot Study (Appendices B and C).

The Hai Hau district (264 km^2) consists of about 25 km of coastline and 48 km of river embankment (fig 2.11 and photo 1). The district has a population of about 330.000 people of which 45% has the catholic religion (this is rather high compared to the national average of 5.6 %). The local economy depends on agriculture (rice, potatoes etc), farming, salt production (coastal strip) and aquaculture (fish, shrimp and crab). Tourism (at the southern beaches of the district) is believed to develop in the near future.

The generally straight sandy coastline of the district has some irregularity resulting from the historical coastal development and coastal protection strategies (photo 1,2 & 3). Sea dykes are the main seadefence system of the district. However, on some parts of the coastline there is an additional protection of small dunes (Tan Thien, southern part), trees (Tan Thien and Hai Dong (northern part) and mangroves (Hai Dong and Cua Ha Lan, photo 4). In front of the dykes is in general a gentle sloping beach which varies along the shore from 1:40 on eroding beaches to 1:200 in other places (figure 2.12). The beach consists of very fine sand, estimated grainsize 80 μm. Measurements show an increase in grainsize on eroding pasts of the coast.

Along 75 % of the coastline of the Hai Hau district the coastal defence system consists of two parallel dykes (fig 2.13 and photo 1) with a distance of about 250 m in between. The area between the dykes has been split into sections alongshore in the range of 500 to 3000 m. The idea behind this strategy is to withstand typhoon attacks. Experience has learnt that with the funds and resources available it was not possible to built one dyke strong enough to resist the attacks. To prevent inundation a second dyke was build behind the first one. In addition the area between both dykes was split into separate sections. During typhoon attacks, which last seldom longer than 6 hours, the fist dyke is usually capable to withstand the attack. However, after some hours of severe typhoons parts of the dyke may fail which will result in inundation of the area behind the dyke. For the remaining time of the storm, which is only a few hours, the second dyke will be attacked. But the strength of the attack will be broken on the remains of the first dyke which then acts as a sort of breakwater. The overall result however is that some coastal areas are 'lost', but due to the strategy applied the losses have been minimized.

Wayne (1986) was the last typhoon which caused casualties at the coast of Nam Ha. 145 people were killed in Nam Ha during that typhoon. On some places the first dyke gave way but the second dyke lasted in all places. 7,000 ha of land, which is 27% of the district, was impacted by salt (figure 2.14). Tropical storms and typhoons cause damage to the dykes every year. Reported damages are usually slope instability (sliding) and overtopping on many locations.

The outer slopes (v:h $\approx$1:2) of the dykes are protected on the heavily exposed areas. The protection consists of limestone rock of about 30 cm diameter (figure 2.10, photo 2, 3 & 5). The size of the stones is determined by the construction methods without any mechanical aids. The rock is placed on a clay layer, the core of the dykes is usually a combination of sand and clay. Sometimes the toe of the protection is reinforced with cement (photo 6, damaged section). The toe level of the protection is at approximately Mean Sea Level (photo 7). At less exposed areas the dykes are unprotected (no armouring).

For the drainage of the area, various structures have been built to release superfluous water from the province. Within the sea defence there are at present 9 sluices to discharge the water. Some of them are also used for shipping.

The beach at the Hai Hau district is known as eroding (figure 2.15). The rates which are reported vary from 10 m/yr [lit 2,3] to 30 m/yr [lit 16, and local authorities]. Also the erosion rates of adjacent areas vary. Some reports mention a main point of erosion which translates along the coast in south eastern direction. Also the start of the erosion is not clear. Some sources mention that the erosion is already going on for one century [lit 2] others (local authorities) state that the erosion started about 40 years ago. These figures are difficult to verify because they strongly rely on positioning systems, vertical datum levels and measurement accuracy. Nevertheless it is completely clear that severe erosion is taking place: old sluice structures and dyke revetments are visible at low tide hundreds of metres offshore (photo 6). In 1955 the river branch Song Nho Dong (photo 8 ,figure 2.1) was dammed.

The on-going erosion of the beach in front of the dykes makes it more and more difficult to protect existing dyke sections. Due to the erosion of the beach the wave attack on the dyke increased over the years. As a result overtopping takes place more often resulting in salt intrusion (figure 2.14) and erosion of the inner slope (photo 9). The erosion of the beach has also led to an undermining of the toe protection of the outer slope which has resulted in toe instability (photos 5 & 6). Since the core material of the dyke is sand and clay and no sound filters layers are applied in the protection core material was easily washed out by the waves. This has led to significant settlements. Additionally, the weight of the limestone protection units is too small to resist the present wave attack. Under storm conditions the protection is therefore unstable and insufficient to prevent high damages to the dyke. These circumstances require a lot of effort and resources to restore the dykes after storm events. This will only worsen when the beach continues to erode.

Because the coast is eroding at such a high pace many dyke sections have been lost in the past. Local authorities mentioned during the site visit that on average every 10 years a dyke section is lost in the Hai Hau district [lit 16]. When a dyke section is lost no efforts are made to restore it. The land in front of the second dyke is considered to be lost. The land will still be used for some years for salt production and aquaculture. Following a breakthrough the authorities will take action to build a new second dyke inland. The strategy which presently is being adopted is clear example of a 'retreat strategy'.

Since this retreat strategy has been adopted for a long time several hundreds of metres of land have been lost to the sea (figure 2.14). As the land in the densely populated Hai Hau district is known as very fertile soil the area is very efficiently used for agriculture. Even less fertile parts are used for aquaculture, salt production and living. At present every piece of land in between the two dykes is in use for aquaculture and salt production or as residential area (photos 9,10 & 11). Hundreds of small villages (grouped together in communes) are spread over the district. Adopting the retreat strategy means that every time a section is lost people who were living or farming on that piece of land have to move. This, of course, has its impact on the local economy and social affairs.

In one of the hardest hit areas the retreat is now threatening the village Hai Thrieu (figure 2.14, photo 2 and 12). In the Hai Thrieu commune 3000 of the total number of 8000 residents are living between the two dykes. In this case a socio-economic problem is developing which will come to a climax when the first dyke collapses and which will remain to exist when the strategy is not changed. The authorities strongly recognize this problem but, according to them, there is no alternative due to very limited financial resources. The main sea dyke related problem in Nam Ha Province in the short term is the salt intrusion by overtopping and the threat of inundation of the land located between both dykes. In the long term this implies removal of complete villages and loss of land.

2.5 Summary and local problem definition

In summary the coast of Thai Binh and Nam Ha provinces are both dynamic silty to fine sandy coasts with accretion and erosion areas. In general, Thai Binh exhibits an accreting coast while Nam Ha shows serious erosion at places. The most severe and sustained coastal erosion is along the coast of Hai Hau district. A specific location was selected for further investigation as the subject of this Pilot Study. The location chosen was the village of Hai Thrieu, which lies in the centre of the worst erosive stretch. The problem definition for the remaining time was therefore formulated as follows:

'Apply coastal engineering practise in the CZM sense to the coastline retreat problem at and near Hai Thrieu village in the Hai Hau district, Nam Ha province. This means that attention will be given to the technical analysis of the problem, to the socio-economic aspects of the problem and to the institutional aspects of the problem. Integration of these aspects will lead to a sound perspective to decide on the defence strategy to be applied.'

3. LOCAL PROBLEM ANALYSIS, DYKE EROSION AT HAI THRIEU

The coastline retreat problem in the Hai Hau district, and, more specific, the dyke erosion at Hai Thrieu, can be divided into three different parts which need to be analysed and integrated in order to make a sound judgement on the most effective measures for the problem.

- The fist part of the coastline retreat problem is related to the socio-economic values in the area. The analysis of the socio-economic values of the threatened area deals with the question:

  'Why is coastline retreat in the Hai Hau district a problem ?'

  The answer to this question can only be given after a thorough analysis of the social aspects (use of the land) and economical aspects (value of the land). Part of the answer to this question has already been described in the previous section. Incorporation of the costs and the effects of measures (technical analysis) will allow a sound socio-economic evaluation of the area which will put the various alternatives into perspective.

- The second part of the coastline retreat problem is related to the technical aspects of the problem. The purpose of this analysis is to answer the question:

  'Why is the coastline retreating, how can we control it and what will this cost ?'

  To answer these questions analyses have to be made of the processes which caused the erosion. Based on the understanding of these processes the most effective solutions can be selected to control the erosion.

- The final and third part is related to the organisational aspects of dealing with an erosion problem. This deals with the question:

  'Which measure is preferred and how will it be implemented?'

  This question can only be answered with the input of the previous analyses results. Alternative measures have to be mirrored against the costs, effectiveness, spin-off effects, politics etc. Further, the organisation of the responsible authorities is essential since these have to initiate, decide on, support and lead any activity.

During the pilot study the execution of these analyses has been started. The adopted methodology and some preliminary results are presented in this chapter.

3.1 Technical analyses

The technical analyses of the coastal problem at Hai Thrieu can be tackled in two ways. The first way is to analyse the erosion problem itself (regional scale analysis) in order to find the causes of erosion. These analyses will result in a (hypothetical) morphological system description of the area which explains the present coastline development. The second way is to analyse the dyke stability problems and inundation processes only (local scale analysis) in order to deal with the coastline erosion. The best solution, from technical point of view, will be achieved when both analyses are integrated into overall design and strategy for the sea defence.

3.1.1 Regional scale analysis

In this paragraph an overview of coastal processes is given which can lead to coastal erosion. Based on the gathered information during this Pilot study and engineering judgement some statements are made about the relevance of the processes in this particular problem. At the end of the paragraph a preliminary hypothesis of the morphological system is presented.

- **yearly deficit of sediment**

Considering the yearly retreat of the coastline it is possible to make a rough estimation of the yearly shortage of sediment along the Hai Hau District coastline. From various data sources average erosion rates were found in the range of 10 to 30 m/year (figures 2.12 and 2.13). The length of the eroding piece of coastline is about 15 km, which is 60 % of the total 25 km coastline of the district. The height of the beach profile which is eroding is not exactly known. However, considering the tidal range of about 2 m and the wave climate an active profile height of 7 m is reasonable.

Using these figures a rough estimation of the yearly sediment deficit is:

$$15 * 0.60 * 25.000 * 7 \quad = 1.6 * 10^6 \ m^3/yr \quad \triangleq 2.6 * 10^6 \ tn/yr$$

This order of magnitude of sediment is needed to stop the ongoing retreat of the coastline in the Hai Hau District. In [lit 2] it is calculated that maximal 29 % of the total sediment discharge of the Red River is contributed to the active beach. The remaining part, 71 % at the least, is deposited in deeper water. In order to maintain the beaches of Hai Hau district a river with a minimum sediment discharge of 9 * 10^6 tn/yr is required. Compared to the adjacent river branches (Red River: 23 * 10^6 tn/yr, Song Ninh Co: 18 * 10^6 tn/yr, see figure 3.1) this is a significant but reasonable amount of sediment.

Compared to other rivers the figure of 29% is rather high. It is expected that a supplying river would have to discharge a sediment load of about 15 * 10^6 tn/yr in order to maintain the beaches of Hai Hau District. This would mean that a significant part of the Red River sediment load would have to be redirected to the Hai Hau District, which potentially can lead to problems in other areas.

- **natural delta development**

The natural development of the delta of a big river is subjected to continuous changes. When we assume a river with a constant sediment load in time and a continuous attack from the sea on the shore the delta will go through the following development steps (figure 3.2):

1st sedimentation at the river mouth, the coastal processes (tides, waves, winds) will redistribute some of the material. The position of the river mouth will move seawards due to the sedimentation.

2nd After some time the river will break through one of the rivers embankments seeking for a shorter way to the sea. This results in a the second branch of the river delta. The sediment load is now divided over two branches

3rd After centuries the delta consists of many branches which divide the total sediment load of the river. The development of the coastline will slow down because of the increase of the coast length of the delta. The importance of branches changes slowly in time.

4th In principle the delta is an exposed feature on the coastline. In a 'stable' delta there is a equilibrium between the sediment supply and the demand removed by the coastal processes. In practise this delicate balance rarely exists. When the sediment supply would stop the coastal processes would redistribute the sediment over a wide area (for example the heavy erosion on the Nile Delta after construction of a reservoir which blocked a big part of the sediment load of the river). The redistribution by coastal processes takes place continuously but the erosion caused by redistribution is usually smaller than the accretion from river sediment. Bearing this in mind in combination with the increasing coast length and the changing importance of river branches it is imaginable that on a very big delta (as the Red River Delta) some areas heavily accrete (near a major branch) and that in other areas erosion occurs because the branch which was feeding this areas has lost its importance.

Within the natural delta development the sediment load in each of the river branches changes on a timescale of decades at the start of the delta development and a timescale of centuries when a delta is fully developed.

Changes made by man usually disturb the natural development of a river delta. On a timescale of decades dykes along rivers will result in a fixed position of the river which will lead in the long term to sedimentation and raising of the bed and waterlevel in the river. This leads to the necessity to increase river dyke crest levels. Dams in the upper branches of the river (Hoa Binh reservoir in the Da river, plans for reservoirs in the Lo river) reduce the sediment load towards the delta, finally resulting in decreased development of the delta and consequent erosion. After the construction of the Hao Binh reservoir (1987, figure 2.1) changes in sediment load have been measured. Erosion of the river bed downstream of the dam has been recorded. About $75 * 10^6$ tn/yr (!) is trapped in the Hoa Binh reservoir [lit 1].

Mining of sand for for instance construction purposes could also reduce the sediment load to the delta. Sand mining has been observed in the Red River but no figures of volumes are available.

The overall accretion tendency of the Red River Delta still seems to be effective in the Thai Binh Province. In Nam Ha province the negative effects of local decreasing sediment supply can clearly be seen to cause significant coastal erosion impacts.

- **subsidence**

The deposits of the rivers of the delta mainly consist of fine sand and clay [lit 1]. The total package has been built up over many centuries. The gradual development leads to gradual increase of the pressure in the soil layers. This will result in the consolidation of the soil layers leading to a reduction of volume and thus in subsidence of the surface. Subsidence rates of 3 mm/yr for the Hai Hau district were calculated based on geological analyses [lit 17]. Subsidence is a natural geological process but it can be accelerated by ground water pumping. Ground water pumping can serve various purposes for instance for drinking water or for aquaculture. Since the delta consists of enormous layers of clay there is a huge potential for subsidence. Ground water pumping should therefore be limited as much as possible.

A special kind of subsidence is tectonic movement. Usually the timescale of these processes is very large. The geologic history of the Red River Delta plain described in [lit 12 and 17]. In general the trend for this area is subsidence but the rates are small and therefore of minor importance for the short term development of the Hai Hau coast.

- **fluidization**

The average grainsize of the accreting material is rather small. On top of this a lot of fine material settles down in a relative short period of time. It could be possible that the newly deposited soil is very loosely packed. In shallow water this will be quickly changed by the wave action but on deeper water it is possible that the sediment remains loosely packed. During typhoon conditions suddenly high orbital motions may fluidize the loosely packed layers. The fluidized sediment can then easily flow to deeper parts. If this process is taking place there will also be an effect on the coastline since the support of the beach in deeper water has reduced.

The existence of this phenomena in at the coast of the Red River Delta is purely speculative. Measurements before and just after a typhoon could confirm the existence of this process.

- **longshore sediment transports**

Longshore sediment transport is the general term for sediment transports along the coastline. The governing transport mechanism is the stirring up of the sediment by waves and the transportation of the sediment by tidal, wave and wind driven currents. The longshore sediment transport redistributes sediment along the coast. Gradients in the transport along the coast can result in sedimentation or erosion areas. Usually longshore transports in both directions exist depending on current and wave conditions.

In the Hai Hau district during the summer the predominant wave-driven current is directed in northeastly direction; in the winter in southwestly direction. Due to the wave climate the longshore sediment transport is expected to be stronger in the winter. However, during the summer 80 % of the yearly sediment load is discharged through the rivers. The bigger part of the river sediment load which contributes to the beach will therefore deposit on the northeast side of the river mouth (assuming a symmetrical tidal current; ebb flow is as strong and as long as the flood flow, figure 3,3a). During the remainder of the year, when the southwest longshore transport dominates, the deposited sediment is redistributed along the shore in southwest direction (figure 3.3b).

