Bank Erosion along the Rajang River in Malaysia

マレーシア・ラジャン川の河岸侵食

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要旨

本稿では，マレーシアの最大河川ラジャン川において，近年進行している河岸侵食の実態を報告し，派生する問題について若干の考察を加える。流域面積約5万平方キロメートルを持つラジャン川の中下流域では，過去30～40年の間に河岸侵食が顕著に見られるようになった。観察および現地住民からの聞き取りによると，侵食を促す間接的背景として，河岸植生の変化，上流からの大量の土砂流入，浚渫などが挙げられ，直接的な契機としては，乾燥が続き土壌がひび割れた後の大雨や，洪水氾濫後の過剰間隙水圧のほか，船舶による航走波や流木の衝突などが考えられる。こうした侵食の影響を避けるため，河岸に位置する村々（ロングハウスという居住形態をとる先住民が多い）は，これまでに幾度もの移転を余儀なくされてきたが，近年では，土地不足や資金不足などにより移転さえも困難になっている。また，近隣の華人による土地の買占めが移転を困難にしている場合もあり，民族間の緊張関係を生み出すなど，社会問題としても顕在化しつつある。一方，現地住民の自己防衛策は非常に緩慢で，政府援助や国際協力に頼ろうとする姿勢が目立つ。こうした姿勢は中央集権化の過程で形成されたもので「補助金症候群」と揶揄される。このように，自然的要因だけでなく，社会的・政治的背景が複雑に絡み合うことで，先住民の脆弱性が増大し，レジリエンスが減退しているという現状が見られた。

Ⅰ．Rivers in Sarawak and a brief sketch of the Rajang River

The purpose of this paper is to report the water disasters along the Rajang River, especially the problems caused by riverbank erosion.

Sarawak, the largest state in Malaysia, has an area of approximately 1,240,000 km^2. According to the Sarawak Rivers Board, the state has 32 major river systems, and the total length of rivers in the state is about 50,000 km[1)]. We have visited more than 30 villages (longhouses) of 4 major river systems, that is, the Rajang, Lupar, Saribas and Kemena (Jelalong) to conduct interviews with village people and observe the situation of riverbank erosion and flood. This paper focuses on the Rajang, the longest and largest river in Sarawak, as well as in Malaysia. The Rajang River is 760km in length and occupies 51,237 km^2 of catchment area (see Figure 1). In the tributaries and uppermost of the Rajang (Balui), we can see gravel and pebbles, but the riverbanks in the middle and lower basin are mainly composed of alluvial soil with small grain size, that is, sandy soil, silt soil and sandy clay.

The Rajang River still has busy river traffic filled with express boat, ***bandong*** (merchant ship), ***tongkang*** (cargo vessel), tugboat/barge, ***perau*** (longboat of local people), etc. This means that inland water transportation in the Rajang area is extremely important in the commercial as well as social

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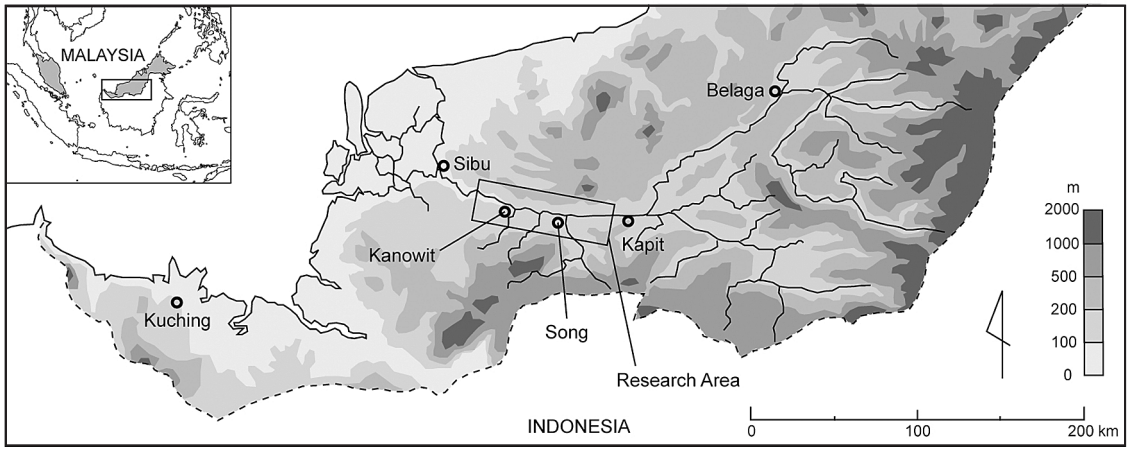

