CHAPTER 6 AN ASSESSMENT OF CAUSES, IMPACTS AND EVALUATION OF RESPONSE OPTIONS

The landmass of Rungkup is subject to the natural processes of erosion, deposition and flooding. Over the centuries, people have utilised most of the land to suit their needs, and in doing so, have created a need to keep some of the more damaging effects of these natural processes at bay. This chapter deals with the physical processes involved, their interrelationships and our developing understanding of them. It also deals with the risk they pose to people and their environment.

6.1 Causes of Bund Failure

6.1.1 Land Conversion

In the peninsula of Rungkup, most of the mangrove forest has been converted for agriculture, mostly for palm plantation. Coastal mangrove forests because of their saline nature, often acidic and anaerobic soils, have been traditionally thought to be marginally suitable for agriculture. However with improvements in amelioration of the saline and acidic mangrove soils (Kanapathy 1971) and the ever-increasing demand for arable land, mangrove forestland was viewed as one of the major alternatives for increasing arable land in the country.

Historical records of Rungkup coastline are shown in Figures 6.1, 6.2, 6.3 and 6.4. From historical surveys, tidal land conversion started as early as 1940s where an area enclosed by bunds from Sg. Batang to Bagan Pasir Laut had been well cleared and coconuts as well as vegetables have been planted (Figure 6.1).

The largest percentage gain of mangrove from 1941 to 1964 were recorded in Sg. Tiang and Sg. Belukang with a rate of advance of about 0.024km per year and a total gain of 2.1km^2 for the period of 25 years.

In response to the increasing shortage of land suitable for agriculture, the Perak Government had pursued a major programme of land conversion in Rungkup. The extensive stretches of bunded mangrove were fallen for the development of land scheme in 1969 (Figure 6.2 and Figure 6.5) (JPT 1974). Total loss of mangrove for that period was about 24.7km^2.

The mangrove belt continues to contract after the major land conversion from 7.4km^2 in 1972 to 6.1km^2 in 1985. The greatest loss of mangroves was recorded in Sg. Tiang and Sg. Belukang with a total loss of 1.4km^2 and 2.1km^2 respectively (Figure 6.3).

Overall mangrove changes between 1941 and 1985 is shown in Figure 6.4. The mangrove aligned coastlines were evidently prograding and retrograding along various stretches. The seaward advance and retreat are found to vary at all places. From 1941 to 1984 it is calculated that a net of 3.2km^2 of mangrove land had prograded. Only about 2.9km^2 of mangrove forests remained stable and a total loss of about 27.3km^2 throughout the period. The greatest loss occurred in Sg. Tiang and Sg. Belukang throughout the 44-year period with a maximum length of retreat of 2.4km in Sg. Belukang.

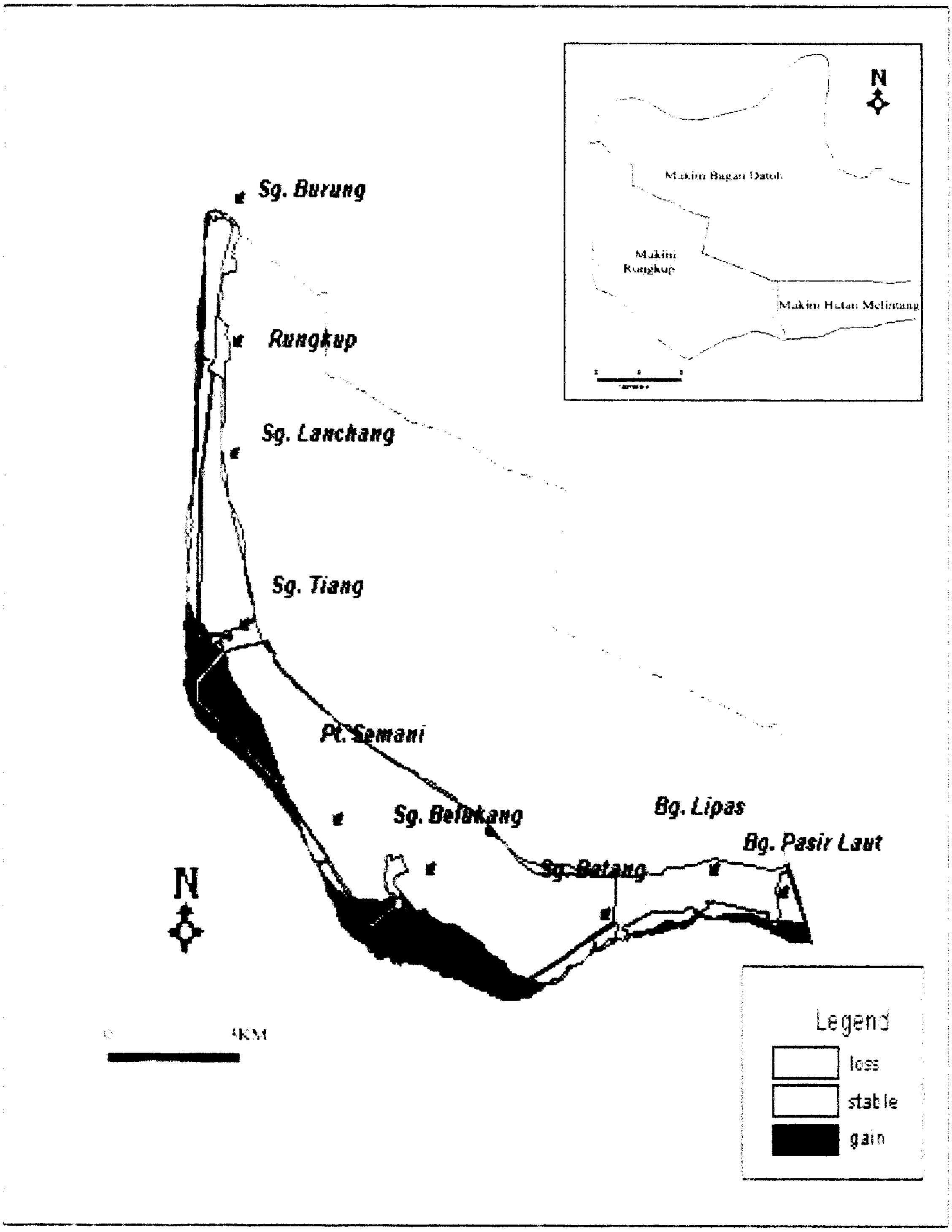

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Figure 6.1. Mangrove changes (1941-1964)

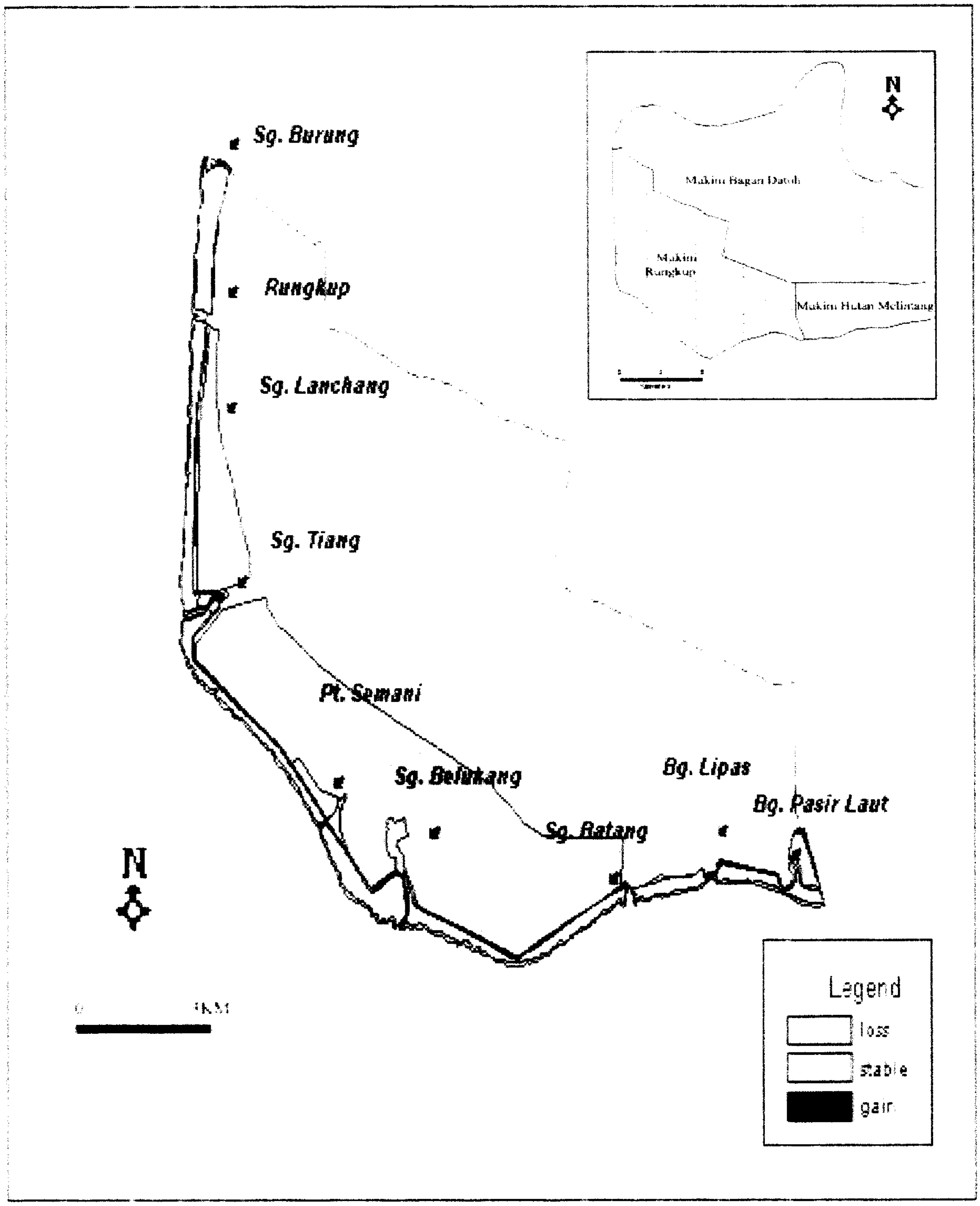

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Figure 6.2. Mangrove changes (1964-1972)

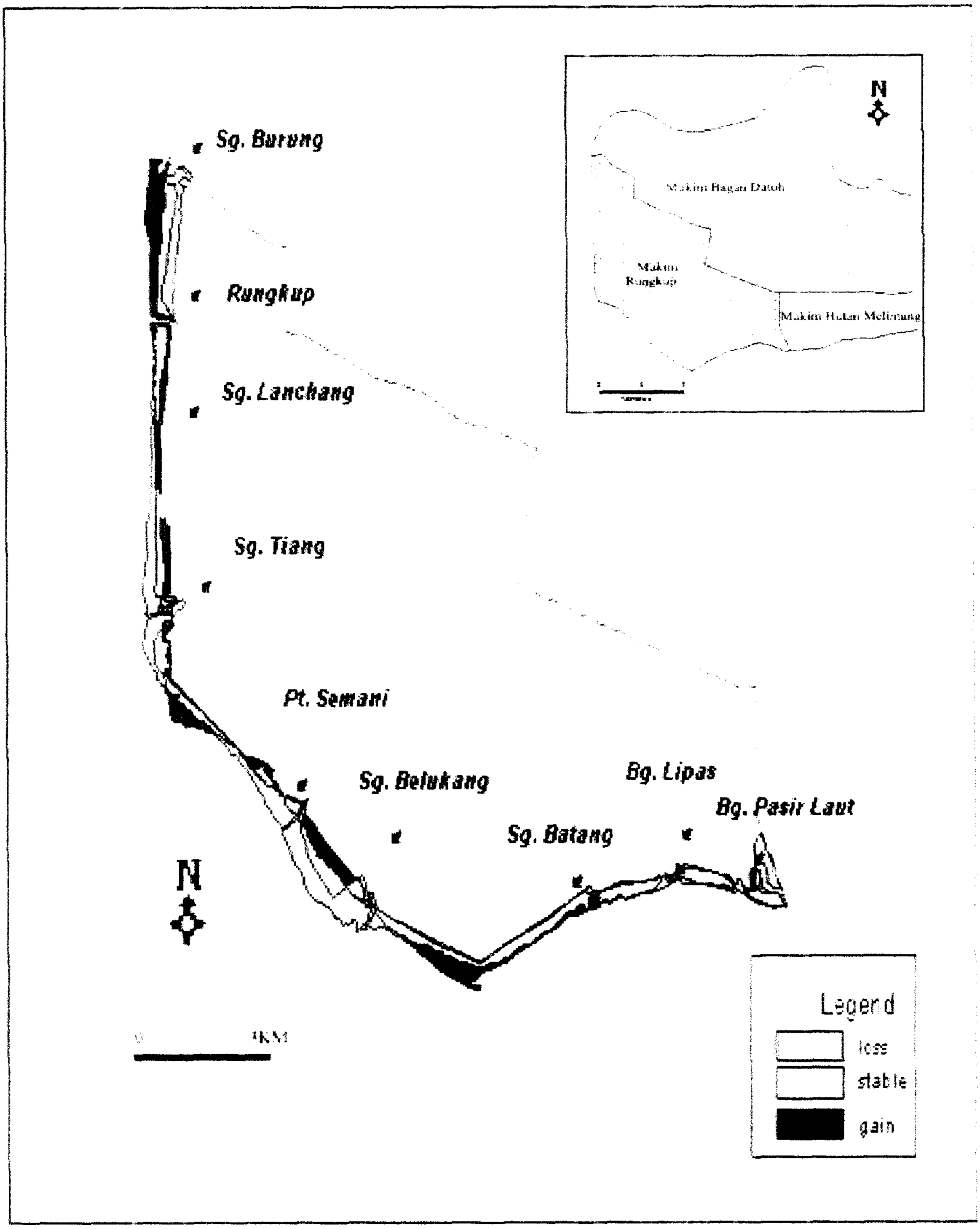

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Figure 6.3. Mangrove changes (1972-1985)

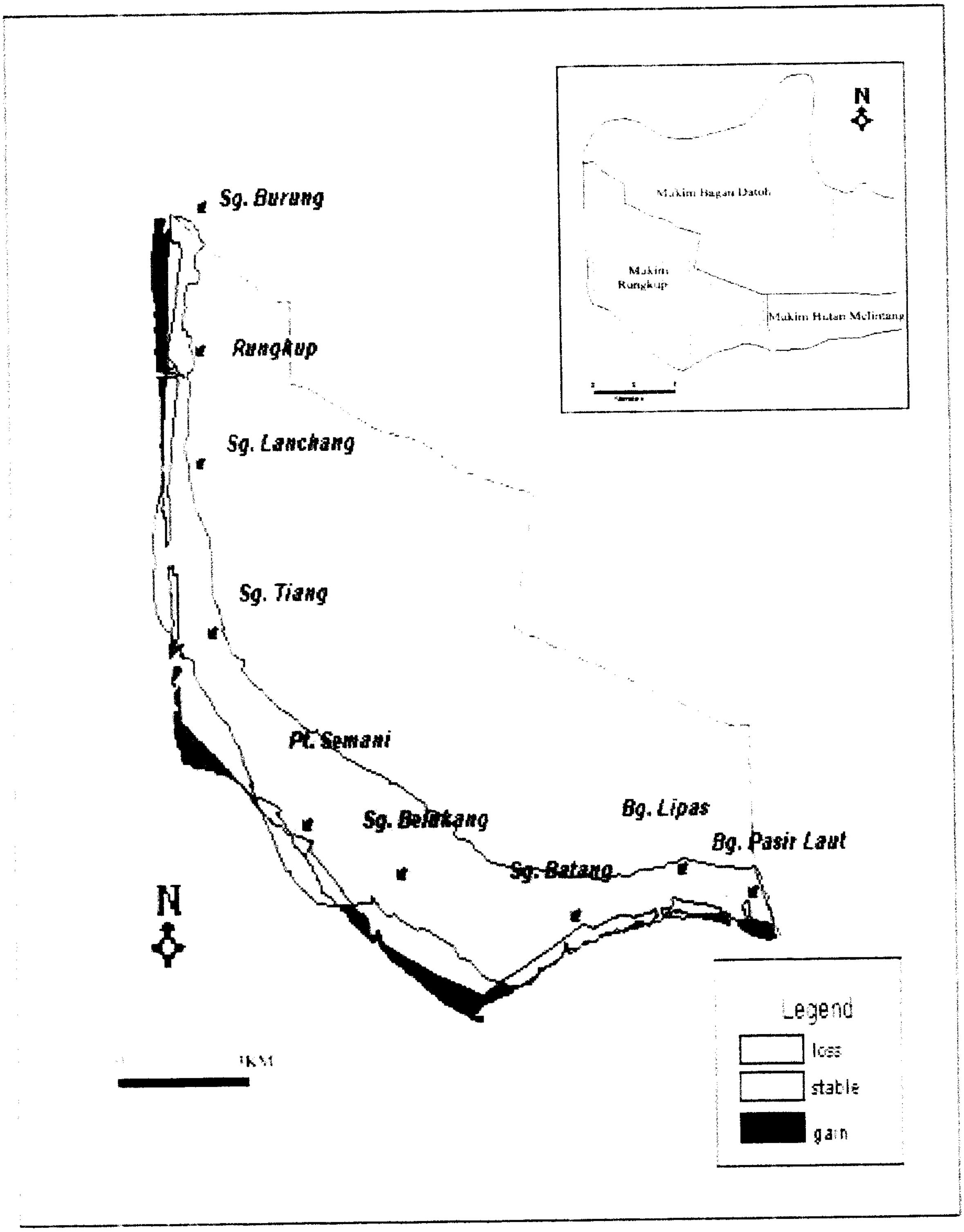

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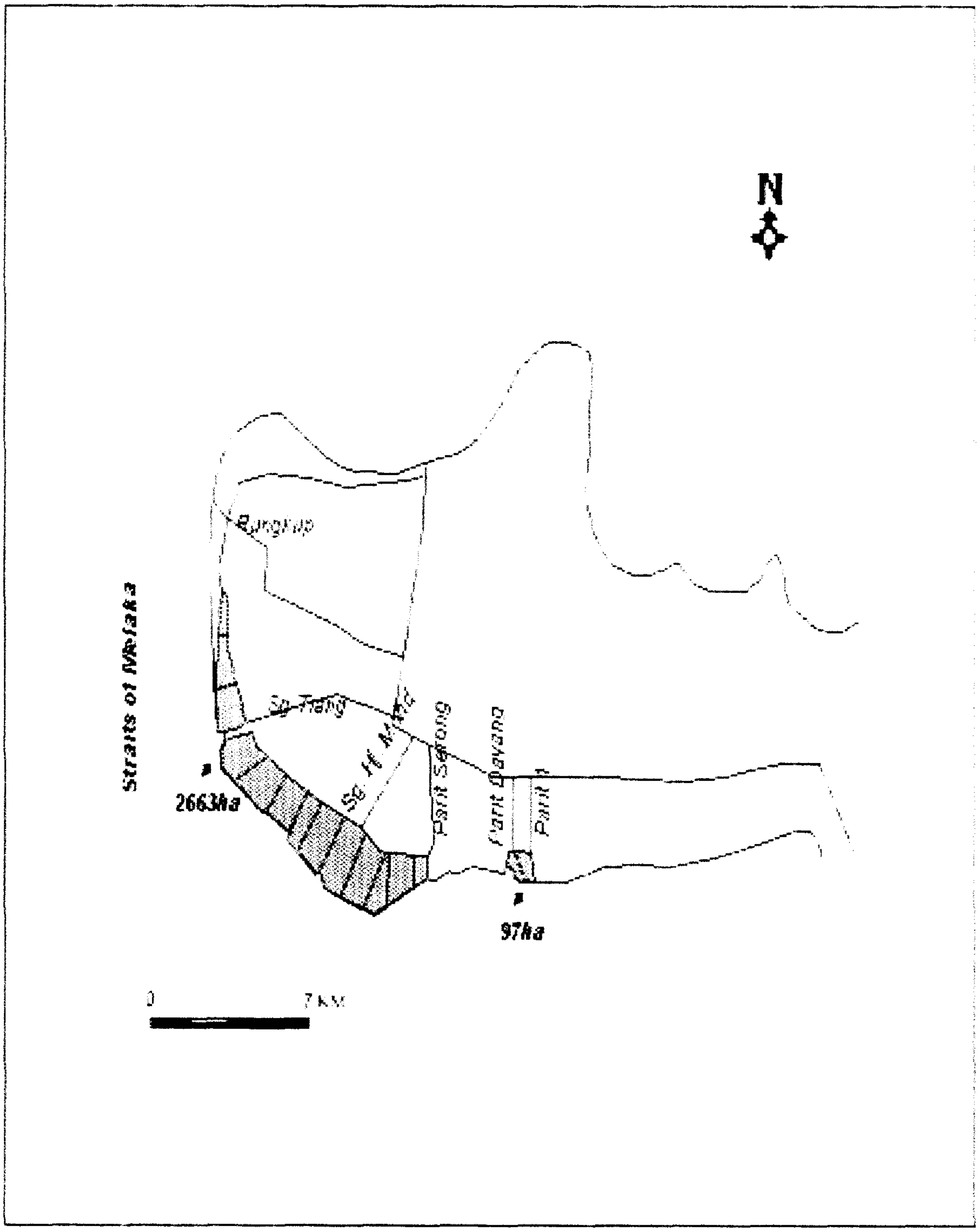
Figure 6.4. Mangrove changes (1941-1985)



Source: Review of 1st Malaysia Plan 1966-1970

Figure 6.5. Land conversion in Rungkup under 1st Malaysia Plan

6.1.2 Setback Lines

A coastal development setback may be defined as a prescribed distance to a coastal feature, such as the line of permanent vegetation, within all or certain types of development are prohibited. Coastal development setbacks have several functions:

a. They provide buffer zones between the ocean and coastal infrastructure, within which the beach zone may expand or contract naturally without the need for seawalls and other structures, which may imperil the entire beach system. Thus in this sense they may reduce beach erosion,

b. They reduce damage to beachfront property during high wave energy.