When this sedimentation and redistribution process is adopted to the Hai Hau coast (figure 3.3) it means that the deposits of the Red River mouth and the Ninh Co River mouth can hardly nourish the beach at Hai Thrieu.

- **cross shore sediment transports**

Cross shore sediment transport is a general name for sediment transport along the coast normal (on and offshore). Non linearities in orbital wave motions and three dimensional wave-induced flow patterns can result in a net cross shore sediment transport.

Based on the above mentioned processes, on the obtained information the following -preliminary- hypothesis is formulated:

Hypothesis

The erosion at Hai Thrieu and the Hai Hau coastline is originally initiated by a natural change of the discharge, and thus the sediment load, of the branches of the Red River. This gradually stopped the accretion of the coastline and, after some decades, turned around into erosion. Since the natural development of the Delta was more and more stopped by fixing the positions with river dykes all the sediment was discharged through a small number of main branches into the sea instead of a large number of small branches which divided the sediment equally over the coastline. As a result major accretion developed at the mouth of the main river branch (Cua Ba Lat). Areas between two river mouths had to be fed via longshore sediment transport mechanisms. Up to 1955 the Hai Hau district beaches were nourished by the Song Nho Dong and Song Ninh Co resulting in a constant or slightly retreating coastline. After the damming of the Song Nho Dong one of the sediment sources of this area was blocked resulting in a deficit of sediment and, probably, an increased accretion at the Red River mouth. Since the nett longshore sediment transport is directed southwesterly erosion problems arose at this side of the old Song Nho Dong mouth. This, perhaps in combination with a strong cross shore transport in extreme (typhoon) conditions, has led to the high erosion rates of the Hai Hau district.

For a -preliminary- prediction of the development of the Hai Hau coastline the following has to be considered:

When no action is taken the coastline will retreat at same pace for the coming years. On a longer timescale it is expected that the accreting coast of Nghia Hung District will develop an increasing nourishing effect at the Hai Hau coastline. The accretion near the mouths of the Song Ninh Co and the Song Day will slow down while the retreat at Hai Hau will decrease (figure 3.4). This effect will develop along the coast starting in the south of the district. It has to be understood that the general trend of sediment supply to the Red River Delta coastline is decreasing. Large scale damming (Hoa Binh reservoirs) and mining (for construction purposes) will reduce the sediment load discharged into the sea. This in combination with the high subsidence potential (ground water pumping for fresh water) and sea level rise will in general lead to an increased reduction of the accretion rates in the red River Delta.

3.1.2 Local scale analysis

In general, about 14 failure mechanisms for sea dykes can be described [lit 18](figure 3.5). Based on the information gathered at the various meetings in Hanoi and at the site visits the following failure mechanisms appear to be governing in the Hai Hau district:

- wave overtopping and inner slope erosion.

  As can be seen from photo 9 inner slope erosion has been observed on a number of locations. This is caused by waves overtopping the dyke. The crest level of the dyke is too low to prevent the wave run up from reaching the crest of the dyke. The superfluous water on the crest will drain over the back side of the dyke causing strong local erosion when unprotected. The more water reaches the crest of the dyke, the more potential back side erosion there will be. When overtopping lasts long enough and the inner slope of the dyke is insufficiently protected big holes will rapidly develop on the back side of the dyke, finally resulting in a dyke failure and thus inundation of the hinterland. Also the dyke will become rapidly saturated increasing the risk of slip circles, liquefaction and other instability mechanisms. At the same time the land behind the dyke is heavily impacted by salt.

Possible measures:

1. Accept the overtopping but prevent the inner slope from washing out.
2. Reduce the wave overtopping by means of raising the crest level or by decreasing the wave run-up (wave height, roughness, slope, berm).

- piping and micro instability

Since the majority of the sea dykes are quite old and built within local communes limitations (funds, equipment) there is no clear picture of the soil layers within the dyke body (figure 3.5). However, it became clear from discussions that the dykes consist mainly of sand and clay. The quality of the dykes largely depends on the presence of clay (water tightness, resistance to failure mechanisms). Sand however is not watertight and is more vulnerable for number of failure mechanisms. Micro instability occurs when the seepage through the dyke transports the smaller grains from the soil. Eventually a material entraining well (piping) may develop. When the 'pipe' reaches the high water side the process will accelerate. These processes also impact the hinterland with salt water.

Possible measure:

1. Investigate the composition of the dyke and take action according to this (widen dyke, clay layers etc).

- fore shore erosion resulting in toe instability

In the case of the Hai Hau coast the foreshore of the dykes is the beach. The beach is supporting the stability of the dyke. The erosion of the foreshore (beach) at Hai Hau has clearly been observed. The continuous decrease of the beach level results in an increasing wave attack on the dyke. Whereas the waves used to break on the beach, the waves now break more and more on the dyke. Further the toe of the dyke may become unstable. At the construction of the slope protection the toe was constructed approximately 0.5 m below the beach level. After some years when the beach has eroded the toe becomes exposed and looses its support from the beach (photo 5). The toe of the slope protection adjusts itself seaward and downward to the new situation (photo 6). Since the toe supports the entire slope protection the stability of construction depends completely on the stability of the toe. Once the toe settles significantly the slope protection will slide downward, disintegrate or become very vulnerable to wave attack. Finally the core of the dyke will be unprotected from washing out.

Possible measures:

1. Construct the toe and the slope protection such that settlements can be followed without loosing the function of support and protection.
2. Maintaining the level of the fore shore .

- erosion outer slope

The erosion of the outer slope is a result of the failure of the slope protection. This can be the result of various mechanisms. The most important are the slope protection failure as response to the toe failure (as described above) and the slope protection failure as response to the wave conditions. When the outer slope of a dyke fails it is usually a result of insufficient design, construction or maintenance. For the case of the Hai Hau district for instance the following stone weights (rubble mount slope protection) would be required on the outer slope:

wave height	Hsig	[m]	0.5	1.0	1.5
wave period	Tm	[sec]	6.0	6.0	6.0
slope	$\cot\alpha$	[-]	2.0	2.0	2.0
number waves	N	[-]	20000	20000	20000
rock density	γ_{rock}	[kg/m^3]	2550	2550	2550
water density	γ_{water}	[kg/m^3]	1030	1030	1030
permeability	p	[-]	0.4	0.4	0.4
wave height ratio	H2%/Hs	[-]	1.2	1.2	1.2
damage level	S	[-]	2.5	2.5	2.5
required stone weight		**[kg]**	**25**	**280**	**700**

Obviously the wave height, which is limited because only breaking waves reach the dyke, is one of the governing parameters for the determination of stone weight. This is also the reason why it is important to maintain the beach in front of the dyke because it will reduce the loads on the dyke face. Further, the supporting (filter) layers and specific details (transitions) should be carefully incorporated in the design. The design should be properly constructed, monitored and maintained regularly.

Possible measures:

1. Increase stone weight. Heavier stones are more stable and therefore give a better protection.
2. Construct berm breakwater. A berm breakwater consists of a large volume of stones which are in itself too light in relation to the wave conditions. Although the stones itself are not stable the breakwater as a structure is because of the large volume of stones. The breakwater will change its chape under design conditions, but it won't fail.
3. Change slope angle. Changing the slope angle reduces the required stone weight under design conditions. However, the volume of construction material of the dyke will increase.
4. Maintain foreshore. When a wide beach is maintained in front of the dyke the design conditions for the dyke revetment will become more favourable. The incoming waves under design conditions will already break on the beach resulting in a limitation on the maximum wave height which can reach the dyke. This will allow a lighter and cheaper construction of the dyke revetment.
5. Change revetment type. An alternative revetment type might be more effective than the presently used revetment of rock. This has to be evaluated not only to the effectiveness but in relation to the construction costs and maintenance costs.
6. Change filter layers. A proper design of the filter layer underneath the revetment (eg. geotextiles) will result in a more stable dyke protection.

The indicated measures should of course be evaluated on its costs and effectiveness for the local Vietnamese circumstances. Especially the construction of any design needs special attention. During the site visit at Hai Thrieu is became clear that the area is lacking good infrastructure to reach the dykes. This will cause problems to supply the site with materials and heavy equipment. The works presently under construction in Hai Thrieu are carried out manually with the help of a small truck only.

3.2 Socio economical analyses

The Hai Hau District counts 330,000 inhabitants on a area of 264 km^2 . This means a population density of 1250 inhabitants per square kilometre which is extremely high. As can be seen from the land-use map (figure 2.11) 67% of the land is in use for rice production. Especially close to the sea dykes salt pans and fish, shrimp and crab nurseries can be found. About 20% of the land can be described as rural area (villages etc).

In 1993 the UNDP and the Department of Dyke Management and Flood Control carried out a study [lit 19, 20] investigating the economical effects of the present defence strategy as well as the effect of four different alternative strategies. In these analyses the capitalized losses of houses, salt facilities and production and agriculture were determined in the case of flooding. As a result of these computations a comparison between various strategies could be made based on financial aspects (benefit/cost ratio). The average annual damage was estimated on 61 $* 10^9$ Dong which includes losses to houses and crops. The calculated benefit of avoiding a failure of the dyke was 300 $* 10^9$ Dong. According to the Ministry of Water Resources the average damage to the sea defences and food losses per year is about 34,5 $* 10^9$ Dong.

In addition to this four alternative measures were capitalized in order to calculate the cost/benefit ratio:

- improved warning system . . . .
- reopening of the Song Dong . . . .
- reopening of the Song Dong and increasing the discharge . .
- massive dyke protection . . . .

The benefit/cost ratio for these three alternatives was calculated on respectively 18, 30, 10 and 5 which makes all the three alternatives attractive from economic point of view. Social aspects, which are in this case in general positive effects, are not taken into account.

3.3 Institutional matters

During this pilot study the organizational structure of the responsible authorities was analysed in order to uncover the strategy to the erosion problems which is being adopted in the Hai Hau district. The national structure of ministries, provinces, districts and communes has already been presented in chapter 2 (see figures 2.3,..., 2.7). The local strategy, organization and the local daily operation are presented in this paragraph. The information has been gathered during the two site visits and at various meetings with representatives of the Ministry of Water Resources (district level) and the Peoples Committee (district level).

3.3.1 Project identification

The sea defence along the Vietnamese coast falls under the responsibility of the Ministry of Water Resources in Hanoi. For the execution of this responsibility the Ministry has its representatives on the various organisational levels throughout the country. At the top of the organisational tree acts the Department of Dyke Management and Flood Control (DDMFC) which manages, finances and supports the lower levels down to the local communes representatives. Between the top and lower end of the organisational tree lies the network of departments and representatives of the Ministry of Water Resources (MWR) at provincial and district level.

In practise every department of the MWR reports to the Peoples Committee (and Party Representatives) at the same level and to the Representative of MWR one level up in the organisational tree (figure 2.4). Communes report to the Districts; Districts to the Province and the Province reports to the Ministry. Requests of local authorities for dyke improvement to the MWR, DDMFC can be made along two separate paths (figure 2.4):

(I) via Water Resources Departments

In this case the representative of the local Water Resources Department will report to the representative one level higher. In this case the request follows only the channels of the Water Resources Departments.

(ii) via authorities (Peoples Committees) on different levels

The local representative of the Water Resources Department can also report the general authorities in his commune or district (peoples committee). The authorities report this to the authorities of the province and they, in their turn, will report to the Central Government. The Central Government in the end will inform the MWR, DDMFC.

Based on information of the District level, the provincial Department of Water Resources will propose major maintenance, improvements and new projects to the Ministry of Water Resources, Department of Dyke Management and Flood Control. The Ministry reviews all the incoming requests and designs of all the provinces. Then it tests the proposals to the policy and selects the most urgent requests which can be executed with the available resources. After the approval and allocation of money the province will invite tenders for the project.

In the case of the Hai Hau district a budget of 1.5 billion Dong (eq 140.000 US$) was allocated by the Department of Dyke Management and Flood Control for maintenance and construction of sea defences in 1995. 70 % of this amount is spent on repair and maintenance work and the remaining 30 % is used for improvement and new constructions. When this 30 % is for instance completely used for the construction of a new dyke with a block protection every year a section of about 85 m can be constructed (estimated unit price is 500 US$/m dyke).

The role of the Department of Dyke Management and Flood Control at the Ministry of Water Resources is at present not only to allocate money, but also to review the designs of proposed projects. In this way every new project will benefit from the expertise of the DDMFC. However, the construction of dykes in the coastal provinces started centuries ago. In those days the construction of dykes were local initiatives (commune or district level) with, in general, inadequate designs and poor construction execution. A lot of these dykes are still in place acting as primary or secondary protection. As a result of this inheritance it is not clear how these dykes were designed and constructed.

3.3.2 Existing defence strategy

For the last decades the defence strategy in the Hai Hau District has been a retreat strategy. The speed of retreat was determined by the available resources. Up to now these have been very limited due to all kinds of special national circumstances. The construction and maintenance of the sea defence strongly depends on the input of the local inhabitants.

As already explained in the previous section the defence system in Hai Hau district consists of two dykes(figure 2.13). As the erosion progressed over the years several dyke sections were lost and, in response, new dykes were built on the land. This ongoing process resulted in the existing coastline.

During the site visits of the Pilot study construction work was being executed in the dry on the second dyke immediately north of the village Hai Thrieu (photo 12). A new slope protection of square concrete blocks on a layer of gravel, geotextile and clay was under construction. This project can be seen as a big improvement on the slope protection compared to the common lime stone revetment which is much too light. It also means that the first dyke has already been given up by the authorities.

Authorities claim that there is not enough money to build one strong dyke nor to construct a suitable slope protection on the first dyke. The construction work on the second dyke is carried out in the dry which is much easier (and thus cheaper) because there is no tide and wave influence. It was stated during the site visit that when sufficient resources would be available that the first dyke will be protected and maintained.

Because of the steady retreat of the coastline in the Hai Hau district construction and maintenance of the dykes is continuously going on. In Vietnam every healthy citizen has to donate 10 days of labour per year to the community. Because of the constant dyke building and relocation this entails a substantial commitment from the whole population in the Hai Hau District: able-bodied workers must donate 40 days of their time per year to these activities, and in times of emergency even more. As mentioned the national norm is 10 days per year [lit 6,19]. Residents can buy this obligation off by paying rice to the village authorities. The rice will then be used to provide lunch for the workers and to give each of them a subsistence allowance of 2 kg/day.

3.3.3 Maintenance

The maintenance of the dykes is led by the District Department of Water Resources. For each section of the dyke a group of people have been assigned with the task to look after their section (figure 3.6). The work consists of the dyke maintenance and the repair of typhoon and monsoon damage to the dykes. Annually the condition of the dyke has to be reported to the MWR together with a plan for the coming typhoon season. Special attention is paid to the five most critical points in the District [lit 21,22]. As part of the maintenance a stock of limestone is put on the crest of the dyke meant for emergency reparations (photo 3). The maintenance of the dykes takes about 70 % of the total available budget for the District's sea defences. This is partly caused by an increased attack from the sea as a result of the heavy erosion and on the other hand by the insufficient strength of the coastal defence. With respect to the latter: In [lit 23] is stated that usually the upgrading of the dykes took place by farmers without any reference to specifications. This has resulted in dykes which do not take full advantage of the materials and resources which were available (general design, compaction, filter layers etc).

3.3.4 Warning system, evacuation and emergency repairs

The national warning system is organized according to figure 3.7 [lit 6]. The actual warning is issued by the National Centre for Hydrometeorological Forecasting. Via the Central Committee for Flood and Typhoon Control (CCFSC) on national, provincial and district level the warning goes finally to the communes where the evacuation will take place. It has been recognized that this warning system is under-resourced and that too many committees are involved in passing the message on to the places where it is really needed. A number of projects have been defined by the MWR in order to improve the forecasting and warning system.