Fig. 1. The Rajang Basin and the main research area.

sense. Local residents in the concerned area mostly live in the longhouses (mostly Iban) and their everyday life is closely related to the river system. In many parts of Kanowit and upper areas, people are still largely dependent on river transport because there is no road linking them with bigger towns and cities.

While we can see many Iban villages (longhouses) along the middle basin, Chinese farmers also reside at the riverside especially in the area between Sibu and Song. Along the downriver from Sibu, there are not only Iban and Chinese, but also Malay/Melanau fishing village.

In the middle reaches of the Rajang, riverbank erosion has become a serious problem for local people (Photo 1). In the last few decades many longhouses in the area have been affected by the erosion and forced to move inland to escape from the collapse. Recently, the rise of longhouse relocation costs and shortage of flat land make the problem even more serious. Besides, there are a lot of public facilities such as schools, clinics and small market towns, most of which are also seriously damaged by the riverbank erosion.

In order to look for effective ways to protect the riverbank, we think it is important to make clear the process and mechanism of a bank erosion. Furthermore, we claim that the opinions of local people who have been affected by the erosion should also be researched because 'scientifically effective measures' sometimes results in a social confusion without paying attention to the local needs.

In the following sections, we will first describe the existing condition of the riverbank erosion along the Rajang based on our observation (Section Ⅱ). Section Ⅲ will show the local people's awareness of the erosion threat based on the data collected from the interviews with them, and in Section Ⅳ we will combine the information from both the observations and interviews to form a hypothesis about the major causes of the bank erosion. Section Ⅴ will discuss the attitude of local people toward the difficulties induced by erosion and point out the social aspects of the problem. The discussion is summarized in Section Ⅵ.

Though we have observed almost the entire Rajang Basin, the main research was conducted in the area between Durin and Kapit. The water current of middle reaches of Rajang, especially the concerned area, is relatively straight. The riverbank of this area is considered to be severely eroded comparing to the other areas. The following discussion mainly concerns this area.

Photo 1. Eroded banks.

Ⅱ. Condition of riverbank erosion in the Rajang River

We hired a longboat to observe the condition of the riverbank in the middle reaches of Rajang. We found that bank erosion is more serious at the place of village settlement and public facilities. On the bank where the longhouse or farmer's hut are located, many jetties are damaged by pier scour (runoff of soil), and some houses and huts are almost collapsed because of the riverbank retreat. Schoolyards in particular are severely eroded probably because of the lack of vegetation (cover crop) at the site (see the left below of Photo 1).

Figure 2 shows the typical condition of riverbank in front of longhouse. The broken line is the original bank slope and the existing riverbank is drawn by the solid line. The upper part of the bank is seriously eroded, making a steep cliff. What is characteristic is that both erosion and sedimentation/siltation can be seen at the same site.

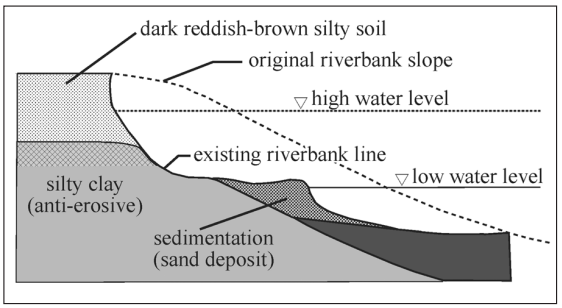

Fig. 2. Soil composition of the riverbank.