Coastal setback provisions ensure that development is prohibited in a protected zone adjacent to the water's edge. However there is an inadequacy of the existing setback line in Rungkup.

According to the DID guidelines, bund should be sited at least 400m behind the outer mangrove fringe to ensure that they will not be damaged or breached by sea and wave action. On an eroding coast, the rate of erosion should be measured and the bund sited at such a distance inland as will give it 20 years of use before being attacked by the sea, should encroachment of the sea continue unchecked at the measured rate (Ferguson 1951).

However the construction of coastal bund in Rungkup did not follow the guidelines provided. When mangrove advanced to the sea in between 1941 and 1964, construction of coastal bund followed where the coastal bund was constructed very close to the sea (Figure 6.1). Only in few places the construction of coastal bund was according to the requirement such as in Sg. Burung where the setback zone for building the bund was about 564m. Another stretch of coastal bund from Sg. Burung to Rungkup was constructed with a setback of about 434m and in Sg. Belukang with a setback of about 456km. Other coastal bunds were built too near and the setback was less than 400m in most of the areas. Only narrow strip of mangrove fringe of less than 200m width remained in Sg. Tiang South and the rest of the coastline after the construction of the bund.

Bund failure in Rungkup was due to the major land scheme, which reduced the existing natural mangrove forest as a buffer zone area. Inter-tidal areas have been reduced by the construction of coastal defences. The narrow strip of mangrove was unable to act as a natural defence against coastal erosion.

The western side of the peninsula along Sg. Tiang, Parit Tebuk Semani and Sg. Belukang was eroding and mangrove forest was retreating at a rate of 0.036km per year in Sg. Tiang while Parit Tebuk Semani to Sg. Belukang recorded a rate of retreat between 0.023km to 0.032km per year (Figure 6.3). The maximum length of retreat was recorded in Sg. Belukang with a retreat of 0.57km. Along these considerable stretches of coastline, mangrove has been eroded away exposing the bunds directly to the waves. In these areas, rock bunds have been built to prevent further erosion. The valuable contribution of mangrove as flood protection has thus been lost in Rungkup area.

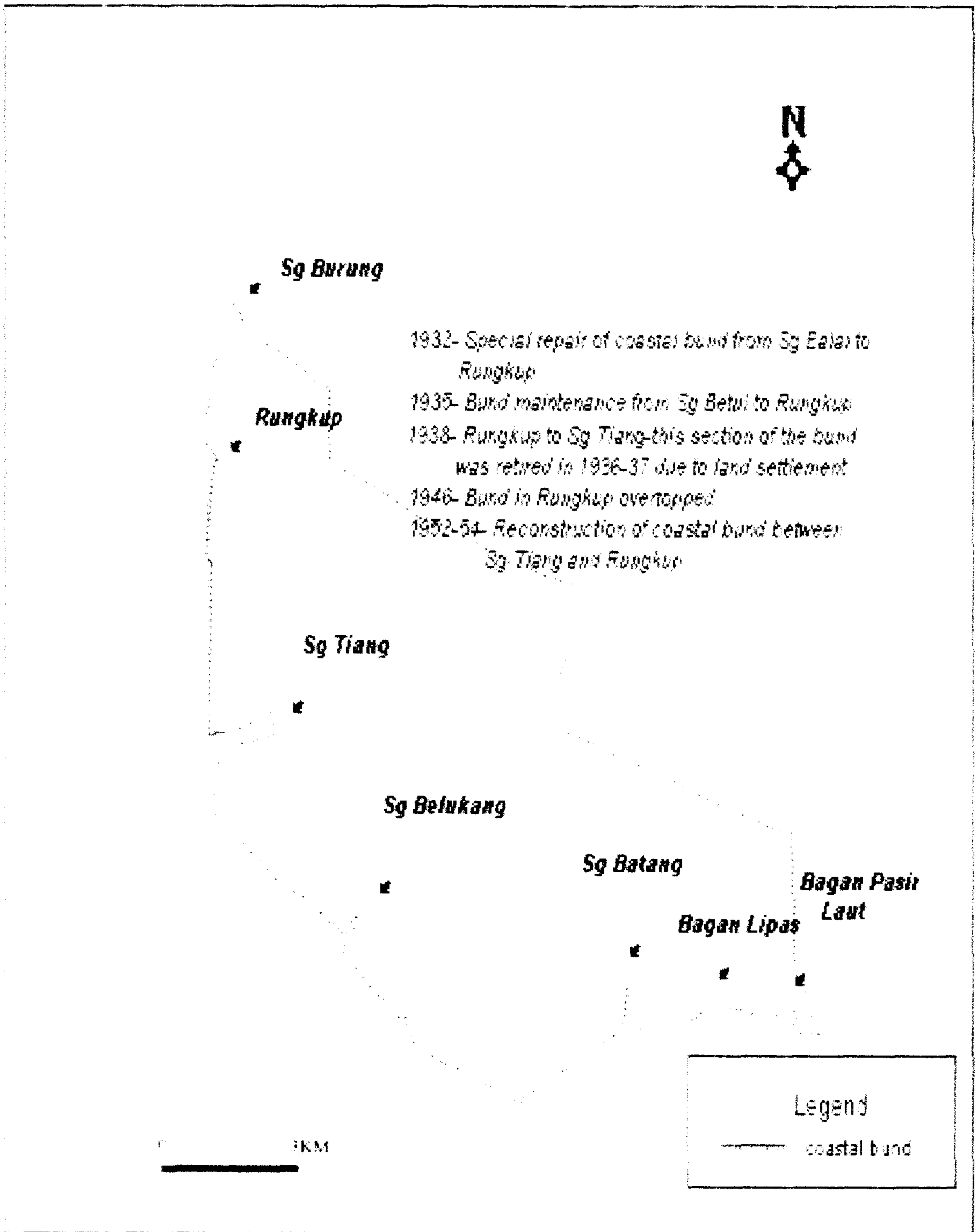
It is very clear that the setback line plays an important role in maintaining the coastline and the coastal structures. Areas where the setback is far enough from the coast, the mangrove forest continue to survive and coastal erosion could be prevented. It can be seen in Rungkup where the stretch of coastline from Sg. Burung to Rungkup is less vulnerable to coastal erosion compared to other parts of the peninsula (Figure 6.14 – 6.17).

The minimum setback requirement may be reviewed on account of site specific conditions but none of the conditions in Rungkup warranting such a review.

6.1.3 Coastal Bund

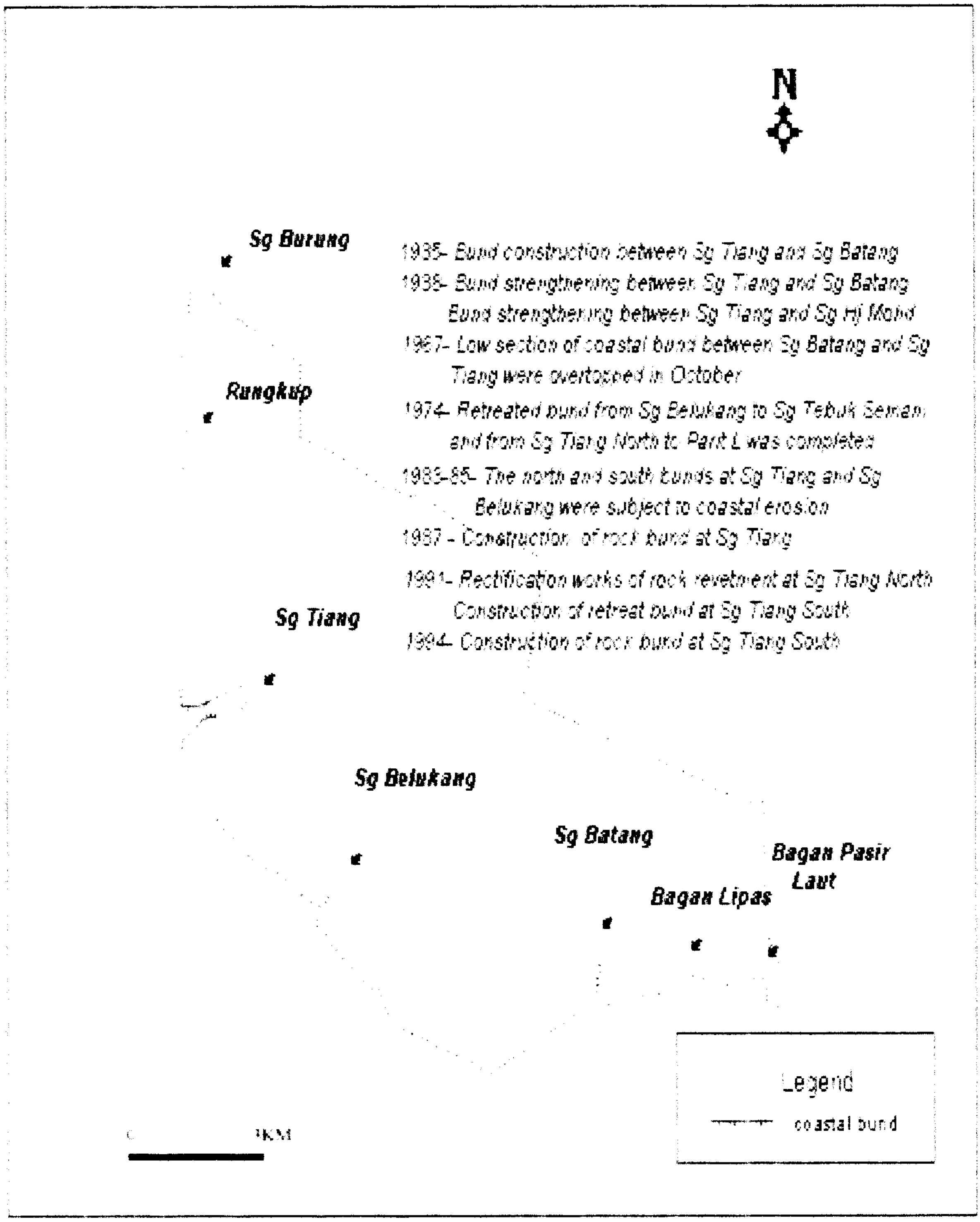
Most of the Rungkup coastline has experienced significant erosion since the earliest available records in 1930s. Slope failures and bund breaching are quite common along the erosion affected coast of Rungkup. There has been a holistic demand for coastline protection throughout Rungkup area beginning in 1930s. Some of the earliest coastal protection works dating from 1930s form part of Rungkup coastline. The conditions of Rungkup coastline that are vulnerable and need special attention to the bund are shown in Figure 6.6, 6.7, 6.8 and 6.9.

The figures show clearly the poor condition of coastal bunds in Rungkup. The coastal bunds constructed in Rungkup peninsula faced numerous problems such as land settlement, overtopping and bund breaching. Constant maintenance to the bunds has to be carried out regularly. When they were unable to be strengthened they were abandoned. Several stretches of the coastal bunds such as from Rungkup to Sg. Tiang (Figure 6.6), and from Sg. Belukang to Sg. Tebuk Semani, Sg. Tiang North to Parit L (Figure 6.7) were retreated in 1938 and 1974 respectively. The coastal bund in Sg. Belukang was again retreated in 1996 (Figure 6.8). The stretch of retreated bund in Sg. Batang was revetted at a very high cost in 2001 (Figure 6.9).



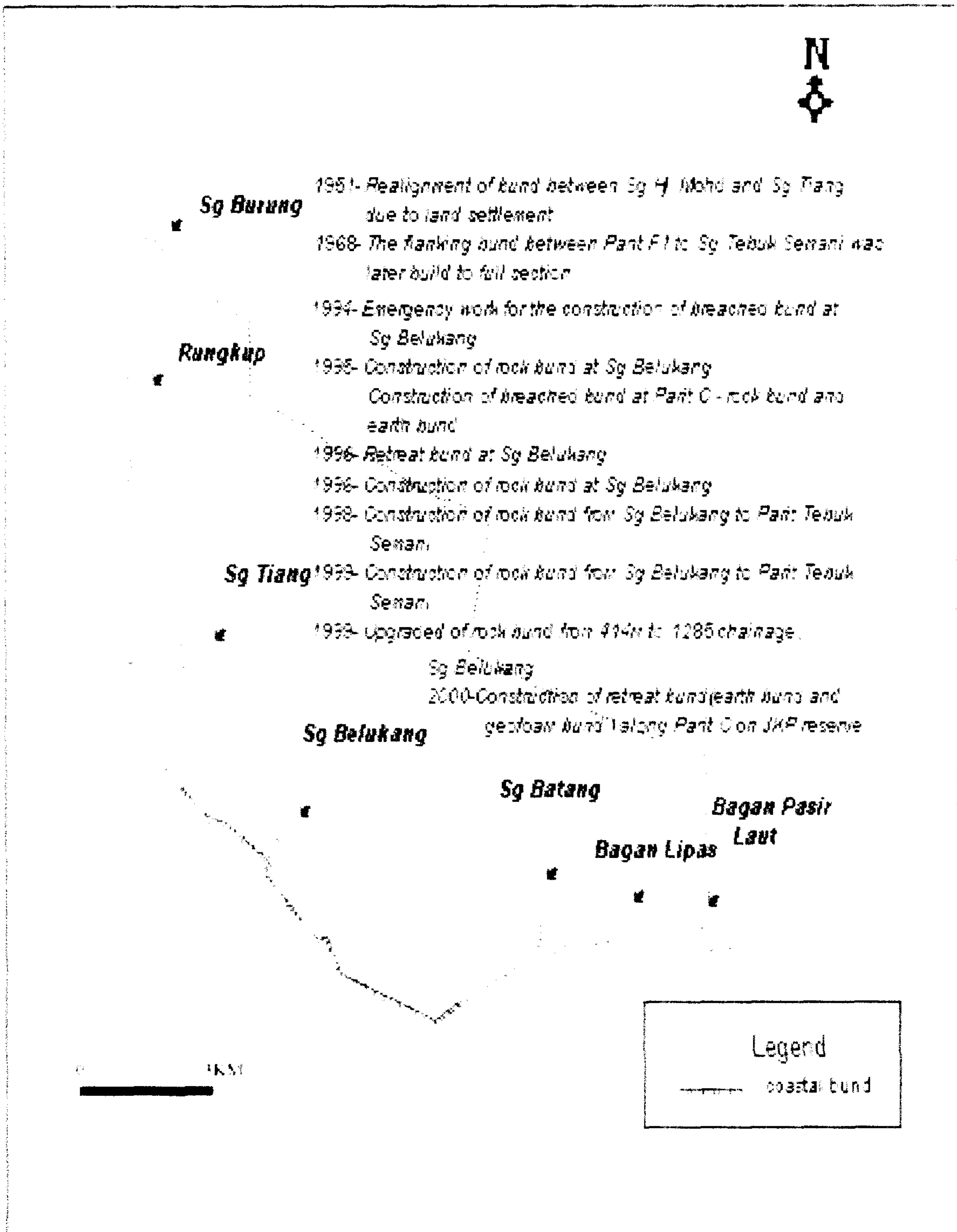
Source: DID/JPT/JPS Annual Reports

Figure 6.6. Conditions of Rungkup coast since 1930s



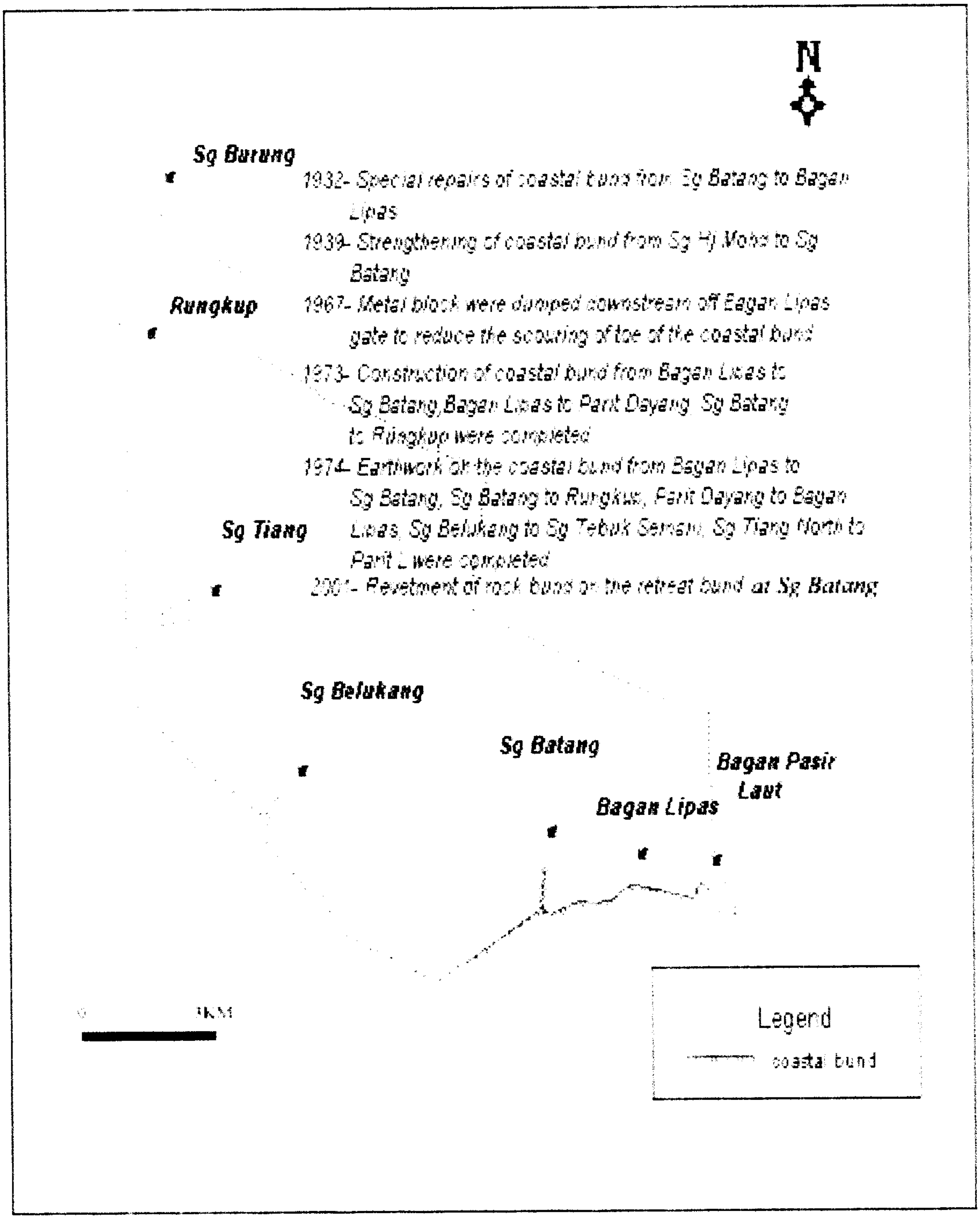
Source: DID/JPT/JPS Annual Reports

Figure 6.7. Conditions of Sg. Tiang coast since 1930s



Source: DID/JPT/JPS Annual Reports

Figure 6.8. Conditions of Sg.. Hj. Mohd to Sg. Belukang coast



Source: DID/JPT/JPS Annual Reports

Figure 6.9. Conditions of Sg. Batang to Bagan Pasir Laut coast

6.1.4 Construction of Temenggor Dam

Severe erosion started in 1970s. Coastline retreat may be the result of a natural shift of eroding marine processes or of a reduction in sediment supply by natural or man made causes or both. The natural systems tend to adjust to the reduction in available sediment by increasing erosion of unprotected coast until a state of equilibrium is reached. As the flow and sediment load of the distributaries change with time, some parts of the coastline may be eroding and retreat at the same time that other parts of the coastline may be prograding. This apparently has taken place at Rungkup.

