RESEARCH REPORT

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River Sand Mining And Management: A Case Of Cau River In Bac Ninh Province, Vietnam

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Sand mining in Cau River in Bac Ninh province, Vietnam has intensified in recent years. Despite the negative impacts of sand mining on the river, local authorities and people have exerted inadequate and ineffective efforts to control the situation as evidenced by the mushrooming of sand mining activities in Cau River. The purpose of this study is to investigate the current sand mining management in Cau River and to give policy recommendations on how to improve this management system.

The study shows that illegal sand mining in Cau River is common and indiscriminate due to the huge demand of river sand for industrial zone (IZ) ground filling and the construction industry in Bac Ninh province and surrounding areas. The number of illegal sand mining dredges as well as extracted sand volume has soared year after year. Illegal sand mining in Cau River has caused serious riverbank erosion, dike degradation, stone embankment collapse, irrigation work damage, and noise pollution. Analysis of sand mining activities indicates that private profit from illegal sand mining is very large. However, due to high external cost, especially the cost due to stone embankment degradation, the net present values of illegal sand mining were all negative at discount rates of 5 percent and 10 percent. It is clear that the external cost of sand mining in Cau River outweighs the total gain of all sand extractors.

Although the local authorities have made efforts in controlling illegal sand mining in Cau River, this activity generally has continued to proliferate. Inadequate legal framework, unclear responsibilities among stakeholders, limited resources for management, and weak coordination among local authorities (nearby localities) all contribute to proliferation of illegal sand mining activities. Of these, limited resources (fund and facilities) and weak coordination among local authorities are the primary ones. Improving the legal framework for sand mining (with clear and heavy penalty), establishing surveillance teams at the commune level, enhancing coordination among local authorities, providing more funds and facilities for management, wider dissemination of information on the external effect of sand mining, and use of alternative materials were seen as feasible strategies to improve sand mining management in Cau River.

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RIVER SAND MINING AND MANAGEMENT: A CASE OF CAU RIVER IN BAC NINH PROVINCE, VIETNAM

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EXECUTIVE SUMMARY

Sand mining in Cau River in Bac Ninh province, Vietnam has intensified in recent years. Despite the negative impacts of sand mining on the river, local authorities and people have exerted inadequate and ineffective efforts to control the situation as evidenced by the mushrooming of sand mining activities in Cau River. The purpose of this study is to investigate the current sand mining management in Cau River and to give policy recommendations on how to improve this management system.

The study shows that illegal sand mining in Cau River is common and indiscriminate due to the huge demand of river sand for industrial zone (IZ) ground filling and the construction industry in Bac Ninh province and surrounding areas. The number of illegal sand mining dredges as well as extracted sand volume has soared year after year. Illegal sand mining in Cau River has caused serious riverbank erosion, dike degradation, stone embankment collapse, irrigation work damage, and noise pollution. Analysis of sand mining activities indicates that private profit from illegal sand mining is very large. However, due to high external cost, especially the cost due to stone embankment degradation, the net present values of illegal sand mining were all negative at discount rates of 5 percent and 10 percent. It is clear that the external cost of sand mining in Cau River outweighs the total gain of all sand extractors.

Although the local authorities have made efforts in controlling illegal sand mining in Cau River, this activity generally has continued to proliferate. Inadequate legal framework, unclear responsibilities among stakeholders, limited resources for management, and weak coordination among local authorities (nearby localities) all contribute to proliferation of illegal sand mining activities. Of these, limited resources (fund and facilities) and weak coordination among local authorities are the primary ones. Improving the legal framework for sand mining (with clear and heavy penalty), establishing surveillance teams at the commune level, enhancing coordination among local authorities, providing more funds and facilities for management, wider dissemination of information on the external effect of sand mining, and use of alternative materials were seen as feasible strategies to improve sand mining management in Cau River.

1.INTRODUCTION

1.1. Rationale

Sand and gravel have long been used as aggregates for construction of roads and buildings. Today, the demand for these materials continues to rise all over the world, especially in newly developing countries (like China, India, and Vietnam) due to rapid economic development and subsequent growth of building activities. This, in many occasions, has resulted in indiscriminate mining of sand from rivers and floodplains. River sand mining is common because the mining locations are usually near the "markets" or along transportation routes, hence reducing transportation costs. However, sand mining and gravel extraction from rivers lead to a number of adverse environmental impacts. The concern about environmental impacts from river sand mining was first addressed by developed countries (Bull and Scott 1974; Erskine 1985; Kondolf 1994, 1997) and was later increasingly reported by other countries such as China (Wu et al. 2007; Lu et al. 2007), Ghana (Mensah 1997), India (Padmalal et al. 2008), and Vietnam (VietnamNet Bridge 2009).

The construction industry in Vietnam grew rapidly by around 6.5-10 percent during 2000-2009 (GSO 2009). Various construction activities and projects had been implemented in the past decade in Vietnam, including houses, industrial zones, and infrastructure projects such as road development, water supply and sanitation, and irrigation. All these required an unexpectedly high quantity of sand. To meet this demand, most rivers in Vietnam have been indiscriminately mined for sand. The results of the investigation by the Police Department for River Transportation in Vietnam (Doi Song & Phap Luat Newspaper 2009) reveal that sand mining is common and indiscriminate in all large rivers of 43 provinces (out of 64 provinces) in Vietnam. It was estimated that there are 659 large sand mining places and thousands of small mining places in all the rivers in the country. Most of the mining activities are carried out without permission from the authorities. Exploitation of sand has therefore become a problem on all of Vietnam's large rivers. The Vietnamese media have unanimously reported that unregulated exploitation of alluvial sand has become a national problem that demands a critical solution.

Cau River is an important branch in the Thai Binh River system, one of the most important water systems in north Vietnam (Figs. 1 and 2). It is 290 km long, running from Bac Kan to Thai Nguyen province, then to Bac Giang and Bac Ninh province, and flows to the Thai Binh rivers. The portion going through Bac Ninh province is about 70 km long. Cau River is also the natural borderline between Bac Giang and Bac Ninh provinces. During the flood season, the water level of Cau River is usually 3-6 meters high; it is only 0.5-1.0 meter high in the dry season.

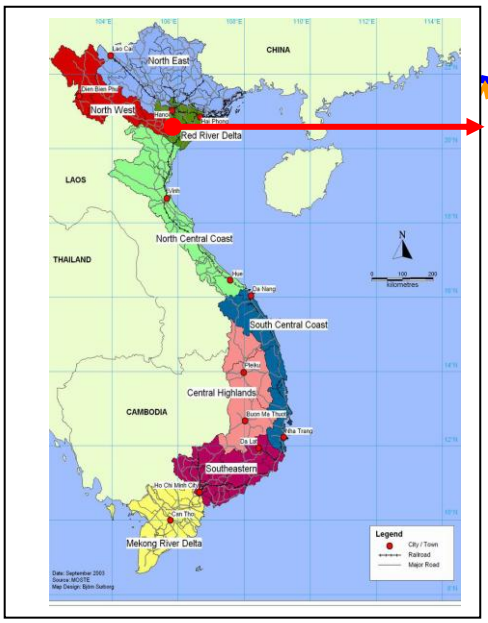


Figure 1. Map of Vietnam

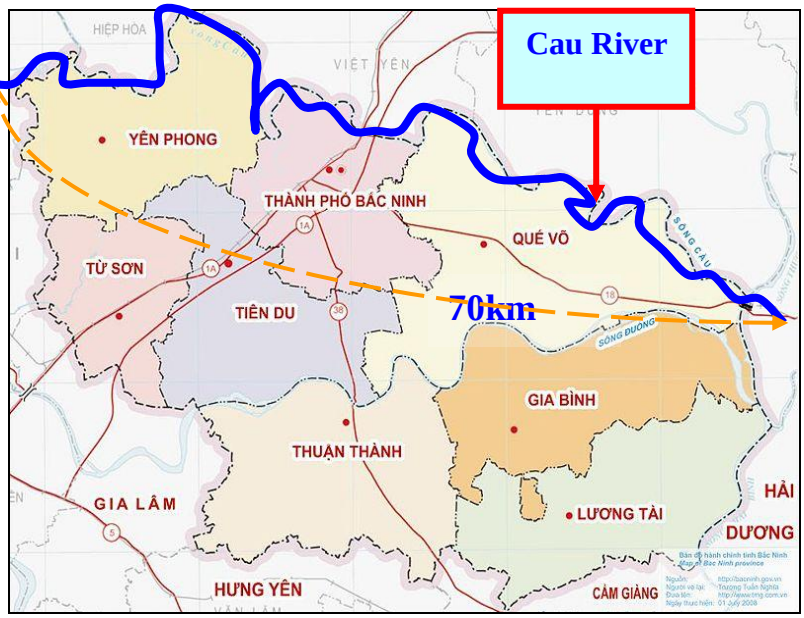


Figure 2. Cau River through Bac Ninh province

As has been happening in other large rivers in Vietnam, sand mining in Cau River is common and indiscriminate and it has become more and more serious in recent years due to the huge demand for river sand by the construction industry in Bac Ninh province and in nearby provinces. Many sand dredges continually extract sand from Cau River. As a consequence, Cau River, similar to other rivers in Vietnam, is suffering from serious problems due to erosion of river banks, lowering of water tables, loss of the aquatic population's habitat, and destruction of bridges, dikes, and roads along the river.

Despite the negative impacts of sand mining on Cau River, efforts by local authorities and the people to control the situation have been inadequate and ineffective; sand mining activities continue to mushroom in the river. A number of questions are raised related to sand mining in general and Cau River's state in particular: What are the concrete consequences and challenges of sand mining in Cau River? How much is the full cost, including external cost, of sand mining in Cau River? Why has so much illegal sand mining been allowed to take place in Cau River (as well as throughout Vietnam)? Is it because not enough is known or understood about the adverse impacts of sand mining on the well-being of a community? Is it because legislation and regulations controlling sand mining are inadequate? Is it because government funds are insufficiently available to tackle the problem? Is there a shortage of professionals to monitor and enforce better sand mining practices? What are the powers and responsibilities of the various government agencies or authorities to specify and/or enforce controls? Are the responsibilities of the concerned agencies in sand mining management clearly stated? What should be done to enhance the effective management of sand mining in Cau River?

Given the above context, this study investigated the current sand mining management in Cau River. The study is expected to shed light on the aforementioned issues and to give some policy recommendations to enhance the effective management of sand mining in the

river. The study is expected to provide insights on improving river sand mining management for other rivers in Vietnam where sand mining is mushrooming as fast as in Cau River.

1.2. Objective of the Research

The overall objective of the study is to investigate the current sand mining management in Cau River in Bac Ninh province, Vietnam and to give policy recommendations on how to improve river management in Vietnam.

The specific objectives of the research are as follows:

- To investigate the current situation of sand mining in Cau River (number of focus points of extraction along the river, extraction time, number of sand dredges, number of workers for sand extraction, extracted sand volume, etc.).
- To estimate the relevant environmental damage caused by existing sand mining practices in Cau River (to help policymakers better understand the situation).
- To investigate the current management of sand mining in Cau River in terms of legislations and regulations, responsibilities of different agencies, government/authority fund, and professionals or human resources for sand mining management (to answer why so much illegal sand mining in general has been allowed to take place in Cau River as well as throughout Vietnam).
- To give policy recommendations on effective management of sand mining in Cau River.

1.3. Research Questions

The study sought to answer the following questions:

- What is the current situation of sand mining in Cau River?
- What have been the consequences of sand mining on riverbanks, dikes, agricultural lands, aqua-resources, and other infrastructure along the rivers (bridges, irrigation systems, etc.)? How much damage has been caused by sand mining in Cau River?
- Why have so much illegal sand mining activities been allowed in general to take place in Cau River (as well as throughout Vietnam)? Is it because not enough is known or understood about the adverse impacts that sand mining may have on the well-being of the community? Is it because legislation and regulations controlling sand mining are inadequate? Is it because government funds are insufficient to tackle the problem? Is there a shortage of professionals to monitor and enforce better sand mining practices?
- What should be done to efficiently manage sand mining in Cau River?

2. LITERATURE REVIEW

2.1. River Sand Mining - a Common Practice in Vietnam and Other Developing Countries

The demand for sand and gravel is growing around the world, particularly in newly developing countries where there is rapid growth of the construction industry. Extraction of sand and gravel resources is done in many countries. Sand is commonly mined from beaches and inland dunes and dredged from ocean beds and river beds. Of these, river sand mining is a common practice since the mining locations are usually near the markets or along transportation routes, hence reducing transportation costs.

In Sri Lanka, the demand for sand for building construction within the country is approximately 7-7.5 million cubic meters per year. This high demand has led to increased and indiscriminate mining in many areas; not only is the sediment sand mined, but also river bed sand and river bank sand. Many rivers in Sri Lanka such as Nilwala River have been experiencing the problems of sand mining, especially in recent years (Ranjana. U.K. Piyadasa 2009).

In India, sand mining is done by the politically-controlled sand mafia. The journal *India Together* recently reported that "despite numerous prohibitions and regulations, sand mining continues rapidly on the riverbed of the Bharathapuzha." A similar situation has been observed on the rivers in the Vembanad lake catchments such as Achankovil, Pamba, Manimala, Meenachil, Muvattupuzha, Periyar, and Chalakudy (Padmalal et al. 2008).

In Nepal, sand used to be mostly supplied from riverbeds. After riverbed mining was prohibited by the Nepali Government in 1991 (Kharel et al. 1992), terrace mining in the same northern regions began. However, illegal mining continues to operate in river areas. Most of the sand supplied to the market comes from riverbeds.

In recent years, rapid development in Malaysia has likewise increased the demand for river sand as a source of construction material. This has resulted in the mushrooming of river sand mining activities, which have given rise to various problems now requiring urgent action by the authorities (Ab. Ghani et al. 2011).