As far as sedimentation is concerned, it is very soft. When we walk on the sediments we got stuck in the mud and our knees submerged. It is guessed that at least a few meters of viscous silt soil is deposited on the toe of slope and riverbed. While we can see silt soil sedimentation in the

entire region in the middle reaches of the Rajang, it is remarkable at the front banks of longhouses, the positions of confluence, and embayment. Sedimentation along the riverbank in the middle basin indicates that a large amount of soil is supplied in the upriver. In the upper areas of the Rajang land development has been propelled since the 1970s, which probably caused an increase in the soil supply. Observing the sedimentation at the toe of bank, it can be guessed that riverbed aggradation have occurred in the last few decades.

Apart from sedimentation on the toe of slope, erosion usually occurs on the upper part of the bank, making a steep cliff on the slope. So far as observing the outcrop of the eroded bank cliff, the geological structure in the concerned area is almost the same. The banks were originally covered by alluvial soils of dark reddish brown color, which have been undermined by the erosion. At present, somewhat consolidated clay appears at the lower part of the bank. As a result of the erosion, we can see two different types of soils on the outcrop. While the lower part is a gray colored clay with high-viscosity that is relatively tolerant to erosion (Photo 2), the upper part is more subject to erosion with reddish/brown silt and sandy soils. The degrees of erosion differ according to the type of soil.

Photo 2. Clay soil.

Thus, the riverbank in the middle Rajang is summarized as the degradation of vegetation especially in front of the longhouse and schoolyard, a large amount of sedimentation at the toe of the bank, and the outcrop of bank cliff composed of different types of soil. Hereinafter, we would like to point out some possible factors that seem to be related to the bank erosion, that is, the shipping traffic, drift timber and dredging works.

The Rajang has a very low water velocity and there are little surface waves, but we can see vessel-induced waves reaching the bank. Local people believe that these waves have a damaging effect and are likely the causes of the riverbank erosion. Although there is no record on the exact number of boats, ships, vessels sailing across the Rajang, it is estimated that at least a few hundreds of ships and vessels (including boats) sailing every day. Express boats in particular, induce relatively big waves (Photo 3). At the time of high water level this wave can undermine sandy and silt soils of upper part of the bank slope.

Driftwoods and dredging work are also possible factors of the erosion. In the dry season we can see driftwoods retention (see Photo 4). When these woods washed up by the current during high water level, they would damage the bank slope.

During our research we often saw dredge ships. Although we do not have detailed data on dredging works in the Rajang, generally speaking, dredging riverbed sand would dramatically change the cross section of the river, which may indirectly cause the riverbank erosion. Further research is needed to elaborate these points.