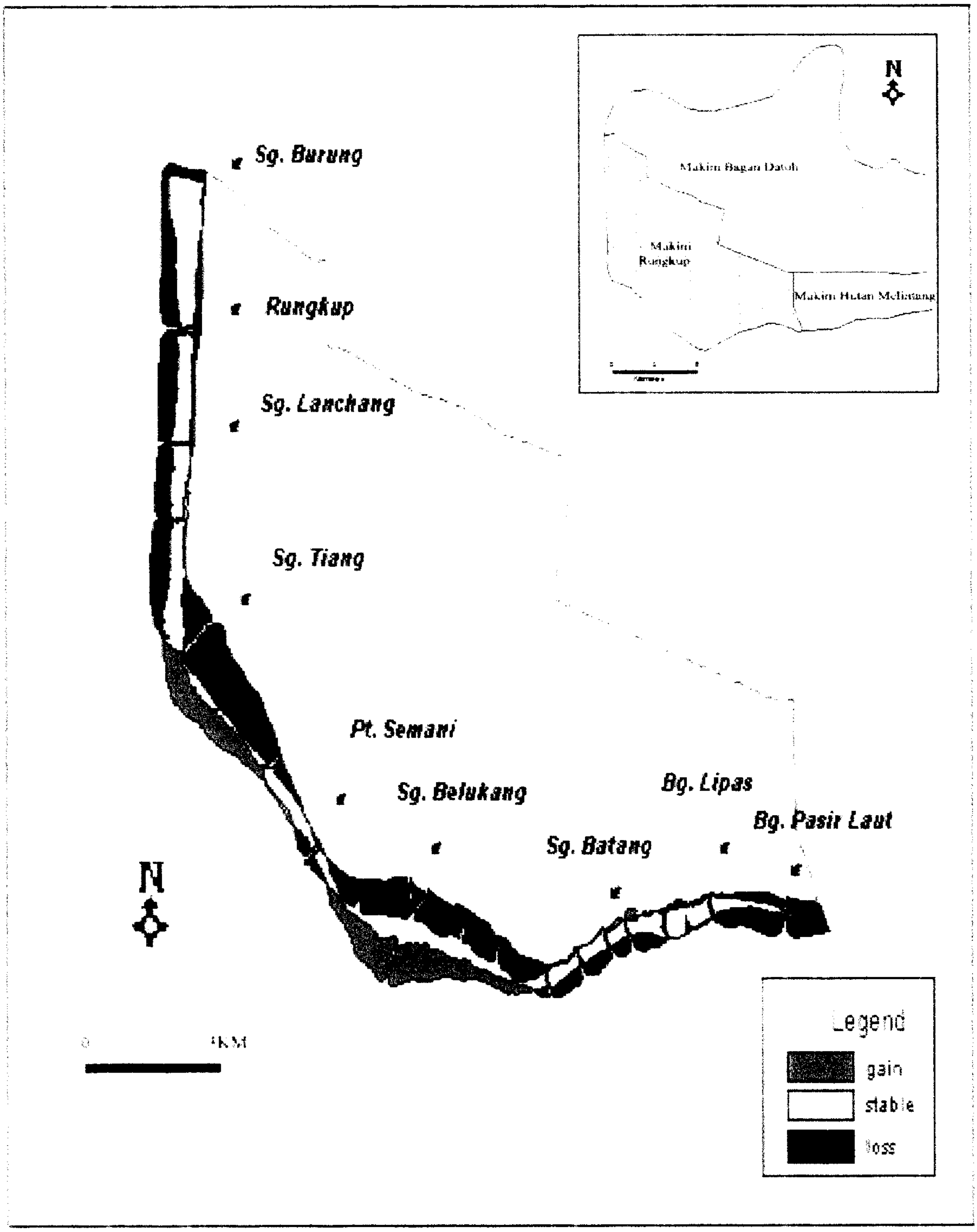
However man's activities commonly affect sediment supply. The reduction of longshore sediment supply due to the construction of Temenggor Dam may be partly responsible for the high rate of erosion. Temenggor Dam was completed in 1976 and it exerts a considerable influence on the flow regime (LLKTM 1973).

Figure 6.10 to 6.13 shows the mud deposition for four different periods of time. The gain and loss of mud flat between 1941 and 1964 is shown in Figure 6.10. The only gain was at the river mouth of Sg. Tiang and Sg. Belukang. This shows that these two rivers were laden with sediment enough for mud deposition to advance. Mud flat advanced at a rate of 0.013km per year at Sg. Tiang while Sg. Belukang recorded an advance of 0.019km per year.

There wasn't much changes in mud deposition between 1964 and 1972 (Figure 6.11). However mud flat shrunk to a thinner belt between 1972 and 1985 especially in Sg. Tiang (Figure 6.12). A drastic reduction in mud deposition during this period coincided with the construction of Temengor Dam in 1976. However a larger deposition was found further south near Sg. Batang. Maximum length of mud flat advance was about 2.2km and the mud flat covered an area of 559ha. A large portion of the mudflat will be above sea water level during low tide.

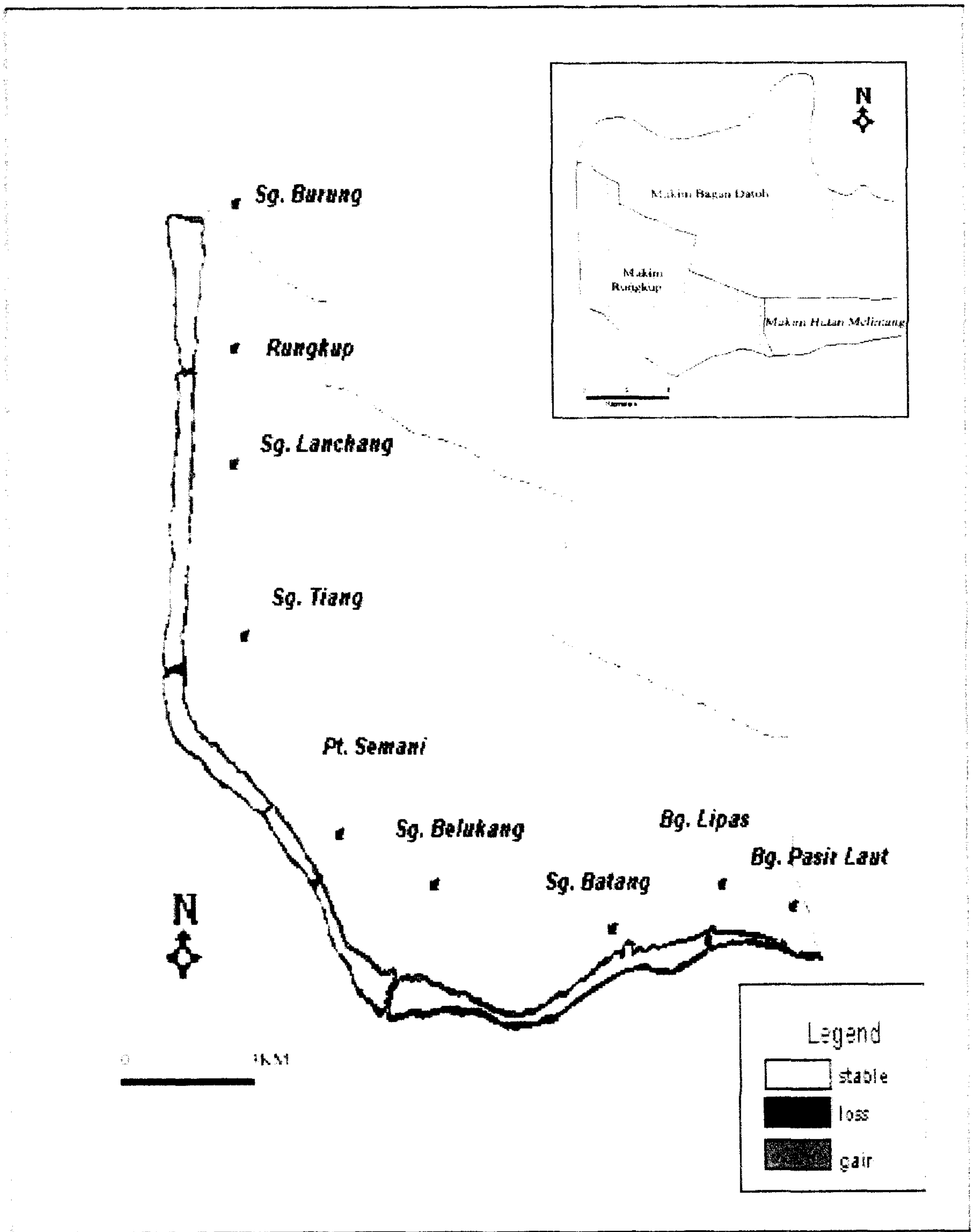
The greatest loss of mud deposition was in Sg. Tiang throughout the 44-year period (Figure 6.13). The reduction of sediment resulted in loss of mangroves and increased likelihood of overtopping of flood and coastal defences because the reduction in mud accumulation decrease the chances of mangrove regeneration.

Attempts to regenerate mangroves in this area by DID failed due to the matter. According to DID Teluk Intan, RM30,000.00 was spent in replanting of mangroves in Sg. Tiang in 1992 but was unsuccessful. This proves that accumulation of mud is important for mangrove to survive and regenerate.



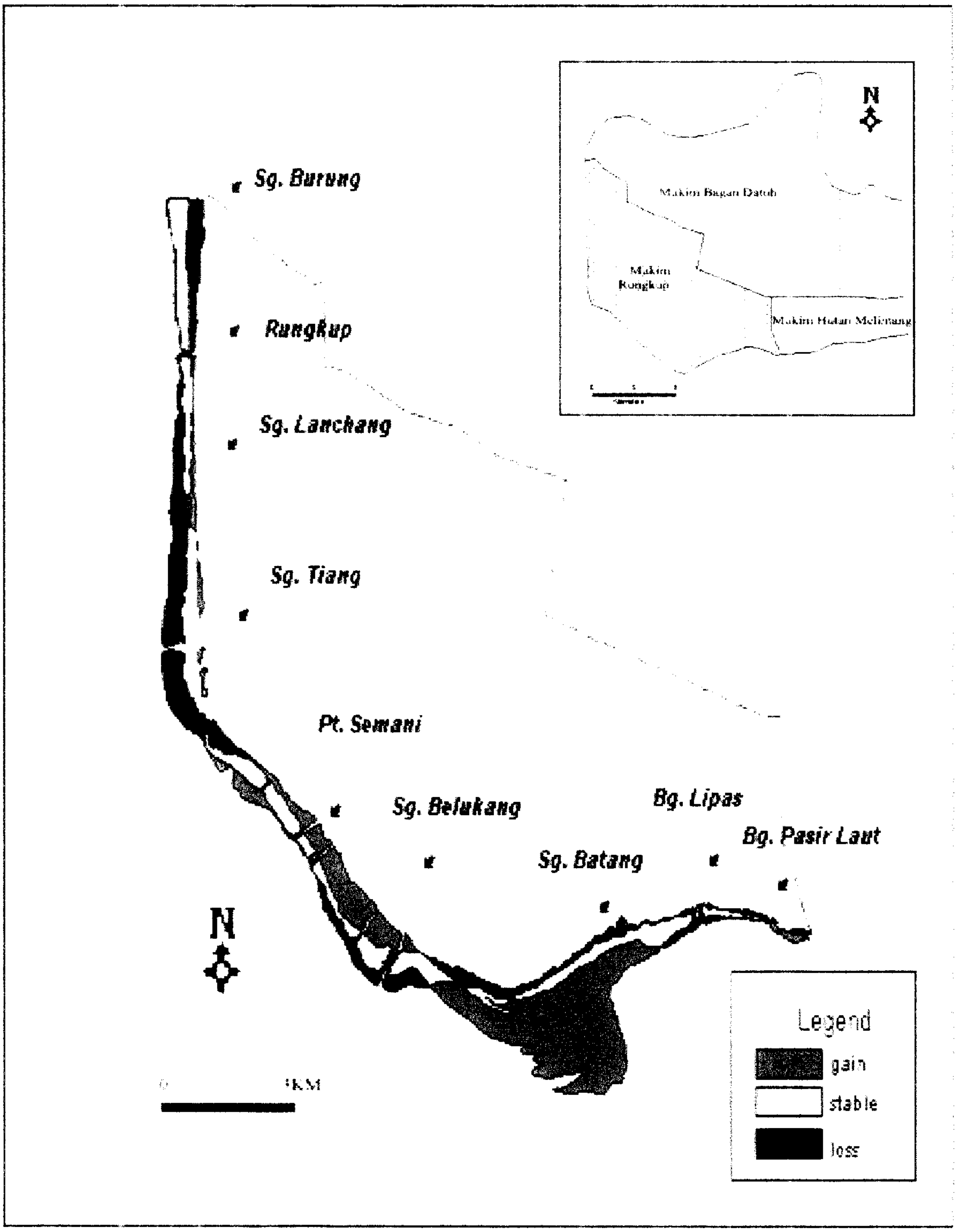
Source: This Study

Figure 6.10. Changes in mud deposition (1941-1964)



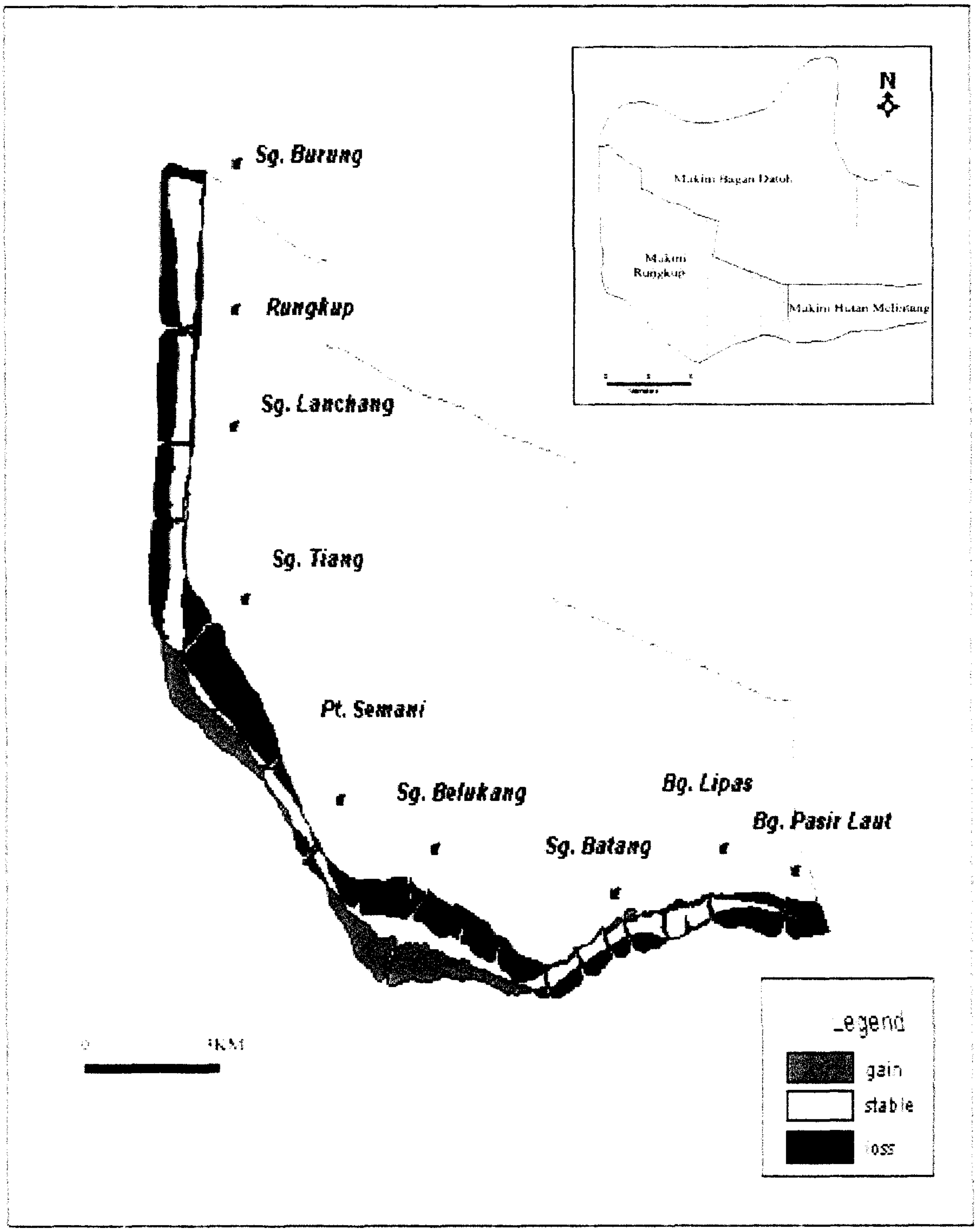
Source: This Study

Figure 6.11. Changes in mud deposition (1964-1972)



Source: This Study

Figure 6.12. Changes in mud deposition (1972-1985)



Source: This Study

Figure 6.13. Changes in mud deposition (1941-1985)

6.1.5 Other Factors

Aquaculture (shrimp farming) in Rungkup takes place in reclaimed mangrove forests. The shrimp ponds are located on reclaimed land to provide a source of brackish water. Aquaculture along the mangrove buffer zone is among the causes of erosion along Rungkup coastline. The widespread felling of mangrove for aquaculture has reduced coastal protection from storm surge and increased sea water intrusion. Removal of mangroves for pond culture can significantly affect coastline configuration and coastal erosion pattern. The destructions of coastal mangrove have also brought about coastal erosion. Some ponds have been abandoned due to erosion. The buffer zone along Rungkup coast is narrowing due to this activity. Due to this matter the district office has frozen all the applications to open more land for aquaculture on state land. However they are unable to stop landowners from converting their own land for aquaculture.

An increase in fishing boats is another factor causing coastal erosion especially in Sg. Tiang and Sg. Belukang. The passage of fishing boats in and out of the river mouth often tends to encourage erosion on the coastal bank.

The clearing of mangrove in Parit Dayang for the construction of a port by Ghadaf Marble has caused erosion along the coastline of Bagan Pasir Laut (JPS undated). The eroded coastline will put the coastal bund in a vulnerable condition thus lead to bund failure.