Once the message has arrived in the district the local CFSC (Committee for Flood and Storm Control) is in charge of the coordination of all the efforts during emergencies. The CFSC will advise the Districts People's Committee to undertake formally action for evacuation. The communes are informed via a radio network which covers the entire district. Every 2-3 years an evacuation is started in the Hai Hau District. In the case of an evacuation the people in the district are warned by bells and gunshots. The elderly, disabled, women and children between the two dykes are evacuated first. Men will go to the dyke to make repairs but will also leave after some time. The people are evacuated to Hai Hoa were an old dyke gives reasonable protection against floodings (fig 2.14).

Emergency repairs are carried out in the first hours of a typhoon attack when it is still relatively safe on the (first) dyke. Damage to the dyke is repaired with the limestone blocks from the emergency stock on the dyke (photo 3). Because of the continuous erosion and retreat of the coastline in combination with the frequent occurrence of evacuations the emergency preparedness of the people in Hai Thrieu and the Hai Hau district is relatively high compared to the rest of the country.

Every year the each District DDMFC issues a report to the Province in which the previous typhoon season is evaluated and how the coming typhoon season will handled [lit 21,22]. This report is based on all the local yearly reports of all the dyke sections by the local dyke monitor teams (figure 3.6).

3.3.5 National Program for Marine Research

In Vietnam marine related studies are carried out within the framework of the 'National Program for Marine Research'. Since the erosion on the Vietnam coast is considered as a point of big concern one of these studies has been defined for the years 1990 - 1995 with the following title:

'Erosion problems at the coast of Vietnam and technical solutions for the most urgent places'

This project is led by the National Institute of Hydraulic Research (Ministry of Water Resources, see figure 2.5) and is funded by the Ministry of Science Technology and Environment. Many other institutes take part in this study. For the 'the most urgent places' the following areas, among others, were selected:

- Hai Phong port development . . . .
- Mekong river delta . . . .
- Nam Ha province (Hai Hau district) . . . .

For these areas technical solutions have to be defined in order to control the ongoing retreat of the coastline. The project will stop by the end of the year.

Within this study an extensive measurement campaign was set up for Nam Ha province which is carried out by the National Institute of Hydraulic Research (figure 3.3).

3.3.6 World Food Program

The World Food Program Project Vietnam 4617 (WFP), which started in 1993 and will continue till 1997, provides in 25 million US$ to be invested in the 454 km of sea defence in 7 central provinces of Vietnam. The program makes geotextile, computers, transport equipment and food available to be used in construction work on the dykes. The United Nations Development Program (UNDP) supports this project with technical assistance and 'institutional capacity' (building a institutional framework in which construction management and quality control can work economically and self sustainable) for the implementation of the WFP. However, within the initial setup of the WFP the Nam Ha province did not belong to the list of 7 nominated provinces. It has been recognized that in this province (and 4 others) the erosion problem is very serious and that any support will be very useful to improve the sea defence. Therefore the initial WFP has been extended to 12 provinces which includes the Nam Ha province (WFP Project Vietnam 5325) [lit 4].

4. INTEGRATED SOLUTIONS AND STRATEGIES FOR HAI THRIEU

From Coastal Zone Management point of view three principle strategies can be applied to vulnerable coastal regions. These strategies have been defined in relation to accelerated sea level rise. In Hai Thrieu however there is beside the long term sea level rise problem a short term salt intrusion and erosion problem which needs a short term response. In order to deal with these problems the possible strategies are described in this chapter. The strategies are defined specifically on the coastal problems in Hai Hau. However, a strategy plan for Hai Hau District should be integrated with a strategy plan for entire district and coast including for instance river flood control.

Irrespective of the strategy applied effects on the environment and local economics as well as social, cultural, legal and institutional implications should be analysed.

The chosen strategy should be implemented by the Ministry of Water Resources. This means that the Ministry will play a leading role in all actions to be taken. The sea defence should be managed nationally, but in close cooperation with the local (province, district, commune) representatives. With improved communication the chosen strategy could be implemented taking full advantage of the available resources.

The chapter is closed off with conclusions and recommendations of the first Pilot Study.

4.1 Retreat strategy

In fact this is the strategy presently applied in the Hai Hau district. The erosion of the coast is not prevented and land is regularly lost to the sea. The speed of retreat is largely determined by extreme events and therefore hard to predict. During such a storm or typhoon event land or dyke sections are lost. People have to abandon their houses and land and have to relocate.

The government should play a role of managing and controlling the process of retreat in order to minimize the effects on the local society. There should be a clear coastal defence plan which will minimize the retreat and which will clearly describe the strategy. Further a social plan would have to be developed to relocate people living in the endangered areas. It could be considered to relocate people from Hai Hau to areas along the coast where significant accretion exists like for instance the Nghia Hung district.

4.2 Accommodate strategy

For the Hai Hau district this would mean that the coastline would be held at the present position and that flooding and salt intrusion is allowed. People living in the area would have to adapt to this situation. They should in that case be thoroughly prepared and informed about the strategy and its risks. Houses might need to be adapted. A sound evacuation plan should be implemented. Infrastructure should be improved to make quick evacuations possible. The dykes need to be strengthened and maintained to avoid further erosion. The land-use in the coastal strip should be accommodated to the circumstances. Salt production, shrimp, fish and crab nurseries as well as cultivating salt resistant crops would be activities best suited for this area.

At present it can be observed in the Hai Hau district that in the coastal strip people have already accommodated to the circumstances with respect to the land-use. The land between the dykes and land which is heavily impacted by salt are used for salt production and aquaculture.

4.3 Protect strategy

Adopting the protect strategy in the Hai Hau district would mean that the present position of the coastline would be maintained and that the protection would be improved. It would involve defensive measures to protect the district against inundation, flooding, erosion and salinity intrusion.

For the Hai Hau district this would mean that the first dyke will be significantly improved to reduce the chance of a breakthrough and to limit the percentage of overtopping. In order to stop the erosion of the beach the Song Nho Dong would have to be reopened. This will increase the sediment supply to the beach resulting in less erosion. In addition artificial beach nourishments could be carried out to stop the erosion in the short term.

The capital costs associated with these measures are high. These should be weighed against the benefits of a well protected area.

4.4 Strategy for Hai Hau

The strategy to be adopted for the Hai Hau province is largely dependent on the available resources. An integration of the above described strategies could include the following measures based on the preliminary analyses:

- reopening of the Song Nho Dong. This includes the rehabilitation of the river dykes in this branch. Further, people living on the wetlands in the old branch would have to be relocated. For instance to the new land which is developing in the Nghia Hung district. This will slow down the erosion at the beaches of Hai Thrieu but, presumably, it will not stop it.

- concentration of efforts on the second dyke line. Design the dyke to be the primary defence line which will be maintained. This includes specifications related to wave run-up, overtopping, water tightness, stability, toe level and armour stability. Construct the dyke in the dry to these specifications.

- plan to relocate the people living between the dykes. Either behind the second dyke or to new land which is developing, for instance, in the Nghia Hung district.

- encourage planting of mangroves and trees on the outside of the dyke.

- encourage cultivating of salt resistant crops near the dyke as salt spray will continue to impact the land behind the dykes in storm conditions.

- explain the coastal protection strategy plan to the inhabitants.

In this way the erosion of the beach will decrease and the shoreline will be maintained at the position of the second dyke. Based on the preliminary hypothesis of the morphological system it is expected that the erosion will continue at the same pace in the coming years which means that within, say 5 to 10 years, the second dyke line will be the primary protection. The land between the dykes should be planted with mangroves and trees as soon as possible or when the first dyke gives way. This will slow down the erosion. Within this five to ten year period the nourishment of the beach from the south will increase (deposits of the Song Ninh Co) and, when the Song Nho Dong is reopened, the nourishment from the north will pick up again. With the construction of the improved dyke and the reduced erosion the threat of inundation will disappear which will encourage the local people to develop the area further.

4.5 Conclusions and recommendations first Pilot Study

The following conclusions can be drawn from the Pilot Study on Sea Dyke Erosion in Nam Ha Province:

- A clear cut coastal erosion problem and retreat strategy has been identified in a densely populated area.
- Dyke design could be improved in order to take full advantage of the available resources.
- Take care of clear warning and evacuation procedures.
- Ground water pumping is not taking place yet. In the future this should be kept to a minimum in order to avoid subsidence.
- Structural changes to the Red River system which influences the sediment budget should be avoided. Every reduction of the sediment load can lead to erosion problems on the coastline of the Delta. Specific examples which might lead to coastal erosion problems: dams (Hoa Binh reservoir) and sand mining from the river.
- The morphological system should be further investigated in order support or to change the hypothesis of the mechanisms determining the development of the coast.
- The socio-economic effects of the various coastal protection alternatives should be evaluated.
- An integrated coastal zone management plan should be developed for the Hai Hau district describing how to deal with present and future floods from the river and the sea. This should be a part of the national coastal zone management plan.
- Inhabitants of the threatened areas could be advised on how to deal with salt intrusion and how to cultivate crops given these circumstances.

5. RELEVANCE TO THE VA PROJECT

5. RELEVANCE TO THE VA PROJECT

The Pilot Study proved to be an excellent means of providing "ground truth" for the VA study by illustrating the realistic opportunities and constraints facing coastal managers at local, provincial and national levels in Vietnam.

Furthermore close working relationships were established with local Vietnamese specialists who took part in the study. Important insights were also gained into the decision making procedures and structures at all management levels from the commune to the national Government level. These insights enhanced and supported the interpretation, quality and recommendations of the full VA study.

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PHOTOGRAPHS

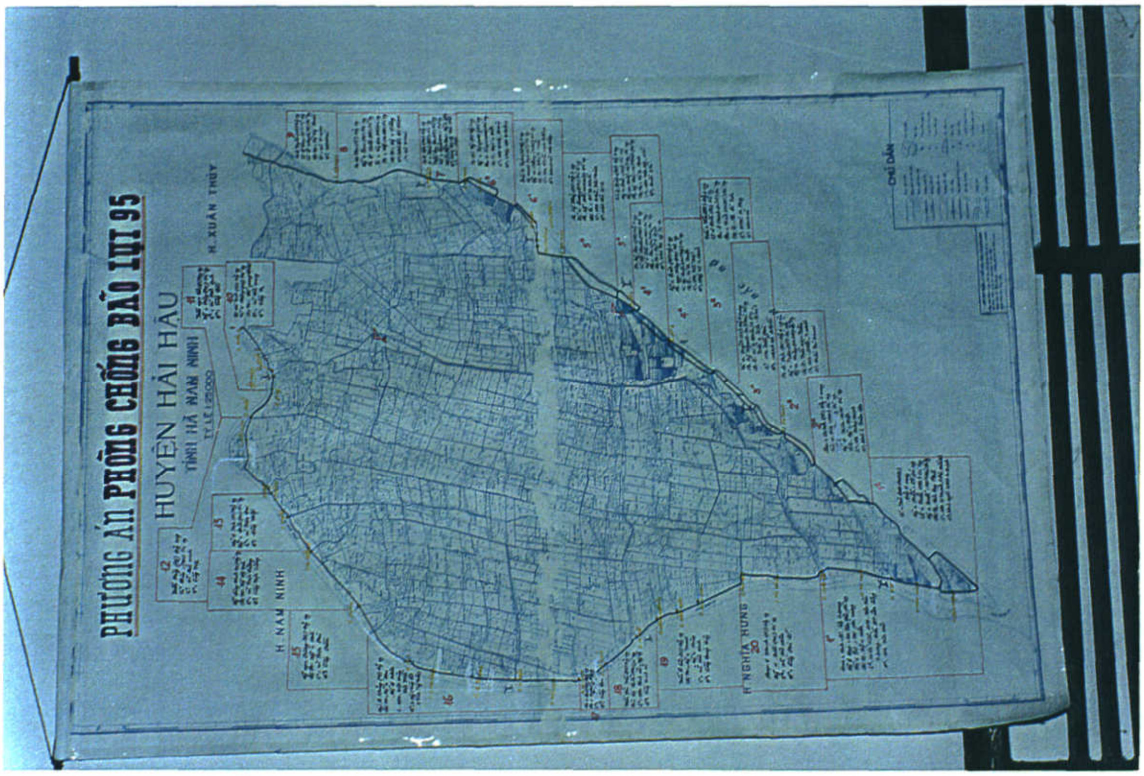


Photo 1 Plan Hai Hau District

Photo 2 Dykes and irregular coastline near Hai Thrieu

Photo 3 Coastline Hai Thrieu and limestone stock on the crest

Photo 4 Construction of slope protection on single dyke, mangroves

Photo 5 Slope protection, exposed toe

Photo 6 Cement enforced toe, groins and slope protection damage

Photo 7 *Dyke near Hai Thrieu at high water*

Photo 8 *Dammed section of the Song Nho Dong*

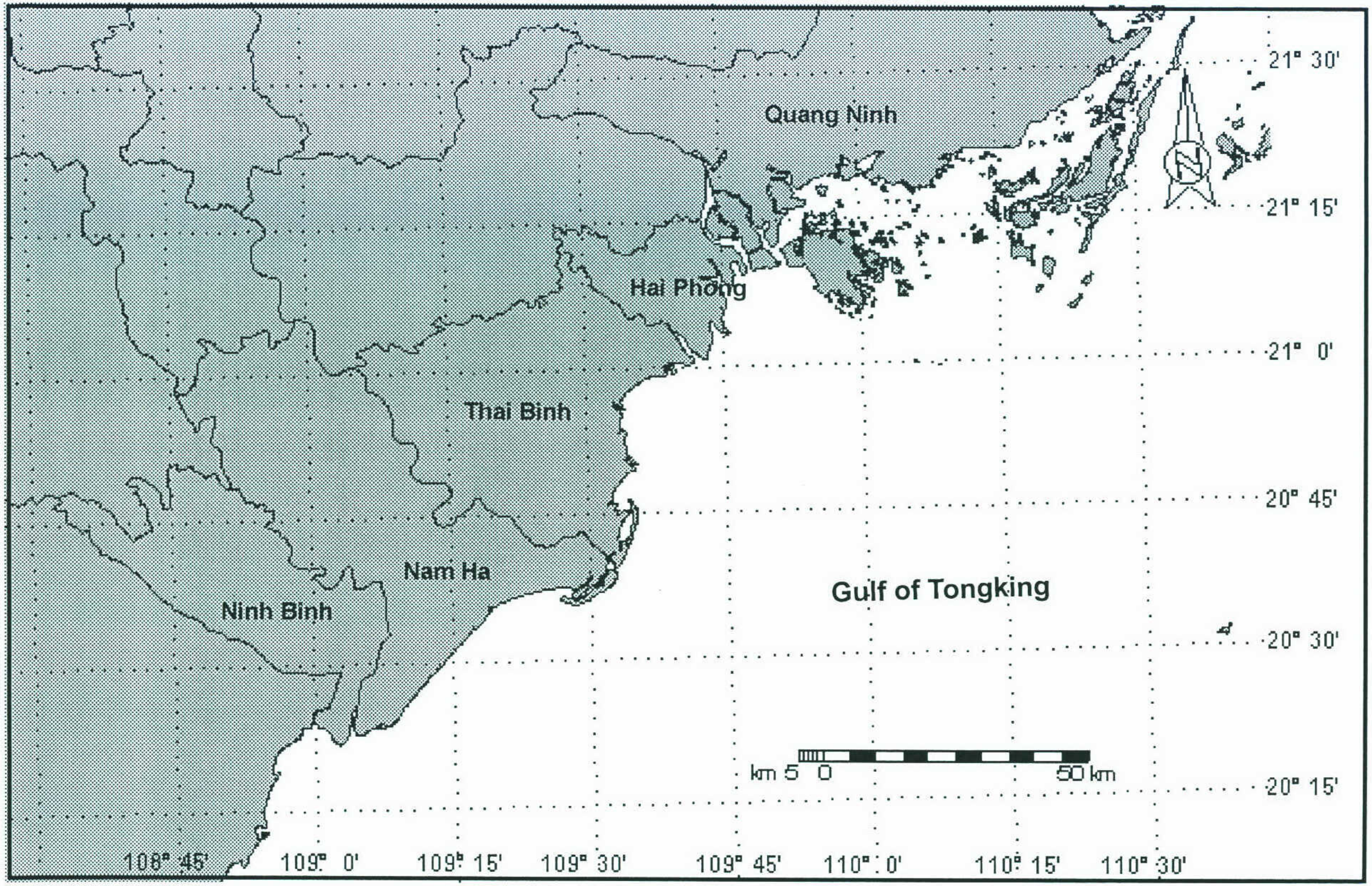
Photo 9 *Backside crest erosion due to overtopping near Hai Thrieu*