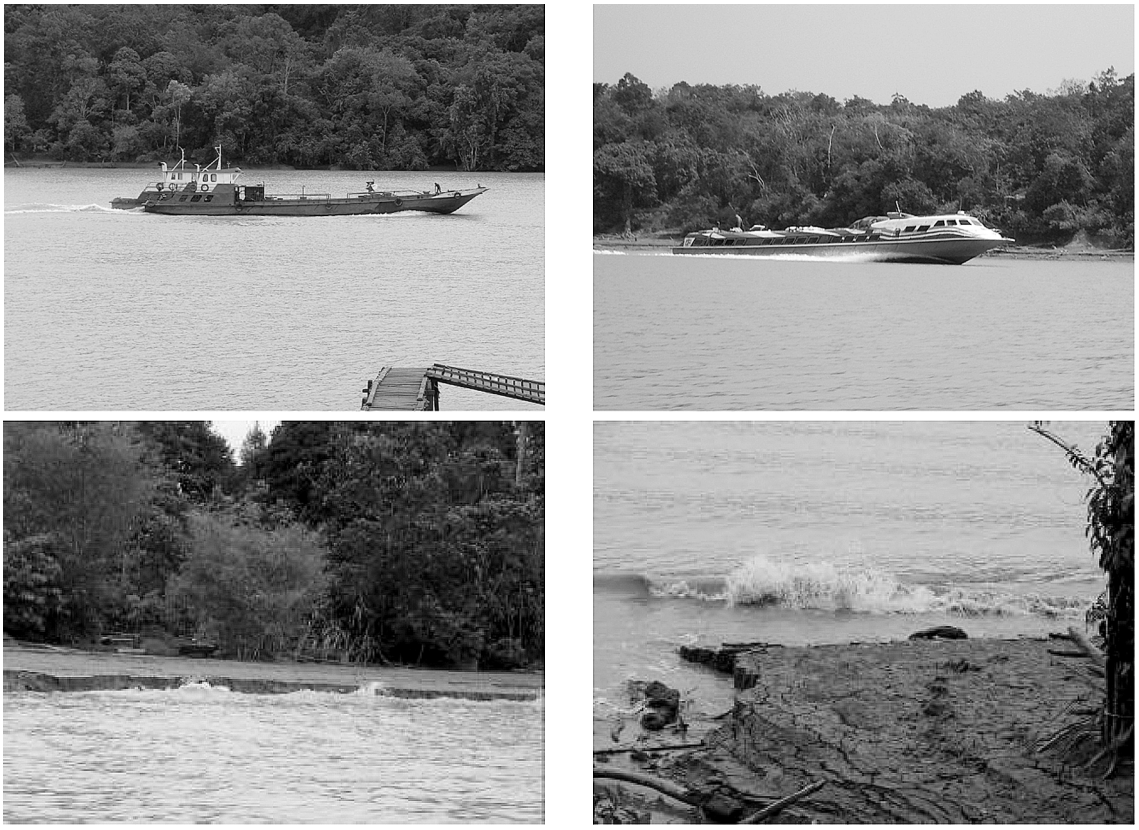

Photo 3. Vessels and vessel-induced waves.

Photo 4. Drift timber.

Ⅲ. Perception of local residents on riverbank erosion

Almost all of the old residents state that the Rajang is gradually widening in the last few decades. In Photo 5, a chief of an Iban village near the Dap Town is showing that the riverbank of thirty years ago was around the broken line, more than 50 meters anterior from the existing bank. He also says "when I was young we could easily swim across the river, but nowadays it is impossible because the river has been widen and the water velocity has become faster." This kind of statement was heard

throughout the middle Rajang. According to the interview with local residents, the riverbanks have been eroded since the 1970s. The length of eroded land is estimated 20–50 meters, that is, an average of 50–150 cm of land is lost every year.

Table 1 summarizes the statements of people we interviewed. Most of them claimed that the main reason for erosion is the shipping traffic[2]. They say that since around 1970 large vessels with powerful engine and high-speed express boats were introduced in the Rajang. As local

Photo 5. An Iban village chief pointing the past riverbank.

Table 1. Summary of interview with local residents along the Rajang River.

Village No.	No. of doors	Population (Approx.)	Location	District	Age of informant	Longhouse construction year	Brief history of the longhouse community	Problems caused by erosion	Reasons of erosion
1	16	150	Ng. Tau	Kapit	80	1983	We moved to the present site due to erosion.	Our land, fruit trees, jetties and concrete path were lost and damaged. We also suffer from erosion and landslide at the backyard of the longhouse.	(1) Barges transporting logs, and (2) express boats.
2	25	83	Ng. Sembawang	Kapit	52	1983	We came to the present site from Nanga Tau.	Very active erosion damaged our jetty and many fruit trees uprooted.	(1) Waves of express boats and barges, and (2) loose sandy soil susceptible to erosion.
3	33	180	Lijau	Song	?	1960s	We moved longhouse twice due to erosion.	Erosion is very damaging. Our verandah, jetties, rice mil, plank walk and fruit trees were eroded away. About 100 feet of land disappeared.	(1) Waves of log barges, tugboats and express boats, and (2) heavy rains coupled with sandy soil.
4	28	200	Ng.Manap	Song	60	1980s	This is the third site. Moved here due to civil animosity among the Iban.	Erosion is very active. We have bulldozed another site at our backyard in order to build another longhouse.	(1) Waves of tugboat, barges and express boats, (2) heavy rain, (3) soil is not hard enough, (4) soft sandy soil on the bank.
5	23	160	Ng. Temalat	Song	48	2000	We moved three times to the present place due to erosion. The former longhouse was gutted by a fire.	About 100 feet of land was gone due to erosion. Fruit trees were uprooted. The water of the Rajang was much darker in the last time, but became yellowish muddy color.	(1) Waves of express boats and motorized vessels, e.g. tugboat, barge and motor launch, and (2) extraction of sand and pebbles along the Rajang.
6	16	85	Ng. Sekedai	Song	63	1988	We moved three times due to erosion.	Some lands and fruit trees were eroded.	(1) Waves of motorized vessels such as express boats, barges, tug boats and motor launches, and (2) torrential rain.
7	47	380	Beguang	Song	70	2005	We moved three times due to erosion and flood.	Rubber garden, land and jetties were eroded (above 80 meters eroded in the last few decades).	(1) Log barges cause big waves besides express boats. (2) torrential rains.
8	12	110	Ng. Sengayan	Kanowit	76	1996	Before Japanese occupation we settled at riverbank of Rajang, and afterwards, moved up due to erosion. In 1996 we moved again to the present site.	Our longhouse is not affected now, but our lands (including titled lands) and fruit trees have been eroded.	Erosion is due to waves of express boats, tugboats, and ships. Especially during water inundation, these waves are main factors for accelerating erosion.
9	13	76	Ng. Bawan	Kanowit	39	1990	Our longhouse was reconstructed 3 times in the past, i.e. 195, 1974, and 1990 due to erosion.	Jetties were destroyed and many fruit trees uprooted. Titled lands were also eroded away.	This area has a very heavy riverine traffic e.g. express boat, tugboat, vessel, barge and motorized launch.