6.2 Assessment of Impacts

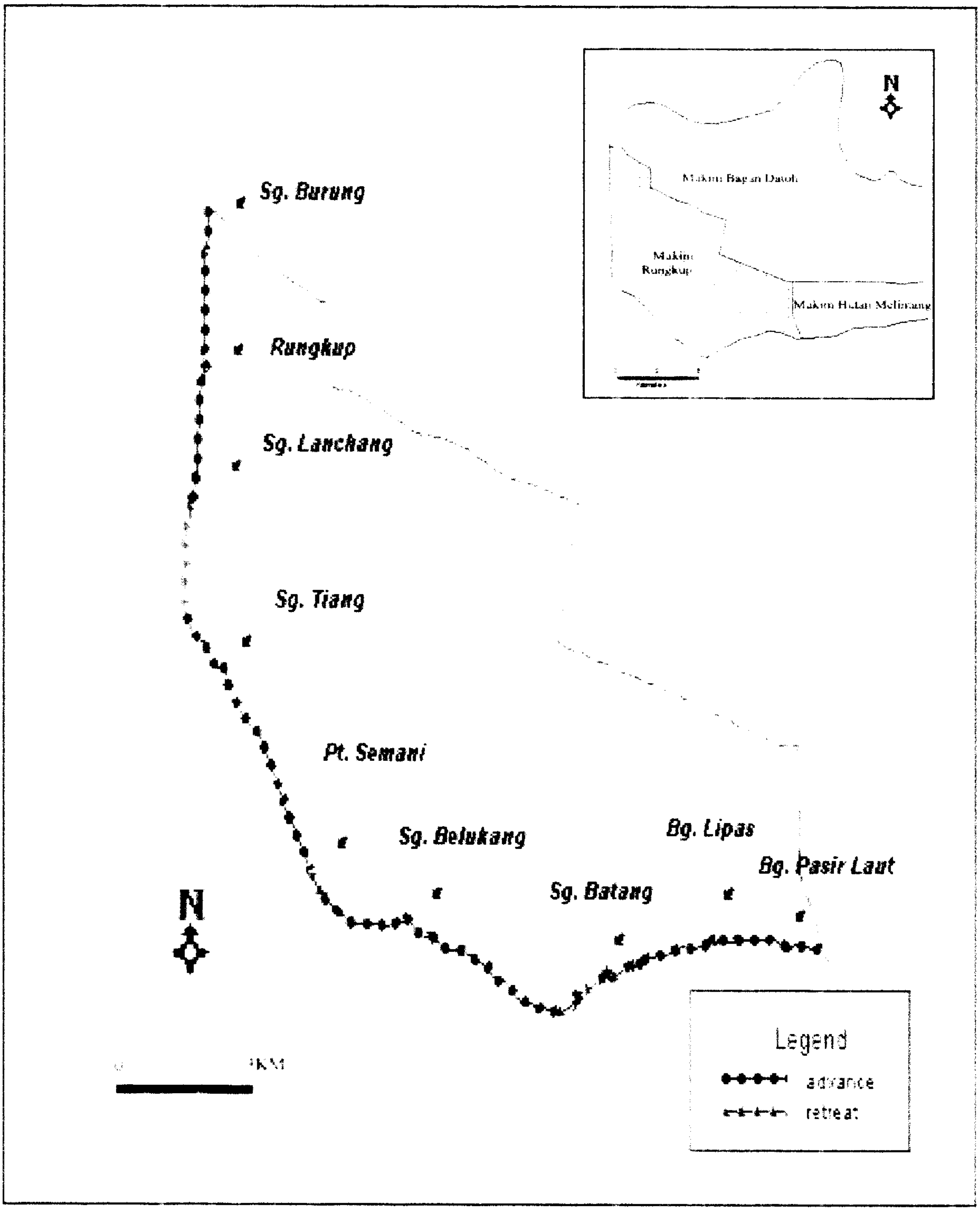
6.2.1 Physical Impacts

6.2.1.1 Coastal Erosion

The impacts of mangrove loss and sediment reduction have changed the condition of Rungkup coastline. Figures 6.14, 6.15, 6.16 and 6.17 show the critical erosion areas of Rungkup coastline.

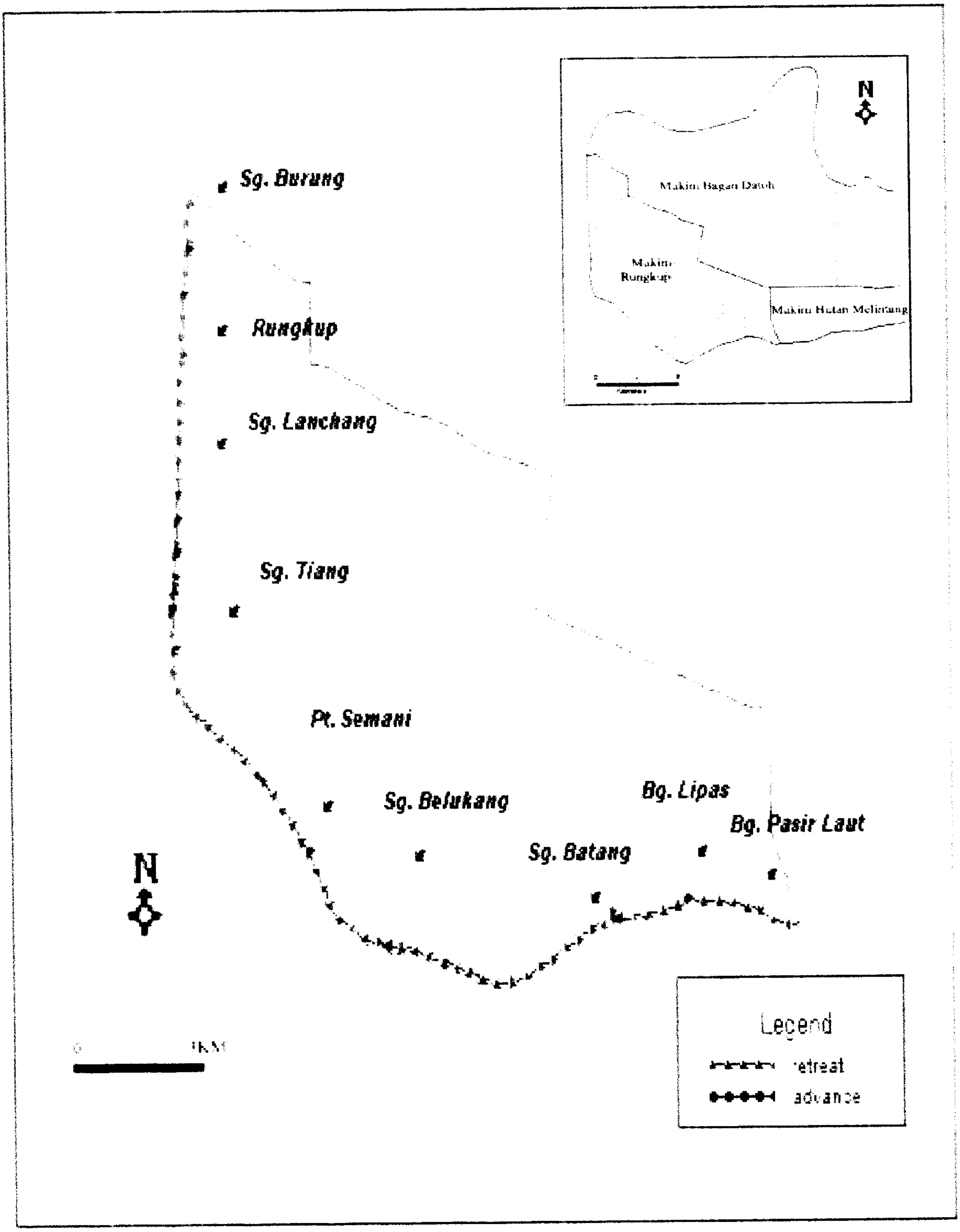
From Sg. Tiang North to Sg. Lancang as well as in Parit Semani and Sg. Batang have experienced coastal erosion since 1941 (Figure 6.14). Almost all the coastline in Rungkup was in erosional trend throughout the period between 1964 and 1972 (Figure 6.15). Coastal erosion in Sg. Tiang North extended to the south, from Parit Semani extended to Sg. Belukang and from Sg. Batang extended to Bagan Lipas between 1972 and 1985 (Figure 6.16). Coastline along Sg. Tiang North, Parit Semani and Sg. Belukang exhibited a long-term erosion trend throughout 1941 to 1985 (Figure 6.17). No doubt "The National Coastal Erosion Study" (1985) carried out by Stanley Consultant and Associates and the Economic Planning Unit of the Prime Ministers' Department has identified Bagan Sg. Tiang and Bagan Sg. Belukang as critical erosion area (Category 1).

The most vulnerable coastline at present is between Sg. Belukang and Sg. Batang where the existing earth bund has been experiencing serious coastal erosion since 1994. A number of locations along the bund breached in 1994, 1995 and 1996 (Figure 6.18).



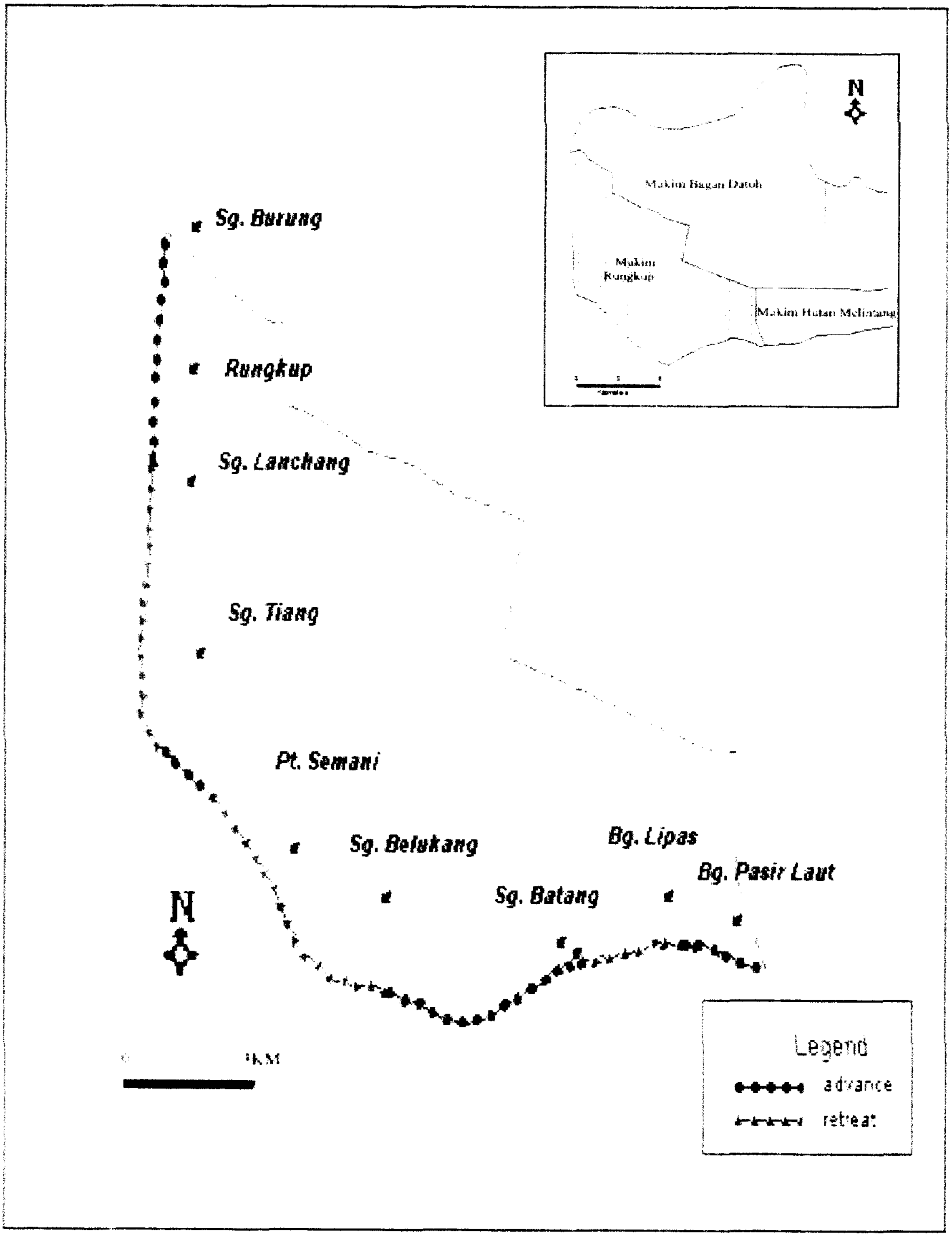
Source: This Study

Figure 6.14. Conditions of Rungkup coastline (1941-1964)



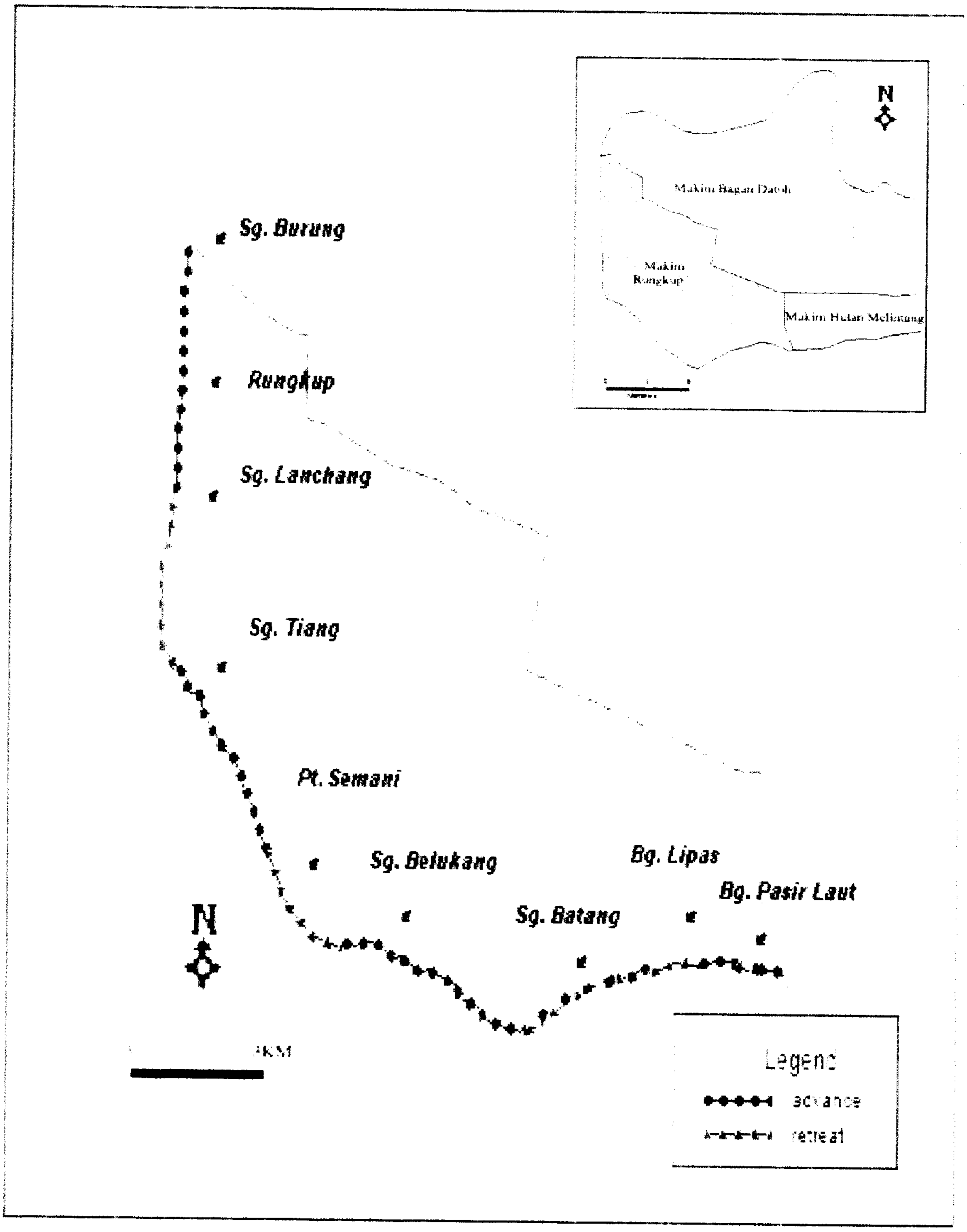
Source: This Study

Figure 6.15. Conditions of Rungkup coastline (1964-1972)



Source: This Study

Figure 6.16. Conditions of Rungkup coastline (1972-1985)



Source: This Study

Figure 6.17. Conditions of Rungkup coastline (1941-1985)

The rising sea level, in combination with large storm and powerful ocean waves, will be a great concern in Rungkup. Rising sea level and increased storminess will lead to an increase in coastal erosion. It will drive erosion and wear away Rungkup coastline. Erosion undermines waterfront homes, public infrastructure, eventually making them uninhabitable or unusable. As the coastline moves inland, erosion also brings nearby structures ever closer to the water, often putting them at greater risk than either their owners or insurers expected. This is already happening in Rungkup where over the years, erosion has claimed many houses within 0.25km to 0.70km of Rungkup coastline (Figure 5.6, 5.7 and 5.8). To the people living and working within this area, the risk posed by erosion is high especially in Bagan Sg. Belukang and Bagan Sg. Tiang. Sea level rise will also threaten to prolong erosion along the Rungkup coast.

6.2.1.2 Tidal Inundation

Coastal flooding is another threat to this vulnerable land of Rungkup. A recent bund breaching between Sg. Belukang and Sg. Batang as mentioned earlier has inundated an area of about 800 hectares of coconut smallholdings and aquaculture ponds (Figure 6.18).

The overtopping of the coastal defence in Rungkup jerks one to the realization of how vulnerable our coast is to a likely sea level rise. Sea level rise presents a series threat to this low-lying area of Rungkup. Even a limited rise in sea level over coming decades could seriously affect the people of Rungkup.

The physical impact of a rising sea in terms of submergence is very much influenced by the coastal profile. The height relationships between mean sea level, bund crest, HAT with a 50cm and 100cm rise in sea level are illustrated in Figure 6.19 – 6.25. The impact of bund failure under present sea level condition and that of future sea level rise of 50cm and 100cm in the study area are assessed under a 'do nothing' option. The assessment is based on the worst possible scenario during HAT, accompanied by waves of one metre.

Based on the projected sea level rise scenarios, the whole bunded coastline of Rungkup will be overtopped by just a 50cm rise in sea level during HAT. The height of all the coastal structures along Rungkup coastline is below critical level should there be a rise in sea level by just 50cm. The progressive land settlement in Rungkup will put the coastal structures in a more vulnerable condition. Information obtained from *Jurutera Konsultant* reveals that the existing bunds indicate a progressive settlement of about 1m in 3 years.