In Vietnam, exploitation of sand has become a problem on all the large rivers. The Vietnamese press reports that unregulated exploitation of sand has become a national problem that demands a national solution. Hundreds of sand dredge sites are running along Red River, from Hanoi to Ha Tay, Phu Tho, Yen Bai, Nam Dinh, and Thai Binh. Many of them are illegal. Also, hundreds of sand sucking boats work along the river. Many boats place sucked sand from sites only 20-30 meters from the bank. Many sections of dikes have become 'sand warehouses.' In central Vietnam, The Huong or Perfume River, an icon of the ancient capital city of Hue, is also suffering from illegal sand dredging. The dredging began around four years ago. Now it takes place both day and night, particularly near the villages of Thuy Bang, Huong Tho, Phu Thanh, Phu Mau, Huong Vinh, and Huong Phong. Hundreds of

big vessels, barges, and small boats are busy all day, seven days a week, transporting sand from the dredging sites. During the high season for construction, from April to July, hundreds of thousands of cubic meters of sand are taken out of Huong River. Dong Nai River, the second largest river in southern Vietnam at 800-km long, traversing 12 provinces and cities, is also a victim of sand miners. Sand has been mined for several years in the river's upper sections, the sections crossing the central highland provinces of Lam Dong, Binh Phuoc, and Dong Nai. Other big rivers in the southern region are also being harmed by sand dredging, including Saigon River in Ho Chi Minh City, Co Chien River in Vinh Long province, Tien and Hau Rivers (upper and lower branches of Mekong River), particularly the sections near Can Tho City and in Dong Thap province and Vinh Long province. The situation in this region has become critical as production has expanded to serve Singapore's sand requirements following Cambodia's embargo on sand exports in May 2009 (VietNamNet Bridge 2009).

2.2. Consequences of River Sand Mining

2.2.1. Consequences of River Sand Mining in the World

The removal of sand and gravel materials from and immediately adjacent to river channels has direct negative impacts on a stream's habitat including channel shape, streambed stability and composition, amount of woody material in the channel, water depth, velocity, turbidity, flow amount, and water temperature (Rundquist 1980; Pauley et al. 1989; Kondolf 1994; Rivier and Seguier 1985; OWRRI 1995). These impacts are described in the following:

- *Channel shape flattens:* In-stream mining basically removes the channel of the river from the riverbed. It leaves behind a flat, featureless plain with virtually no place left for many, if not most, of the river fauna to exist.
- *Streambed stability decreases:* River mining decreases streambed stability because of the removal of streambed armoring. Streambed stability is the single most important aspect of a river system's ecology. The streambed is made up of variable curves and straight sections (meanders), deep holes with slow water movement, shallow riffles with fast water movement, log or woody debris jams, long pools with slow water movement, and overhanging banks. A natural stream develops "armoring" along its bottom and sides. This armoring is developed over many years or decades. The process consolidates or strengthens the bed of the river where it meets the flowing water. This armoring is stronger than the gravels beneath and helps protect the stream or river from erosion due to flooding. Without this armoring, even small rises in normal river level can create erosion that damages the river. The removal of this armoring by mining is difficult to restore naturally or with man's assistance and can continue to impact the river long after mining is completed.
- *Removal of woody material from the channel:* the first thing that happens with river mining is that all of the tree trunks, branches and organic material are

removed from the stream. This means that the fauna living in and around these materials no longer have a habitat. This woody material also provides the stream with a way to build bars and pools. As river water stacks up in front of these debris materials and rushes around or over them in different ways, sand, gravel and sediment are deposited, thus creating river features. When the sand and gravel removal is completed, the increased water velocity during floods tends to wash these materials downstream much faster and reduces the chance that they will catch and build back the bars and holes that benefit the stream. This process is self-continuing; that is, without these normal obstructions in the channel, the formation of the structures that capture the woody materials never occurs and the waterway stays shallow without holes and bars.

- *Change in water depth*: The flattening of the river channel resulting from in-stream mining allows the river water to spread out over a larger area. It may result in shallower than normal water depth. On the other hand, sand mining in the riverbed could result in a deeper riverbed, the water level in the river can be lower.
- *Velocity increases:* When the natural channel of a river is destroyed, water spreads out over a larger area and its speed increases relative to the stream bottom. A given amount of water can therefore erode a larger amount of streambed. If the water is confined to a deep channel, that same amount of water flowing in the deep channel that is not directly in contact with the streambed causes little or no erosion on the streambed.
- *Turbidity increases:* Increased erosion creates greater turbidity (cloudiness or murkiness) of the river water. When a stream or river is deep, the flow slows down, and sand and gravel and fine sediments drop to the bottom where they remain until a large runoff event occurs that increases the bottom water velocity. With a shallower river, the higher bottom water speeds occur more frequently and so there is often more fine sediment in the water. This changes the character of the stream from being clear to murky. As such, fauna that require clear water can no longer survive.

According to Kondolf et al. (2001), in-stream sand mining can damage private and public properties as well as aquatic habitats. Excessive removal of sand may significantly distort the natural equilibrium of a stream channel. By removing sediment from the active channel bed, in-stream mines interrupt the continuity of sediment transport through the river system, disrupting the sediment mass balance in the river downstream and inducing channel adjustments (usually incision) that extend to considerable distances (commonly 1 km or more) beyond the extraction site itself. The magnitude of the impact basically depends on the magnitude of the extraction relative to bed load sediment supply and transport through the reach.

Collins and Dunne (1990) summarized the effects of sand and gravel mining as follows:

- Extraction of bed material in excess of replenishment by transport from upstream causes the bed to lower (degrade) upstream and downstream of the site of removal. Bed degradation can undermine bridge supports, pipe lines, and other structures. It may change the morphology of the river bed, which constitutes one aspect of the aquatic habitat. Degradation can deplete the entire depth of gravelly bed material, exposing other substrates that may underlie the gravel, which could in turn affect the quality of aquatic habitat.
- Rapid bed degradation may induce bank collapse and erosion by increasing the heights of banks.
- If a floodplain aquifer drains to the stream, groundwater levels can be lowered as a result of bed degradation. The supply of overbank sediments to floodplains is reduced as flood heights decrease. Lowering of the water table can destroy riparian vegetation.
- Flooding is reduced as bed elevations and flood heights decrease, reducing hazard for human occupancy of floodplains and the possibility of damage to engineering works. In rivers in which sediments are accumulating on the bed (aggrading) in undisturbed condition, gravel extraction can slow or stop aggradations, thereby maintaining the channel's capacity to convey flood waters.
- The reduction in size or height of bars can cause adjacent banks to erode more rapidly or to stabilize, depending on the amount of sand and gravel removed, the distribution of removal, and on the geometry of the particular bend.

Although river sand mining causes serious environmental and economic impacts, studies on it are quite limited. Only a few studies have quantified some impacts of river sand mining. One such study is by Padmalal et al. (2008) who investigated the environmental effects of river sand mining in a river catchment of Vembanad Lake in India. They found that on average, 11.73 million tons of sand and gravel are being extracted annually from the active channels and 0.414 million tons of sand from the river floodplains. The quantity of in-stream mining is about 40 times higher than the sand input estimated in the gauging stations. As a result of such indiscriminate sand mining, the riverbed in the storage zone is getting lowered at the rate of 7–15 cm/year over the past two decades. This, in turn, has imposed severe damages on the physical and biological environments of the river systems.

Willem de Lange et al. (2009) investigated the external cost of river sand mining in South Africa. They estimated the benefits of sand mining based on the market price of sand at source; whereas the costs were estimated based on the opportunity costs of sand mining (i.e., the value of services that could be lost as a result of depletion of the resource). The benefit transfer was used to estimate some value of the rivers. The external cost of mining 1

m^3 of sand in the rivers was computed to be between 18- 379 rupees while the market price was around 30 rupees per m^3.

2.2.2. Consequences of River Sand Mining in Vietnam

Exploitation of sand has become a problem on all of Vietnam's large rivers. Many articles in Vietnamese newspapers have reported the alarming situation due to river sand mining all over the country. However, there has been no study yet to investigate the impacts of sand mining on these rivers.

The most serious impacts of river sand mining in Vietnam, according to Vietnamese newspapers, are the erosion of riverbanks and the collapse of the river dikes, resulting in the loss of agricultural lands and houses and damages on other infrastructures such as bridges and irrigation works. According to *VietnamNet Bridge* (2009), many sections of the banks of Red River, the largest river in northern Vietnam, are being eroded. Since October 2006, over 20 houses in Ngoc Thuy ward alone of Hanoi's Long Bien district have fallen into the river because of landslides. Local residents said landslides have suddenly become serious in the past two years. In Hatay province where Red and Da Rivers flow for 105 kilometers, the government allocates annually hundreds of billions of dong to deal with landslides. Early in 2009, the province received an additional VND 30 billion for this purpose, yet the landslides are getting worse and worse. Experts say that the landslides now are different from previous years. In the past, the banks eroded gradually. These days, large chunks of land suddenly fall to the river. It means that there are big holes under the bank and these holes are caused by sand dredging. Many sections of dikes have become 'sand warehouses.'

Sand mining has also resulted in a significant decrease in the bed elevations of rivers in Vietnam. According to *Hanoimoi* (2008), sand mining in Hatay province has lowered the bed of Day River by around 50-100 cm in recent years. The lower riverbed leads to lower water level, and some problems with the existing irrigation systems has appeared as a consequence. Fishing activities in the rivers has been significantly reduced also; fish stock in the rivers has declined because the river water is polluted and the morphology of the riverbed has changed due to sand mining. Other impacts such as the change in the river channel and the increase in water velocity have been cited also in some newspapers, but not in detail.

2.3. Management of River Sand Mining

The increased demand for river sand as a construction material has resulted in the mushrooming of river sand mining, which has given rise to various problems requiring urgent action by the authorities. These include river bank erosion, river bed degradation, river buffer zone encroachment, and deterioration of river water quality. Very often, over-mining occurs, jeopardizing the health of the river and the environment in general.

In 2009, Malaysia's Department of Irrigation and Drainage approved a set of river sand mining management guidelines. The guidelines are aimed at ensuring that sand and gravel extraction is carried out in a sustainable way. They are also intended to maintain the river equilibrium with the application of sediment transport principles in determining the

locations, period, and quantity of sand and gravel to be extracted. The general guidelines are as follows (MONRE-Malaysia 2009):

1) Parts of the river reaches experiencing deposition or aggradations shall be identified first. Operators may be allowed to extract the sand and gravel deposit in these locations to lessen aggradations problem.

2) The distance between sites for sand and gravel mining shall depend on the replenishment rate of the river. Sediment rating curve for the potential sites shall be developed and checked against the extracted volumes of sand and gravel.

3) Sand and gravel may be extracted across the entire active channel during the dry season.

4) Layers of sand and gravel that could be removed from the river bed shall depend on the width of the river and replenishment rate of the river.

5) Sand and gravel shall not be allowed to be extracted where erosion may occur, such as at concave bank.

6) Sand and gravel shall not be extracted within 1,000 meters from any crucial hydraulic structure such as pumping station, water intakes, bridges, buildings, and such structures.

Similarly, Geological Survey of India also drew several recommendations on sustainable sand mining in the rivers, which include the following:

1) Mining below subterranean water level should be avoided as a safeguard against environmental contamination and overexploitation of resources.

2) Mining at the concave side of the river channel should be avoided to prevent bank erosion. Similarly, a meandering segment of a river should be selected for mining in such a way as to avoid naturally eroding banks and to promote mining on naturally building (aggrading) meander components.

3) Mining of gravelly sand from the riverbed should be restricted to a maximum depth of 3 m (10 feet) from the surface. For surface mining operations beyond this depth, it is imperative to adopt quarrying in a systematic bench-like disposition, which is generally not feasible in riverbed mining. Hence, for safety and sustainability, restriction of mining of riverbed material to a maximum depth of 3 m is recommended.

4) Mining of riverbed material should also take cognizance of the location of the active channel bank. It should be located sufficiently away, preferably more than 3 m away (inwards), from such river banks to minimize effects on river bank erosion and avoid consequent channel migration.

In Vietnam, river sand mining is covered by the 2005 Mineral Laws of Vietnam and other regulations related to mineral exploitation management. By law, in order to be able to mine river sand, the mining individuals or organizations need to get permission from the

management agencies, usually the provincial people's committee. The mining individuals or organizations also have to pay the mineral tax and environmental fee for sand mining. Mining could be implemented only in planned areas, and they must ensure to cause no effects on infrastructures (bridges, dikes, etc.).

3. RESEARCH METHODOLOGY

3.1. Description of Cau River and the Research Areas

Cau River originates from Van On Mountains in Bac Kan province and ends where it meets Thai Binh River in Hai Duong province. Its total length is 290 km. It is around 70 km long in Bac Ninh province and considered as the natural borderline between Bac Giang and Bac Ninh provinces (Fig. 3). The bed of Cau River is quite narrow and steep. Therefore, during the rainy season from June to October, the water current is high, causing the riverbanks to erode and dikes to collapse, resulting in flooding.

The total water volume that goes through Cau River is around 5 billion cubic meters annually, of which 75 percent occur during the rainy season (Industry Dept. of Bac Ninh 2001). Its water level in the flooding season is usually 3-6 meters; it is only 0.5-0.8 meter in the dry season (Table 1). The water flow in the rainy season could reach 1,870m^3/sec, but it is only 200-300m^3/sec in the dry season. Flooding may appear 4-8 times during the rainy season each year at Cau River.

Bac Ninh province has three districts that border Cau River at one side: Yen Phong district, Bac Ninh town, and Que Vo district. Similarly, three districts of Bac Giang province border the river at the other side: Hiep Hoa, Viet Yen, and Yen Dung districts. The contiguous areas of Cau River (outside dikes) are rice fields and some villages. The majority of people living in contiguous areas of Cau River are farmers with low income.

Due to limitations of time and other resources, the research focused only on Que Vo district in Bac Ninh province and Yen Dung district in Bac Giang province through which around 20 km of Cau River flow through and where sand mining happens quite often, similar to other parts of the river.