Village No.	No. of doors	Population (Approx.)	Location	District	Age of informant	Longhouse construction year	Brief history of the longhouse community	Problems caused by erosion	Reasons of erosion
10	41	325	Teluk Jambu, Ng.Ngemah	Kanowit	68	1984	We built a new longhouse due to structural deterioration of longhouse.	The playground was eroded, fruit trees uprooted and jetties damaged many times. Constant maintenance is needed.	During high tide, the waves of express boats and tugboats pose active erosion.
11	31	240	Ng. Ngemah	Kanowit	64	2006	We moved once due to erosion and a fire (former longhouse built in 1965).	(1) Jetties are frequently destroyed and had we have to de maintenance. (2) Our present longhouse is situated inland, so not directly affected by erosion, but a few individual houses had to be relocated up. (3) Four to five feet of land is eroded in average per year. The Rajang was a small river in the past.	(1) Waves induced by motorized vessels, e.g. express boat and tugboat, (2) torrential rain, and (3) drift timber remnants entrained from upper Rajang.
12	22	238	Ng. Kabah	Kanowit	56	1989	We constructed longhouses three times on the present site (first longhouse was built in the 1900s, second one in 1950, and the last one in 1989 due to active erosion).	(1) Erosion forced us to build a new longhouse. (2) Fruit trees were uprooted. (3) Jetties are often damaged. (4) There is no land for planting vegetables near longhouse. (5) It is difficult to find a new site for longhouse. In 2008 erosion did not progress so much because we had much rain even in the dry season.	(1) Waves of express and tug boats, (2) sand dredging, (3) heavy rain, and (4) strong velocity of river current driving raining season.
13	11	60	Ng. Dap	Kanowit	43	1975 2006 (in the process of moving inland)	In 1975 we moved to riverbank of the Rajang from the upper Dap River joining RASCOM (anti-communist) scheme, and now severely affected by erosion.	Major problems: (1) fruit trees uprooted, (2) jetties destroyed, so maintenance needed very often, (3) no more land for planting vegetables, (4) cannot extend room (bilik) on backyard because of hilly land behind the longhouse. When moving a bit inland, we divided our community into two groups because of the shortage of flat land.	(1) Dredging of sand pulls riverbank soil down. (2) Waves of vessels during high tide are very effective to erosion.
14	20	215	Ng. Dap	Kanowit	65	1973	We moved twice to the present site due to erosion.	Fruit trees and jetties had been destroyed by erosion Our neighboring longhouse was severely destroyed and moved upland.	During high water inundation these waves pose very serious to erosion.
15	12	91	Batu Luking	Kanowit	53	1964	We moved once, from upper site towards the riverbank.	Jetty had been replaced twice and some fruit trees being uprooted.	Erosion is due to waves of motorized vessels as express boats, tugboats, and barges. The worst waves are from tugboats.
16	36	260	Ng.Mam	Kanowit	65	1975 2004 (under construction)	We moved to the present place in 1975, and began to reconstruct new longhouses in 2004. Both resettlement/ reconstruction were due to erosion.	Erosion and landslide at the riverbank of our former longhouse were dangerous. That is why in the year 2004, we dismantled our longhouse and moved to the present site.	Riverbank is badly eroded because of express boat and tugboat breaking waves and heavy rain.
17	60	350	Kg. Bedil 1, Kanowit	Kanowit	77	1890	We moved twice to the existing village (kampong)	Major problem here is riverbank erosion. So, we had applied for retaining wall to mitigate erosion. Because o inflow of soil into the water, the riverbed should have risen, which brought bank erosion and fatal flood.	Main reason for erosion is due to big breaking waves of express boats, tugboats, ships, etc. Another reason is dredging of sand along the Rajang