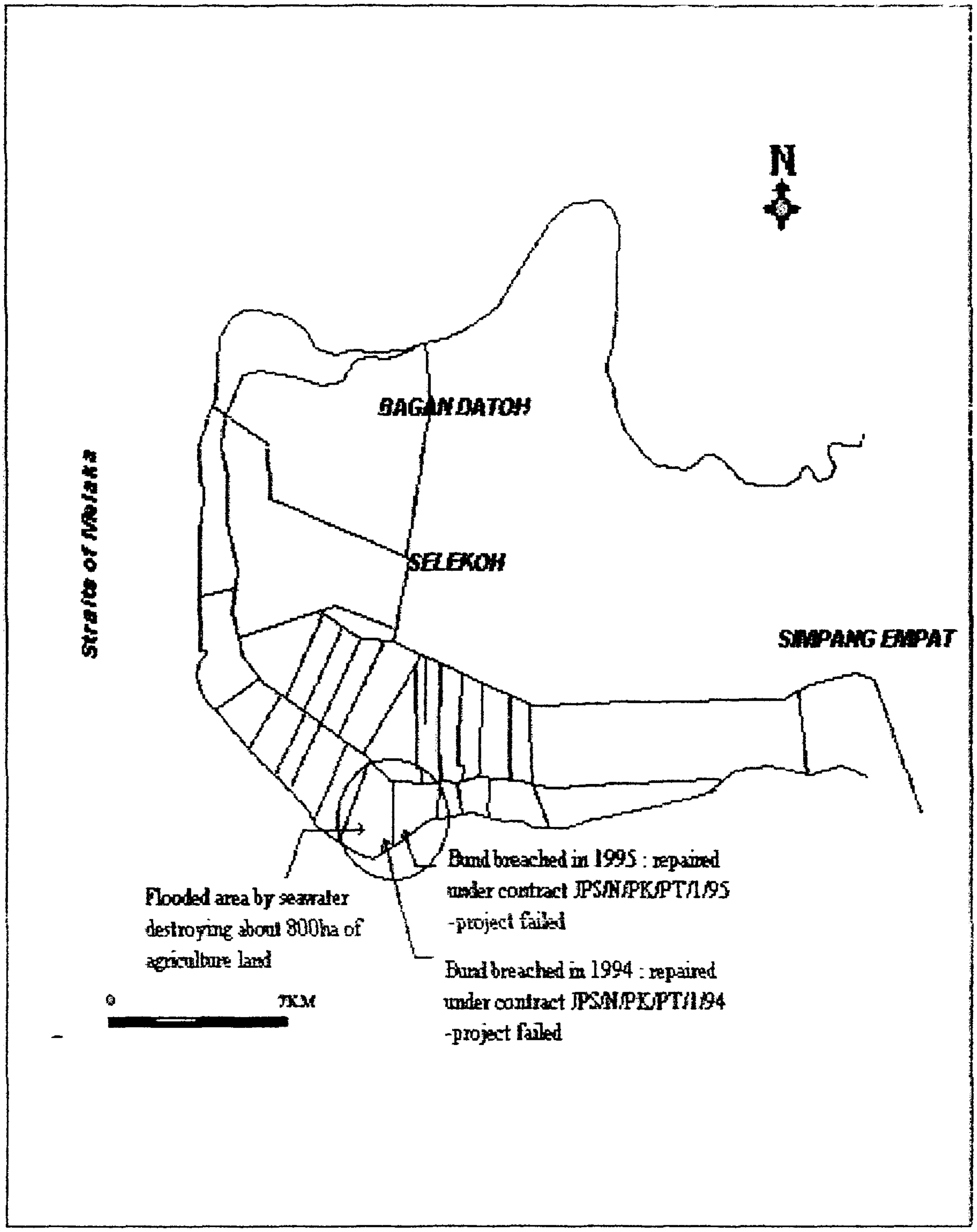
Bund failure in Rungkup would certainly result in sea intrusion during HAT. Besides that the height of the new coastal road is lower than the height of the coastal bund as shown in the figures too. Therefore this new coastal road is unable to serve as a barrier to farther landward inundation. The condition worsens when there is an absence of borrow pit in Sg. Batang. The new retreat bund in Sg. Batang was constructed on the old borrow pit which has been filled to make way for the construction of this road.

Since Rungkup is characterized as a low lying coastal plain as the average elevation is below 1.8m, a sea level rise of 50cm would overflow the bunds and inundated the whole *mukim* Rungkup.

If sea level rise is gradual, wave overtopping can be prevented by routine bund maintenance and as long as bund raising is carried out in stages, the tendency for rotational slip to develop can be arrested by flattening of the seaward slope (Zamali and Lee 1989). All this is complicated by the possibility that the land datum for mean sea level in Peninsula Malaysia is 10-30cm lower than what it should be (Azmy Abd. Rahman 1989).

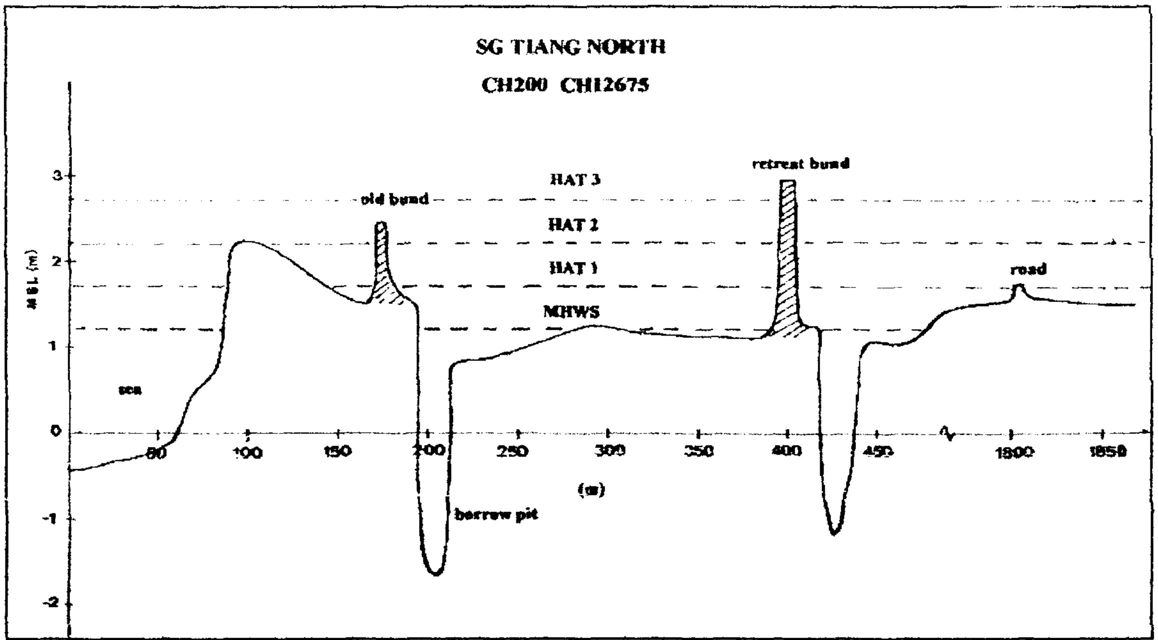
The construction of coastal bund along the Rungkup coastline will also hinder the mangroves to advance. Mangroves will also be lost when there is no room for mangrove colonisation should there be a rise in sea level. If sedimentation does not keep pace with sea level rise then the remaining mangrove will eventually drown.

Rungkup coastal zone is highly susceptible to the impacts of sea level rise and in critical need of protection. Rungkup existing response capability provides the area only a moderate degree of protection against the forces of sea level rise. It is important that serious and prompt consideration be given to suitable responses in this area.



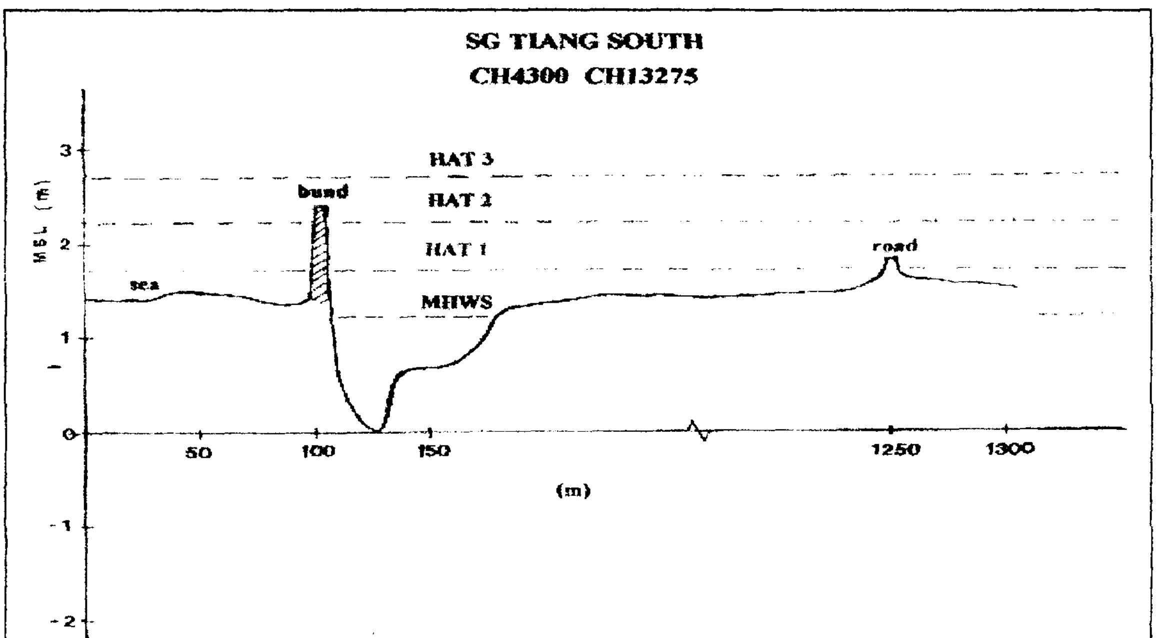
Source: Hidzrami 1999

Figure 6.18. Bund failure in Rungkup 1



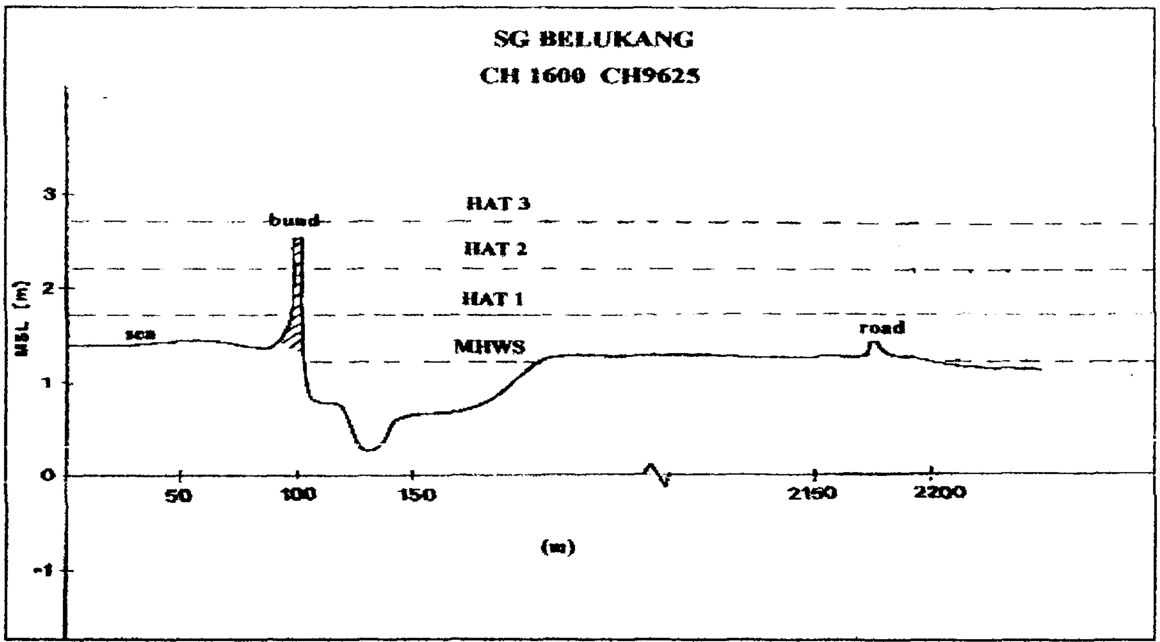
HAT 1 - present sea level HAT 2 – 50cm rise in sea level HAT 3 – 100cm rise in sea level

Figure 6.19. Cross section of coastal bund and road in Sg. Tiang North



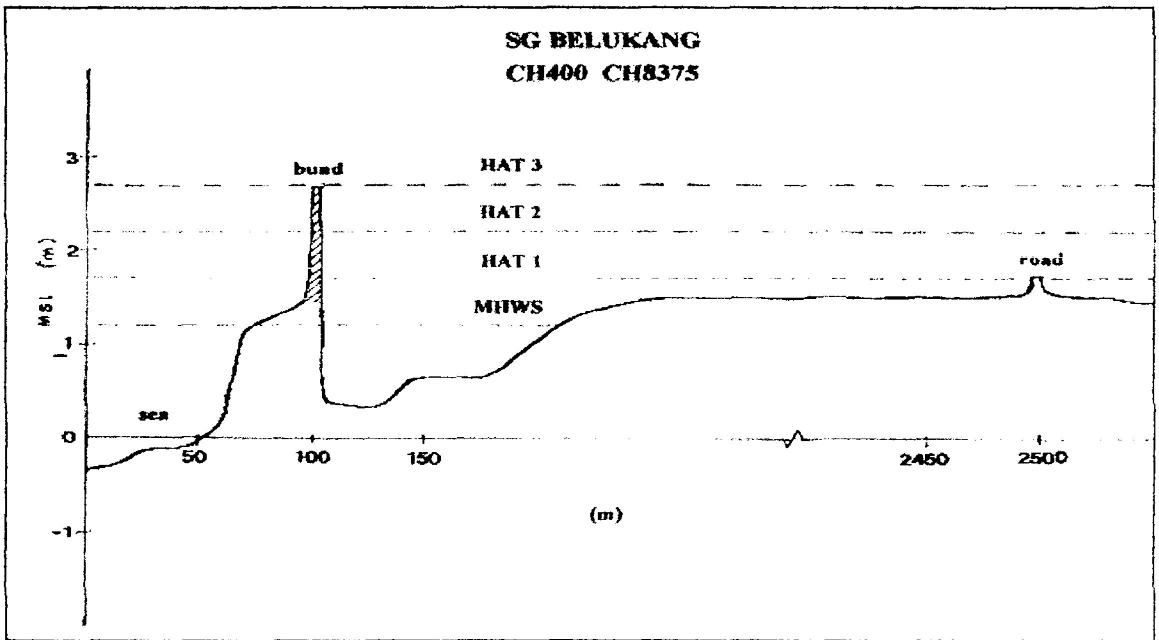
HAT 1 – present sea level HAT 2 – 50cm rise in sea level HAT 3 - 100cm rise in sea level

Figure 6.20. Cross section of coastal bund and road at Sg. Tiang South



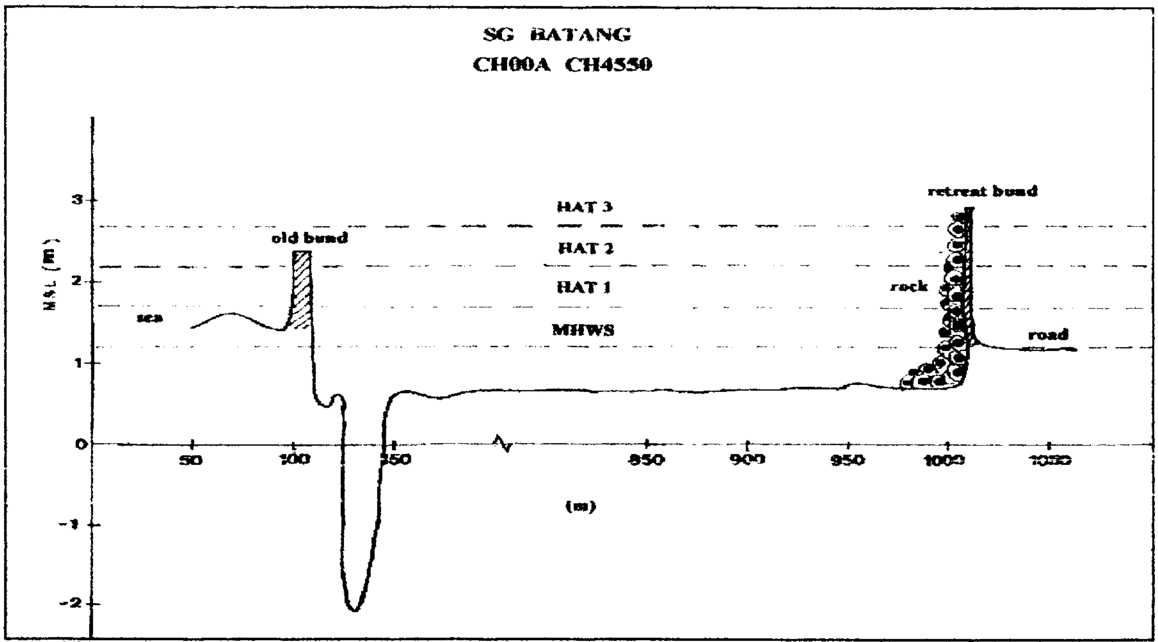
HAT 1 – present sea level HAT 2 – 50cm rise in sea level HAT 3 – 100cm rise in sea level

Figure 6.21. Cross section of coastal bund and road in Sg. Belukang (A)



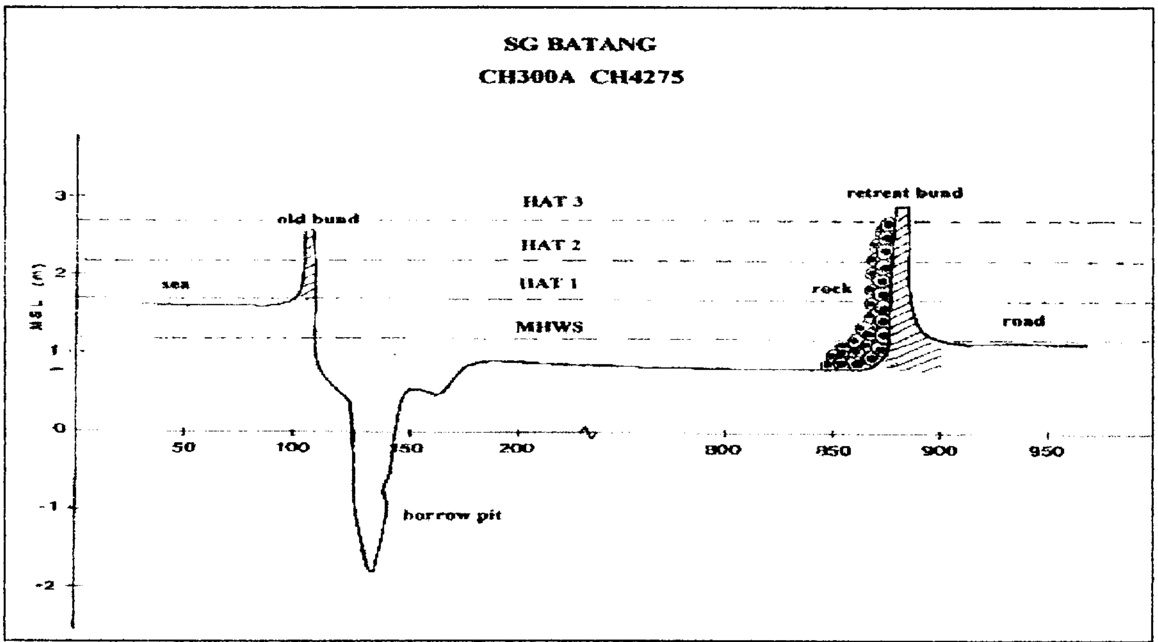
HAT 1 – present sea level HAT 2 – 50cm rise in sea level HAT 3 – 100cm rise in sea level

Figure 6.22. Cross section of coastal bund and road in Sg. Belukang (B)



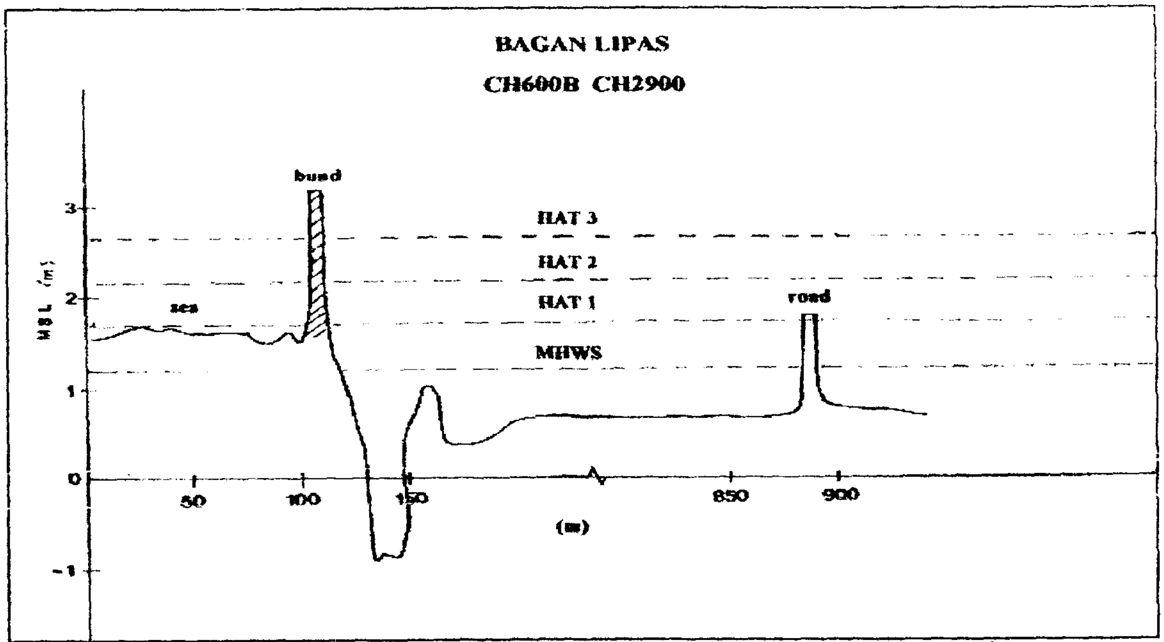
HAT 1 – present sea level HAT 2 – 50cm rise in sea level HAT 3 – 100cm rise in sea level

Figure 6.23. Cross section of coastal bund and road in Sg. Batang (A)



HAT 1 – present sea level HAT 2 – 50cm rise in sea level HAT 3 – 100cm rise in sea level

Figure 6.24. Cross section of coastal bund and road in Sg. Batang (B)



HAT 1 – present sea level HAT 2 – 50cm rise in sea level HAT 3 – 100cm rise in sea level

Figure 6.25. Cross section of coastal bund and road in Bagan Lipas

6.2.2 Socio-Economic Impacts

6.2.2.1 Loss of Land

Rungkup's major land scheme was carried out under 1st Malaysia Plan where RM1.4 million was spent to convert a total of 2760ha of coastal flat for coconut cultivation. Surveys and investigations of the area were completed in 1961 and construction works started in 1962 under the 2nd Five Year Development Plan (1961-65). By the end of 1965, a total sum of RM931,257.00 out of RM1.4 million was expended. The total cost of the scheme was originally RM1.3 million. This was later increased to RM1.4 million to take in 97ha at Parit Dayang and also to improve the drainage served by Parit Dayang. The scheme was expected to be completed in 1968 and planting to commence in 1970. Allowing 4 years for the coconut palm to bear fruit, the 1st yield should be realised in 1973. The coconut palm was expected to last for 30 years. Thus the life span of the whole scheme was taken to be 40 years. As all the area will be given out as small holdings, the total gross benefits after 1973 was estimated to be RM1,195,000.00 with a net annual benefit of RM484,500.00. Total present benefits from 1974 to 2001 were estimated to be RM1, 948,126.00.