Photo 10 *Landuse between double dyke system, salt pans*

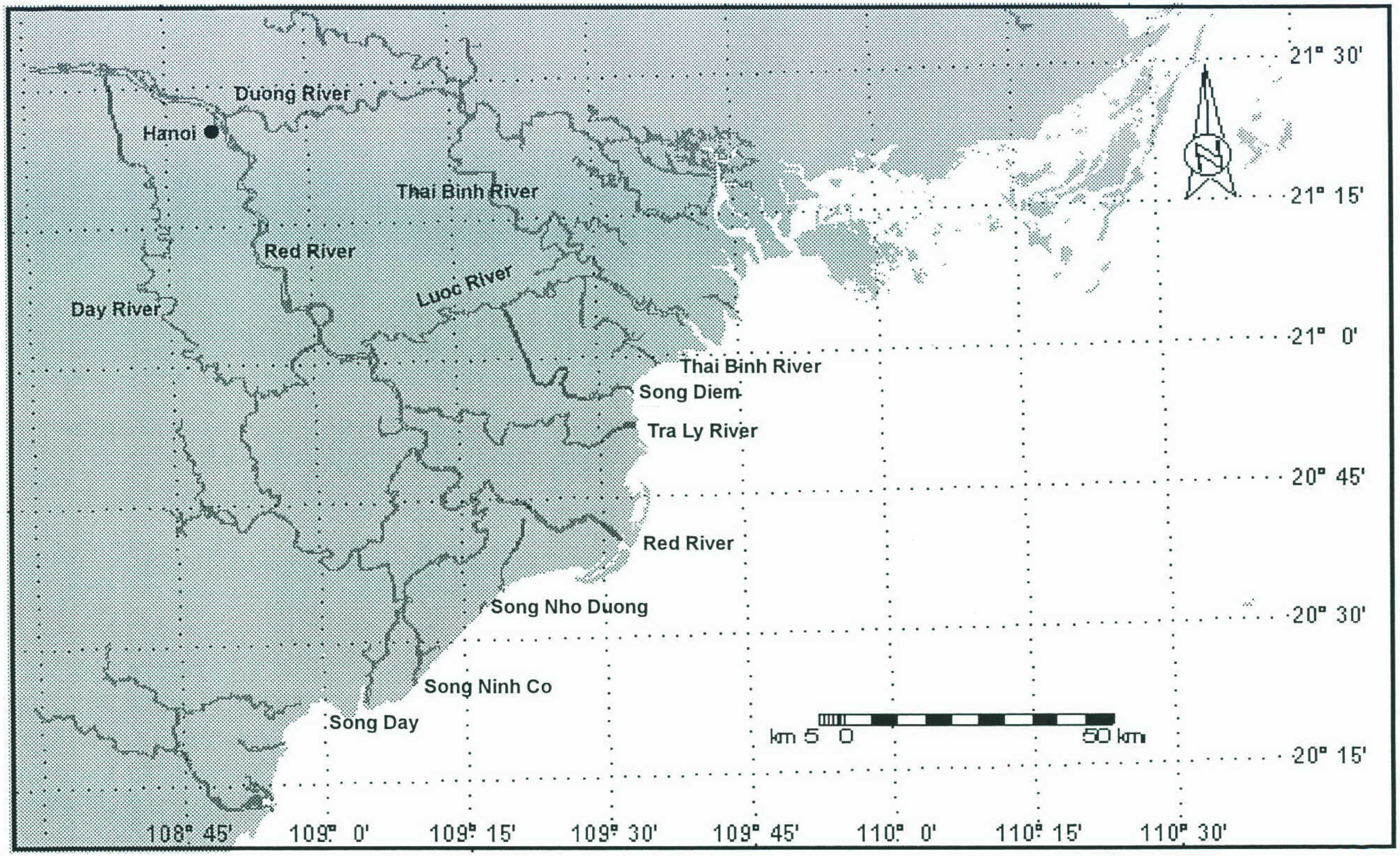
Photo 11 Village Hai Thrieu (between both dykes)