residents claim, vessel-induced waves seem to play a role in causing the bank erosion, which was often observed during our research. However, we guess that the degradation of vegetation and water level fluctuation have more damaging effect on the erosion.

Concerning the vegetation degradation, some interviewees said that after cutting trees in front of longhouse for their convenience, erosion became more active. For the longhouse people, river is important for their daily life. They use it for transport, fishing, bathing and washing. they apt to remove useless trees to make it easier to access the river. This would cause the bank intolerant to erosion.

According to the interviewees, the size of land lost by erosion is not constant. Many of them point out that the more frequently floods occur, the larger land is eroded. It is easily guessed that silt and sandy soils are drawn by the leakage of infiltrated water after the flood ebb away. Besides, it is a common perception among the local residents that the frequency of fatal flood is increasing, and the speed of the rise in water level becomes quicker.

Another important observation is that heavy rain after drought causes a collapse of the bank. The riverbank is often cracked up because of a long period of dryness (Photo 6), and then, once heavy rain comes, abundant water infiltrates into the cracks, and rips the cake of soil away from the land. This is supported by another statement; "in 2008 erosion did not progress so much because we had much rain even in the dry season (July and August)." (see Table 1)

Other statements such as "the water of the Rajang was much darker in the last time, but became yellowish muddy color" and "because of inflow of soil into the water, the riverbed should have risen for a few meters" make us imagine the changes in the riverbed cross section, that is, the rise of riverbed indirectly causes the bank erosion and widening of the Rajang River.

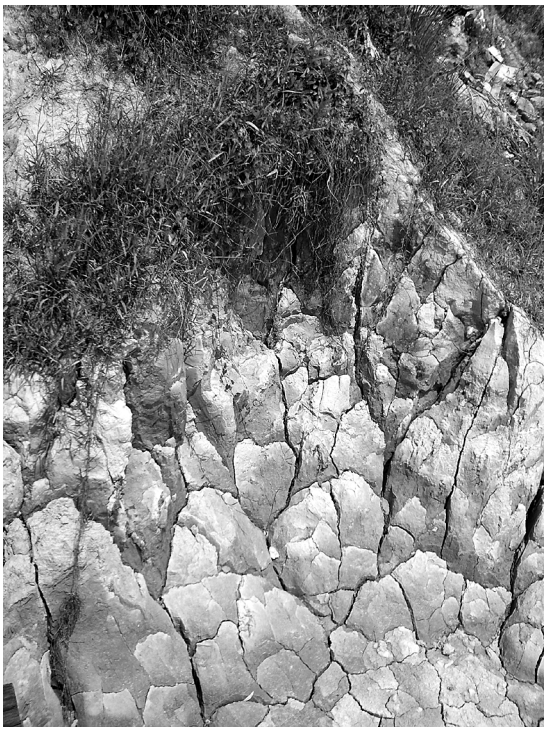

Photo 6. Cracks of the bank caused by draught.

Ⅳ. Possible factors for the riverbank erosion

We have briefly described the condition of an existing riverbank (Section Ⅱ) and the perception of local residents (Section Ⅲ). Based on the above information, we can form an empirical assumption about the process and mechanism of the riverbank erosion in the Rajang. To make clear the factors in the process of the bank erosion, we should discuss the direct prompts that trigger the collapse of soil apart from the background that caused the riverbank to become fragile and subject to erosion.

The background of the increased fragility of riverbank soils is mainly summarized into three points as follows.