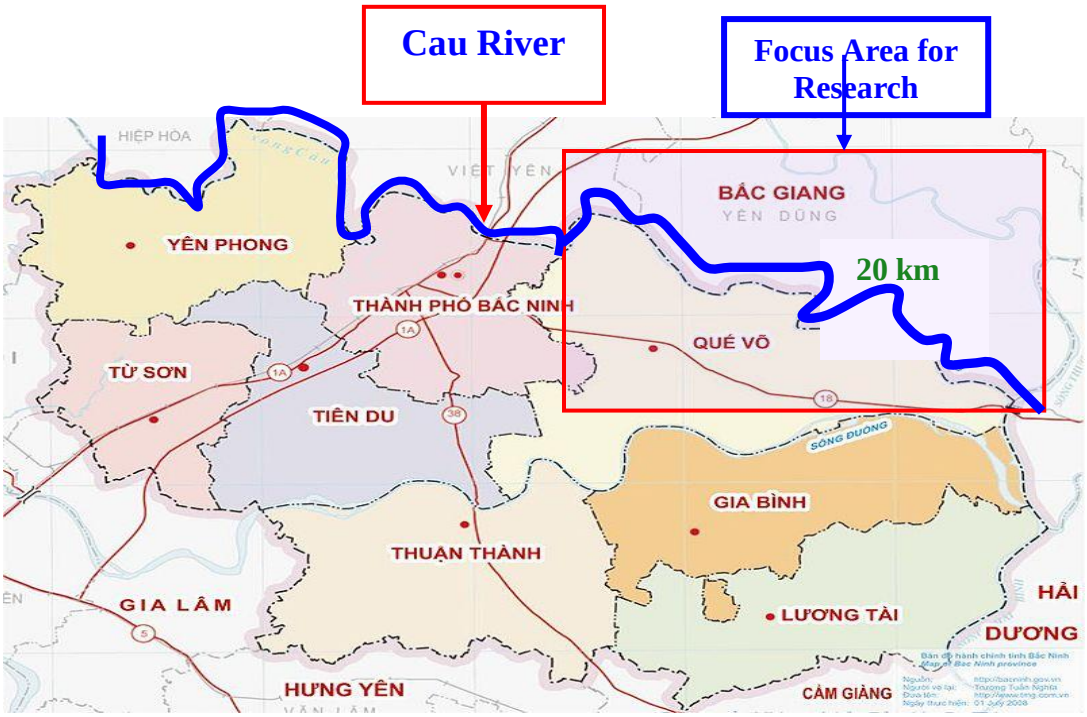


Figure 3. Map of Cau River and the focus area for research

Table 1. Monthly change in water-depth of Cau River (m)

Month	Average depth	Highest Depth		Lowest Depth	
		Aver. Depth	Year appeared	Aver. Depth	Year appeared
Jan	0.991	1.41	1984	0.77	1963
Feb	0.899	1.16	1990	0.52	1963
Mar	0.851	1.80	1990	0.48	1963
Apr	1.116	2.17	1990	0.61	1966
May	1.606	3.48	1986	0.90	1977
Jun	2.669	4.33	1989	1.10	1983
Jul	3.759	5.54	1990	2.09	1989
Aug	4.198	6.42	1971	2.66	1991
Sep	3.655	5.51	1985	1.85	1962
Oct	2.574	3.89	1978	1.75	1962
Nov	1.835	2.75	1984	1.14	1962
Dec	1.251	1.68	1985	0.81	1962

(Source: Industry Department of Bac Ninh province 2001)

3.2. Analytical Framework

The general approach adopted for the study can be broadly divided into three main stages as described in the analytical framework (Fig. 4).

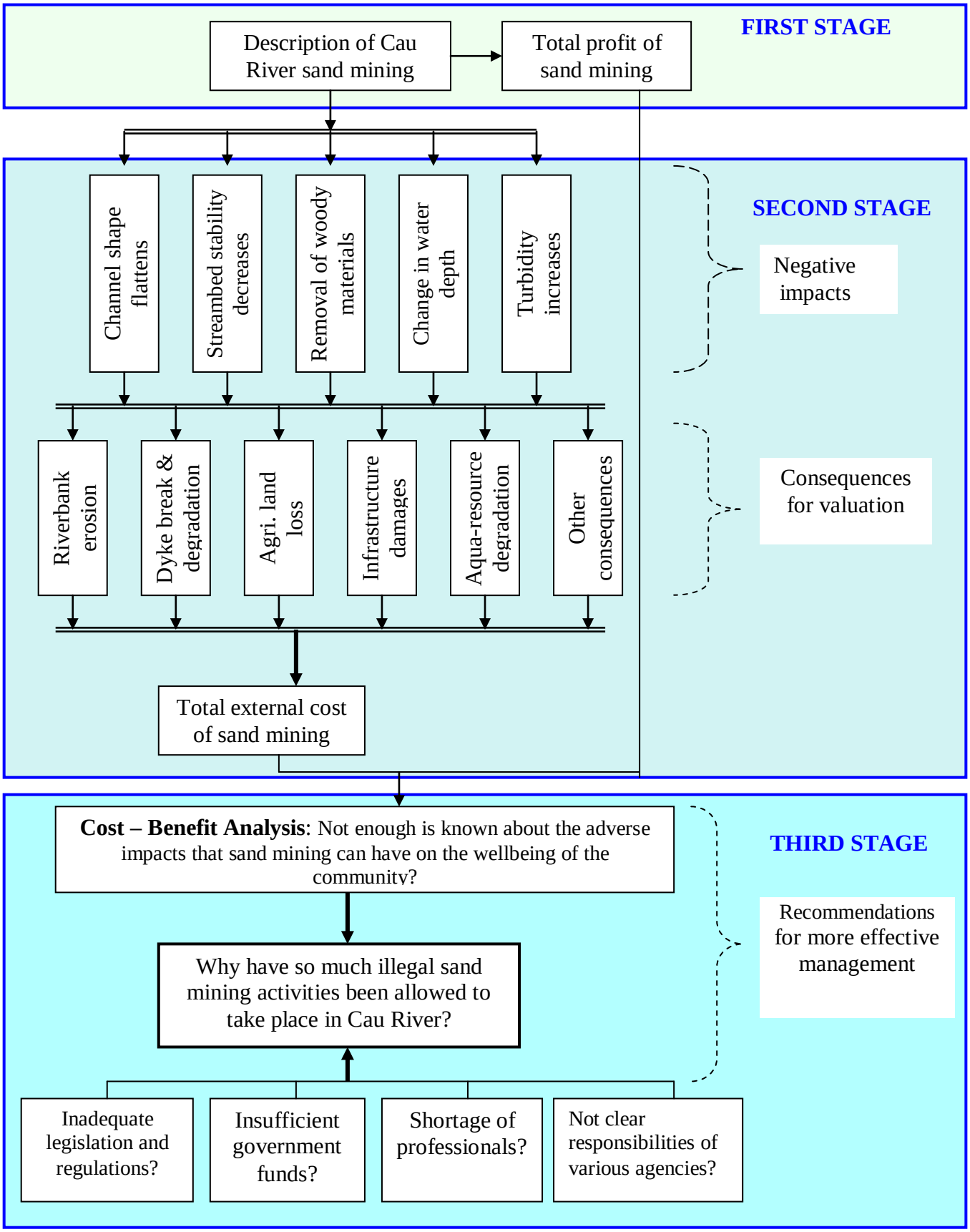


Figure 4. Analytical framework of the research

The ***first stage*** involves obtaining the profile of current and projected sand mining in the river system. The kinds of information obtained were numbers of operators, their sizes, amounts of sand extracted, etc. As part of the first stage, the *private* financial benefits of sand mining operations were estimated. This assessment is expressed as a financial NPV, taking into account the time period (2001-2010) over which the estimates were applied; the volumes or weights extracted over time; the sale price of sand; the costs of mining operations; and an appropriate discount or interest rate.

The ***second stage*** involves an economic assessment of the external damage costs of mining operations and deriving an NPV reflecting the *social* economic welfare associated with river sand mining. The same basic assumptions were adopted for the economic NPV calculations as for the financial NPV calculations, using the same time period, prices, costs, and discount rate. The main difference between the financial and economic NPVs is the inclusion of environmental damage costs in the estimates.

According to Rundquist (1980), Pauley et al. (1989), Kondolf (1994), Rivier and Seguier (1985), and OWRRI (1995), the negative impacts of river sand mining are seen in the changes in channel shape, streambed stability and composition, the amount of woody material in the channel, water depth, velocity, turbidity, flow amount, and water temperature. These changes lead to several consequences such as riverbank erosion, dike breakage and degradation, other infrastructure damages, land loss, and aqua-resource degradation. This study tried to estimate the external costs of these consequences of sand mining practice in order to demonstrate to the authorities that uncontrolled sand mining has significant and widespread adverse environmental and economic consequences.

The ***third stage*** focuses on policy interpretations and recommended actions. For this purpose, this study investigated the current legislation/regulations, government funds, human resources, and power and responsibilities of various agencies over sand mining management in order to understand why so much illegal sand mining has generally been allowed to take place in Cau River as well as throughout Vietnam. Policy recommendations were made based on the analysis' results for a more effective management of sand mining in the river in the future.

3.3. Data Collection

3.3.1. Secondary Data

Firstly, all legislation and the regulations at the national and provincial/district levels related to sand mining in Cau River were collected through the concerned agencies in Bac Ninh and Bac Giang provinces (Department of Natural Resources and Environment, Department of Agriculture and Rural Development, Water Inland Administration No. 4). The regulations were reviewed to understand the current management framework of sand mining in Bac Ninh province.

Secondly, data on past and current sand mining in Cau River were collected. The data include information on the licensed mining sites along Cau River of Bac Ninh procince, such as number of licensed sites, number of organizations/individuals with permission for sand mining from the authority of Bac Ninh province, details of the permissions (e.g., where or what specific places, time of the year, and volume of sand they are allowed to extract). Such data were obtained mainly from available reports and statistical data from Department of Natural Resources and Environment (DONRE), Department of Agriculture and Rural Development (DARD), and communes located along Cau River.

Thirdly, information on management and enforcement activities or the efforts of various agencies to manage or prevent sand mining in Cau River was obtained from DONRE, Department of River Transportation Management, and district authorities. It was also gathered from reports of the communes located along Cau River.

3.3.2. Primary Data

The study's primary data came from observations of sand mining in the river, from field surveys of individual households near the hot spots of sand extraction of Cau River, and from focus group discussions with local staff and residents.

Observation on Sand Mining

There are no adequate official statistical data and information on the number of sand dredges, extraction time, extracted sand quantity, etc. in Cau River. It was therefore necessary to go along the river to observe how sand mining is taking place and its visible consequences. Information from these observations was used to describe the current situation of sand mining in the river and its consequences.

Field Survey

The main purpose of the field survey was to gather both qualitative and quantitative information on (1) the situation of sand mining in Cau River; (2) the consequences or impacts of sand mining on infrastructure, agriculture, aquaculture, and the residents' livelihoods; and (3) the respondents' opinion on the management of the situation.

Focus Group Discussion

Focus group discussions (FGDs) were mainly used to get information on sand mining situations, financial feasibility, consequences, and recommendations to mitigate the negative consequences. Facilitative discussions initiated by open-ended questions provided the respondents with the opportunity to explain more clearly the issues. Nine group discussions were organized; each group had 5-7 people with different backgrounds in terms of age, gender, and social position. Three group meetings in different villages (participated by villagers and village staff) were held to discuss the practice of sand mining in recent years, its consequences, current management efforts, and recommendations for more effective management in the future. Five groups with local staff (at the district and provincial levels) discussed the consequences of sand mining, recent investments of local authorities to overcome the negative consequences of sand mining, legislations/regulations, problems on

funds availability, human resources, sharing of responsibilities among different agencies for sand mining management and recommendations for improvement. One group, participated by sand extraction workers, discussed the financial cost of sand mining and responsible behaviors of dredge owners toward management regulations and enforcements.

Technical Expert Consultation

A group of technical experts in civil engineering and agricultural science was invited to join the research. The experts helped the research team to get a full understanding of the behavior of the river system and the ways by which sand mining might increase the incidence of riverbank erosion, failures of protection dikes, and other adverse physical effects such as possible loss of agricultural land and reductions in crop yields. The experts and the research team estimated the physical consequences of sand mining practice. Based on the results, the study team estimated the external costs of current sand mining, which was used for the cost-benefit analysis.

3.4. Analysis Procedure

Collected data, both primary and secondary, were compiled, sorted, categorized, and adjusted to suit the methods employed. First, descriptive statistical method was used to describe sand mining in Cau River, its consequences, current management practices, respondents' awareness of the consequences, state of human resources, available funds, and responsibilities of various agencies in sand mining management. Then, the methods of replacement cost, preventive expenditures, and productivity change were used to estimate the external cost of sand mining. The cost-benefit analysis was employed to identify the net benefit of current sand mining in the river.

3.4.1. Descriptive Statitics

Descriptive statistical methods (mean, percentage, frequencies, tabulation) were used to decribe the legal farmework for sand mining in Cau River, the current situation of this activity, the extent of its consequences, and respondents' awareness of the consequences. They were also used to reflect the opinions of repondents on how to mitigate the negative consequences of sand mining. Moreover, they were used to describe the current management practices of authorities and to assess the state of human resources, available funds, and responsibilities of various agencies in sand mining management. Through these assessments, challenges on enforcement were identified and recommendations for better management and enforcement were drawn.

3.4.2. Valuation of Negative Consequences of Sand Mining

There are a number of consequences of sand mining as indicated in the literature (see previous section). However, due to limitations of time and resources, this study focused only on investigating several consequences that are quite clear and can be easily observed. These include riverbank erosion, river dike breakage and degradation, damages to other infrastructures along the river (bridges, irrigation system, houses), agricultural land loss, and aqua-resource degradation (see analytical framework in previous section).

Cost of Riverbank Erosion

The riverbank erosion is a very clear consequence of sand mining. The study team, in cooperation with the river management board and local staff of districts and communes along the river, estimated the area of the eroded riverbanks and assessed the extent of the current erosion situation. The whole riverbank area of Cau River is divided into four types based on the effects of sand mining: very serious effect, serious effect, slight effect, and no effect.

Since the riverbanks are usually allocated to farm households for crop production, the cost of riverbank erosion would be equal to the net loss of crops planted on the riverbanks. The riverbank erosion would certainly result in decreased crop yields (under the same condition of fertilizers and labor cost). The net loss of crop production would be equal to the decreased value of financial profits that the farmers could earn from their crops on the riverbanks.

In order to gather data on agricultural land loss and crop yield decrease, 45 farm households with agricultural land on the riverbanks (with different erosion types: very serious, serious, and slight) were surveyed.

The survey questions gathered data on riverbank areas that the households originally had, land loss due to riverbank erosion in recent years, and currently cultivated areas. Changes in crop yields were determined by the households and by comparing the yields of plots affected by erosion and those that were not. The total loss due to riverbank erosion was estimated as follows:

$$TLO = \sum_{i=0}^{n} LO_i = \sum_{i=0}^{n} (LP_i \times P_i \times k)$$

$$LP_i = \sum_{j=0}^{3} Y_{ij} \times A_{ij} - \sum_{j=1}^{3} Y_{0j} \times A_{oj}$$

where TLO is the total loss due to riverbank erosion, LOi is the loss on year i, LPi is product loss in year i (vs. base year or year 0), Pi is crop price, k is parameter for crop profit, Yij is crop yield on year i according to riverbank type j (j = 0 to 3, corresponding to no erosion, slight erosion, serious erosion, and very serious erosion, respectively), and Aij is crop area of year i on riverbank type j.