Photo 12 Construction of new pretection on second dyke, Hai Thrieu

FIGURES



Red River Delta		
Vietnam Vulnerability Assessment Project		Figure 1.1



Vietnam Vulnerability Assessment Project		Figure 2.1

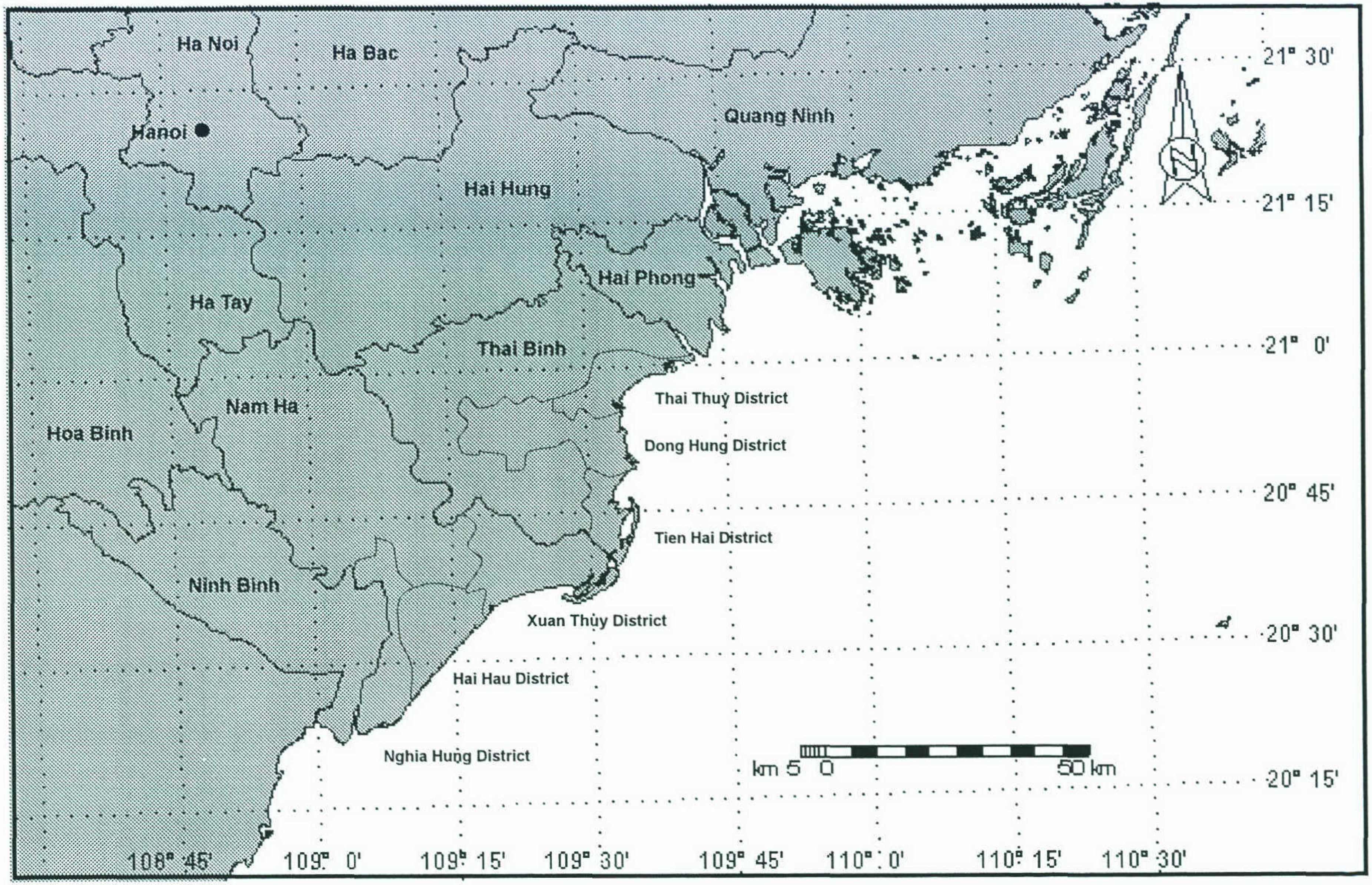


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Figure 2.2

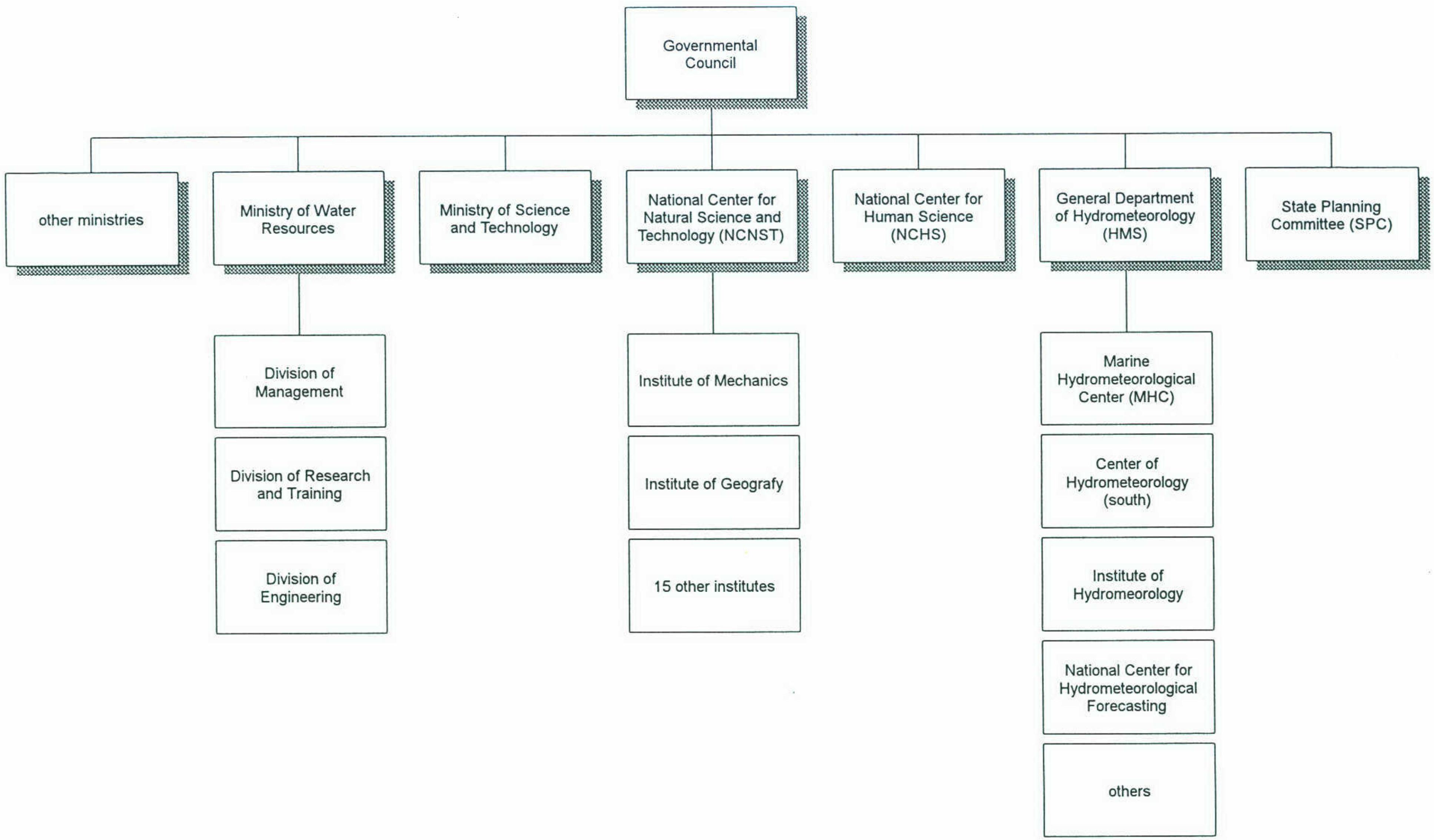

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Figure 2.3

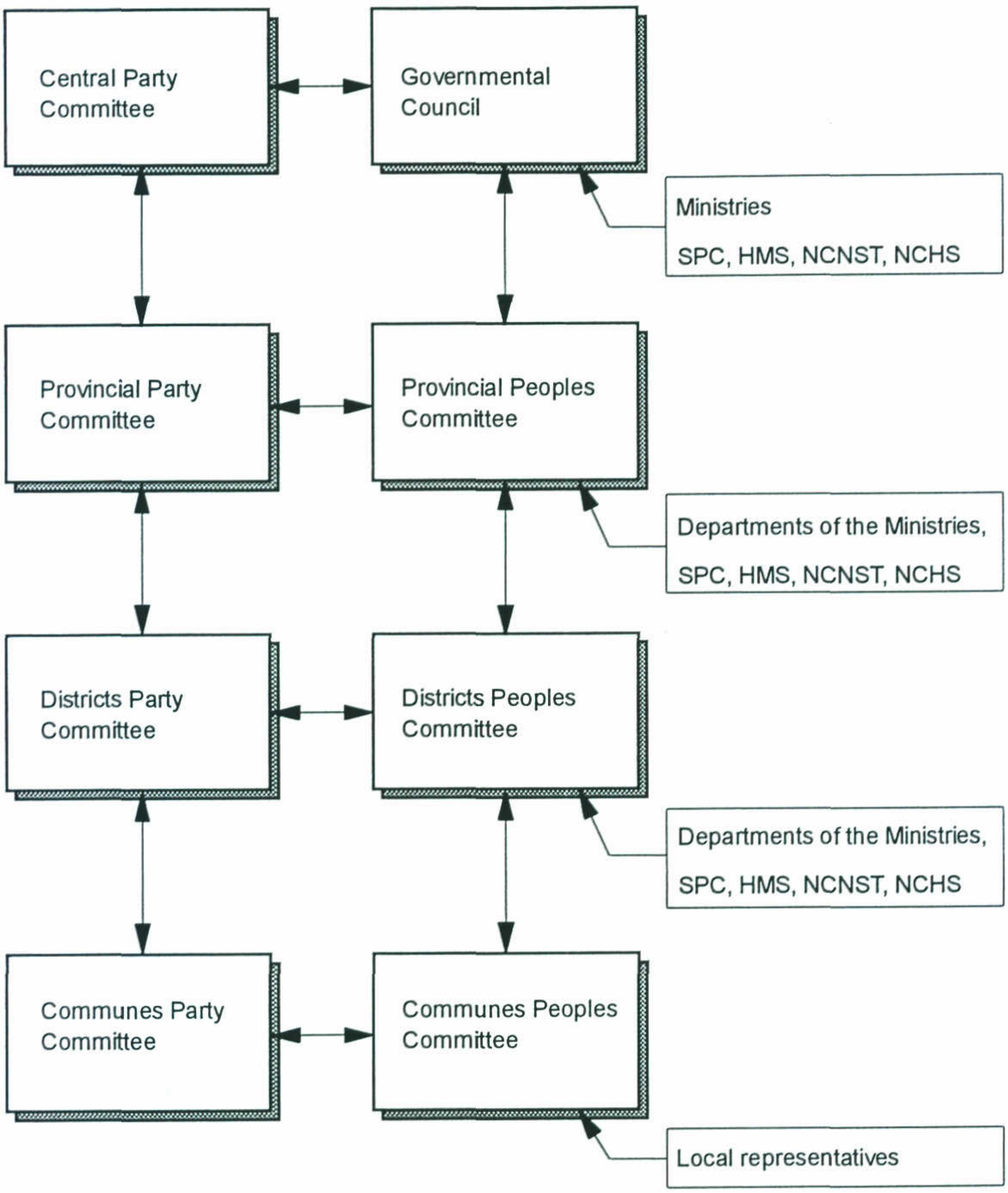

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Figure 2.4

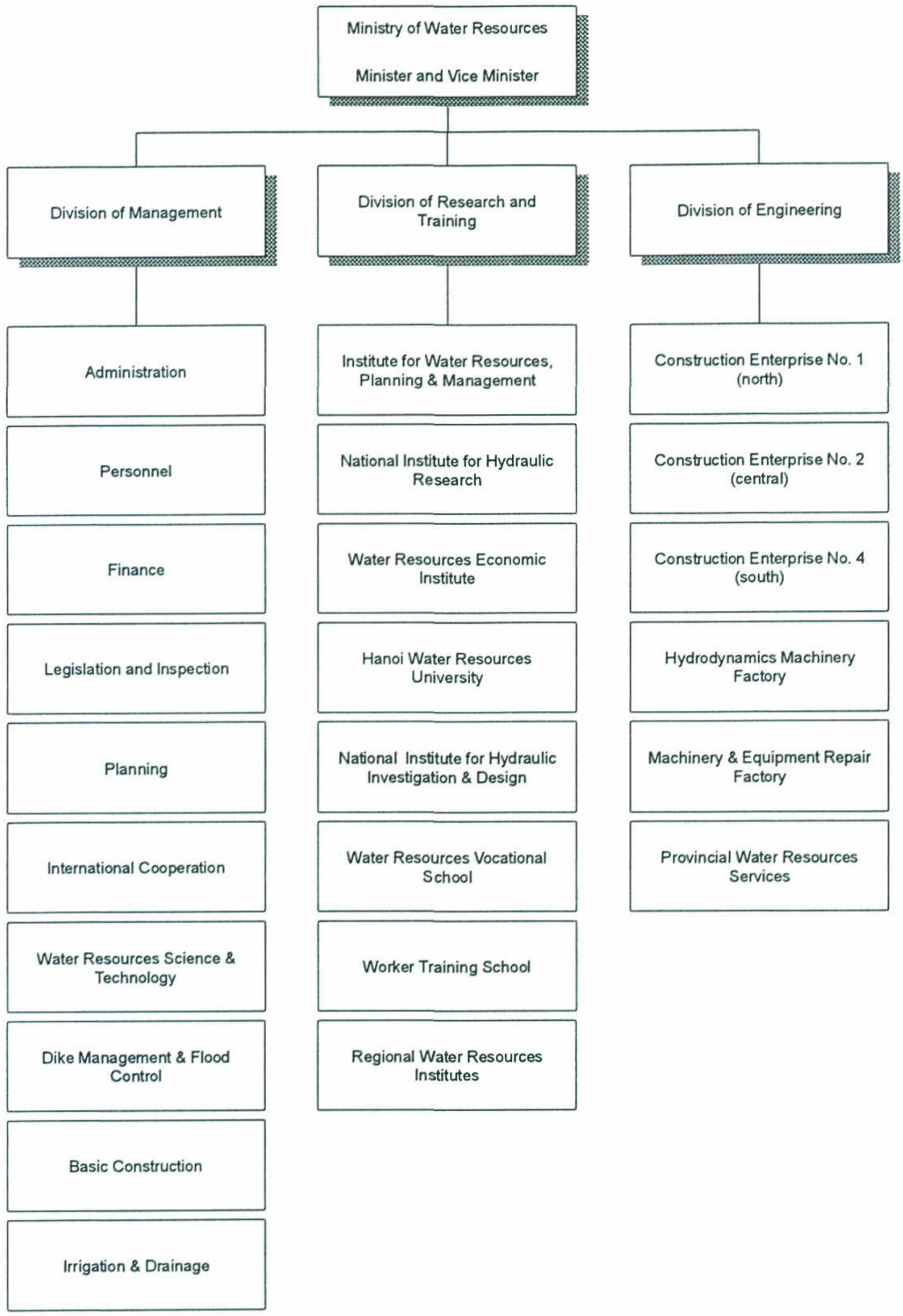

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Figure 2.5

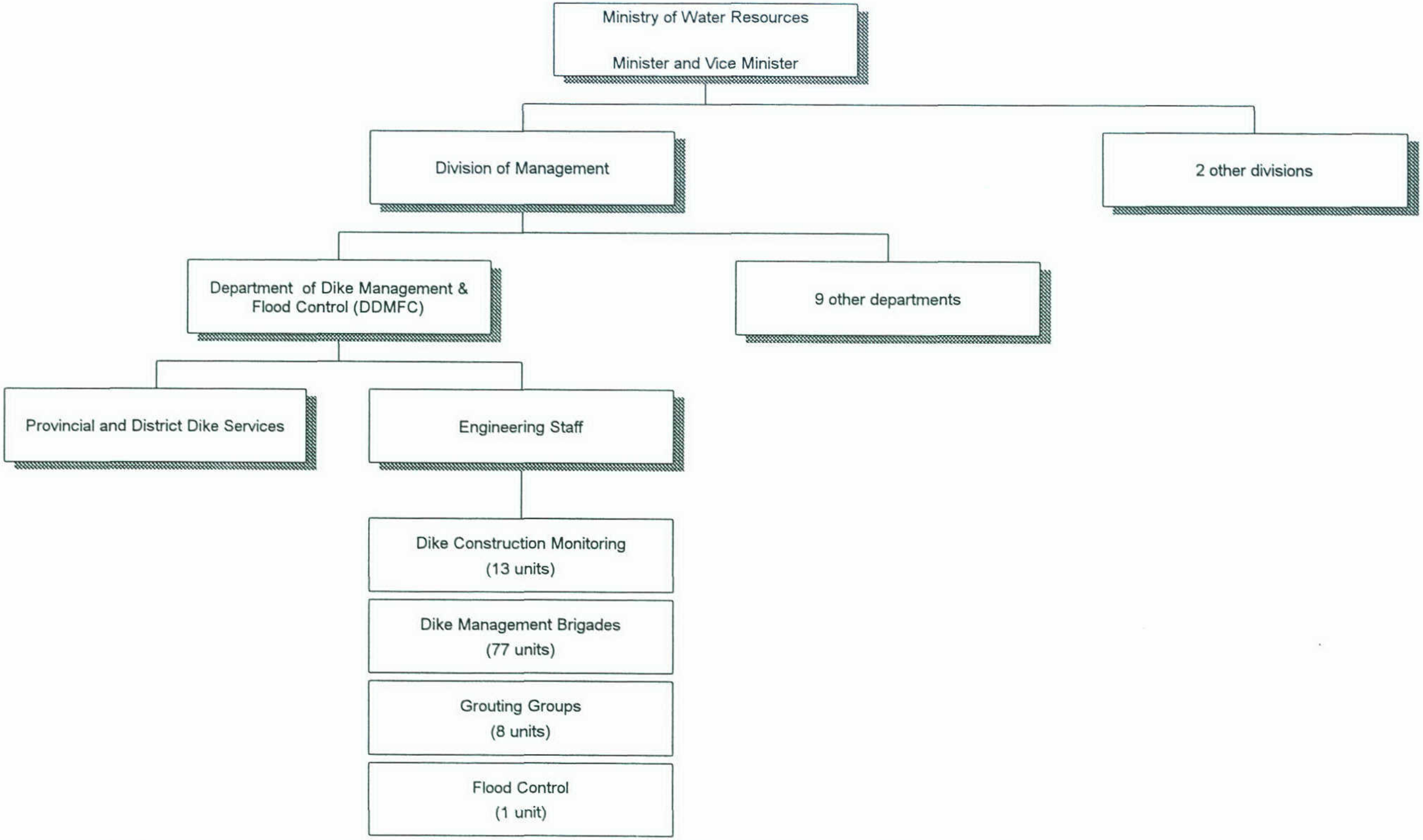

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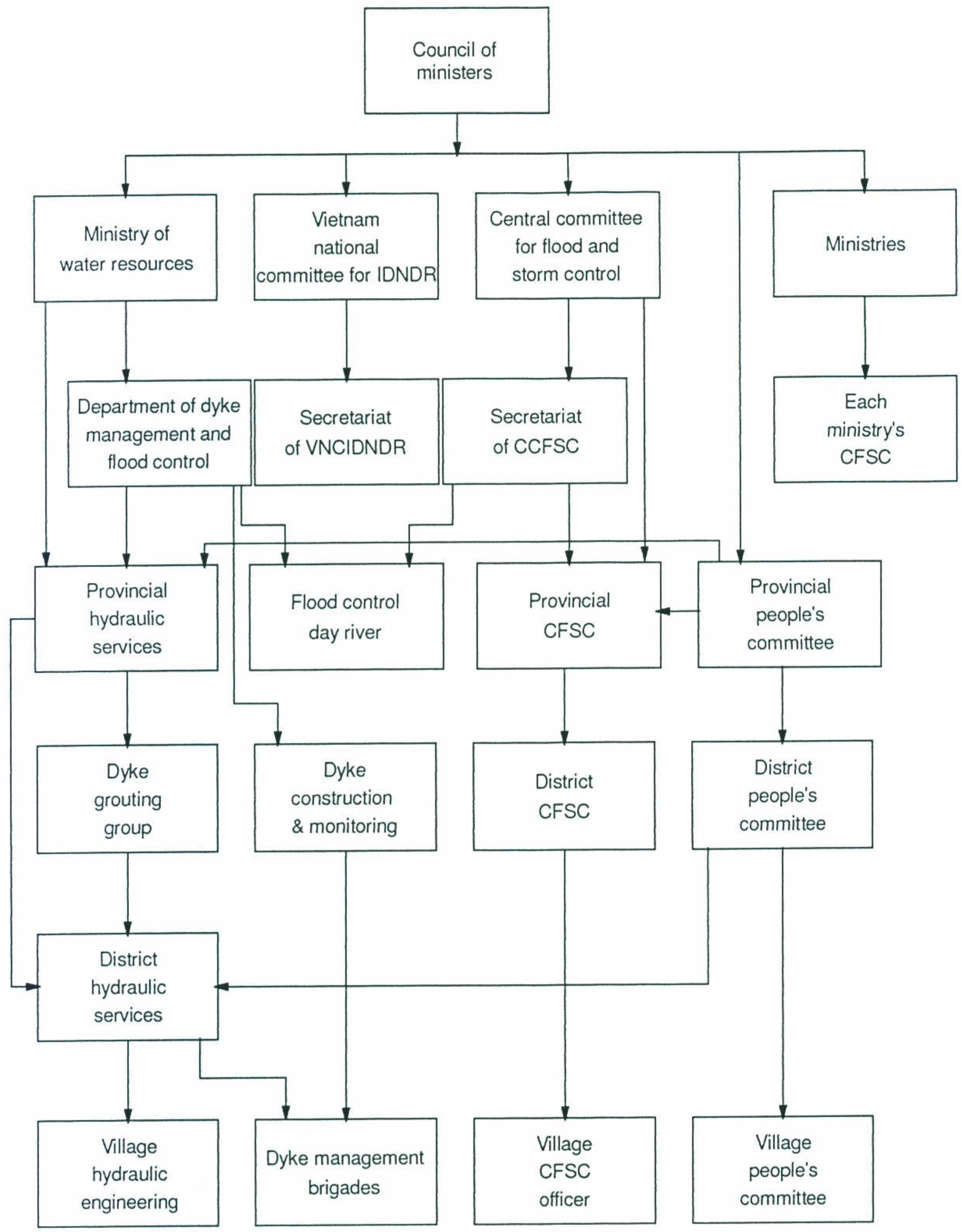
Figure 2.6

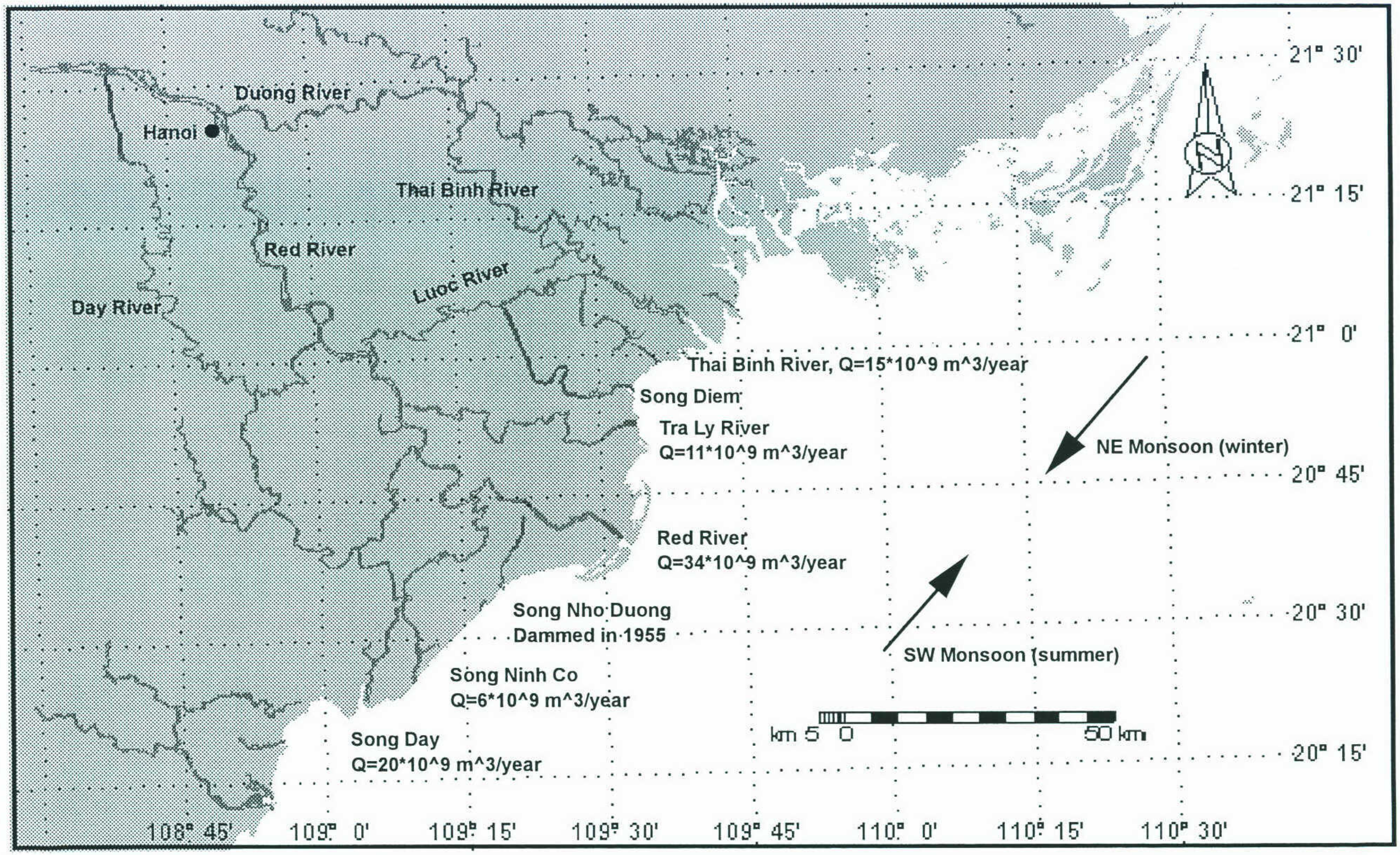


from: Strategy and Action Plan for Mitigating Water Disasters in Vietnam, DHA, UNDP and MWR, Hanoi 1994 [lit 6]