1) Local residents cleared the vegetation in front of their longhouses in order to improve the accessibility to the river (the lack of vegetation is much more applicable to schoolyards), then soils of riverbank become easily eroded.
2) Inflow of soil in the upper areas resulted in the rise of riverbed, and the water current becomes likely to flow in a lateral/horizontal direction. This led to expand the width of the river and to increase in the level of floodwater.
3) Dredging continues to change the cross section of the riverbed all the time and make the riverbank soil unstable.

As for the direct factors that undermine the banks and lead to the collapse of bank slope, we can point out at least four.

4) The infiltration of large amount of water into the drought-led land cracks causes the collapse of the bank.
5) When the flooded water returns to the river, soils are drawn out because of the seepage pressure.
6) Vessel-induced waves wash away soils of the upper part of bank slope during high water level.
7) The crash of drift timber against the bank during high water level peels off bank soils, and also disturbs the wooden constructs along the river to be destroyed.

As stated above, local residents strongly complain about the damaging effects of vessel-induced waves, but it is regarded as one of the direct factors for erosion only when in combination with other indirect/remote causes. As the wave-caused collapse of land is visible and impressive for local residents, they are quick to conclude that the shipping traffic is directly causing the erosion.

There seems to be another reason why people attribute erosion to the vessel-induced wave. According to them, it was 1970s that the erosion began to be remarkable along the Rajang, when express boats started its service. Because of this coincidence, local residents may tend to correlate erosion with shipping traffic. As described above, however, it seems too simplistic. The 1970s also saw the acceleration of the development in the upper Rajang, which might cause the increase in the soil supply into the Rajang. Moreover, it is possible that direct/indirect factors for erosion have been changing in the last few decades. These points need more careful examinations.

V. Problems caused by erosion

According to the interviewees, almost all of the longhouse sites along the Rajang are affected by the erosion. All the interviewed persons claimed that certain amount of land was lost. This means that fruit, rubber and other useful trees in front of their longhouses were uprooted to drop into the river, and the shortage of front yard of longhouse makes it difficult to plant vegetables for diet.

Another major problem that interviewees pointed out was the frequent collapse of jetties and plank walk. Piers of jetties are often washed away by water current and ship-induced waves. This increases the burden of the longhouse residents with frequent works for jetty repairing and rebuilding.

Thus, many of their properties have been lost in the last few decades. As for land, most of rural areas in Sarawak have not been surveyed and registered except for some pieces of land along the major rivers and roads. Therefore, a registered/titled land has a special meaning for local residents.

Among the interviewees, a few persons claimed that their titled lands were also eroded away, which is regarded as a considerable loss by them.

What is most important is that the increase in the river width has been eroding the foundation of longhouse itself (see Photo 7). Many longhouses have experienced relocations in order to escape from the collapse of the bank. Regarding the long history of Iban migration, abandonment of the present site to resettle on another new land frequently occurred in their society. To escape from the disasters could be one of major factors causing their migration and resettlement. At present, however, it is difficult to move longhouse because of the shortage of land and budget.

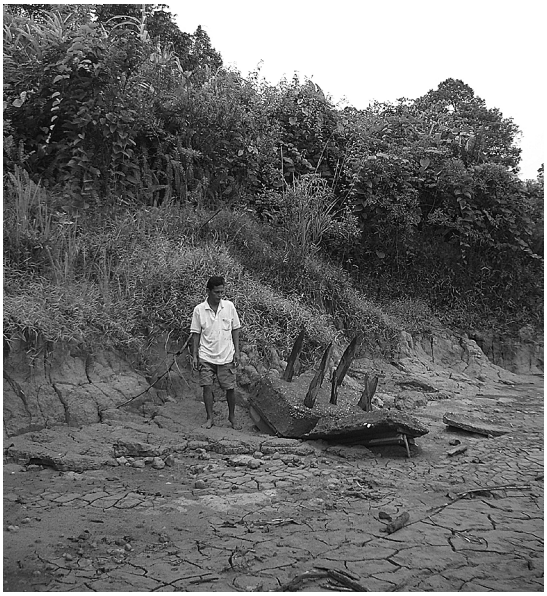

Photo 7. Fallen foundation stone of the past longhouse.