Cost of Dike Degradation

Similar to riverbank erosion, dike degradation is also a very clear consequence of sand mining. The cost of dike degradation is equivalent to the sum of preventive cost and restoration cost for the dikes, as follows:

$$TDDC = \sum_{i=0}^{n} AP_i + \sum_{i=0}^{n} RCi$$

where APi is the annual preventive cost in year i (this cost is considered the usual cost for improving dikes) and RCi is the unusual cost in year i for restoration of dike breakage or stone embankment collapse. Data on these investments were collected from statistical data on expenditure for dikes. The study team also worked with the DONRE and DARD at the provincial and district levels to get the data.

Damage Cost to Other Infrastructures/Assets along the River

There are many pumping stations and main sewers along Cau River, and they have been negatively affected by sand mining. Sand mining causes more deposits of sand and mud on the pumping stations, which means more cleaning activities have to be done. The damage cost of sand mining to pumping stations would be equivalent to the additional cost of cleaning out the deposits. This was calculated by first determining the number of pumping stations and obtaining data (via group discussions with the management boards of pumping stations) on the average additional cost for cleaning out the deposits in typical pumping stations. The total damage cost is equal to the number of stations multiplied by the average additional cost.

Sand mining has caused also damages to the main sewers along the river. The total damage cost to the main sewers was calculated from the number of broken or collapsed sewers in recent years and the average restoration cost for each of these as gathered from discussions with the irrigation departments of the districts along the river.

Cost of Aqua-resource Degradation

The degradation of the river's aqua-resources is a possible consequence of river sand mining due to changes in the water's turbidity and living environment. Due to the lack of official statistical data on aqua-resources of the river, the assessment of the degradation over time was done through the focus group discussion. Furthermore, the changes in number of people/households fishing on the river and in the amount of their fish catch were used to estimate the cost of aqua-resource degradation. Fishing households/people participated in the focus group discussion, during which the study team was able to get an estimate of the quantity and value of their fish catch and the changes in these, and associated costs for fish catching.

3.4.3. Financial Analysis and Cost-Benefit Analysis of Sand Mining

The net benefits of sand mining were analyzed from a social (cost-benefit analysis) and a private (financial analysis) perspective.

An economic analysis is conducted from the perspective of the community as a whole. It focuses on "real" resource costs and benefits, including any "external" environmental costs and benefits that affect the broader community. From a private perspective, similar concepts apply as in the economic analysis, but the benefits and costs are estimated in terms of the financial benefits received and costs borne by private producers. Because the financial analysis focused only on the sand dredge owners' private financial prospects and did not take into account externalities or external environmental costs, it is

inadequate in determining the efficiency of resource allocation. The main reason for conducting a financial analysis in this study was to see how much profit the dredge owners could earn from sand mining. This would help explain why sand mining is mushrooming and could be valuable information in developing some management measures such as sand extraction taxes.

Financial analysis: The total profit per year that a dredge owner can receive from sand mining was calculated as follows:

Total Profit = Unit Profit x Sand Extract Volume

Unit Profit = Market Value of 100 m^3 of Extracted Sand – Total Costs of Extraction of 100 m^3

The market value of sand was calculated based on the market price of sand; the cost of sand extraction includes cost of labor, fuels, equipment depreciation, and other costs.

Economic analysis: The net benefit that a society receives from sand mining was calculated as follows:

$$\text{NPV} = \sum_{i=0}^{n} \frac{Bi - Ci}{(1+r)^i}$$

where NPV is net social benefit from sand mining; Bi is the financial benefits of sand mining for society through the years; Ci is the cost of sand mining through the years, including the financial cost (cost of labor, fuel, and equipment that the dredgers have to pay), external costs of riverbank erosion, dike breakage and degradation, agricultural loss, and aqua-resource degradation; and r is the discount rate.

The analysis was expected to show if the external cost of current sand mining does outweigh the combined gains/profits of all the individuals involved in sand mining. A sensitivity analysis was also done on changes in market price of sand and discount rate. This information was used to demonstrate the need for better enforcement of regulations and more effective management.

3.4.4. Management Capacity Analysis

Current government policies on sand mining were reviewed and evaluated vis-a-vis the identified sand mining problems. The evaluation and discussions with various related agencies revealed a list of problems arising from weaknesses in the current policy; policy gaps were identified.

In parallel, the various government agencies that have authority and responsibility over sand mining management, using Cau River as a particular case, were identified through discussions with key informants, including staff of Ministry of Natural Resources and Environment (MONRE), nongovernment organizations (NGOs), academics, and other appropriate individuals. The coordination among these agencies and between provincial authority and district/commune authorities was also assessed.

The human and financial resources that government agencies used for sand mining management were identified through the responsible staff of these agencies in Bac Ninh province. The purpose was to determine their level of sufficiency in addressing sand mining problems in monitoring and enforcing sand mining regulations. From the information gathered, relevant recommendations were drawn to improve sand mining management.

The information on the weaknesses and recommendations for effective management were presented to a workshop participated by all stakeholder representatives, including the key informants who initially provided the information. The workshop's purpose was to confirm the proposed measures that should undergo further assessment and analysis. The workshop participants assessed (using the scoring method) the proposed measures based on the following criteria: financial acceptability, administrative acceptability, efficiency in sand mining management. The workshop also drew up alternative measures/recommendations that could be adopted by the government at different levels. By making the process participatory, there was greater likelihood that the proposed measures would be applicable, fill policy gaps by eliminating the weaknesses in current policies, be effective and efficient to implement compared with others, and be accepted by the stakeholders.

4. RESULTS AND DISCUSSIONS

4.1. Sand Mining Activities in Cau River

Cau River has served as the natural borderline between Bac Giang and Bac Ninh provinces since 1998 when the former Ha Bac province was separated into these two provinces. Half of Cau River is currently managed by Bac Ninh province and the other half by Bac Giang province.

According to Decision No. 96/2006/QD-UBND of Bac Ninh Provincial People Committee (2006), the total reserve of sand (sand that can be extracted) in all rivers in Bac Ninh at that time was 11.661 million m^3, including 514,000 m^3 in Cau River. The provincial authority also determined three areas along Cau River where sand may be extracted and other associated regulations such as depth and length. However, the decision does not state the potential reserve of sand (sand potentially available) or sand resource endowment (the natural occurrence of sand resource in the rivers). In Bac Giang, according to Decision No. 18/2009/QD-UBND on sand extraction planning toward 2020 in Bac Giang Rivers, the total current reserve sand capacity of all rivers in Bac Giang is 7.89 million m^3, including the 1.76 million m^3 in Cau River. There are a total of 23 sand extraction points along Cau River; of these, 12 are large and 11 are small. The decision also indicates that the total potential reserve of sand resources of all rivers in Bac Giang is 9.641 million m^3, of which 1.91 million m^3 is from Cau River. Therefore, the total current reserve of sand resource in Cau River is around 2.27 million m^3; the total current reserve of sand resource in all Bac Ninh and Bac Giang rivers is around 19.55 million m^3.

The local authorities of both Bac Ninh and Bac Giang provinces have explored the nature of sand resources along Cau River. They also determined the specific areas for extraction, as well as the extraction depth and duration. According to the regulations, individuals or firms wanting to extract sand from the river should apply for an extraction permit from the local authorities and must follow the set of extraction rules. The local authorities provided only a limited number of such permits.

Sand mining in Cau River started many years ago along, but at a low extraction rate vis-a-vis with the demand then for sand by the construction sector. However, mining activities have boomed since 2000 when the industrialization and urbanization of Bac Ninh and Bac Giang provinces started speeding up. According to MONRE (2009), Bac Ninh has established nine IZs with a total area of 3,295 ha (Bac Ninh has the largest IZ area in northern Vietnam); Bac Giang has formulated five IZs with a total area of 1,239 ha. Vietnam's statistical data reflect the country's rapidly increasing rate of urbanization, especially in Bac Ninh province. The rate of Bac Ninh's urban population increased from just 4.3 percent in 1995 to 23.6 percent in 2009 (GSO 2010). Bac Giang's growth in this matter has not been as fast: from 5.7 percent in 1995 to 9.6 percent in 2009. The sand demand for IZ establishment (e.g., ground filing), road development, and house construction has therefore soared up to more than 1 million m^3 per year in Bac Ninh [author's estimate based on the national demand estimate by Vietnam Federation of Civil Engineering Association (Xaydung newspaper 2010) and around 0.6 million m^3 per year in Bac Giang (estimated by Bac Giang DONRE – Baomoi newspaper (2010)]. The demand for sand in Bac Ninh and Bac Giang is expected to continue to rise at the rate of at least 8.5 percent per annum (national rate) during 2010-2015 (Xaydung newspaper 2010). Sand extraction from all rivers in Bac Ninh and Bac Giang as well as in Cau River will thus probably continue to intensify despite the local governments' efforts to control it.

Table 2. Detailed information on sand extraction sites along Cau River

Extraction site	Coordinate axis in VN2000		Whole sand site				Extraction allowance				Potential reserve (m^3)	Current reserve (m^3)
	X	Y	Length (m)	Width (m)	Depth (m)	Area (m^2)	Length (m)	Width (m)	Depth (m)	Area (m^2)		
1. In Bac Giang side												
Site 1	2370664	599397	550	70	3.0	38,500	550	50	2.0	27,500	115,500	55,000
Site 2	2369301	599180	400	60	0.7	24,000	400	40	0.7	16,000	15,800	11,200
Site 3	2367885	598885	800	35	1.5	28,000	800	20	1.5	16,000	42,000	24,000
Site 4	2366560	597420	450	150	3.5	67,500	450	120	3.0	54,000	236,250	162,000
Site 5	2365900	597820	650	50	0.5	32,500	650	20	0.5	19,500	16,250	9,750
Site 6	2363646	597165	600	50	2.5	30,000	600	50	2.5	30,000	75,000	75,000
Site 7	2363869	596101	500	45	1.0	22,500	500	35	1.0	17,500	22,500	17,500
Site 8	2363823	593995	600	40	1.5	24,000	600	30	1.5	18,000	36,000	27,000
Site 9	2362508	593483	400	40	0.7	16,000	400	10	0.7	4,000	11,200	2,800
Site 10	2361511	592646	700	55	1.5	38,500	700	40	1.5	28,000	57,750	42,000
Site 11	2347719	609914	1,000	40	2.0	40,000	1,000	30	2.0	30,000	80,000	60,000
Site 12	2359902	591131	1,000	35	0.5	35,000	1,000	20	0.5	20,000	17,500	10,000
Site 13	2358800	592900	700	55	0.7	38,500	700	35	0.7	24,500	26,950	17,150
Site 14	2355134	596477	500	50	1.5	25,000	500	30	1.0	15,000	37,500	15,000
Site 15	2351460	596314	800	85	1.5	68,000	800	70	1.0	56,000	102,000	56,000
Site 16	2350250	597031	450	60	2.5	27,000	450	40	0.8	18,000	21,600	14,400
Site 17	2347330	601340	1,500	50	3.0	75,000	1,500	30	2.5	45,000	225,000	112,500
Site 18	2350758	602144	1,500	55	0.7	82,500	1,500	35	0.7	52,500	57,750	36,750
Site 19	2351831	602918	600	40	2.5	24,000	600	30	2.0	18,000	60,000	36,000
Site 20	2345314	613188	800	50	2	40,000	800	30	2.0	24,000	80,000	48,000
Site 21	2344611	616305	1,500	50	2	75,000	1,500	30	2.0	45,000	150,000	90,000
Site 22	2344241	620501	1,150	170	1.7	195,500	1,150	150	1.5	172,500	332,350	258,750
Site 23	2340515	627650	650	75	2.5	48,750	650	60	2.0	39,000	121,875	78,000
2. In Bac Ninh side												
Site 1	na	Na	na	Na	na	na	na	na	2.0	na	na	61,000
Site 2	na	Na	na	Na	na	na	na	na	2.0	na	na	193,000
Site 3	na	Na	na	Na	na	na	na	na	2.0	na	na	260,000

Source: Decision No. 18/2009/QD-UBND, Bac Giang; Decision No. 96/2006/QD-UBND, Bac Ninh province

Table 3. Sand extraction situation in Cau River on the Que Vo district section

	2001-2005 period	2006-2010 period
1. Extraction duration	Peaks in dry seasons (Nov – Apr)	Peaks in dry seasons (Nov – Apr)
2. Number of sand dredgers	Average of 10 a day (range of 5-20)	Average of 20 a day (range of 10-35)
3. Extraction volume	30-100 m^3/time/dredger	40-120 m^3/time/dredger
4. Number of times/day	1-2 times	1-4 (peak: 4 times)
4. Peak extraction time	10:00 AM – 10:00 PM	8:00 PM – 4:00 AM
5. Estimate extraction volume	500-800 m^3/day	1,000-3,000 m^3/day

(Source: Focus group discussion, 2010)

The FGDs with local staff and residents living along Cau River asserted the increase in sand extraction activities in Cau River. The number of sand dredgers in 2006-2010 (along the Que Vo river section, which is around 20 km long) was nearly twice that in 2001-2005. Moreover, the extracting capacity of each dredger has increased also as the extractors used more powerful engines. In addition, the dredgers nowadays are equipped with better facilities (e.g., pump trunk) and more workers are employed. While a total of 500–800 m^3 of sand were extracted per day during 2001-2005, in 2006-2010, 1,000–3000 m^3 per day were extracted. The total sand extraction in the 20-km river section in Que Vo district alone was estimated at over 200,000 m^3 a year, while the total current reserve is just around 514,000 m^3 for the river's entire length of 60 km in Bac Ninh.

There have been quite many sand mining dredges in Cau river (Fig. 5). Nowadays, dredge owners conduct their operations during the night (instead of in the daytime as before) due to the closer surveillance done by the district teams and the local commune teams. The peak time of extraction is at 8:00 p.m.-4:00 a.m. when the surveillance teams are not at work. The dredge owners also avoid the surveillance teams by posting a guard to inform them of the appearance of the surveillance teams. They also arm themselves with some weapons to defend themselves against the surveillance teams or local guards in case of arrest. The control of sand mining activities has therefore become more complicated and dangerous to the local authorities.