Institutional structure for combating the annual effects of floods and typhoons

Vietnam Vulnerability Assessment Project

Figure 2.7



Site conditions

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Figure 2.8

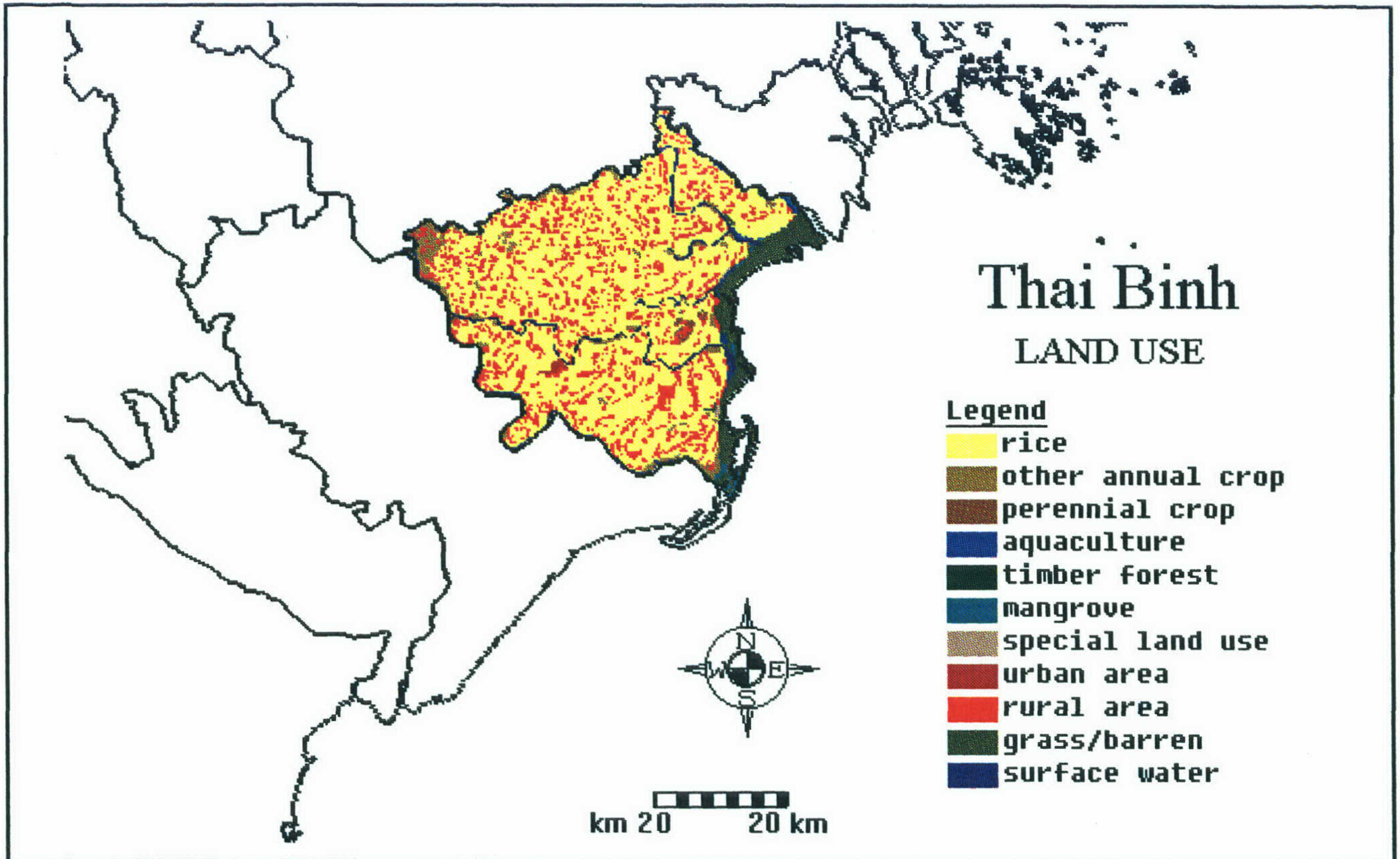

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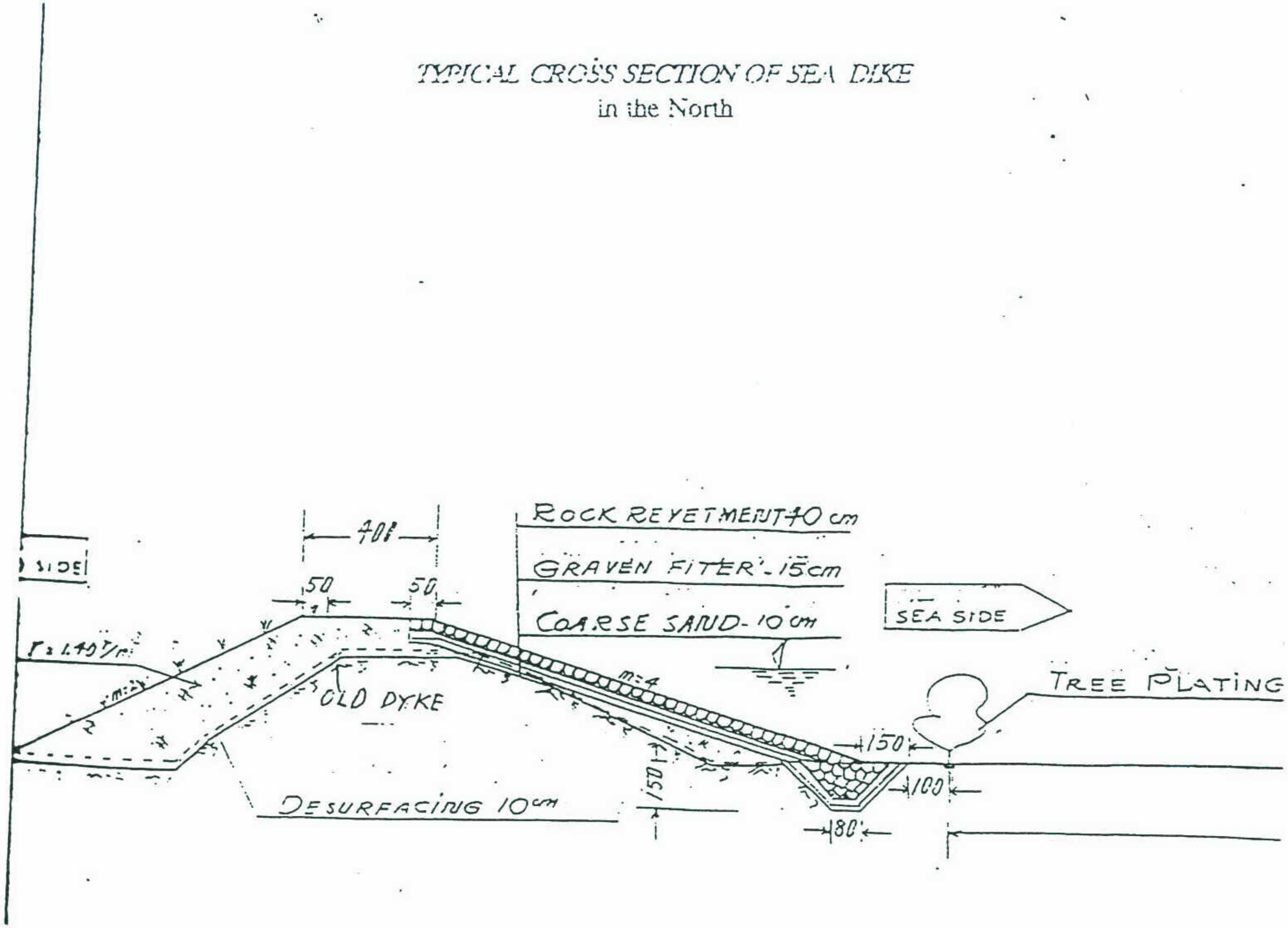
Figure 2.9



Typical dyke cross section	
Vietnam Vulnerability Assessment Project	Figure 2.10

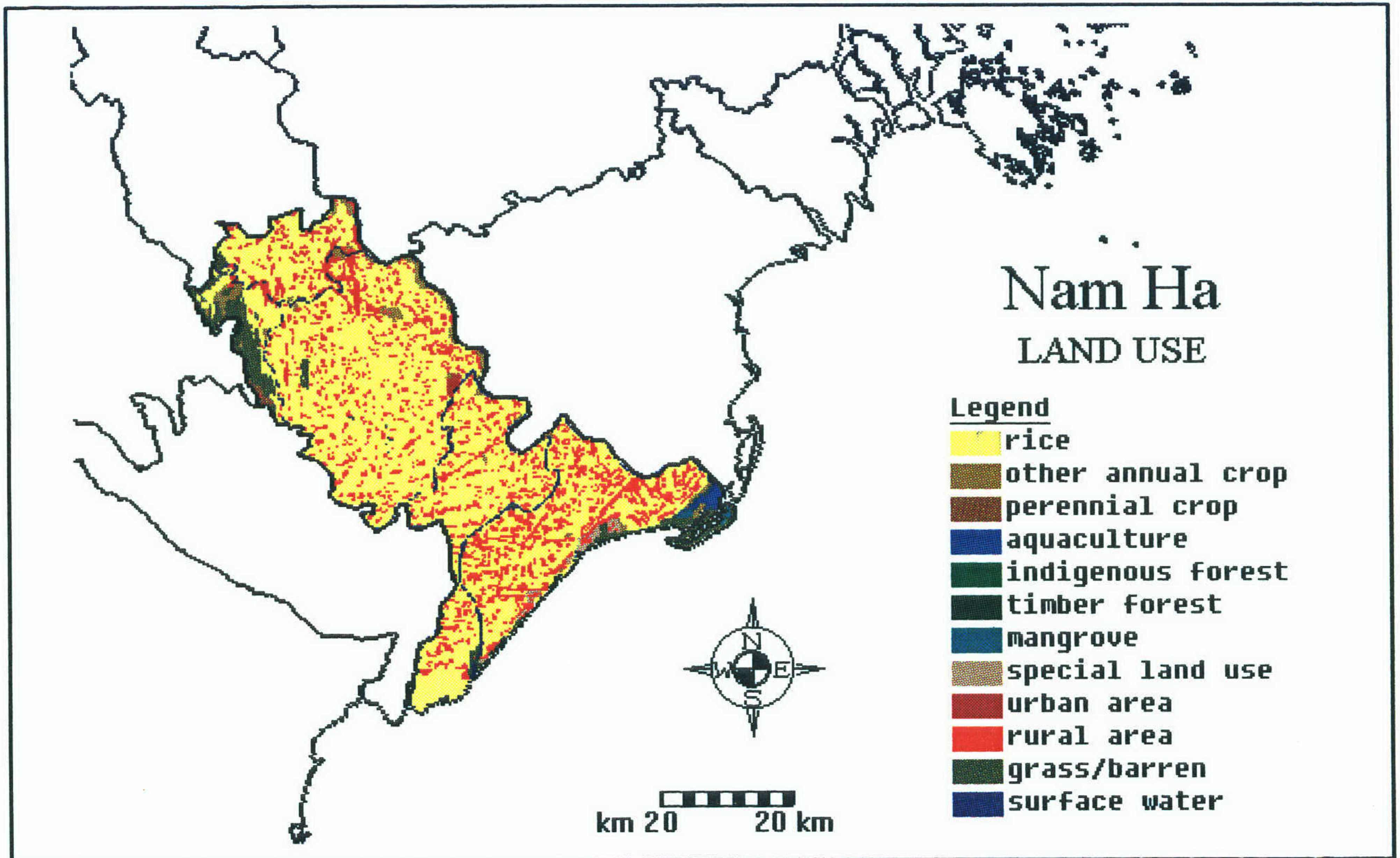


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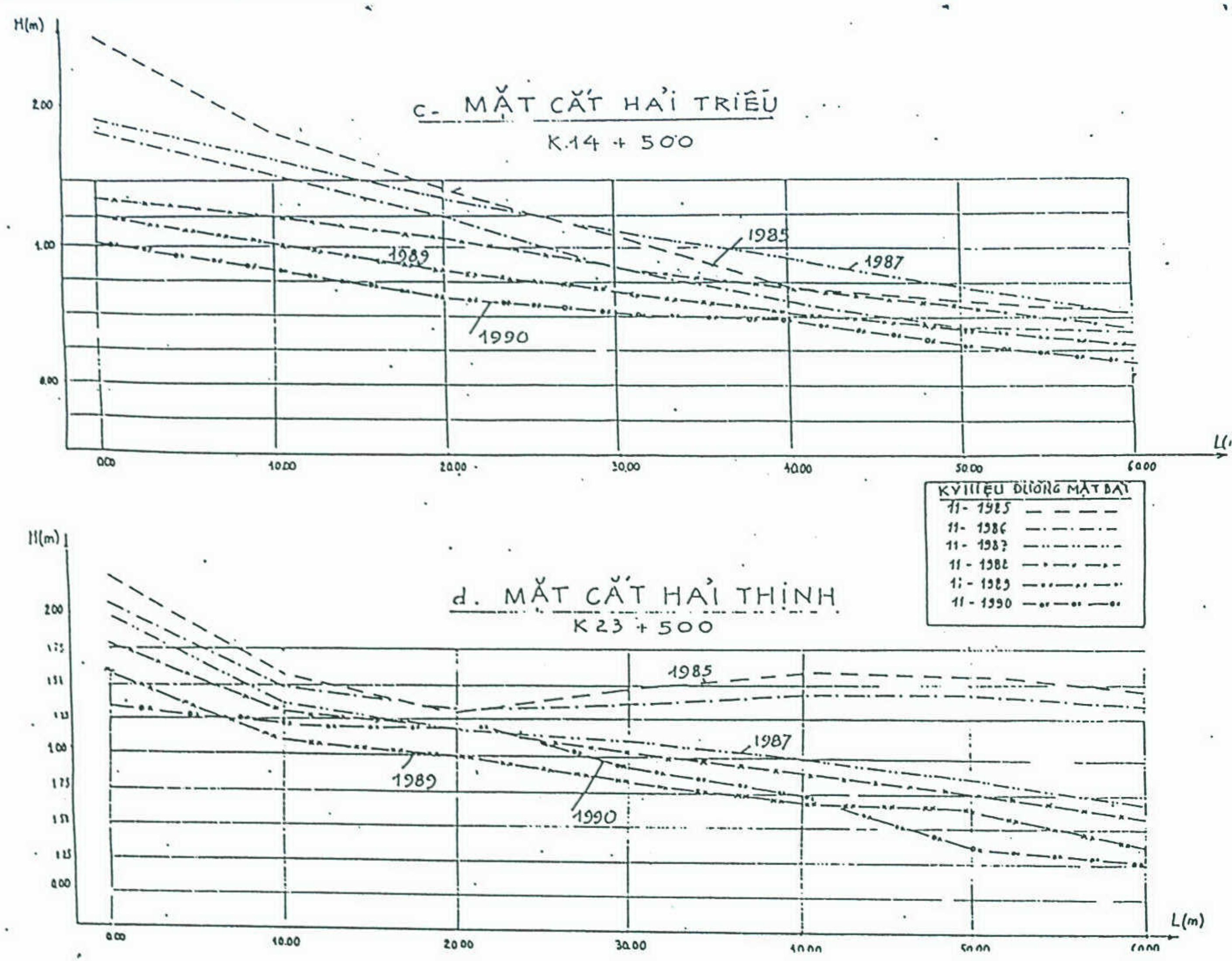
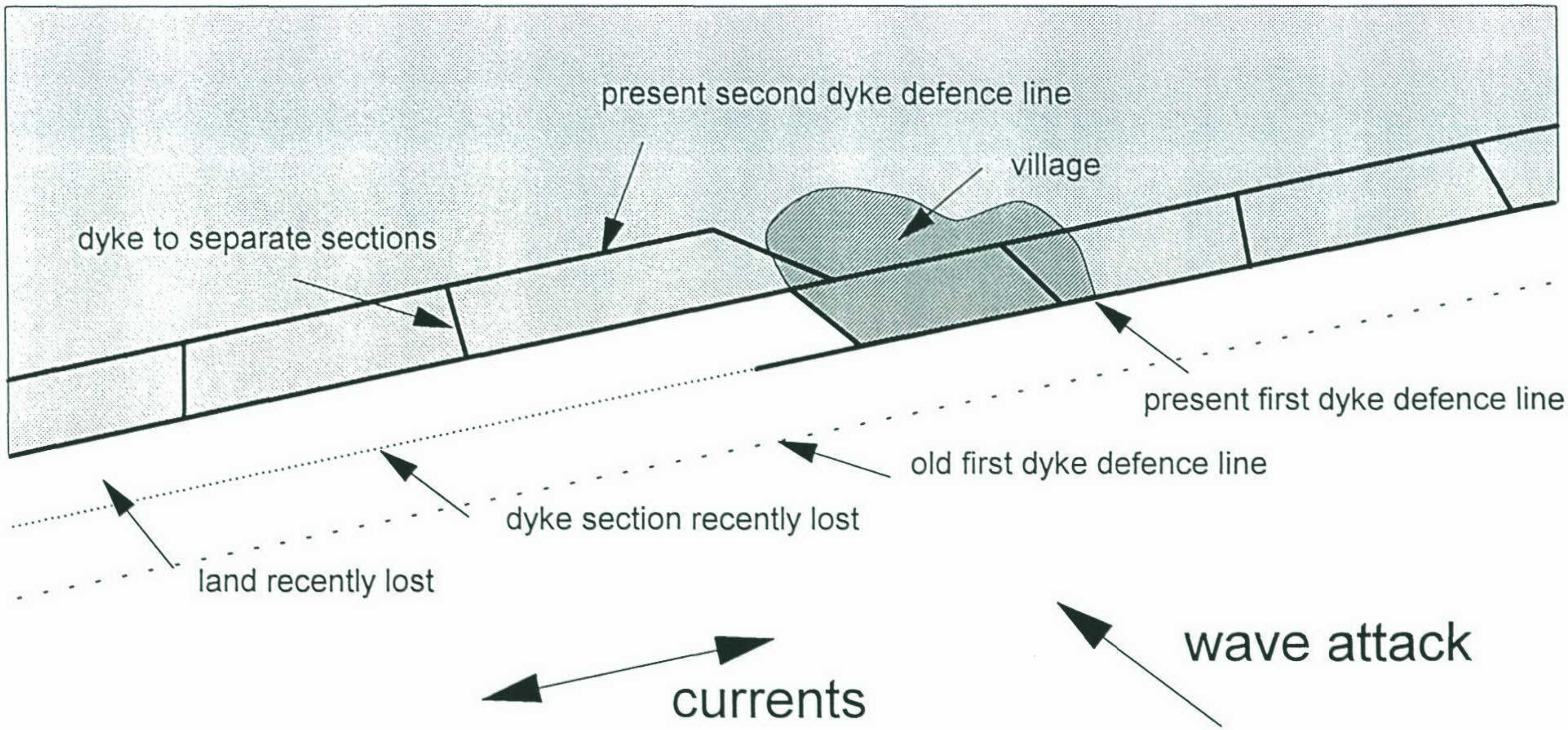
Figure 2.11