Under 2nd Malaysia Plan, intercropping was introduced. With the improved of existing drainage facilities, increased yield will be obtained from 1979 at RM1334.00 per hectare. This project was extended into the 3rd Malaysia Plan and the 4th Malaysia Plan with the hope of increased yield. Maintenance cost of RM30.00 per hectare on DID works was increased to RM50.00 per hectare.

There was a delay in land alienation on the polder land and this was delayed until 3rd Malaysia Plan. The work was completed in 1970s as shown in Table 3.7 and Figure 3.11. This converted land was only alienated in 1973 for Rungkup I and II whereas Rungkup IV was alienated in 1988. There is no information when the land was alienated for Rungkup III.

However after the land was alienated, about 1390 hectare of this land conversion in Rungkup has been lied idle or abandoned due to acid sulphate conditions in the soils. According to the District Officer, Rungkup III has never been cultivated since the day of land conversion due to the vulnerable site of flooding. Rungkup IV too has never been cultivated and it was handed over to Felcra. Even Felcra has not taken any initiative to cultivate the land. Only Rungkup I and II were cultivated. Unfortunately the bund failed in Rungkup I destroying all the coconut palms before they were first harvested in 1995 as shown in Figure 6.18 and Plate 6.2.

The land conversion project has not materialised with the amount of money spent if it is measured in terms of profit per unit of land considering the cost of the capital investment is taken into account.

Hundred of thousands if not millions of ringgit have been spent in this area to save the land from being inundated. RM2.2 million had been spent on construction of rock bund at Sg. Tiang North (0.6km) under 5th Malaysia Plan. RM4.7 million in Sg. Tiang South (1.5km) and RM1.6 million in Bagan Lipas (0.55km) under the 6th Malaysia Plan and RM12.6 million was spent in Bagan Sg. Belukang (1.46km) under the 7th Malaysia Plan (JPS 1996).

The vast changes to land conversion occurred in an era when environmental regulation was absent and economic development of mangrove was more highly valued than their natural state. This changed in the early 1970s with the advent of the Environmental Quality Act 1974, Environmental Quality (Prescribed Activities) Environmental Impact Assessment Order 1987. But with the new regulations, land conversion on mangrove forests is still continuing in Rungkup. Another 85ha of tidal lands in Parit Dayang were cleared recently not for agriculture but for the construction of a port by Ghadaf Marble (District Office Teluk Intan).

The amount of mangrove acreage in Rungkup has greatly decreased and fragmented due primarily to human impacts. Neither local government nor other programme comprehensively addresses historic loss. Permitted or unpermitted development and absent of some regulatory improvement may result in some additional mangrove acreage loss

6.2.2.2 High Cost of Maintenance

Protecting coastal assets (or relocating them) may be costly. Any increase in the frequency with which coastal defences are over-topped or breached would have major financial implications. The problems caused by rising sea levels and increased storminess will be exacerbated due to the landmass subsiding.

A lot of money has been spent in reconstructing of coastal bund in Rungkup. Since the Rungkup coast is so vulnerable to coastal erosion and coastal flooding, various mitigation measures have been taken to overcome or reduce the impact. Constant maintenance and repairs to coastal bund started in 1931. Maintenance cost spend in this area includes retirement of coastal bund, desilting, construction of outlet drain, repair of watergates etc. Figure 6.26 shows the total expenditure spent on Bagan Datoh Drainage Area under various Malaysia Plans.

Out of the total expenditure spend on the whole Bagan Datoh Drainage Area, a small sum of money will be spent on maintaining the coastline of Bagan Datoh as shown in Figure 6.27. The total cost incurred on the maintenance and repairs to coastal bund shown was only until 1972.

Table 6.1 shows the total cost spent on bund maintenance and repairs in Rungkup from the 1930s till year 2000. RM38,201,401.00 had been spent so far. Two third of this amount has been spent to maintain the coastal bund of this vulnerable coastline of Sg. Belukang.

Repair works which cost almost RM2.4 millions was carried out in Sg. Belukang and Sg. Batang when the bund breached in 1994. However another failure occurred at nearby area in 1995 and caused additional RM1.3 millions of emergency remedial works (Hidzrami 1999). The remedial works carried out seemed to be insufficient where eventually, both repair works failed due to the continuous wave attacks and the damage is no longer repairable (Figure 6.18).

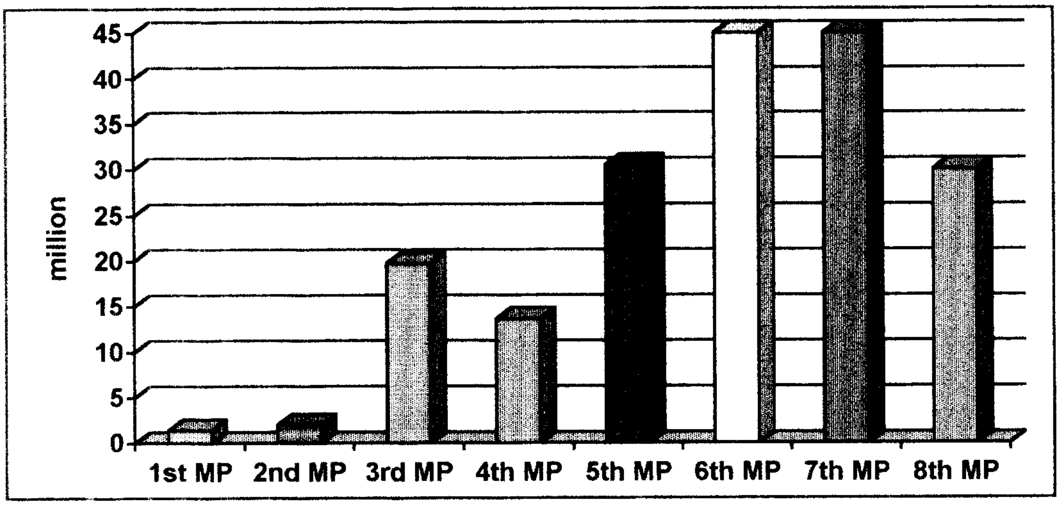


Figure 6.26. Total expenditure on Bagan Datoh Drainage Area under Malaysia Plans

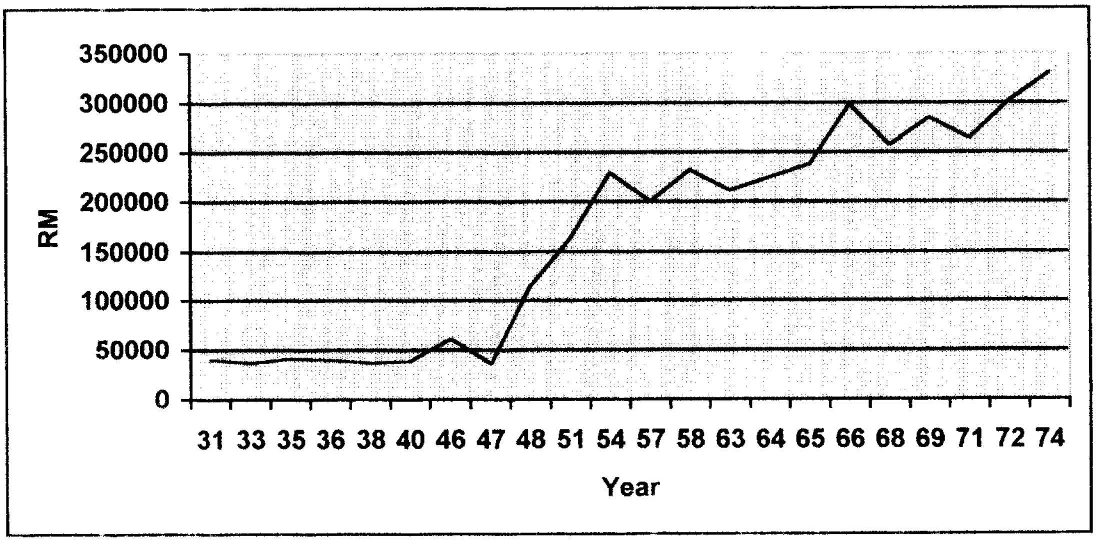


Figure 6.27. Total maintenance cost on Bagan Datoh coast

In order to prevent further damages, DID decided to build temporary bunds along the Public Works Department (JKR) road reserves at the centre of the affected area that is about 2.3km inland from the original (destroyed) bund alignment. This 5km bund which was called 'retreat bund' (Figure 6.28 and Plate 6.3) was then constructed from the local earth which cost about RM3.6million (Hidzrami 1999). However, since the bund is a temporary bund, damages and failures continued to occur partly due to the weak local soil structure.

To overcome the problem this temporary bund was strengthened using geofoam technology and imported soil. Estimated cost of the project is about RM4.0 million. Since the cost of the construction is going to be too high and cannot be fully financed by the Federal Government, the geofoam technology was applied only in the critical parts, i.e. about 1.0 km long of the overall 5.0 km long (Hidzrami 1999).

Geofoam solution has performed satisfactorily. It reduces the surcharge on the foundation and hence the excess pore pressure built up which increases the stability of the foundation. It also reduces the settlement of the foundation. Its main set back is its high cost. The cost was estimated at RM1400 per meter run. It is about twice the estimated cost of Geogrids (Tan 1999).

However the retreat bund, which was constructed, further inland caused a complete loss of at least 475 parcels of land (DOA 1994). The loss of landownership would be permanent and almost impossible to replace.

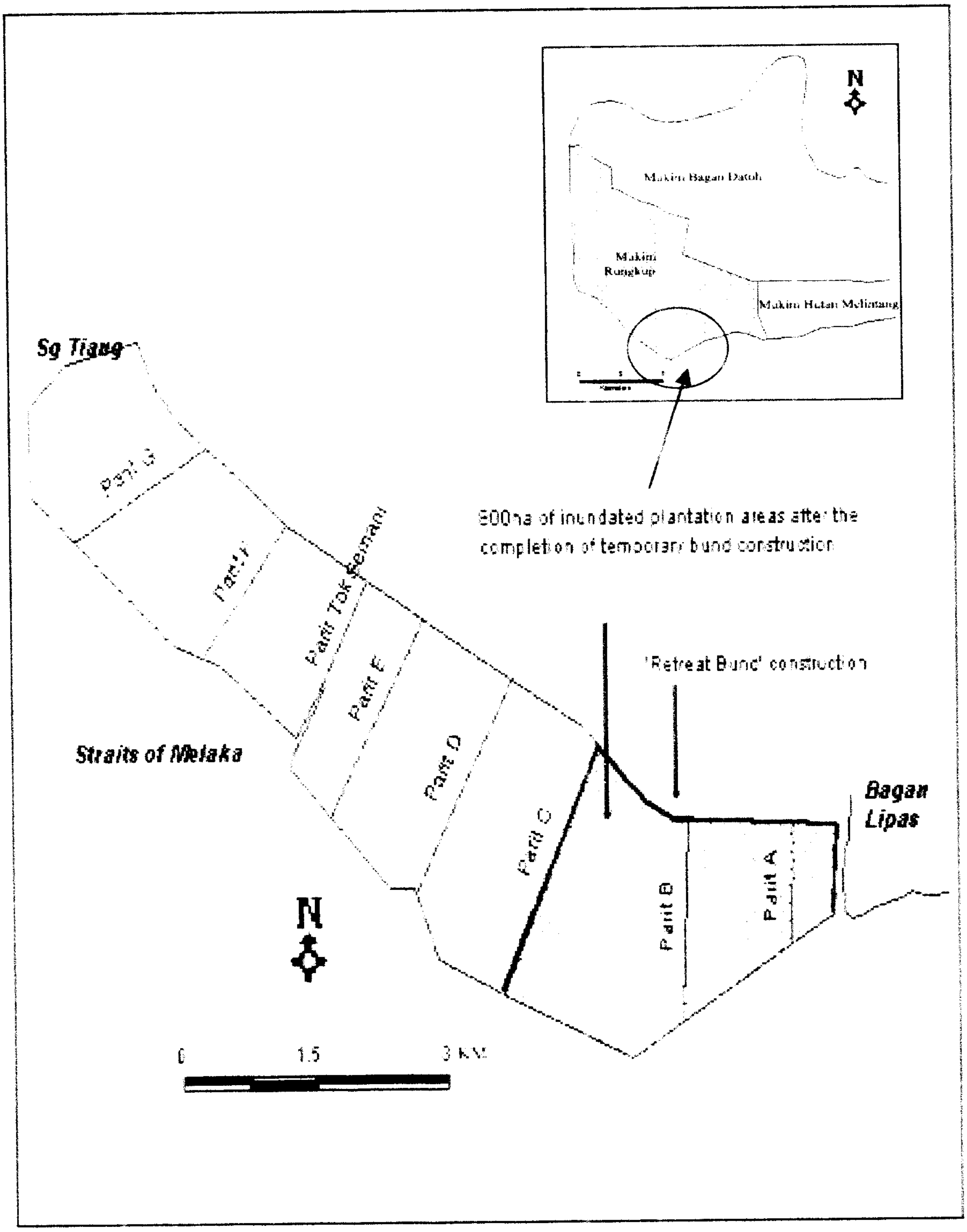
Figure 6.29 shows the proposed alignment of permanent coastal bund by DID. The permanent protection bund is planned to be implemented within the 8th Malaysia Plan with the hope that this coastal protection project will be a successful measures against the attacking waves thus resolving the flooding caused by sea water inundation so that the agriculture area will be recovered. It is suggested that the cost of land restoration (drainage only) would cost RM237,500.00 (DOA 1994).

The cost of repairing the damages was much higher than it was thought. It was much higher than the capital cost of land conversion. Since the remedial works have been a costly affair and so much money has been spent, should we still consider recovering the inundated land? How long will the new permanent protection bund last? Will this permanent protection bund totally arrest the problems of bund failure in future?

Table 6.1. Maintenance and repairs to coastal bund in Rungkup

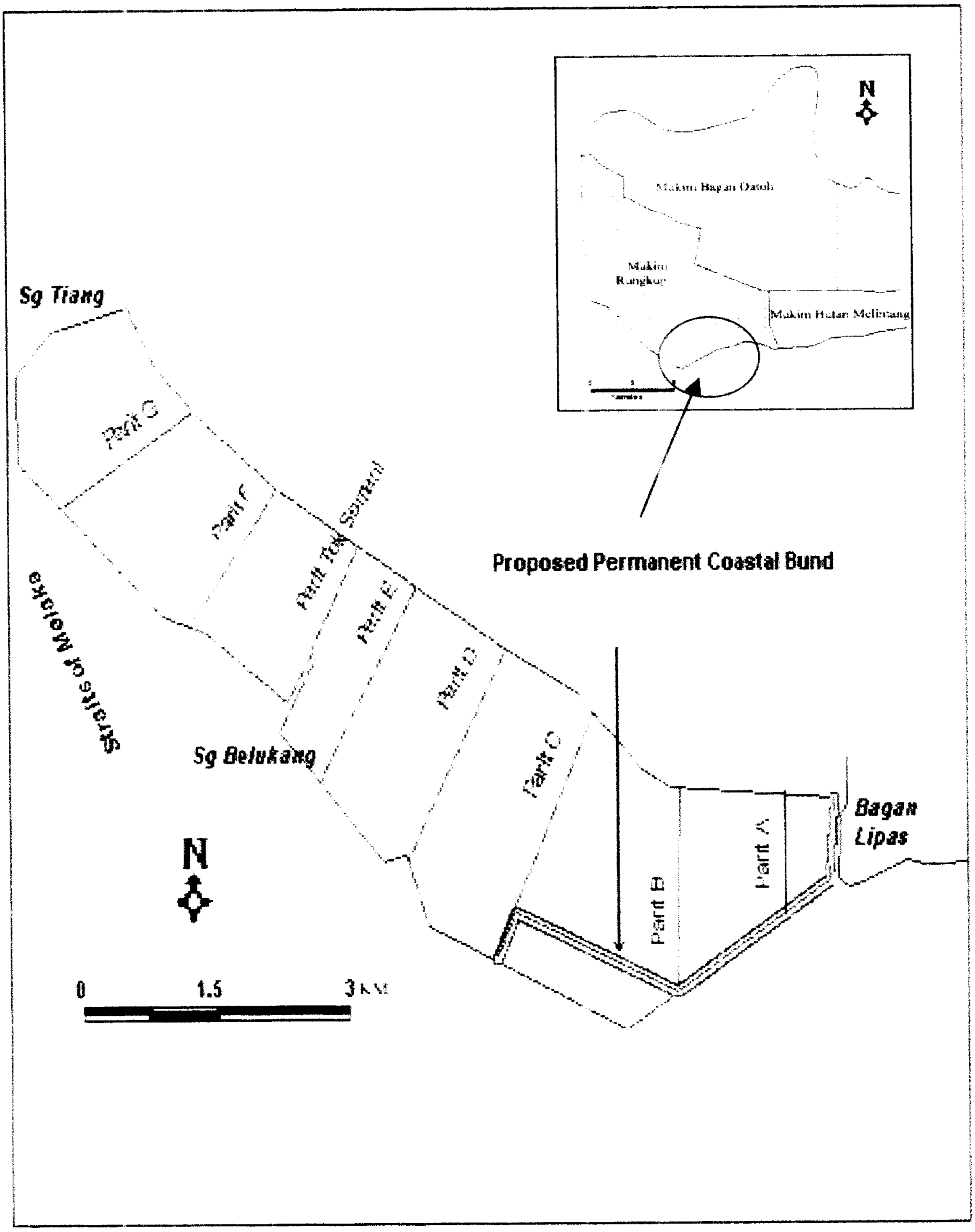
Year	Location of Coastal Structures	Total Cost RM
1932	Special repairs of bund at Sg. Balai to Rungkup, Sg. Batang to Bagan Lipas	1600.00
1935	Bund construction between Sg. Tiang and Sg. Batang	3752.00
	Bund maintenance between Rungkup and Sg. Betul	3608.00
1987	Erosion control works (rock bund) at Sg. Tiang (600m)	2,873,717.00
1991	Rectification works of rock revetment at Sg. Tiang North and construction of retreat bund, single 6'.0" x 6'.0" tidal control gate type 1 and creek closure at Sg. Tiang South (591.5m)	2,162,855.75
1994	Erosion control works (rock bund) at Sg. Tiang South (1490m)	5,152,797.24
	Erosion control works (rock bund) at Bagan Lipas (300m)	1,096,472.00
	Emergency control works to reconstruct the breach bund at Sg. Belukang (60m)	2,396,826.56
1995	Emergency works (rock bund) at Sg. Belukang (230m)	170,087.30
	Emergency works on reconstruction or retreat bund (rock bund, 60m and earth bund, 540m) at Sg. Belukang, near Parit C	1,301,942.15
	Erosion control works at Bagan Lipas (Additional)	541,130.00
1996	Emergency works on erosion control and construction of retreat bund (earth bund, 100m and rock bund, 100m) at Sg. Belukang	480,000.00
	Erosion control works (rock bund) at Sg. Belukang (1210m)	9,064,925.04
1998 –	Additional erosion control works (earth bund, 5.1km and rock bund, 945m) at Sg. Belukang	3,602,994.72
1999	Erosion control works (rock bund) from Sg. Belukang to Tebuk Semani (2km)	4,666,215.00
	Upgrading of rock bund at Sg. Belukang from CH 414m to CH1285m (1.2lm)	726,531.50
2000	Reconstruction part of retreat bund (earth bund, 4 km and geofoam bund, 1 km) along Parit C and JKR reserve at Sg. Belukang	3,955,945.40

Source: DID/JPT/JPS Annual Reports
Hidzrami 1999



Source: Hidzrami 1999

Figure 6.28. Retreat bund in Sg. Batang



Source: Hidzrami 1999

Figure 6.29. Proposed permanent coastal bund in Sg. Batang

6.2.2.3 Loss of Livelihood

Smallholders dominate the study area, and this implies that the livelihood of the farmers could be jeopardized. The inundated land in Sg. Batang is no longer suitable for cultivation and it may take years to recover the land. It was estimated that the loss incurred to the smallholders was about RM1.8 million (DOA 1994).