Figure 5. Sand mining dredges in Cau River

Very few individuals or organizations were provided permits for sand mining along Cau River in the past. From 2001 to 2009, Bac Ninh authority gave out seven permits only, with a total allowable sand volume of 300,000 m^3. In practice, many extractors without permits conduct sand mining. According to Bac Ninh DONRE (Bac Ninh Newspaper 2007), of the 17 areas of extraction currently in the whole Bac Ninh province, only 11 are licensed (Fig 6). Moreover, only 7 of the 48 sand extractors (both individuals and firms) have legal permits from the Bac Ninh authority. On the other hand, nearly all extractors do not follow the sand extraction regulations. Recognizing the potential danger of sand mining on the riverbanks and dikes in Cau River, the Bac Ninh authority has decide not to grant any permit for this activity in Cau River since 2009 (per Decision No. 71/2009/UBND). Therefore, since May 2009, any sand mining in Cau River on the Bac Ninh side is deemed illegal.

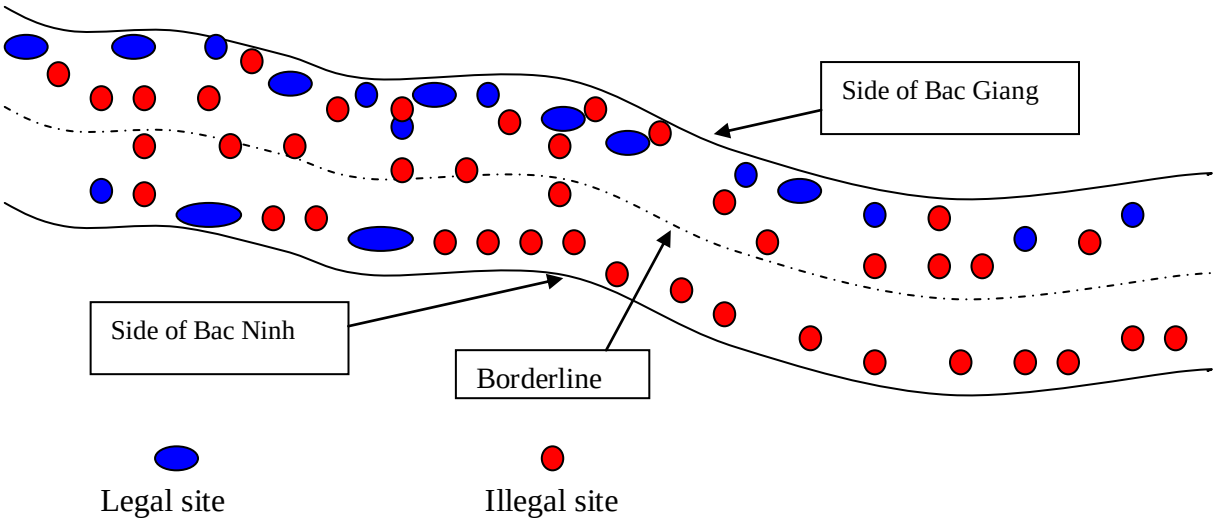


Figure 6. Legal and illegal sand extraction sites along the Cau River

The regulations state that sand extraction should take place only at the sand dune on the river. The Law on Dike Protection 2006 in Vietnam also bans any activities on the dike protection corridor (i.e., 20 m from the dike footing toward the river), including sand mining. However, the mine operators extract sand in any place where sand is available. In the past, the extractors pumped sand only from the riverbed. Recently, due to the decreasing availability of sand in the riverbed, they have been extracting even from the dike protection corridor using long trunks to pump a mix of sand and water). Several extractors have gone to the extent of placing the pumping trunk right at the dike footing, thus creating a large hole under the dike, which places the dike and stone embankment (for the dike's protection) in danger since they can be easily broken.

4.2. Environmental Consequences of Sand Mining in Cau River

4.2.1. Riverbank Erosion and Damage Cost

Like in other rivers, illegal and indiscriminate sand mining in Cau River has caused serious riverbank erosion in some sections. This is because sand extractors now use long trunks, which can reach quite close to the riverbanks, to pump a mix of water and sand. Such extractions could create a vault under the riverbank, causing the erosion or collapse of the riverbanks later. In addition to sand mining, brickmaking also contributes to riverbank erosion. According to estimates from Que Vo and Yen Dung districts, the total riverbank area for agriculture in the section of the river being studied was 146 ha in 2001; it declined to 109.5 ha in 2010 (Table 4). The decrease was mainly due to riverbank erosion caused by sand mining. Moreover, the levels of riverbank erosion have also become more serious year after year.

Table 4. Changes in the Cau riverbank, 2001-2010

	Unit	2001	2010
* Total riverbank area for agri.	ha	146	109.5
1. Very serious erosion	%	5	15.0
2. Serious erosion	%	15	22.5
3. Light erosion	%	50	45.0
4. No erosion	%	30	17.5

Source: FGD with staff of DARD in Que Vo and Yen Dung district, 2011

Other than sand mining, erosion and loss of the riverbanks are also caused by brickmaking and water flow. The FGDs with the staff of River Transport Management Board (RTMB) and local village staff and people living along the river disclosed that sand mining contributes around 70 percent to riverbank erosion in Cau River.

Figure 7. Riverbank erosion due to sand mining

The larger areas of the riverbanks are used by local farmers for rice and maize cultivation while the smaller areas are planted to vegetables such as water spinach, kohlrabi, and cabbage. The erosion of riverbanks has shrunk the cultivation areas and decreased crop production (Fig. 7). Assuming that all areas of the riverbanks are cultivated with two rice crops per year, the yield losses due to very serious erosion, serious erosion, and slight erosion would be 75 percent, 50 percent, and 25 percent, respectively. This means total rice production decreased by 329.7 tons between 2001 and 2010 (Table 5). At a 70-percent contribution factor, sand mining thus account for 230.7 tons of the decrease.

Table 5. Change in rice production between 2001 and 2010

	Unit	Riverbank with very serious erosion	Riverbank with serious erosion	Riverbank with slight erosion	Riverbank with no effects	Total
1. Riverbank areas						
- Year 2001	ha	7.3	21.9	73.0	43.8	146.0
- Year 2010	ha	16.4	24.6	49.3	19.2	109.5
2.Rice yield at normal riverbank condition	ton/ha /yr	8.5	8.5	8.5	8.5	8.5
3.Rice yield loss due to erosion	%	75.0	50.0	25.0	0	-
4.Rice production						
- Year 2001	ton	15.5	93.1	465.4	372.3	946.3
- Year 2010	ton	34.9	104.7	314.1	162.9	616.6
5.Decrease in rice production, 2010 vs. 2001	ton	-	-	-	-	**329.7**

Source: Author's estimates

4.2.2. Dike Degradation and Damage Cost

In the past, Bac Ninh authority had built four stone embankments on the Que Vo dike section, namely, Thong Thuong, Yen Ngo, Dong Vien, and Hien Luong, to protect the dike at dangerous points where the water flow could encroach on or invade the dike. However, due to the water flow, more sand is usually deposited on those points. Also, sands on those points often have high quality. Recognizing this, sand miners, using long trunks (up to 8 meters), target those areas. Such sand extraction can create vaults under the stone embankments and the dike footings (where there is no riverbank anymore). Due to the constant action of waves, the affected areas could gradually collapse and part of the dike can crash down. The vault can even cause the stone embankment, which protects the dike, to slide down or collapse. The dike on riverbanks with serious erosion would certainly become weakened and easily break during floods. According to a DONRE report, despite efforts to improve the dike, the length of dike classified under very serious erosion and serious erosion increases each year due to the more forceful sand extraction, which now is also done on the riverbanks where more sand is available. Sand mining is thus considered to be the major cause of dike degradation.

Expenditures on dike protection and improvement have become a financial burden to the local governments due to the increased damages. During the 2001-2010 period, Bac Ninh and Bac Giang provinces invested significant amounts for stone embankments in Cau River. In 2008, VND 3.5 billion (more than USD 210,000) was spent to improve the Thong Thuong stone embankment, part of which had collapsed due to impacts of sand mining. Similarly, VND 4.2 billion was also spent to improve the Yen Ngo stone embankment in 2009. One hundred cubic meters of stone were used to prevent the dike footing from its collapse as sand mining has caused very deep (12 m) vaults under the dike footing. In addition, the embankment was built longer (from 500 m to 800 m) to better protect the dike. Similar improvements were also done on Dong Vien and Hien Luong embankments, incurring huge costs (Table 6).

While the stone embankment degradation is mainly due to sand mining, the degradation of dike footings could also be caused by other reasons such as brickmaking and the natural water flow. The FGDs with local village staff and district staff revealed that sand mining contribute 50-60 percent of dike footing degradation.

Table 6. Investment cost for improved dike and stone embankments in Que Vo district, Bac Ninh province

Investment item	Unit	Amount	Note
1.Annual dike improvement in Bac Ninh side			
- Soil volume for improvement	1,000 m^3	10 - 30	
- Total cost of improvement	million VND	200-450	
2.Annual dike improvement in Bac Giang side			
- Soil volume for improvement	1,000 m^3	10 - 20	
- Total cost of improvement	million VND	200-350	
3.Stone embankment			
- Yen Ngo	million VND	4200	Improved in 2009
- Thong Thuong	million VND	3500	Improved in 2008
- Dong Vien	million VND	3350	improved in 2006
- Hien Luong	million VND	2700	improved in 2005
- Yen Ngo and Thong thuong	million VND	1500	improved in 2002

Source: FGD with Que Vo district staff, 2010

4.2.3. Damage to Irrigation Work

Cau River provides water to rice fields in both Bac Giang and Bac Ninh provinces. In the section of the river covered by the study, there are five pumping stations on the side of Bac Ninh and four on the side of Bac Giang. Altogether, 13 sewers are associated with these pumping stations. According to the local staff, sand mining does not have much effects on the pumping stations and sewers, except that it causes more deposits of sand and mud on the pumping stations, making it necessary to do more cleaning on the pumping areas in recent years (Table 7). The damage cost is therefore equivalent to the additional cost of cleaning out the deposits in the pumping stations. The frequency of additional cleaning has been one per year for each pumping station since 2006 when sand mining has boomed in Cau River. The total annual additional cost varies due to input price changes.

Table 7. Additional cleaning cost of the pumping stations due to sand mining

Year	No. of pumping stations	Additional time of cleaning / station	Average additional cost/pumping station (million VND)	Total addition cost (million VND)
2006	9	1	1.5	13.5
2007	9	1	1.6	14.4
2008	9	1	1.8	16.2
2009	9	1	2.0	18.0
2010	9	1	2.1	18.9
Total				81.0

4.2.4. Other impacts

As mentioned in the literature review, sand mining could have other impacts such as lowering ground water, catch volume of fishery, and noise pollution. The FGDs with villagers and local staff along Cau River did not find any impact by sand mining in Cau River on ground water as the water level in the villagers' wells have not changed (compared with the previous years' level). Similarly, no significant effects were observed on fish catch from Cau River since there has been nearly no fishing activities on the river in recent years. However, sand mining caused noise that disturbed the villagers, especially at night. Due to this, several people experienced insomnia. Moreover, sand mining also made the riverbed much deeper and uneven, making it more dangerous to the local people.

4.3. Financial Analysis and Cost-Benefit Analysis of Sand Mining

4.3.1. Financial Analysis of Sand Mining in Cau River

Usually the dredges for sand mining are simply constructed using cement, thus their price varies between VND 40 million and VND 100 million, depending on their carrying capacity. The equipment associated with these dredges includes engines with trunks for pumping a mix of sand and water from the rivers. The small dredges are often equipped with two engines while the large ones have 3-4 engines. The main costs of sand mining are workers' wages, diesels for dredges and pumping engines, and depreciation of dredges and associated equipment. Table 8 shows the results of the financial analysis of sand mining by dredges. Each time a large dredge extracts its full capacity of 100 m^3, it can make a profit of VND 1.14 million. A small dredge has a capacity of 40 m^3, and can make a profit of VND 0.4 million. At peak time, one dredge can extract at full capacity three times a day. Thus, a large dredge can earn a daily a profit of VND 3.4 million and small one can earn VND 1.2 million per day. Given that the average income of rural labor is just between VND 2-3 million per month, the earnings from sand dredging are quite high. This is why sand mining has been mushrooming in Cau River as well as in other rivers in recent years.

Table 8. Financial analysis of sand mining in Cau River

	Large dredge of 100 m^3 (VND 1,000)	Small dredge of 40 m^3 (VND 1,000)
1. Incurred Cost		
- Labor cost	360 (6 persons x 4 hr x VND 15,000/hr)	157 (3 persons x 3.5 hr x VND 5,000/hr)
- Diesel	800 (4 h x 10 liter/hr x VND 20,000)	350 (3.5 hr x 5 liter x VND 20,000)
- Depreciation	104	55
- Others	100	60
2. Revenue	2,500	1,000
3. Profit		
- Profit/dregde/time	1,136	378
- Average profit/100 m^3	VND 1,012,000 (35% extracted by large dredges and 65% extracted by small one)	

Source: Survey data, 2011

4.3.2. Cost-Benefit Analysis of Sand Mining in Cau River

Benefit of Sand Mining in Cau River

The main benefit of sand mining is the profit gained by the sand extractors. Based on the estimated total sand mining volumes from 2001 to 2010 in the studied river section, the total profit of all private sand extractors was calculated and presented in Table 9.

Table 9. Total private profit from sand mining in Cau River

Year	Sand extracted volume (m^3)	Unit profit (thousand VND /100 m^3)	Total private profit (million VND)
2001	45000	720	324.0
2002	60000	749	449.4
2003	75000	779	584.3
2004	95000	810	769.5
2005	120000	842	1010.4
2006	150000	876	1314.0
2007	180000	911	1639.8
2008	210000	947	1988.7
2009	250000	985	2462.5
2010	200000	1012	2024.8

Source: Estimates from sand miners and local people, and author's calculation

External Cost of Sand Mining

As discussed in the previous section, the external damages caused by sand mining include agricultural loss due to riverbank erosion, the cost of improving dikes and stone embankments, the additional cost to irrigation work (pumping station), and noise pollution.

A reduction of 230.7 tons in total paddy production between 2001 and 2010 was estimated in section 4.2.1. Assuming that the riverbank erosion was at the same rate through the years, the value of rice production losses could be calculated (Table 10).