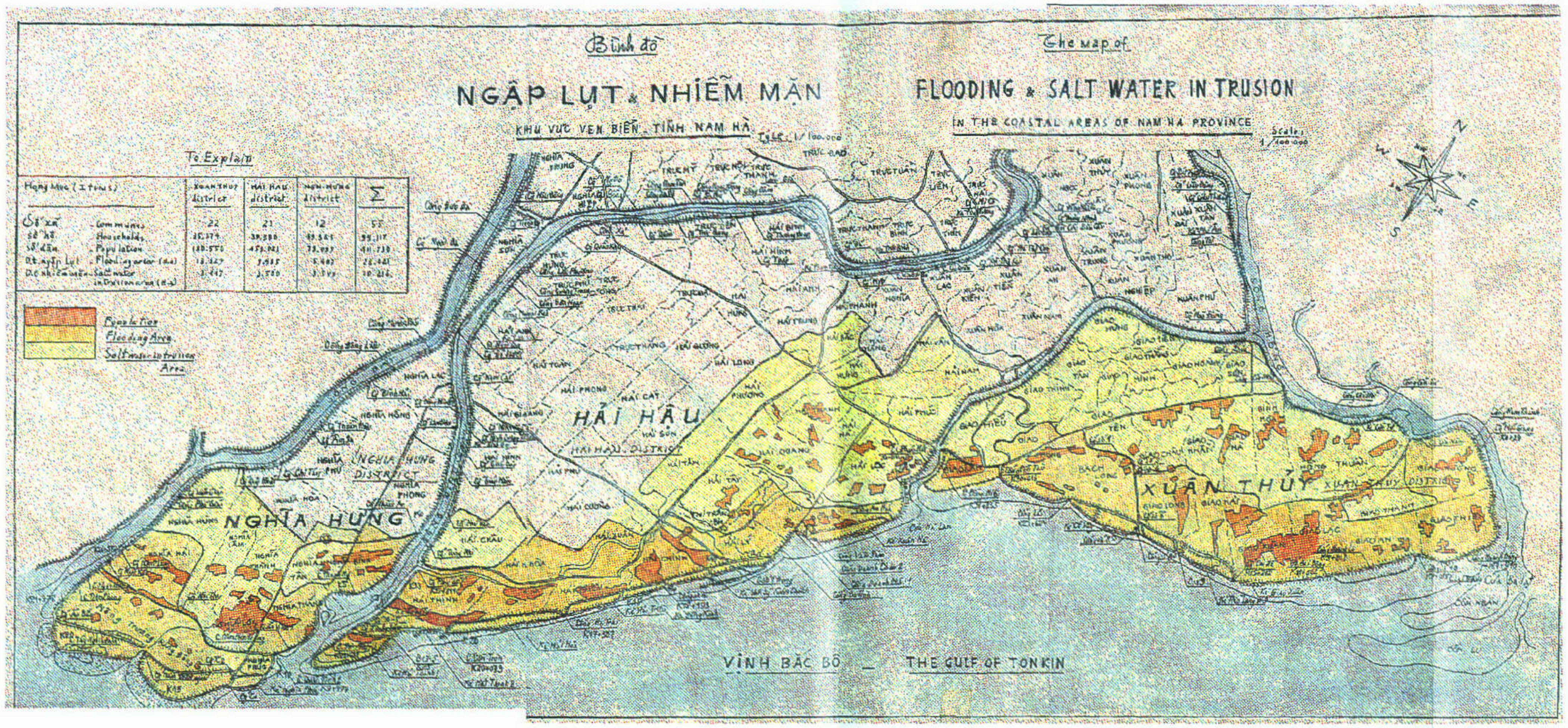


Source: National Institute of Hydraulic Research

Profile survey results		
Vietnam Vulnerability Assessment Project		Figure 2.12



Double dyke strategy		
Vietnam Vulnerability Assessment Project		Figure 2.13



Flooding and salt intrusion, Nam Ha province

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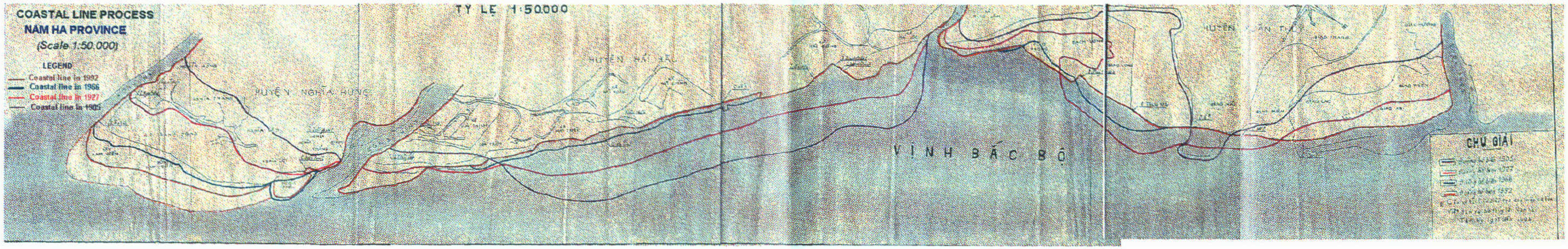
Figure 2.14



Nam Ha coastline development, 1905 - 1992

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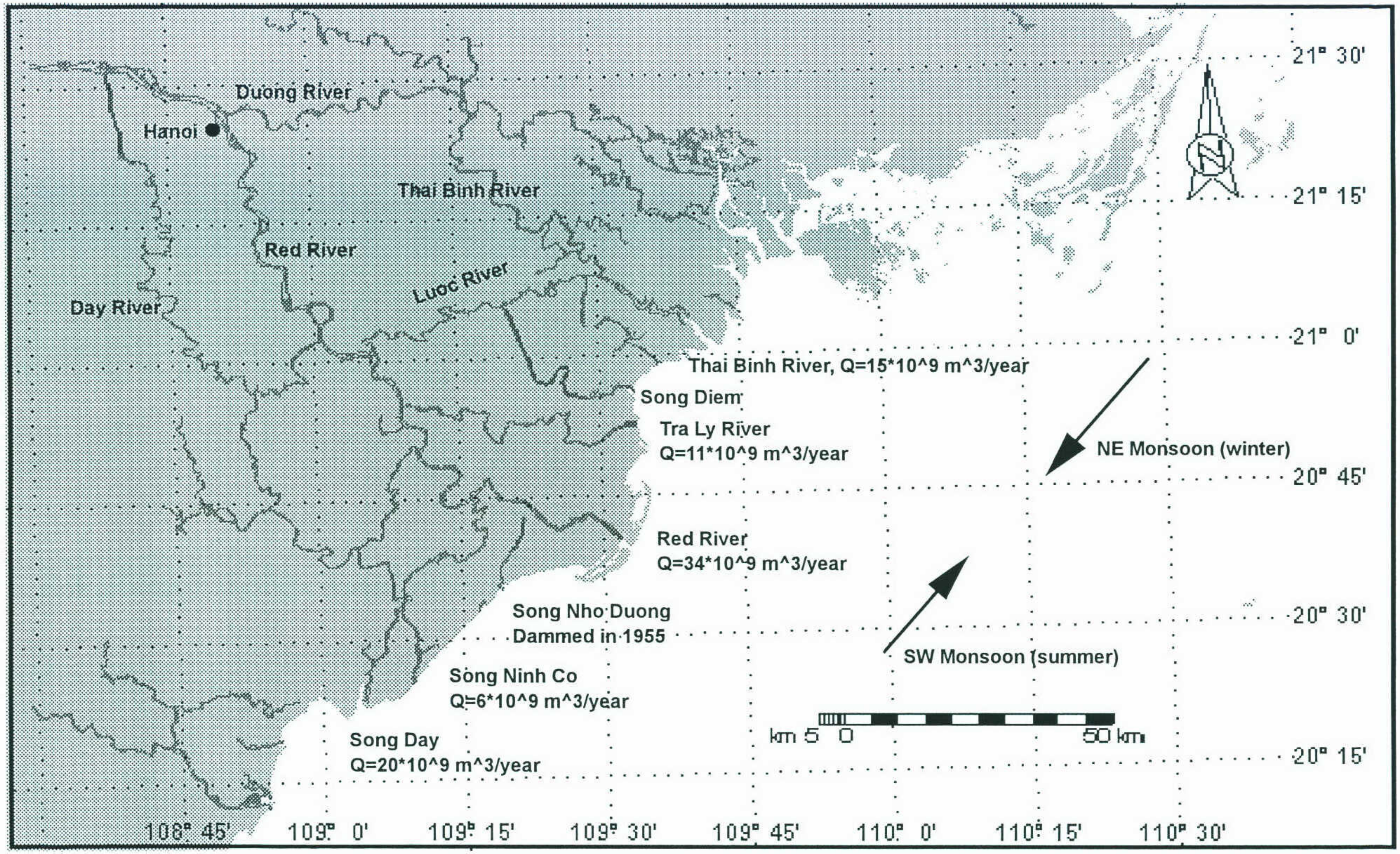
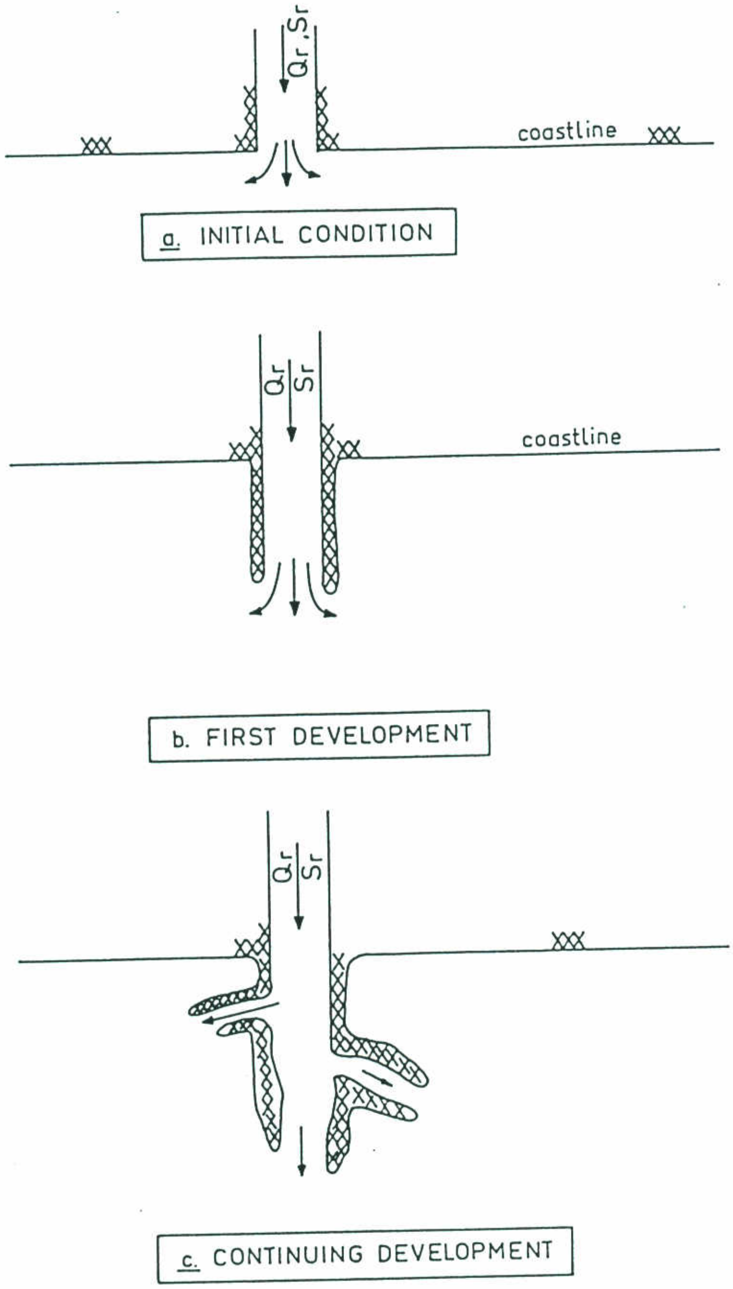
Figure 2.15