The biophysical characteristics of the neighbouring areas not permanently inundated by seawater could also be affected and this may render these areas unsuitable for agriculture. The dying of coconut palms and low yield in the neighbouring areas faced by the farmers at present is the effect of inundation. Seawater intrusion to the neighbouring area may reduce the resistance of the crops. When resistance is low, it can easily be attacked by pest (Utusan Malaysia 1997).

Other than farmers, fishermen in the area will be affected too. Shrimp farms may have to be relocated and coastal fisheries might disappear should the bund failed and the land inundated. Self-employed fishermen suffer too when their means of production is lost, and they may not have the requisite capital to resume work in a timely fashion, therefore, they may seek alternative employment.

6.2.2.4 Loss of Amenities

Increased wave heights and storminess may lead to increased damage to coastal amenities. Flooding caused by storm surge and sea level rise may damage coastal roads and other infrastructures. It was lucky the latest bund failure in Rungkup has not damaged the public amenities there except lost of land, houses and some personal belongings.

Damages to houses and other social amenities are unavoidable. If the destruction of building and infrastructure is severe, it is likely to have economic impacts that extend far beyond the direct costs associated with repairing or rebuilding. The new coastal road may have to be reconstructed. Increased expenditure will be necessary on flood protection and the planning and zoning of activities in this area.

Communities living in coastal areas vulnerable to increased flooding may be relocated. This is already happens in Bagan Sg. Tiang, Bagan Sg. Belukang and Sg. Batang.

6.3. Evaluation of Response Options

In assessing the response options in Rungkup, the researcher has identified three types of coastal response options. The response options to protect human life and property fall broadly into three categories; protection, accommodation and retreat.

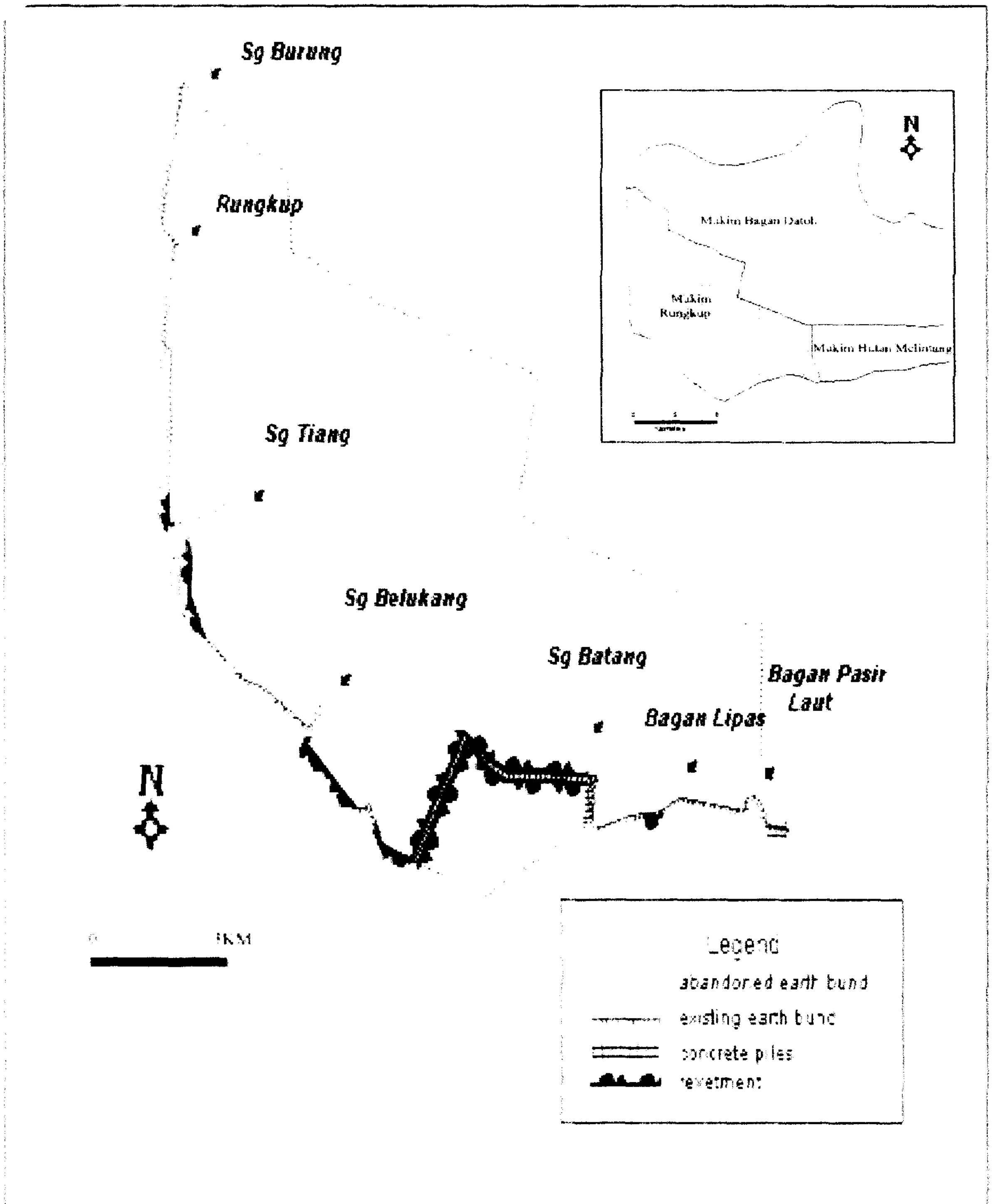
a. **protection**, which aims to protect the land from the sea so that existing land uses can continue,

b. **accommodation**, which implies that people continue to occupying the land but make some adjustments,

c. **retreat**, which involves no attempt to protect the land from the sea, in an extreme case, the coastal area is abandoned.

Figure 6.30 shows the latest structural control works along Rungkup coastline which was mapped in September 2001. Nearly the whole length of the coastline of 27.4km in Rungkup is protected by bunds, 11km of which have been revetted with rocks and 0.4km with concrete piles (Plate 6.1).

None of the agricultural lands was protected by rock revetments from erosion before 1980s but now part of it is protected by rock bunds. This is likely to continue since erosion seems to have increased in many of the agricultural land and armouring for a large agricultural parcel would be necessary but expensive.



Source: Personal Study 2001

Figure 6.30. Existing coastal structures along Rungkup coastline

The coastal bund in Rungkup is in vulnerable condition due to a number of factors such as lack of maintenance, soil condition, activity of the boring crabs, design of the bund, etc.

A large amount of coastline armouring in the study area has been put into place under 'emergency' circumstances, either during or after bund breaching. A good many breaches in coastal bund were not caused by the violence of storms and floods, but through neglect. Closing breaches and topping up the bunds wasn't carried out until the coastal bund breached to a greater extent affecting the coastal community as had happened in Sg. Batang recently (The Star 1995).

Traces of old and abandoned embankments are ubiquitous sights in Sg. Tiang South. Minimal maintenance there too leads to the abandonment of two coastal bunds (Figure 6.30). The construction of the new existing earth bund in Sg. Tiang South is the 3rd defence system against coastal erosion. These bunds were repaired only when breached and many less damaged stretches of the embankments are often left untended due to a shortage of funds. Priority is also given to repairs in certain areas based on socio-economical considerations.

Besides that there is very little regulatory review of any project, which took place during emergency process. Without project review, coastline protective devices are created or altered with minimal technical analysis/engineered design, minimal review of potential alternatives and minimal review of adverse impacts. As the result, bund breaching, overtopping and bund retreat continue to be a major problem along Rungkup coastline.

Past records show that coastal erosion and flooding isn't new to Rungkup. The construction of coastal bunds here failed in the initial pioneering. It is also observed that the bunds in Rungkup are prone to erosion and breaching mainly associated with geotechnical problem. The bunds were built with locally available materials such as coastal clay. Coastal clay is invariably very soft and high natural moisture content. When the spoil dries out after being placed on the bund site, it shrinks and the superimposed load of this spoil usually results in a certain amount of ground settlement accruing. The low shear strength of the coastal clay also limits both the height and the steepness of the slopes to which these bunds can be built.

Slip and breaches of bund in Rungkup may also be partly due to the activity of boring crabs. Certain species of crustaceans are a menace to the safety of the bunds. They burrow the soft mud under the bunds and eject the spoil on to the surface round the edge of the hole, causing leakages through the bunds.

A study of the existing coastal profile too provides a second identification that new portions of this 27.4km of coastline may be armoured in future. Based on this screening effort, 25km of the coastline except from Rungkup to Sg. Burung were considered in need of future protection. Figure 6.31 to 6.39 show the condition of the existing coastal profile that needs further attention.

The coastal bund, built of local or imported earth is about 1.2m to 1.4m wide on the crest that lies about 2m to 3m above mean sea level. According to DID Teluk Intan during southwest monsoons, squalls known as 'Sumatras' may develop and this can result in wave of 2m to 3m in height with a maximum period reaching 9 seconds. Based on the 25, 50 and 100 year of storm surge recurrence interval, storm surge in Bagan Datoh can reach more than 3m in height (Table 3.4). Thus these less than 3m high earthen or rock bunds in the figures shown are clearly inadequate to sustained high-energy waves of the erosive monsoons.

The coastal profiles along Sg. Tiang North (Figure 6.31-6.32) show the lowest coastal bunds among Rungkup defence system. The less the 2m bunds in Sg. Tiang North will be overtopped should there be a slight rise in water surface elevation during HAT. Generally bund overtopping occurs here during monsoon.

Figure 6.33 shows the shrimp ponds being protected by coastal bund in Sg. Tiang North. This area was once covered by mangroves. Previously mangrove belt dissipated quite a lot of wave energy but now it has to be dissipated by the bunds that protect the ponds. There is a high risk that erosion will damage the bund in future.

Bunds in Sg. Tiang South (Figures 6.34, 6.35), Sg. Belukang (Figure 6.36) and Bagan Lipas (Figure 6.38 and 6.39) are steep. These bunds are susceptible to slope failures thus affecting the integrity and stability of the bund structure.

An eroding coastline in Rungkup is shown by the development of micro cliff in Sg. Tiang North (Figure 6.31) and Sg. Belukang (Figure 6.37). Revetment found in Rungkup coast is mainly loose revetment where rocks were dumped into the sea especially in Bagan Lipas and Sg. Tiang. These coastal structures tend to fail unless permanent protection works carried out.

Rungkup coastline is indeed inadequate protection based on the figures shown. The identified areas do need future protection.

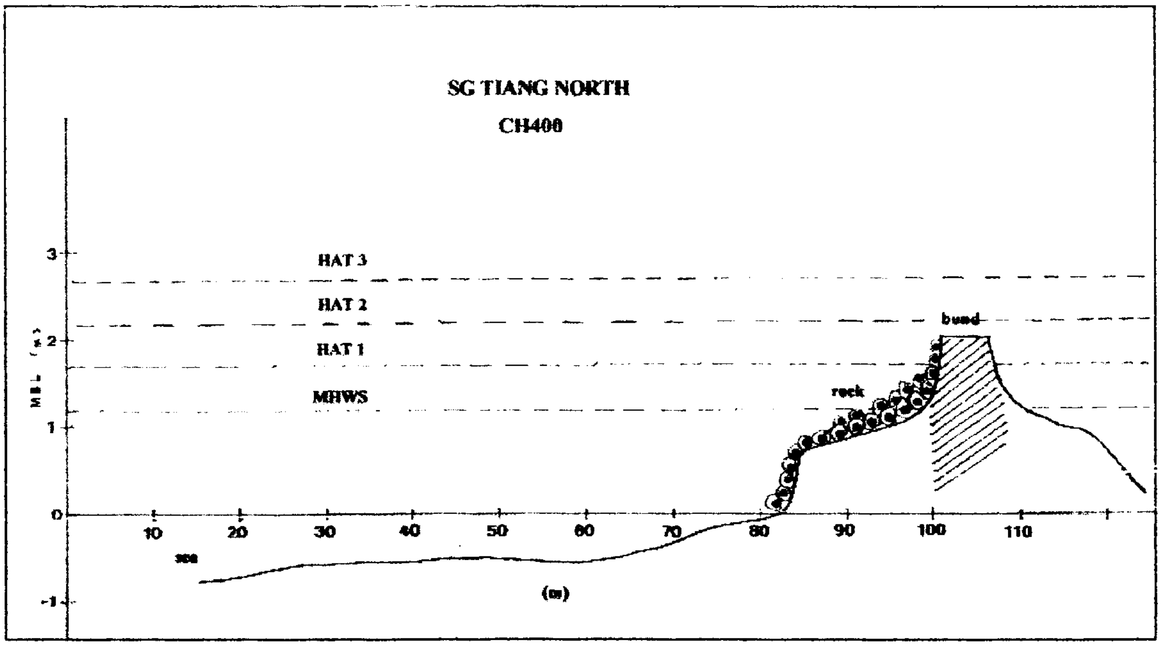


Figure 6.31. Cross section of coastal bund at Sg. Tiang North (CH400)

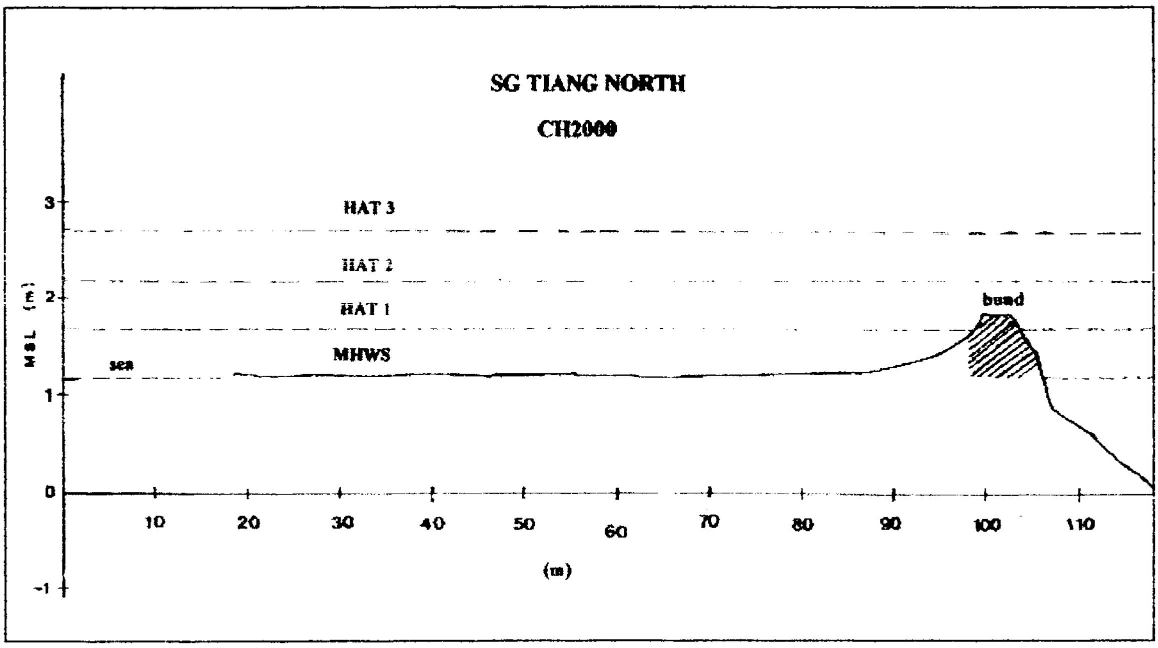


Figure 6.32. Cross section of coastal bund in Sg. Tiang North (CH2000)

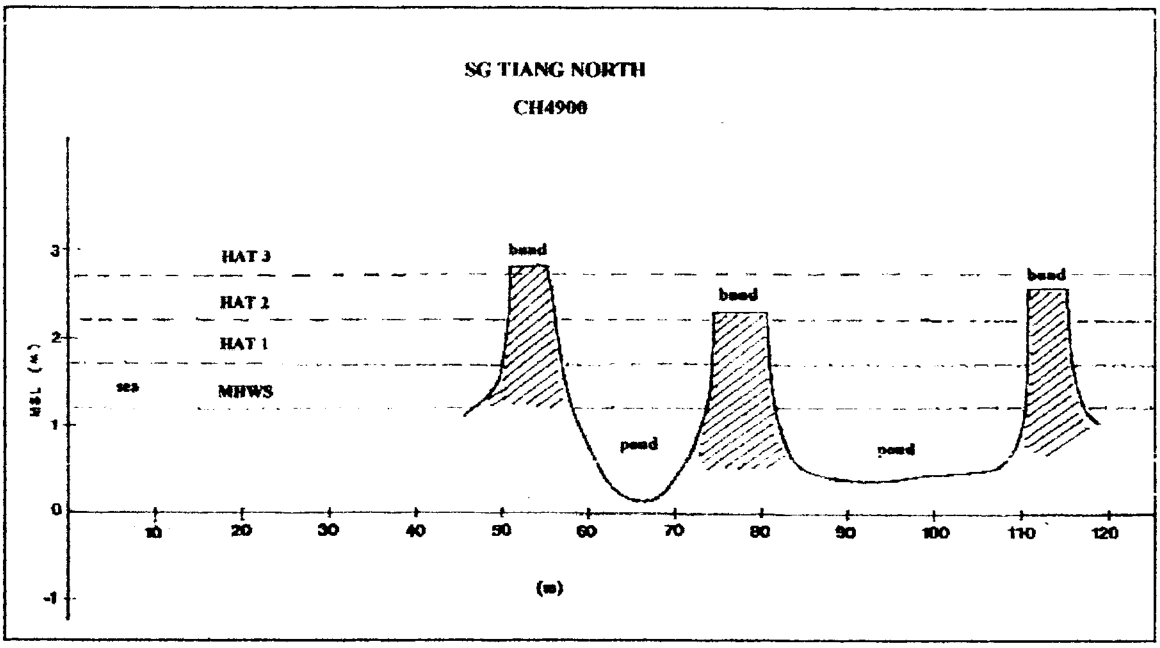


Figure 6.33. Cross section of coastal bund in Sg. Tiang North (CH4900)