The annual investment for dike improvement on the river section under study was obtained from DARD of Que Vo and Yen Dung districts. Sand mining was estimated to account for 50 percent of the degradation of dike footings. Moreover, the degradation of stone embankments was due totally to sand ming. Table 10 shows the estimated total cost for improving dikes and stone embankments due to sand mining. The additional cost of cleaning the pumping station due to sand mining was presented earlier in Table 7. The cost of noise disturbance from sand mining was ignored in this study although the cost was real.

Cost-Benefit Analysis of Sand Mining in Cau River

Based on the total private profit of sand miners and the external cost caused by sand mining,a cost-benefit analysis was done (Table 11). Due to the high external cost, especially the cost of stone embankment improvement or repair, the NPVs of sand mining are all negative at discount rates of 5 percent and 10 percent. At these discount rates, sand mining respectively reduces social welfare by VND 5.82 billion and VND 4.64 billion during the 2001-2010 period.

The sensitivity analysis shows that even if the unit profit of sand mining increases by 20 percent, sand mining would still reduce the social welfare by VND 3.94 billion (at a discount rate of 5% per annum). Certainly if other costs such as those due to noise and monitoring and enforcement of regulations are included, the social welfare would be further reduced. Therefore, it is quite clear that the external cost of sand mining in Cau River outweigh the total gain of all sand extractors. Thus, a more effective management of sand mining in the river is certainly necessary.

Table 10. Agricultural loss and cost for improving dikes and embankments due to sand mining

Year	Loss due to riverbank erosion				Cost for improving dikes and stone embankments			
	Paddy loss (ton)	Price (000 VND /kg)	Value loss (million VND)	Profit loss (million VND)	Investment for improved dikes (million VND)	Investment for dikes due to sand mining (million VND)	Investment for stone embankment (million VND)	Total cost due to sand mining (million VND)
2001	0	2.5	0.0	0.0	400	200	0	200
2002	25.64	3.0	76.9	26.9	440	220	1,500	1,720
2003	50.37	3.2	161.2	56.4	480	240	0	240
2004	75.11	3.5	262.9	92.0	520	260	0	260
2005	99.84	3.7	369.4	129.3	560	280	2,700	2,980
2006	124.57	4.0	498.3	174.4	600	300	3,350	3,650
2007	149.31	4.2	627.1	219.5	640	320	0	320
2008	174.04	4.5	783.2	274.1	680	340	3,500	3,840
2009	198.77	5.0	993.9	347.9	720	360	4,200	4,560
2010	230.70	6.0	1,384.2	484.5	760	380	0	380

Source: Author's estimate

Table 11. Net present value of sand mining in Cau River (million VND)

Year	Total private profit	Total external cost	Net benefit	NPV (with discount 5%/yr)	NPV (with discount 10%/yr)
2001	324.0	200.0	124.0	124.0	124.0
2002	449.4	1746.0	-1296.6	-1234.8	-1178.7
2003	584.3	295.4	288.8	262.0	238.7
2004	769.5	350.9	418.6	361.6	314.5
2005	1010.4	3108.1	-2097.7	-1725.8	-1432.8
2006	1314.0	3836.6	-2522.6	-1976.5	-1566.4
2007	1639.8	552.5	1087.3	811.3	613.7
2008	1988.7	4128.9	-2140.2	-1521.0	-1098.3
2009	2462.5	4924.3	-2461.8	-1666.2	-1148.4
2010	2024.0	866.4	1157.6	746.2	491.0
Total	-	-	**-7442.5**	**-5819.2**	**-4642.6**

Source: Author's calculation

4.4. Assessment of Sand Mining Management Practices

4.4.1. Overview of Sand Mining Management Practices

Recognizing the serious damages on riverbanks, dikes, and stone embankments caused by illegal sand mining, the local authorities have made efforts to control the situation. In recent years, the local people who live in villages along Cau River also put pressure on authorities to manage sand mining more effectively since sand mining directly damages their agricultural land, the roads (dikes) they daily use, and their living environment (due to the noise). To combat illegal sand mining, the authorities assigned the responsibilities for sand mining management to more agencies including the police department and army and ordered more frequent surveillance of river sand mining. The illegal sand miners were also treated in a more forceful way. Before 2008, the local authorities only tried to evict the sand miners from the river section that they managed, but did not arrest them. However, since 2008 the authorities have tried to chase and arrest the illegal sand miners. Moreover, since 2009, Bac Ninh province no longer granted any permits for sand mining in Cau River (Table 12). In 2010, the district also sent the management team to some hot spots to set up sentry boxes nearby with the hope of effectively controlling the situation. As a result, around 20 dredges were caught and fined (in comparison, only three were caught in 2007-2010). Illegal sand mining in Cau River has been reduced significantly after such events. However, when the district team assigned its daily work to the commune team, illegal sand mining started to appear again, although at a low frequency.

Table 12. Sand mining management in practice

	Activity/Measure	Result
Before 2007	- Only evicted the illegal sand miners, did not catch or fined them - Provided permits - Limited surveillance due to lack of funds and poor facilities - No close coordination with neighboring districts	- Illegal sand miners increased (reduced only at the time they were evicted)
2007-2010	- Caught sand miners (not only evicted as before) and fined them up to VND 15 million - No permits issued since 2009 - Limited surveillance due to lack of funds and poor facilities - No close coordination with neighboring districts	- Only 3 dredges were caught and fined - Illegal sand miners increased (reduced for a short time only after they were chased)
May 2010 – Aug 2010	- Caught sand miners and fined them up to VND 20 million - District surveillance team with sentry box at hot areas for 4 months continually - Arranged to have policemen and army work with the district surveillance team - Better facilities for chasing illegal sand miners (high speed canoe) - More funds for surveillance - Close coordination with neighboring districts	- 20 dredges were caught and fined. - Illegal sand mining reduced significantly
Sep 2010 - nowadays	- Surveillance team at commune with high speed canoe to inspect the river section daily/at night (with militiaman of commune). The team can catch the sand miners (fine are decided by district). - Close coordination with nearby commune is set up - District surveillance team coordinates with commune team to inspect the situation in a limited time - Limited funds for commune surveillance team	-2 dredges were caught -Sand miners sometimes appeared at the border of communes.

Source: FDGs with the local staff at districts and communes, 2010

4.4.2. Assessment of Sand Mining Management

Despite certain management efforts by the authorities, sand mining in Cau River continued to proliferate. The number of sand mining dredges as well as the extracted sand volumes from Cau River continued to rise until 2010 when very forceful management activities were implemented. In recent months, when management activities have been loosened, the reappearance of sand mining dredges has been observed. It is feared that sand mining at a high rate could recur in the future. The reasons why sand mining has proliferated and that the situation could recur in the coming time were investigated with the participation of the local staff and people. Legal framework, assignment of responsibilities among stakeholders, and resources for management are factors that contributed to the situation. Of these, limited resources (such as fund and facilities) are considered to be the main cause of ineffective management of sand mining in Cau River (Table 13).

Table 13. Constraints on effective management

Constraint	*Level of constraints*
1. Legal framework on sand mining	+
2. Assignment of responsibilities among agencies	++
3. Coordination with nearby local authorities	+++
4. Limited funds and poor facilities	+++++
5. Participation of the local people	+
6. Information leakages on illegal sand mining siege	+++

+++++ Very high level; + Low level

Source: FDGs with local staff at districts and communes, 2010

4.4.3. Factors Affecting Sand Mining Management

Legal Framework for Sand Mining Management

Sand mining management in Cau River is based on legal issuance by the Vietnamese national government as well as by local authorities. At the national level, sand mining is controlled by the Law of Dike issued in 2006 (Ordinance of Dike was issued in 2000) and Law of Natural Resource Tax issued in 2009 (Decree 63/2008/NĐ-CP issued in 2008). According to provision 7, item 10 in the Law of Dike in Vietnam, any sand mining activity on the dike protection corridor is prohibited. The dike protection corridor is 20 m from the dike footing on the riverside, and 50 m from the footing of the stone embankment (provision 23). The Law of Dike also stipulates that any sand mining activity on the riverbed and riverbank needs a permit from the provincial authorities. The Law on Natural Resources Tax (November 2009) stipulates that the tax on sand mining will be 5-15 percent of the total revenue from the activity. The specific tax level is decided by the concerned provincial authority. The Vietnamese prime minister also promulgated Directions No. 16/2002/CT-TTg (31 Jul 2002) and No. 29/2008/CT-TTg (2 Oct 2008) to enhance the control of illegal sand mining in the country. According to Directions No. 29/2008/CT-TTg, the provincial authorities in coordination with related ministries need to suspend/stop all illegal sand mining activities while the Vietnamese government would stop sand exports starting 2010.

Table 14. Regulations on sand mining in Bac Ninh province

	2000-2006	2006-2010
Mining place	Approved places (banned sand mining in places that are not explored and have no impact assessment [IA] report on water flows and dikes)	Approved places (banned sand mining in places that are not explored and have no IA report on water flows and dikes)
Mining time	Anytime	Not allowed in flood season (15 May – 30 Oct)
Procedure for getting permits	• Application form • Mining plan's technical aspects • Approved documents by the district and commune • Exploration report approved by legal offices • Description of transportation routes	• Application form • Mining plan's technical aspects • Approved documents by the district, communes, provincial DARD, RTMB • Exploration report approved by legal offices • Description of transportation routes
Duration of permit	≤ 3 years	≤ 1 year
Mining areas and volume per permit	• For individuals: ≤1 ha and ≤16,000 m^3 • For firms: ≤5 ha and ≤80,000 m^3	• For individuals: ≤1 ha and ≤16,000 m^3 • For firms: ≤10 ha and ≤160,000 m^3
Permit extension	• Possible if extractors comply well with all sand mining regulations (tax) and had extension form application. • No specific duration	• Possible if extractors comply well with all sand mining regulations (tax) and had extension form application. • Extension duration ≤ 6 month
Granting offices	Department of Industry	Provincial People Committee (through DONRE)
Responsibility of extractors	• Fee for providing permit • Tax for natural resource extraction	• Fee for providing permit • Tax for natural resource extraction and fee for environmental protection • Deposit of VND 20-50 million for damage restoration
(Monitoring agencies) Responsibilities of related agencies	Not specific	DONRE, DARD, Police, Dept of Transportation, RTMB District People's Committee, Commune People's Committee

Source: Reviews by the author

At the provincial level, Bac Ninh issued decisions (No. 70/2000/QĐ-UB dated 14 Jul 2000, No. 96/2006/QĐ-UBND dated 10 Aug 2006 and No. 68/2010/QĐ-UBND dated 21 Jun 2010) on sand mining management in the rivers of its province. The decisions stipulate the necessary conditions and procedures on granting the permit for river sand mining and the responsibilities of local authorities and units. Any sand mining activity without a permit is prohibited in Bac Ninh. The duration of the permit is no more than 1 year, and it can be extended for less than 6 months. The permitted volume for an individual extractor cannot exceed 16,000 m^3/year and the mining area is within 10,000m^2. Moreover, extraction by an enterprise or organization shall not exceed 160,000m^3 of sand volume per year within 100,000m^2 of mining area. The decision 68/2010/QD-UBND bans any sand mining activity on the rivers during flood season (from 15 May to 30 Oct annually). Any illegal sand mining dredge will be caught and fined up to VND 20 million each time.

Similarly, Bac Giang province issued decisions (No. 31/2005/QĐ-UBND and 55/2009/QĐ-UBND) on sand mining in the province's rivers. These stipulate the necessary conditions and procedures on granting the permit for sand mining and the responsibilities of local authorities and units. In 2009 Bac Giang province approved the river sand exploration and mining plan until 2020 (Decision 18/2009/QĐ-UBND). For the mining areas along Cau River, the specific sand reserve volume was identified and the mining depth was stipulated for each area. The decision also shows out where the sand mining would be banned to protect dikes and stone embankments. The responsibilities of and coordination between the local authorities were also identified in the decision.

Furthermore, Bac Ninh and Bac Giang provinces approved the coordination regulations (Regulation 01/QC-LT date 30/9/2004) on sand mining management in Cau River since the river is the borderline between the provinces. In recent years, even the districts located next to each other also signed regulations on sand mining management coordination in the river. District authorities annually issued official documents to enhance the management responsibilities of their associated units (such as DARD, DONRE) and communes along the rivers.

The regulations on Bac Ninh province (as well as in Bac Giang province) during 2006-2010 were more tough and specific than those during the 2000-2006 period (Table 14). Since 2006 the duration of permit has been limited to only 1 year (before 2006 it was 3 years) and the extractor has to deposit VND 20-50 million when they get a permit. Decisions No. 96/2006/QĐ-UBND and No. 68/2010/QĐ-UBND stipulate that any illegal sand mining activity will be subject to fines or that operators will be treated as criminals and will be ordered to pay for the restoration cost of damaged dyies and other facilities caused by illegal sand mining. However, there are several concerns. For example, the maximum fine for one illegal sand mining dredge could not exceed VND 20 million each time (if caught). This amount is relatively small and it thus does not have the expected effect of preventing illegal sand mining since the extractor could earn quite big profit from sand mining (up to VND 3 million per day). Several extractors were thus willing to pay the fine to get back to their dredge and continue sand mining. Some mining dredgers tried to escape when they were being chased. For that purpose, some dredges were equipped with weapons (such as stone

and swords) and the workers, under the guidance of dredge owners, fought back against the local surveillance teams. They would leave the dredges on the river with the engine locked when the surveillance team arrived. This prevented the surveillance team from driving or moving the dredges to the storage places. Once the team is gone, the dredge owners, with assistance from their workers or others, would get back to the dredges (the surveillance teams cannot stay long in the dredges at night). Even if the team could drive the dredges, it was also difficult to find places to safely keep the caught dredges. The team also found it difficult how to treat the workers who work on the sand mining dredges.

Stakeholders and Their Responsibilities on Sand Mining Management

There are many stakeholders at different levels that engaged in sand mining in Cau River. In general, the stakeholders at the national level are mainly responsible for issuing the legal framework for sand mining in the whole country and enhancing the management coordination between provinces. The stakeholders at the provincial level have the main responsibility of directly managing sand mining in the rivers, i.e., provide and withdraw permits, coordinate inspections, impose fines, provide the budget for sand mining management activities (Table 15). The staff of district and communes was, however, the ones who directly participated in inspections of sand mining activities and chase of the illegal miners. They face dangers from the aggressive reaction of illegal sand miners.