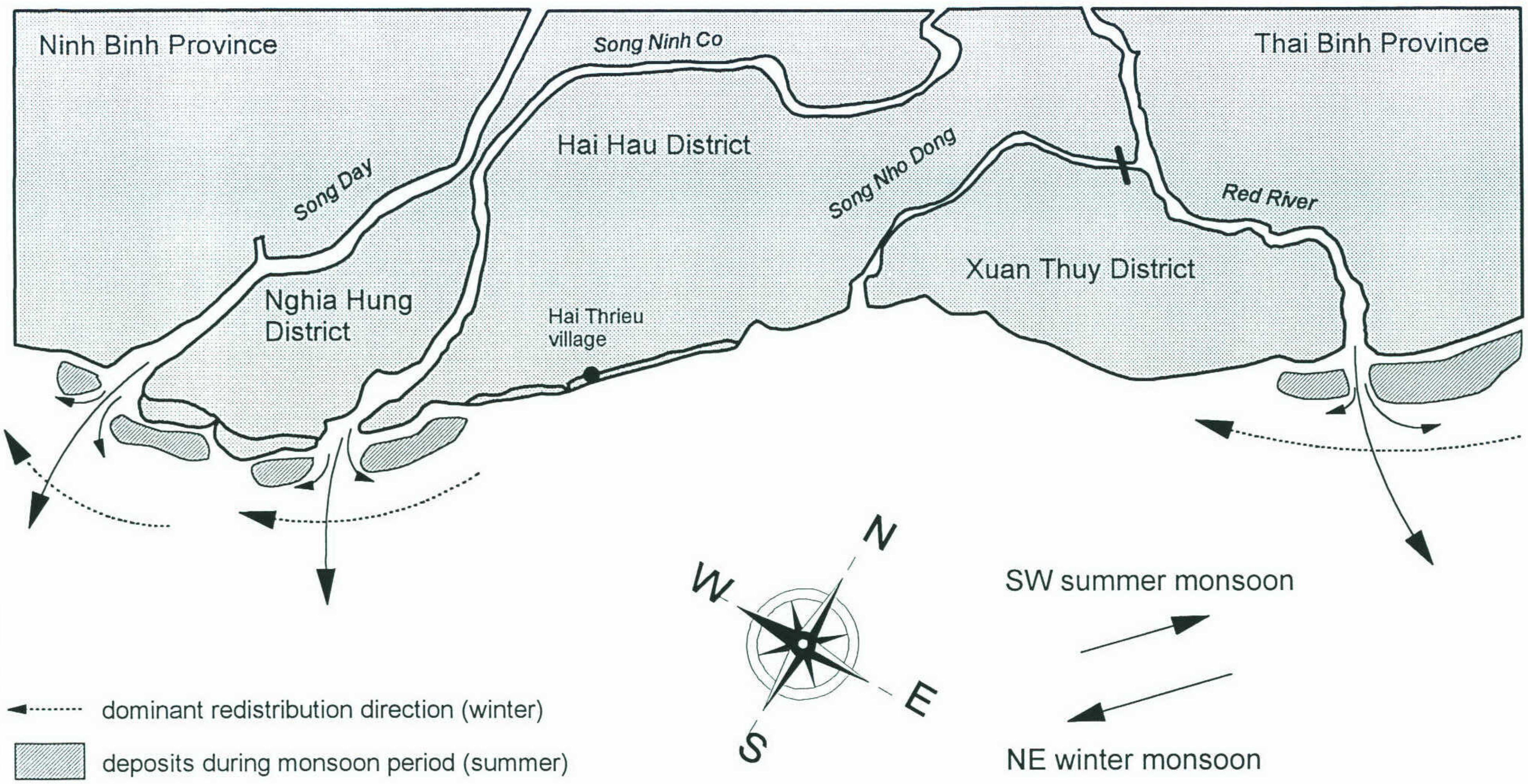


Yearly sediment budget and redistribution		
Vietnam Vulnerability Assessment Project		Figure 3.1



Typical (initial) delta development

Vietnam Vulnerability Assessment Project | Figure 3.2



Sediment deposit and redistribution patterns

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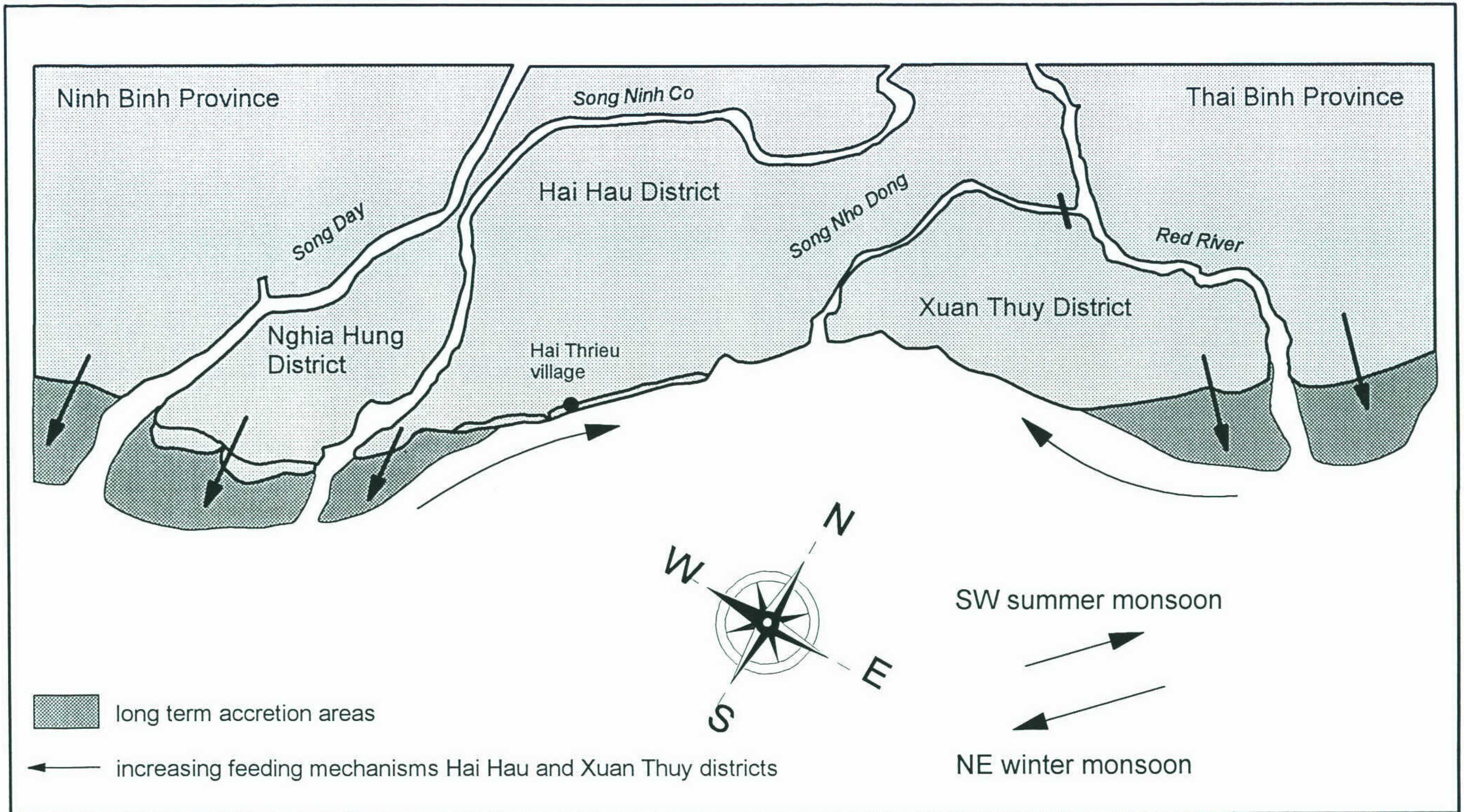
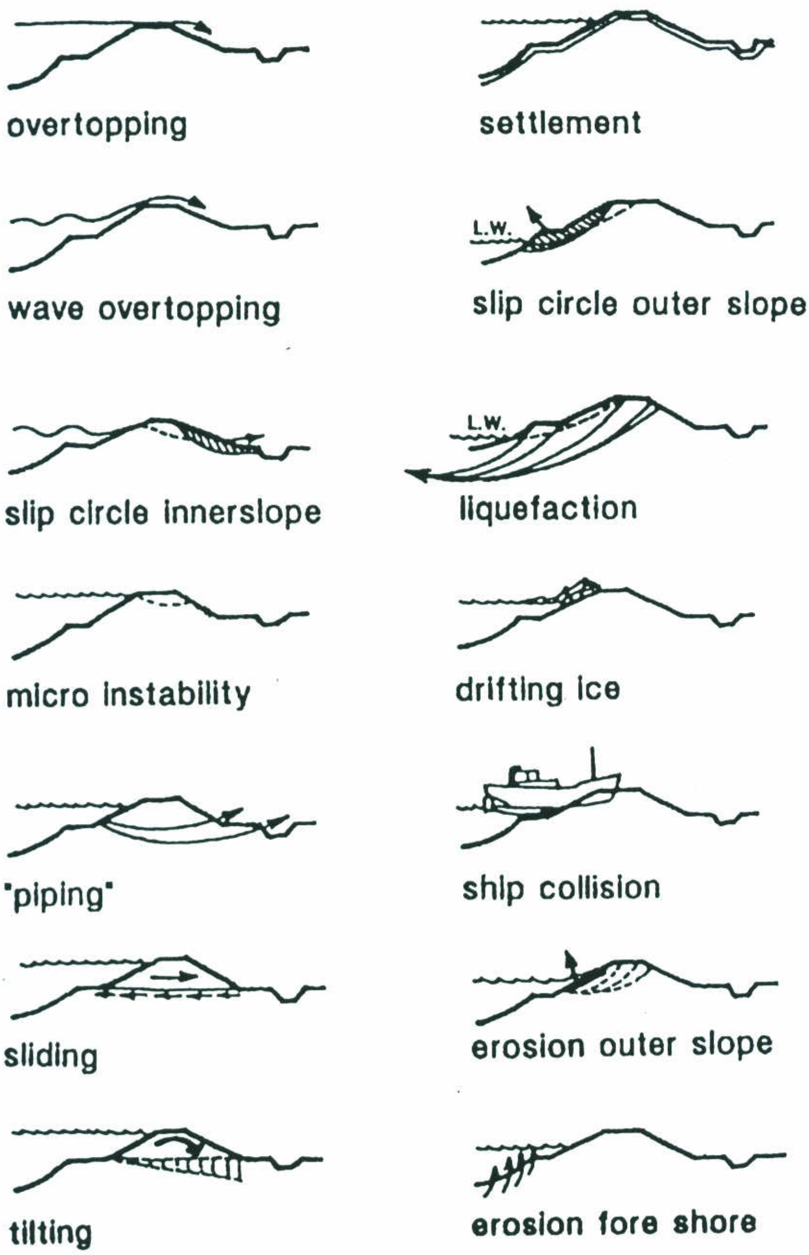
Figure 3.3



Increasing feeding mechanisms Hai Hau and Xuan Thuy Districts (long term)		
Vietnam Vulnerability Assessment Project		**Figure 3.4**



from: Coastal Protection, proceedings of the short course on coastal protection, Delft University of Technology, K.W. Pilarczyk, 1990.

Dyke failure mechanisms

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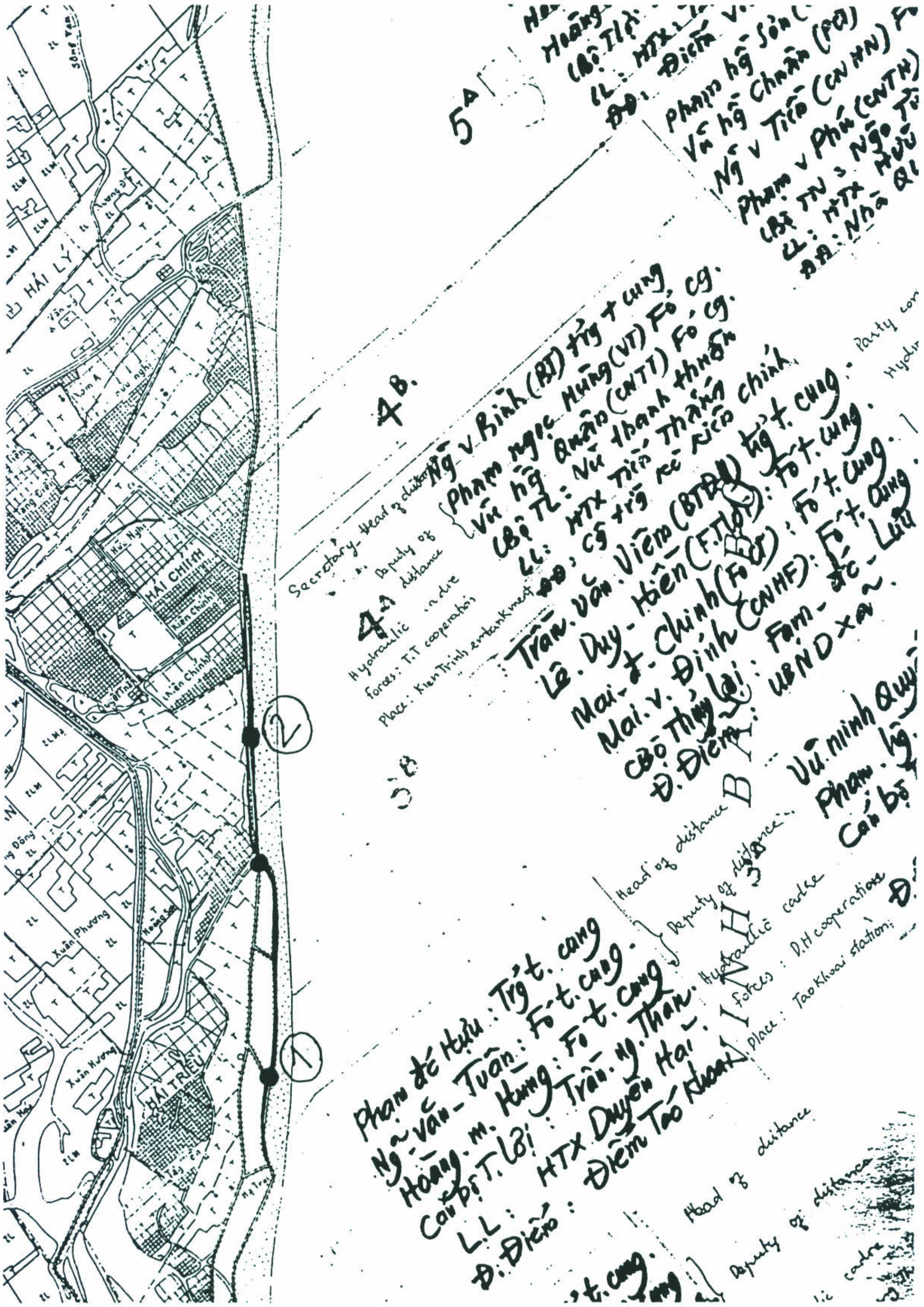
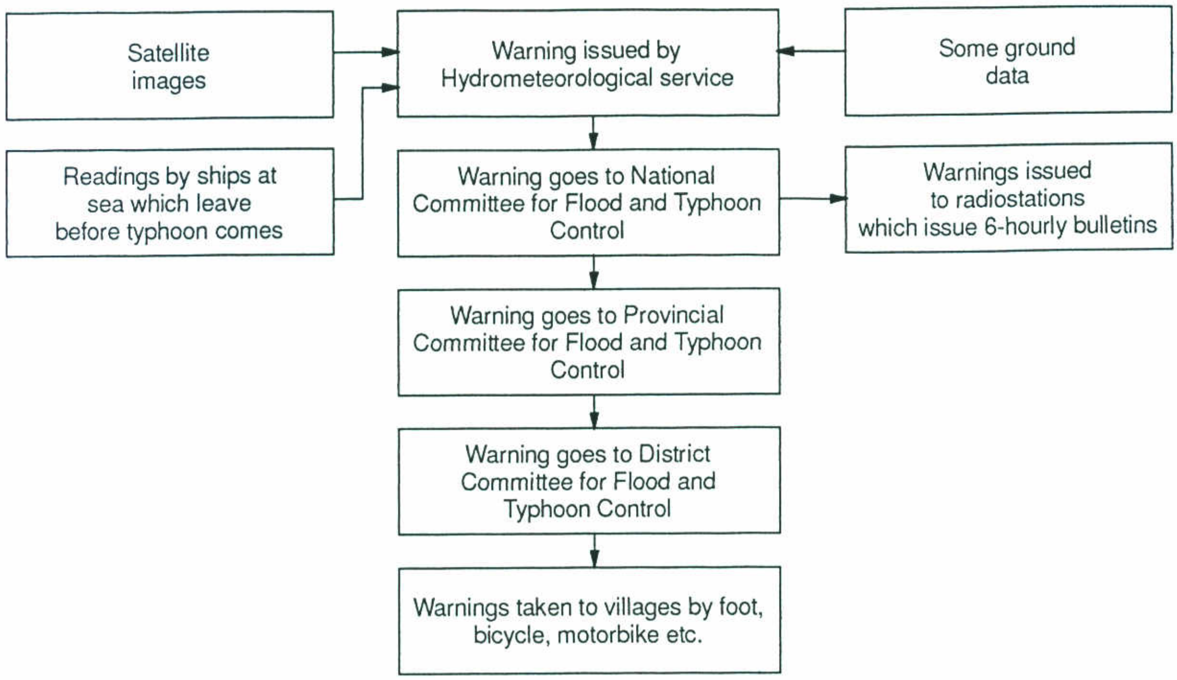
Figure 3.5



Local dyke monitor teams		
Vietnam Vulnerability Assessment Project		Figure 3.6



from: Strategy and Action Plan for Mitigating Water Disasters in Vietnam, DHA, UNDP and MWR, Hanoi 1994 [lit 6]

Warning procedures

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Figure 3.7