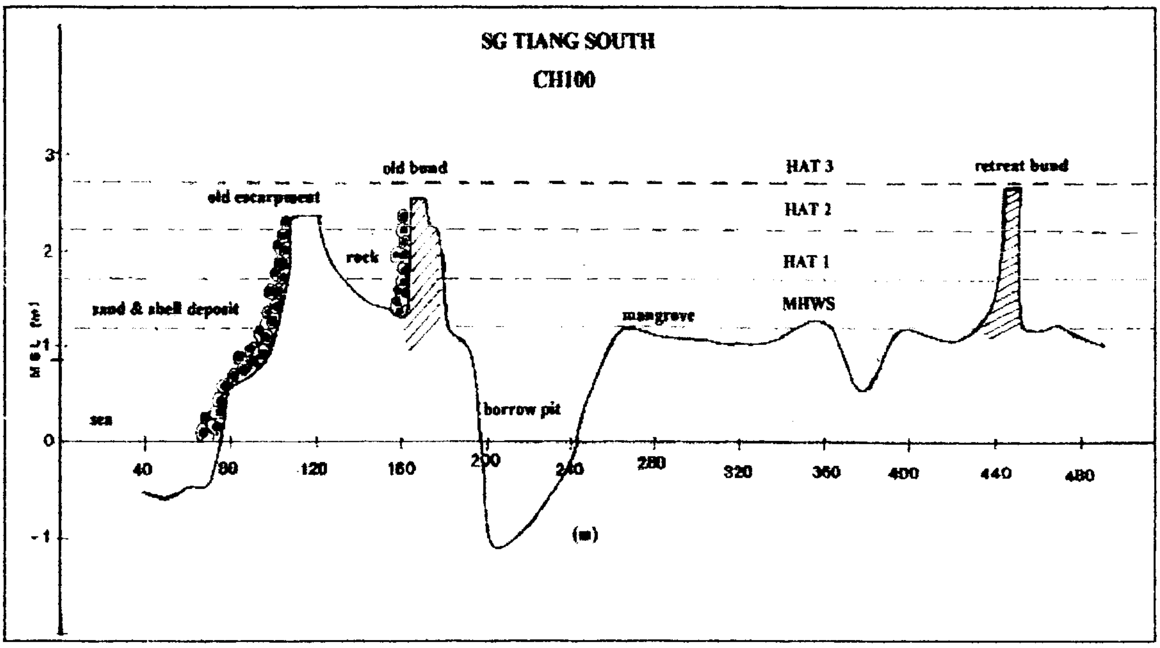


Figure 6.34. Cross section of coastal bund in Sg. Tiang South (CH100)

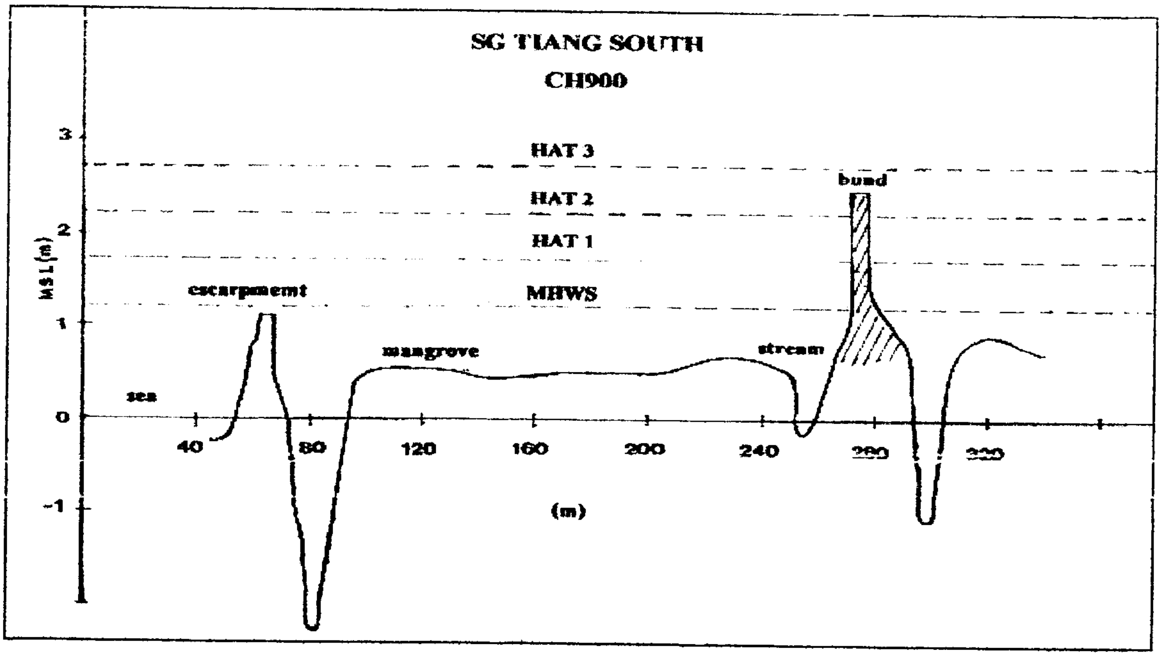


Figure 6.35. Cross section of coastal bund in Sg. Tiang South (CH900)

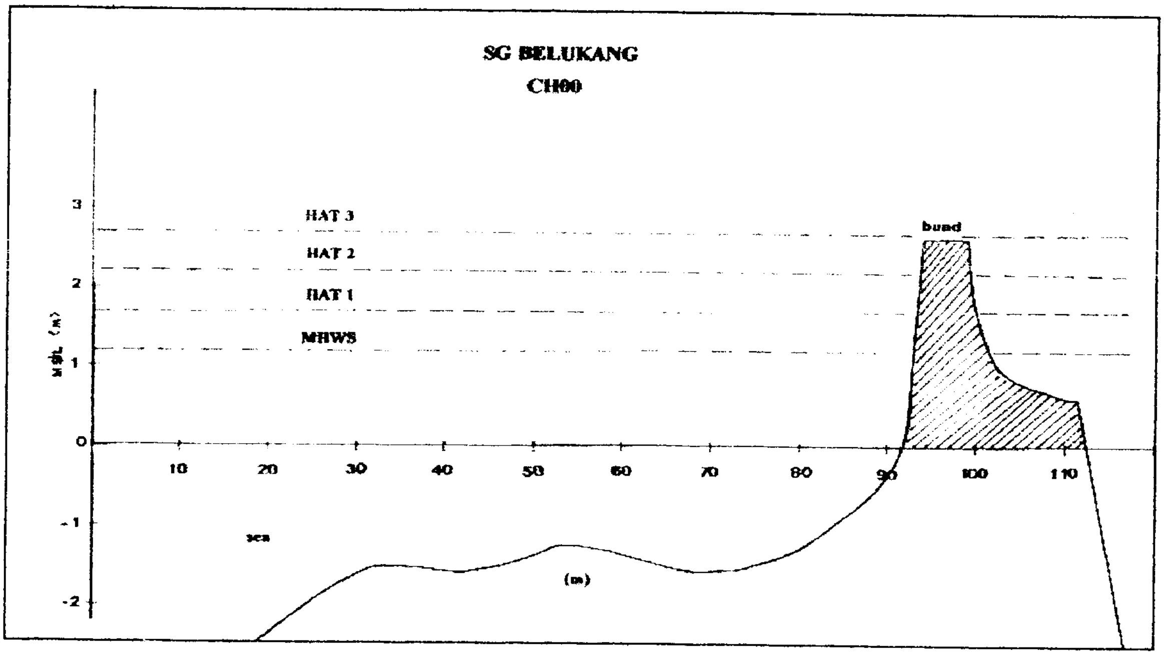


Figure 6.36. Cross section of coastal bund in Sg. Belukang (CH00)

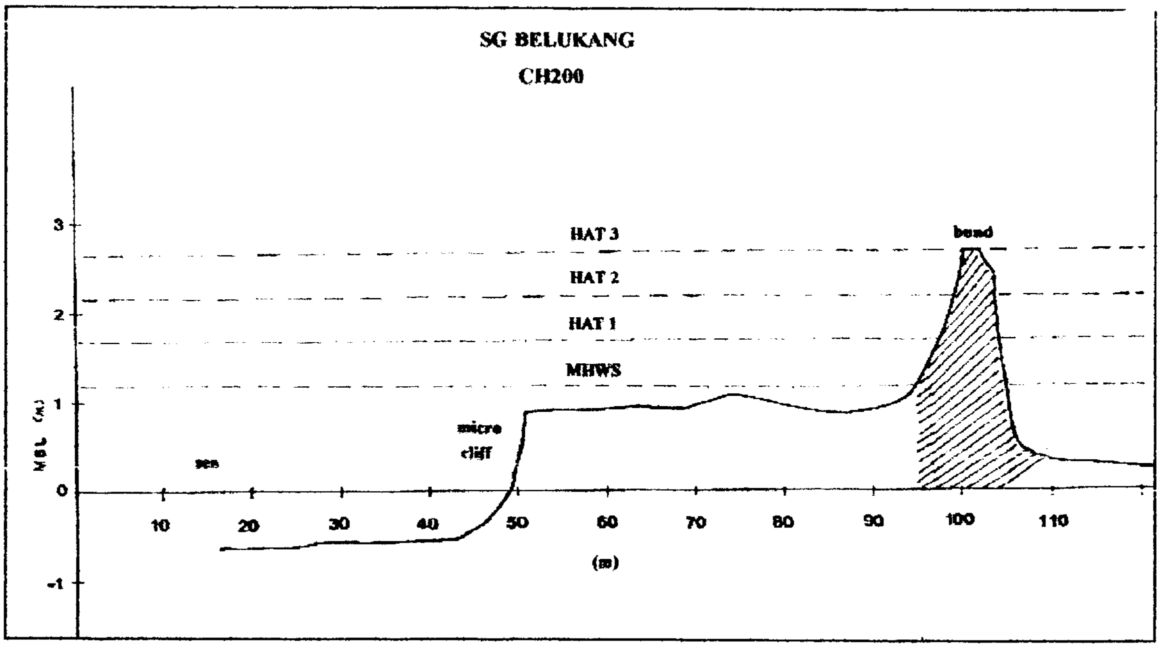


Figure 6.37. Cross section of coastal bund in Sg. Belukang (CH200)

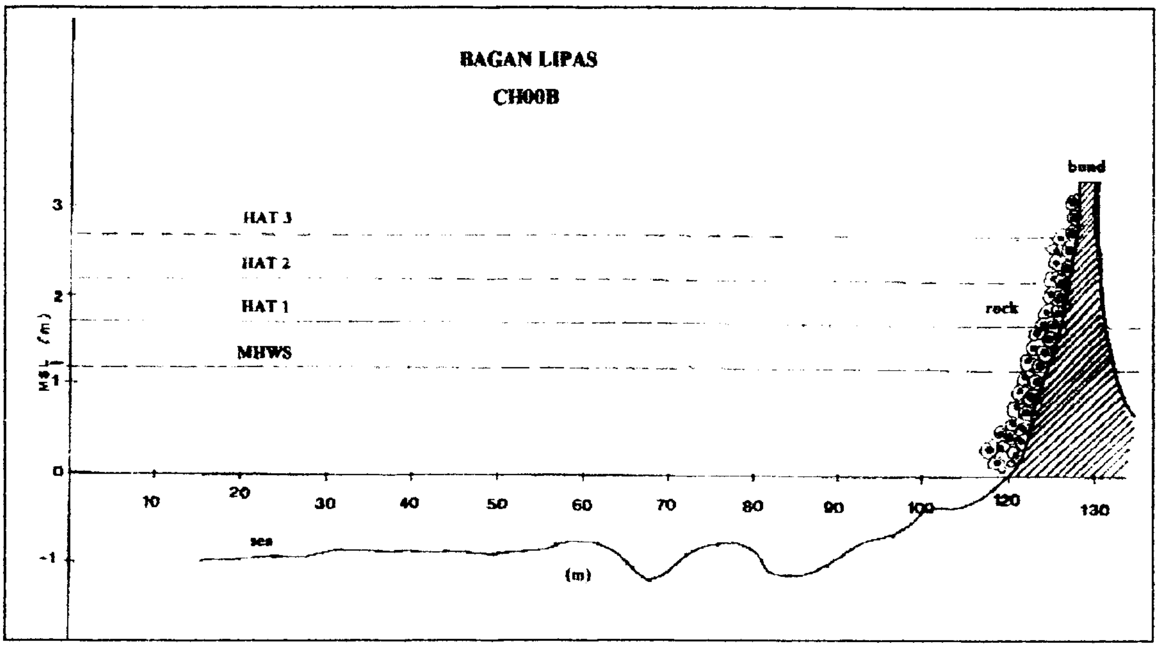


Figure 6.38. Cross section of coastal bund in Bagan Lipas (CH00B)

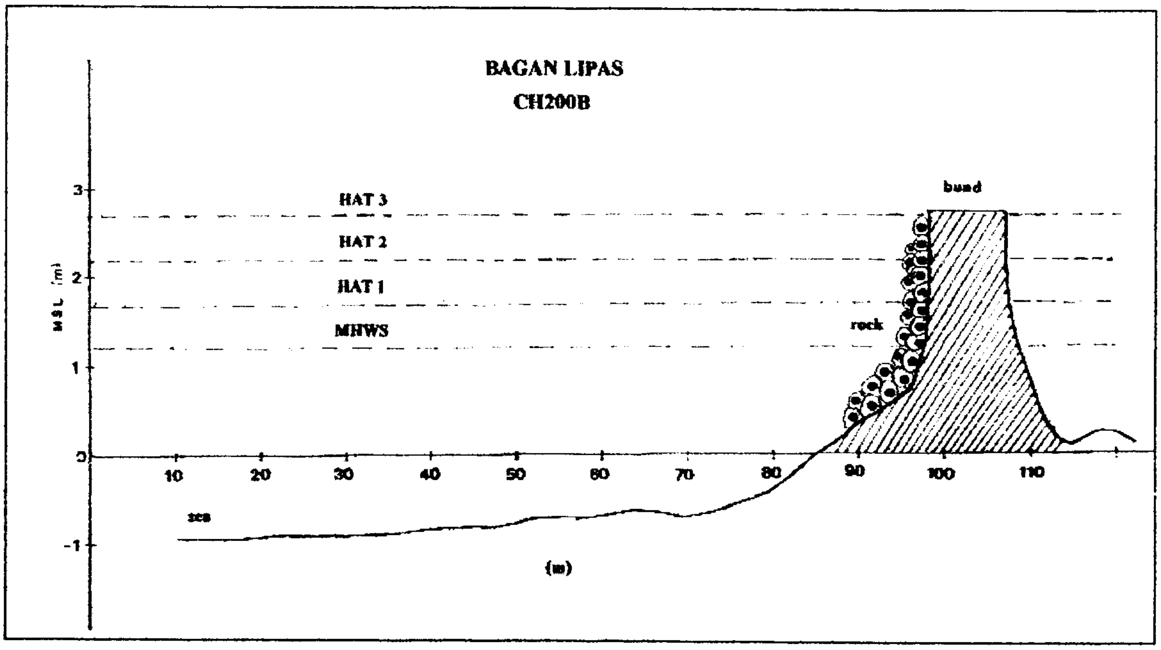


Figure 6.39. Cross section of coastal bund in Bagan Lipas (CH200B)

Another response option in Rungkup is accommodation where people in Rungkup continue to use the land at risk. They make some adjustment to prevent the land from being flooded. People in Bagan Sg. Belukang elevated their buildings on piles from time to time to avoid coastal flooding whereas some in Bagan Sg. Tiang used old tyres to reduce the impact of coastal erosion. Some are converting agriculture to shrimp farming along Rungkup coastline.

Retreat involves no effort to protect the land from the sea. The 800ha of inundated land in Sg. Batang is abandoned at present whereas houses that have been damaged by erosion were abandoned in Bagan Sg. Belukang, Bagan Sg. Tiang and Sg. Batang. This can be traced in topographic maps and field survey and these abandoned and damaged houses were mapped as shown in Figure 5.6, 5.7 and 5.8. Coastline erosion along Rungkup will continue to occur in the absence of protective fringing mangroves. Therefore replanting of mangroves in Sg. Belukang and Sg. Tiang has been carried out by DID as a form of response option to overcome coastal erosion in Rungkup.

Response options to coastline change around the Rungkup Peninsula should be based on an evaluation of the erosion risk, the value of the coastline being eroded, cost effectiveness of protection measures and the long term environmental implications of the response.

In the retreat option, coastal landowners and communities in Rungkup would suffer from loss of property, resettlement costs and the costs of rebuilding infrastructure. Resettlement could create major problems. The loss of traditional environments which normally sustain economies and cultures and provide for recreational needs could disrupt family life and create social instability. No wonder majority of the survey respondents were unwilling to be relocated at a new location.

Under the protection option, nations and communities would face the costs for the necessary structures. The structures would protect economic development, but could adversely affect economic interests that depend on fisheries. The amount of money spent to protect Rungkup coastline so far does not include costs necessary to meet present coastal defence needs. The estimate does not include the value of the unprotected dry land that would be lost, nor does it consider the costs of responding to seawater intrusion or the impacts of increased storm frequency. The overall cost will therefore be considered higher.

Under accommodation option, there would be changing property values where land vulnerable to coastal flooding and erosion is of lower value. However land under TOL status such as in Bagan Sg. Tiang and Bagan Sg. Belukang will not be much affected but people occupying this land have to prepare for increasing damage from storms and costs for modifying infrastructure. Smallholders in Rungkup are practising intercropping and converting their crops from coconut palm to oil palm to reduce the impact of coastal flooding.

To ensure that coastal development in Rungkup is sustainable, decisions on response strategies should be based on long term as well as short term costs and benefits. Regardless of the response eventually chosen, community participation in the decision making process is the best way to ensure that these implication are recognized.

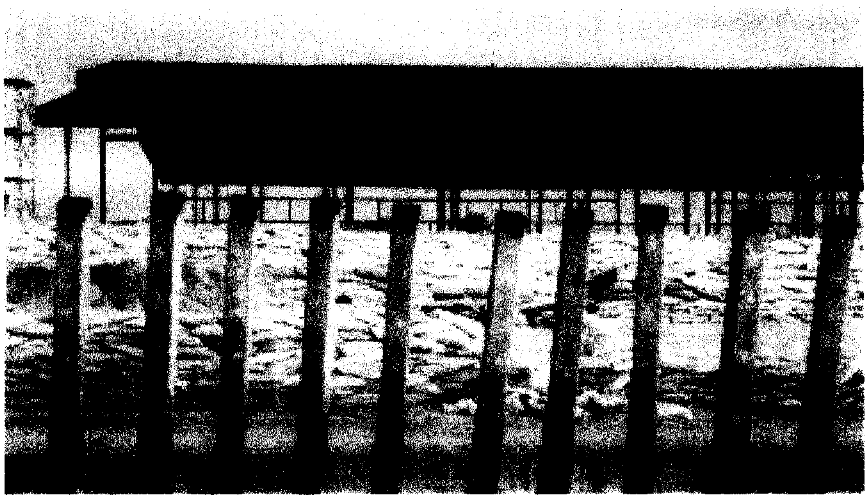


Plate 6.1. Used of concrete piles and sand bags to protect the land

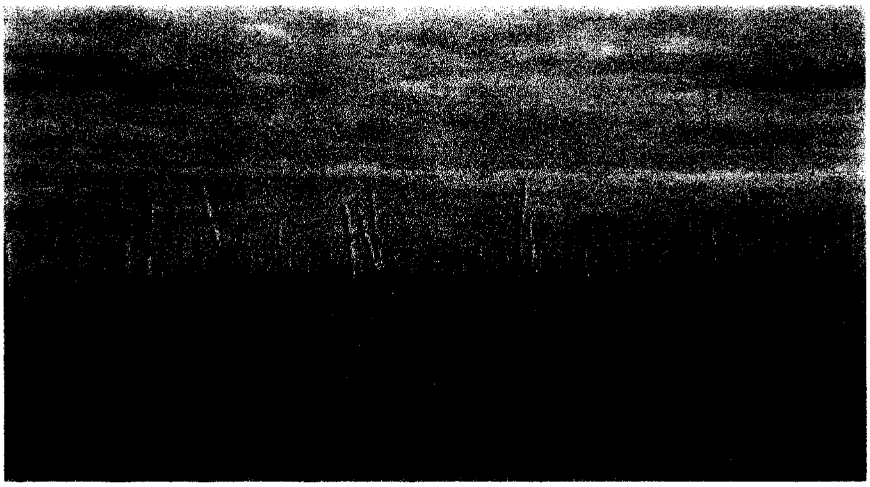


Plate 6.2. Dying of coconut palm due to land inundation in Rungkup

Plate 6.3. Construction of retreat bund in Sg. Belukang