Since each stakeholder is responsible for one different aspect of sand mining management, the inspection requires the participation of several different stakeholders including the DONRE, DARD, Police, CPC, etc. Moreover, as Cau River is the borderline of Bac Giang and Bac Ninh, the effective inspection of the river would need the participation of staff from both provinces. Furthermore, the limited budget for implementing inspections, the dangers during inspections, and the low level of fines for illegal dredges constrained the conduct of inspections. The number of inspections in Cau River organized by DONRE had been very few. In 2009, for example, only five inspections with the participations of district staffs were implemented.

Table 15. Stakeholders' responsibilities on sand mining management in Cau River

Level	Stakeholder	Responsibility
National	Government MONRE MARD, IWA (Inland Water Administration)	- To issue the legal framework, including the related laws, regulations, guidance, and directions for river sand mining (SM) management in the country - To provide the budgets for national dike improvement
Province	Provincial People's Committee	- To issue the regulations and directions for river SM in the province - To provide the SM permits and permit extension - To assign the responsibilities on SM management to concerned agencies in the province - To decide the fine level - To develop the coordination framework in SM management between the two provinces
	DONRE	- To proceed with the procedures and recommend to PPC who gets the SM permits. - To identify the places where SM activities are banned. - To develop the master plan for SM in the river - To inspect the SM activities in the river
	DARD	- To manage the dikes and to take measures for flood prevention and reaction - To get involved in approving the SM areas (to protect the dike footings) - To place the signs on places where SM activities are banned - To propose the withdrawal of permits if any illegal activities are discovered
	Transport Dept.	- To coordinate with other agencies in implementing the inspection on SM activities and proposing the fine
	Police Dept.	- To coordinate with other agencies in implementing the inspection on SM activities and proposing the fine
	IWA Unit	- in coordination with DONRE and other agencies in province, to check and inspect the SM activities and propose fine if there are violations
	Tax Dept.	- To check and collect the natural resource tax in coordination with the people's committee of the districts and communes
District	District People's Committee (DPC)	- To monitor the SM activities on the river section (belonging to district) - To report to provincial authority the SM activities on the river section - To propose countermeasures against illegal SM - To exchange information and coordinate with other nearby districts in monitoring SM activities on the river
	DONRE	- To organize the inspection and check on SM activities - To report the SM activities to the DPC
	DARD	- To coordinate with other agencies in implementing the inspection on SM activities and proposing the fine
Commune	Commune People's Committee (CPC)	- To directly manage the SM activities in the river section which belong to the commune - To participate in the inspection and check on SM activities under the supervision of DONRE at the district level.
	Local people	- To discover illegal SM activities and to inform the CPC about these

Source: FGDs, 2010

Resources for Sand Mining Management on Cau River

Due to the high private profit derived from illegal sand mining it is happening on a wide scale in Cau River as well as in other rivers in Vietnam. Illegal miners usually post guards to spot the arrival of the surveillance team. The miners also changed their extraction time from day to night. Several of them also equipped themselves with weapons to use against the surveillance team in case they will be caught.

Despite the complicated situation and the dangers posed by sand miners, the local authorities used simple tools to carry out their task of monitoring sand mining. Before 2009, the team only used a small canoe of normal speed (around 30 km/h) and no blackjack and guns. Once informed by their guards of the surveillance team's arrival, the sand miners therefore had enough time to run away or to erase any evidence of sand mining. They even aggressively used their weapons to oppose the team because they know the team was not equipped with any weapons. After several experiences of being aggressively opposed by sand miners, the team has been using a high speed canoe (up to 50 km/h) starting in May 2010. Moreover, armed policemen and military force were included in the surveillance team in order to be able to overpower anyone who aggressively opposes the inspection team (Table 16). At some mining hot spots such as Viet Thong commune, the district (under the direction of the Provincial Authority) established a surveillance team of around 20 people (including staff of DONRE and DARD, police and military force at the district level, and commune staff). The team built one sentry box at the riverbank and arranged two people to stay there at night to discover sand mining dredges, then to inform the team for quick action. Thanks to the better facilities, the team has caught around 20 illegal sand mining dredges between May and August 2010. Illegal sand mining had significantly declined since then.

Despite its effectiveness against illegal sand mining, the district team could not be maintained for long due to the high cost and lack of staff (the involved staff were also responsible for other assigned work in the district). After four months of operations in the hot spots and scoring some successes, the district team assigned its role to the commune team and its facilities (including the sentry box and high speed canoe). The commune team could use the facilities to catch illegal sand mining dredge in the areas that the commune managed. However, the commune had to pay the allowance of the team members and other costs incurred in surveillance activities such as gasoline for the canoe; the district provided only partial support for this cost. In 2010, Viet Thong commune spent over VND 100 million for sand mining management while the district provided only VND 30 million to the commune for this work. Given the limited budget of the commune, it has found it difficult to maintain the intensity of surveillance activities like before.

Table 16. Resources for sand mining management

	Before 2010	May – August 2010	August 2010 – May 2011
1. Human resource	- District team of DONRE, DARD, commune staff: only 3-6 times per year; takes the major role - IWA: nearly no surveillance	- District team of 20 persons: DONRE, DARD, Police, Military force, commune staff: stayed at hot areas for 4 months; takes the major role - IWA: coordinates with district team	- Commune team of 11 persons: daily watch against illegal sand mining, and takes the major role - District team of DONRE, DARD, Police, Military force, commune staff: 3 times/year; - IWA: coordinates with district team
2. Facilities	Canoe with normal speed	- Canoe with high speed - Sentry box at hot area built - Blackjack - Guns of police and military force	- Canoe with high speed (for both commune and district teams) - Sentry box - Blackjack - Guns of police and military force (for district team)
3. Spending	VND 60 million per year for the district team	VND 200 million for the district team	+ Around VND 100 million per year for the commune team + VND 60 million per year for the district team

Source: FGDs

At present, the commune team consists of 11 members (include the leaders of the commune and villages as well as professional staff for land, transports, and agriculture management). The team assigns two people to stay at the sentry box to keep close watch over the river section at night. The allowance for these people is only USD 2-3 per night. The use of high speed canoe for surveillance is also rare to minimize gasoline consumption (around 40 liters per hour). The commune could not afford the cost for gasoline if canoe is used for long due to its limited budget (total budget of the commune is only VND 1.9 billion per year).

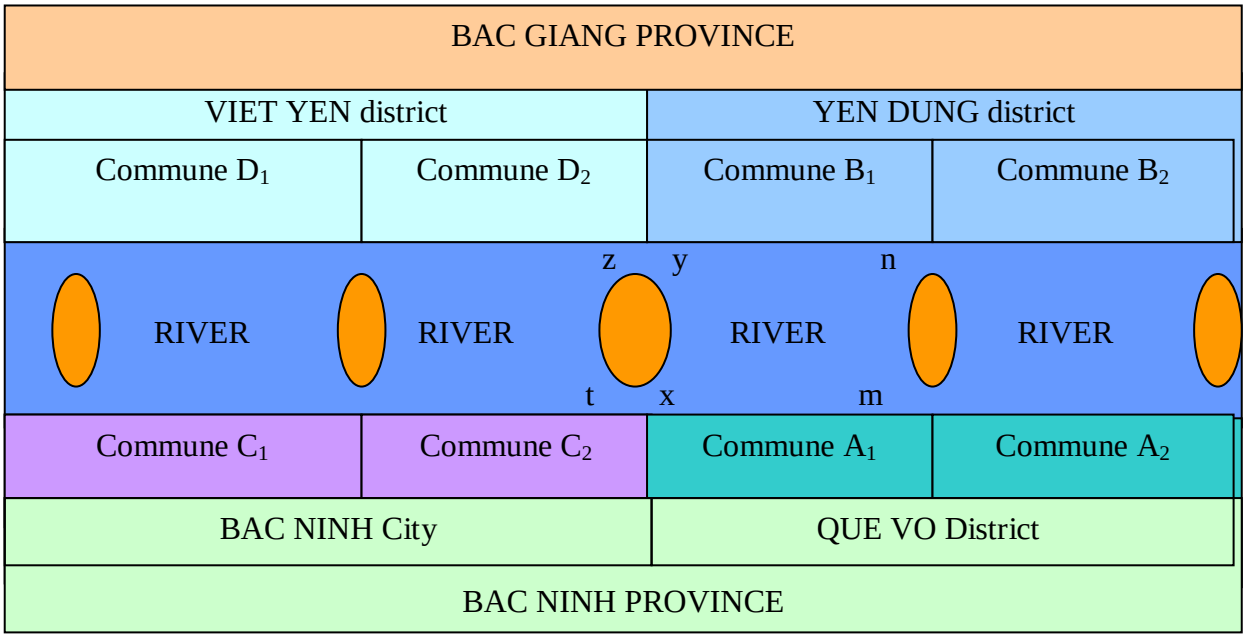
Local Participation on Sand Mining Management

Recently, the local people living along the river participated quite actively in sand mining management since they have come to clearly recognize the mining's serious consequences on riverbank, dikes, and their daily life. They therefore informed the responsible persons/staff when they discover any illegal sand mining dredges on the river. They also sometimes participated with the commune and district teams in evicting and chasing the illegal dredges. They even evicted and chased the illegal dredges by themselves (without the surveillance team). These active engagements of the local people contributed to better sand mining management in the river.

However, the local people usually paid attention only to sand mining dredges that appeared on the areas of their villages or communes. In other words, the local people in each commune did not coordinate with each other in preventing illegal sand mining. This led to failures in discovering and chasing the illegal miners.

Coordination between Authorities of Nearby Localities

Since half of Cau River (left side) belongs to Bac Giang province and the other half to Bac Ninh province, this means that the surveillance team of each province does not have the right to catch illegal sand mining dredges on the other side of the river. This arrangement caused many difficulties in catching the illegal sand miners. For example, when an illegal sand mining dredge was seen to extract sand at Bac Ninh side and the surveillance team of Bac Ninh tried to catch it, the dredge owner would just quite quickly go to other side of the river on the side of Bac Giang province, and would be "safe." The success of sand mining management in Cau River therefore needs the close coordination between authorities from both river sides.



Borderline areas: Difficult for management
(If no coordination: A_1 team could catch only illegal dredge x; QueVo team can catch dredges x, m but not n, y, z and t

Figure 8. The need for coordination against illegal sand mining management

In theory, Bac Ninh and Bac Giang provinces already approved the coordination regulations (Regulation 01/QC-LT) in 2004 for sand mining management in Cau River. However, this coordination only existed on paper. In practice, due to limited resources of fund, facilities and people, and other reasons, Bac Ninh and Bac Giang usually conducted surveillance separately and just 2-3 times only per year. Only in recent years starting in 2009 when sand mining in Cau River has become a very hot issue that the district authorities of Yen Dung and Que Vo have begun to recognize the necessity for coordination. These two districts therefore set up arrangements for close coordination to chase the miners. This contributed to the success of catching up to 20 sand dredges in 2010. Since the late 2010, the commune teams along the two sides of the river have tried to coordinate with each other in catching the dredges.

In addition, coordination among districts in the same province as well as among communes in the same districts is very important for sand mining management. This is because the surveillance team of one district or commune could operate only on the areas administered by that district or commune, thus unable to catch miners who extract sand in other districts/communes even if these two districts/communes are located just next together. Recognizing this, the miners usually extracted sand at the borderline of two districts or two communes so that they can easily escape to the other area when the surveillance team of one commune/district comes. In Que Vo district, illegal sand mining dredges recently appeared quite often at the borderline between communes (such as m and x) after the district team was withdrawn from the hot spots.

Information Leakage on Illegal Sand Mining Chase

In order to catch and impose fines on dredge owners for illegal sand mining, it was necessary to surprise them in the act of sand mining. Secret and sudden chases were therefore very important for catching illegal sand miners. However, this was quite difficult due to several reasons. Firstly, sand miners were able to post guards to observe the river and discover the arrival of the surveillance team. Secondly, the sand miner also managed to get information on the time and scope of the chase. Usually, organizing one chase by the district surveillance team needs to have a plan and enough time for preparation with the participation of local staffs (more than 10 staff). The information on the chase could therefore be leaked out by some staff (some miners act like a mafia). Once information is leaked, the chase would be ineffective since the miners could destroy the evidence, evade, or not cancel their extraction activity. This is also considered to be one of the reasons for ineffective management.

4.4.4. Alternatives for Sand Mining Management

Through discussions with the local staff of Bac Ninh province, three options for sand mining management in Cau River have been proposed, as follows:

Option 1: Absolute ban on sand mining

Option 2: Mining in selected areas with permits

Option 3: Mining in selected areas subject to high royalty fees

The advantages and disadvantages of these management options are presented in Table 17.

Table 17. Advantages and disadvantages of sand mining management options

Option	**Option 1** **Absolute ban as at present**	**Option 2** **Mining in selected areas with permit**	**Option 3** **Mining in selected areas subject of high royalty fees**
Advantage	- Easy to detect illegal sand mining - Easier for monitoring and enforcement	- Able to meet part of the demand for sand in the region - Ensure good water flow in the river	- Able to meet part of the demand for sand in the region - Ensure good water flow in the river
Disadvantage	- Unable to meet the demand for sand in the region - Flow of water in the river will be affected by some sand dunes (but very little possibility)	- Difficult to ensure permitted miners extract in only selected areas only at permitted volumes and depth - Possibility of illegal sand miners appearing again is very high -Difficult to discover illegal sand mining and to monitor the situation	- Difficult to ensure permitted miners extract in selected areas only - Very difficult to collect the royalty fees because many dredge owners do not register their dredges with management agencies, difficult also to measure the extracted volumes

Source: FGDs with local staff and people, 2010

In the Short Run

Sand mining done properly can provide some benefits for the river because it can take away some sand dunes that form gradually in the river, thus enabling the water to flow smoothly. The extracted sand would also contribute to meeting partly the demand for sand in the region. For such purpose, it is necessary to explore the sand capacity and status along the river in order to determine particular areas that can be mined for sand, including the suitable depth and proper mining techniques. In Cau River, such areas have been explored and determined already. However, the majority of local staff and people believe that with the current limited resources for monitoring and enforcement, they will certainly encounter difficulties in implementing options 2 and 3, as follows:

- It is very difficult to ensure that sand miners will extract sand at the designated places only. They will probably extract wherever sand is rich or sand quality is high and easy to extract. Usually, those places are near the dike and thus have been already banned from sand extraction.