The construction of a new longhouse needs a large area of flat land. However, many of the interviewees claim that there is no more flat land suitable for longhouse. It is indeed that their land was undermined by the bank erosion, but there are social/ethnic factors, too. As described above, many Chinese farmers live on the riverbank. These Chinese farmers have informally bought their land mainly from the Iban in the last hundred years. An old Iban in Kanowit told;

> Our fathers and grandfathers were so stupid that they sold their land to Chinese as they like. The Iban in old time did not understand the value of land, so they sometimes sold an acre of land in exchange with just a ***gantang*** (approx. 18 ℓ) of paddy or salt. As a result, we do not have enough land facing the river. Now, proper land is almost owned by the Chinese. Once they obtained a land, they never sell it back to us.

A longhouse in Nanga Kabah conducted a negotiation with the neighboring Chinese landowners to buy the land back to build a new longhouse, but their effort was in vain because of the budged shortage. Many people claim that in order to escape from the disaster caused by the bank erosion they have to move far inland, which means the decrease in the accessibility to the river.

Another longhouse community near the Kanowit Town composed of 36 doors has demolished their longhouse in 2004 to escape from the collapse, but because of the shortage of large flat land they were forced to divide their longhouse community into three different places. Moreover, in the process of discussing how to divide the community, hidden conflicts among them came to surface.

Thus, people affected by the erosion also face the ethnic/internal tension. In this sense, water disasters in the Rajang could lead to social problems.

Ⅵ. Summary

Although it is quite seldom that the local residents try to protect the riverbank by themselves, we could see some examples for trials to mitigate the bank erosion[3].

Photo 8 shows a longhouse in Nanga Beguan near a little downriver from the Song Town. In 2003 they could obtain a government subsidy to make a gentle slope on the riverbank. This slope slackened the pace of erosion, but without recovery of vegetation, erosion would be accelerated again in the near future. Although longhouse residents are aware of that the slope has been less effective as time advanced, they do not take any further action on the bank protection.

Photo 8. Constructed slope at Nanga Beguan.

Photo 9. The wreckage of eroded sheet pile walls.

Another case is in Nanga Mam, where longhouse residents established sheet-pile walls for several times in the last 20 years to mitigate the effect of water velocity and vessel-induced waves. However, the wave-braking walls were collapse in a few years, and afterwards, they never done any bank protection work (Photo 9).

Although the longhouse residents earnestly appeal to us for the measures against erosion, their discussion is easily to be followed by the request for government subsidies and international cooperation projects. This kind of attitude is critically called "subsidy syndrome" that has been nurtured in the last few decades, being influence by the so-called development policy in Sarawak. We think it important to recover their 'resilience', that is, their own awareness and efforts to cope with the existing problems by themselves. In other words, they have to establish their own 'culture of disasters.'

It is indeed that the analysis of the water disasters in the Rajang River inevitably needs the aspects of physiography and river engineer, but socio-cultural and politico-economical aspects are also required to understand the entire problems. Riverbank erosion in particular, seems to be deeply related to the changes in industry and people's life styles. The combination of natural, industrial and human factors seem to increase the damage and loss caused by the erosion.

We do not think it meaningful to judge whether the existing problems in the Rajang are natural disasters or human disasters. Rather, it is more significant to know how and why local residents became exposed to the water disasters in the course of development and modernization. In other words, what should be analyzed are the processes of the increase in their vulnerability and the reduction of their resilience, both of which are the key concepts in the disaster studies at present.

Notes

1) According to the Department of Irrigation and Drainage, there are 22 major river systems in Sarawak (4,516 km of total length), and the number of Gazzetted rivers in Sarawak is 35. The ways of counting river systems and measuring the length or catchment area seem to vary among the different agencies.

2) There are some people who attribute their difficulties to *kudi'* (a kind of punishment of heaven). This will be examined in another paper.

3) Although his paper focuses on longhouse communities, public facilities such as school, clinic and small market town have placed river protection constructs such as gabion and sheet-pile. However, most of them have been eroded to become a malfunction because of the outflow of sand behind the constructs. We would like to investigate the effects of this kind of small-scale local protection works in another paper.