- It is very difficult to collect tax payments from the miners. Usually the owners do not register their dredges with the management agency. They therefore do not pay tax.
- Even if they registered their dredges with management agency, it will also be a challenge to know how much sand they have extracted because the management agency is unable to monitor their operations. If some dredgers are permitted to extract sand, it is very difficult to distinguish them from illegal ones (especially at night). In other words, it will be extremely difficult to detect illegal mining dredges and monitor them since illegal dredges can mingle with the legal ones.

Therefore, options 2 and 3 were considered nearly impossible to carry out at present. During the FGDs, the majority of local staff and people said that option 1 would be the best management option at present since it will be easy to enforce. However, this option will not address the increasing demand for sand in the region.

In the Long Run

In the long term, with adequate investments allocated for monitoring and enforcement of sand mining guidelines in Cau River, option 3 would be the best option. Currently, the sand dredge owners can earn quite a huge financial profit from sand mining (see section 4.3.1) yet they do not pay any royalty to compensate for the significant damages they cause because they are illegal miners. According to a government decision, the royalty for river sand mining could be 5-15 percent of the sand price; the royalty rate applied to mining in Cau River is 15 percent. This rate is considered high enough, but the problem is that it is not possible to control illegal sand miners and to collect royalty from them. Efforts by the local authorities to manage illegal miners have failed mainly due to limited resources allocated to monitoring and enforcement. In order to properly and successfully implement option 3, it is necessary to undertake the following actions:

1) Provide permission for dredgers that meet the technical requirements

Most of the individual miners in Cau River use small dredgers and they are the main cause of dike and bank degradation because they can easily approach the dikes and banks and extract sand there. Moreover, it is hard to monitor their mining activities as they can move very fast from one place to another. In order to better manage sand mining in Cau River, besides the procedures required during permit application (as described in provision 5, chapter 2, decision 31/2005/ QD-UBND Bac Giang), the authorities should also require a minimum dredge size. Based on the applicant's proposal, the authorities should select the dredgers that meet all the requirements and a staff from the concerned agency should inspect the applicant's dredge to be certain. The sand miners whose applications are confirmed by the staff will be required to sign the commitment form that they will extract sand only as indicated in their approved proposals.

Box 4.1. Application Procedures for Sand Mining Permits

Sand miners who would like to apply for a permit to extract sand from rivers should send to DONRE two copies of following documents for consideration:

(1) Application form

(2) Detailed mining plan, including the following additional items:

- Land map and geographical map at 1/500 – 1/2000 ratio for the proposed mining sites
- Map and information on site for sand storage

(3) Approved documents on sand exploration at the proposed mining site from the concerned agencies

(4) Other related documents such as enterprise establishment decision and business registration.

(Source: Provision 5, chapter 2, decision 31/2005/ QD-UBND Bac Giang)

2) Require a higher deposit from dredgers

In order to get a permit for sand mining, the dredge owners are required to deposit the amount of VND 20-50 million for use in restoration in case they cause damage and do not make enough restoration effort (Decision 31/2005/ QD-UBND). However, the deposit amount is not high enough to pay for the cost of restoring damages caused by the mining dredges. Moreover, since the mining dredges can earn quite a huge profit from sand mining, they can easily afford the deposit and do not care about violating the mining rules. It is proposed that the deposit should be increased to VND 50–100 million per dredge. At this level, the deposit is expected to enhance sense of responsibility of sand miners; it will also be sufficient to pay for the cost of restoring the river dikes and banks and other facilities in case the sand miners damages them and do not implement the necessary measures for restoration. This deposit could also help exclude the small dredgers from sand mining since the amount is relatively high compared with their total annual financial profit.

3) Coordinate with the local people in managing sand storing sites and tax collection

There are many sand storing sites along Cau River. The dredges usually take their extracted sand to these storing sites and then sell the sand from there. Usually, sand volume is measured through the number of truckloads used to transport sand to the constructing areas. Therefore, if sand storing sites are well managed, it is possible to determine the extracted volume of sand and to calculate the corresponding royalty or tax.

For better management of sand storing sites along Cau River, only a few storing sites should be permitted to operate; if possible, there should be only one site for each commune section. The sand storing sites should be managed by the commune's local team in coordination with the district inspection team. Their tasks would include: (1) inspection of the sand mining dredges to ensure the dredges extract sand at permitted areas only; (2) measurement of the extracted volume of sand dredged from the areas of the commune

section; (3) collection of the sand tax from dredge owners based on the extracted volume of sand; (4) remittance of the share (50-75%) of the tax revenue to the district tax office. The remaining share of tax revenue will be used by the commune to pay the local team and to develop the local commune economy. This benefit sharing mechanism is expected to enhance the participation of the local commune in managing both the sand mining and storing sites.

4) Enhance the inspection

The role of the district inspection team should be enhanced by equipping it with more facilities such as high speed canoes, blackjacks, and even guns for inspection and repression of illegal sand miners. The district inspection team should coordinate with the communes along the river to organize more inspections of the rivers. It should also respond more quickly by implementing supportive actions when the local commune teams discover illegal sand miners and request for help.

5) Implement stronger countermeasures against illegal sand mining dredges

The fine for illegal sand mining is currently up to VND 20 million only. This level is too affordable nowadays considering the high financial profit that dredge owners earn from sand mining. Therefore, it is proposed that the fine should be raised to VND 40-50 million. Moreover, if the dredge owners get caught a second time, their dredges should be confiscated forever.

4.5. Recommendations for Better Sand Mining Management in Cau River

4.5.1. Absolute ban of sand mining in the short run and imposition of taxes in the long run

With the limited resources for monitoring and enforcement, absolute ban of sand mining in Cau River is currently the best management option. However, in the long run, more investments should be allocated for monitoring and enforcing sand mining guidelines in the river. When such time comes, mining in selected areas subject to high taxes would be the best option. The tax rate of 15 percent of sand market price should be applied in order to reduce the financial profit of dredge owners while increasing the social benefit. In order to do that, a series of monitoring and enforcement countermeasures should be implemented such as granting permits only to dredges that meet the technical requirement; requiring a higher deposit from dredge owners; coordinating with the local commune for effective management of sand storing sites and tax collection; enhancing the inspection; and stronger countermeasures for illegal mining dredges.

4.5.2. Improved Legal Framework for Sand Mining Management

In general, the current legal framework for sand mining management is adequate. However, due to the increasingly aggressive reactions by illegal dredge owners and mine workers, it is necessary to increase the fine level and change the way of dealing with the illegal operators. Based on the FDGs with local staff, it is proposed that the fine for illegal dredges be raised to VND 40-50 million per time (currently it is VND 20 million only) or that the mining dredges should be confiscated. It is also suggested that the illegal dredge

owners be considered as criminals and that they should be jailed since they directly or indirectly damage national assets (dikes, embankments, bridges), especially if they use weapons to oppose the surveillance team. The mine workers should also be fined and reported to the commune people's committees where the workers belong for more education and help in finding jobs other than illegal sand mining.

4.5.3. Establishing the Surveillance Team at the Commune Level

Before 2010, only district surveillance team had the responsibility of monitoring and catching illegal sand mining dredges in the river. However, it was quite difficult for the district team to organize frequent surveillance trips because its members worked in different departments (DPC, DARD, DONRE, Police, etc.) and given different assignments work and because funds for surveillance were very limited. The team could therefore undertake 2-3 surveillance trips per year only. These and the possibility of information leakage make the monitoring efforts not so effective.

Since 2010, commune surveillance teams at some hotspots areas have been officially established with the right to catch illegal sand mining dredges in the commune management areas. The commune team plays an important role in preventing illegal sand mining up to now. Its effectiveness is high due to several reasons. Firstly, it could quickly react to reports or sightings of illegal sand mining dredges in its area because the team is located right there and the local people could contact it at once. Secondly, the commune team can also quickly organize a surveillance trip, thus minimizing the possibility of information leakage and having a greater chance of catching the dredge at the very act of illegal sand mining.

In Que Vo district, however, the commune team was established only in the commune with a hot spot for illegal sand mining. Other communes along the river do not have an official commune surveillance team yet. The establishment of a commune surveillance team at every commune along the river will certainly contribute to a more effective management of sand mining due to its above-mentioned advantages. However, the district authority should provide the commune teams some support, including the facilities and equipment (high-speed canoe) and some little funds to maintain the activities of the commune team.

4.5.4. Enhancing Coordination among Local Authorities

The fact that Cau River is the borderline between several districts of Bac Ninh and Bac Giang provinces makes the sand mining management more complicated due to constraints posed by jurisdiction of authority. Although the two provinces approved the coordination regulations in sand mining management back in 2004, such cooperation has been weak since the coordination regulations are at the provincial level while the illegal activities are primarily addressed by the district teams and commune teams. In this regard, districts having the same river sections as borderline should enhance their coordination through meetings or seminars to share information and experience in controlling illegal sand mining, to develop plan for coordination in urgent situation (e.g., chasing of illegal dredges). The district authority should also encourage coordination among its communes and with the communes in the other side of the river.

4.5.5. Provision of More Funds and Facilities for the Surveillance Teams

In order to effectively address illegal sand mining in the river, it is necessary to equip the surveillance team with modern facilities, especially high-speed canoes. Thanks to the support of the provincial government, each district has been equipped with one high-speed canoe since 2010. However, the monitoring operations will be further improved if each district could have more than one canoe for its use. The district should allocate funds for the additional canoe, which should be sent to the team of the communes that have hot spots for illegal sand mining.

It is noted that the commune team can address quite well illegal sand mining. The practice of the Viet Thong commune team, for example, of coordinating closely with other commune teams has resulted in successfully catching two illegal dredges and played an important role in preventing illegal sand mining on its hot spot area. However, catching the illegal sand miners cost a lot of money due to high fuel consumption of the high-speed canoe and provision of allowance to the team members who work at night. The commune's budget cannot afford such high expense. The district authorities as well as the DONRE and DARD at provincial levels should thus allocate funds to the communes to enable their teams to maintain effective sand mining management work.

4.5.6. More Dissemination of Information on Consequences of Illegal Sand Mining

Several illegal sand miners are local people in Bac Giang and Bac Ninh provinces while others come from nearby provinces (Hai Duong, Thai Nguyen). While the dredge owners earn huge profits from the illegal operations, the mine workers are general poor and do the work to eke a living. The mine workers usually do not know or pay attention to the consequences of sand mining. They only care about working and getting paid for it. More activities to disseminate information and educate them on the consequences of illegal sand mining should be done so that they do not work as sand mining workers anymore. To do this, the commune authorities should identify these mine workers and then educate them on the serious consequences of illegal sand mining and persuade them to change to other jobs. For dredge owners, it is also necessary to educate them about the serious consequences of illegal sand mining and to warn them of the heavy penalty if they continue with their illegal operations.

4.5.7. Use of Alternative Materials

River sand is currently used for many purposes including building construction, road development, and IZ ground filling. In recent years, the fast rate of urbanization in the region has led to a construction boom, thus resulting in huge volumes of sand extraction. According to the local staffs, it is possible to use other materials such as hill soil or hill sand to replace a part of the river sand for road development and IZ ground filling. There are many hills and mountains in the regions, especially in Bac Giang province. The exploitation of hill soil/sand may therefore be considered. Further study on the extent that river sand could be replaced by hill soil/sand in ground filling and road development is recommended, including coming up with a plan for exploiting hills for this purpose. By so doing, the demand for river sand will

declined, thus contributing to reduction of illegal sand mining in Cau River and other rivers as well.

5. CONCLUSION

Illegal sand mining in Cau River is common and indiscriminate; it has become more and more serious in recent years due to the huge demand for river sand by the construction industry in the region. The number of illegal sand mining dredges in the section of the river that was studied increased from around 10 in 2000-2006 to 20 in 2006-2010; the extracted volume increased from around 120,000 m^3 in 2005 to 250,000 m^3 in 2009. The illegal and indiscriminate sand mining in Cau River has caused serious riverbank erosion, dike degradation, stone embankment collapse, irrigation work damage, and noise pollution. Sand mining accounts for the annual decrease of 230.7 tons of paddy due to the decline in usable riverbank area for agriculture. It also damaged the stone embankments that required huge investments for repair and improvement in 2001-2010, as well as significant additional cost for irrigation works along the river.

The financial analysis of sand mining activities shows that the private profit from illegal sand mining is very large. A large dredge can earn as much as VND 3.4 million per day, and a small one could get VND 1.2 million per day. Since the average cost of rural labor is just VND 2-3 million per month, the earnings from sand mining are really high. This explains why sand mining has been mushrooming in Cau River as well as in other rivers in recent years.

The cost-benefit analysis showed that due to high external cost, especially the cost due to stone embankment degradation, the NPVs of illegal sand mining activities are all negative at discount rates of 5 percent and 10 percent. Sand mining reduced the social welfare by VND 5.82 billion and VND 4.64 billion during the 2001-2010 period at discount rates of 5 percent and 10 percent, respectively. The sensitivity analysis show that even if the unit profit of sand mining increases by 20 percent, sand mining would still reduce social welfare by VND 3.94 billion (at a discount rate of 5 percent per annum). Certainly if other costs such as those of noise pollution and monitoring and enforcement of sand mining in the river are included, sand mining in Cau River would further reduce the social welfare. Therefore, it is quite clear that the external cost of sand mining in Cau River outweighs the total gain of all sand extractors. More effective management of sand mining activities on river is therefore necessary.

Although the local authorities have exerted efforts to control illegal sand mining in Cau River, illegal operations continue to proliferate. The inadequate legal framework, unclear responsibilities among stakeholders, limited resources for management, weak coordination among local authorities (nearby localities) are the main constraints to effectively addressing illegal sand mining. Of these, limited resources (fund and facilities) and weak coordination among local authorities are the primary factors. Given the limited resources for monitoring and enforcement, an absolute ban of sand mining in the river would

be the best management option at present. However, in the long run, with more investments allocated for monitoring and enforcing the guidelines on sand mining in Cau River, allowing mining in selected areas subject to a tax rate of 15 percent of sand market price would be the best option. This option helps reduce the financial profit of dredge owners while increasing the social benefit. To do this, a series of monitoring and enforcement countermeasures should be implemented such as granting permits only to dredges that meet the technical requirements; requiring a higher deposit from dredge owners; coordinating with local commune for effective management of sand storing sites and tax collection; enhancing the inspection; and stronger countermeasures against illegal mining dredges. In addition, improving the legal framework for sand mining (with clear provisions for heavy penalty), establishing a surveillance team at the commune level, enhancing coordination among local authorities, providing more funds and facilities for management, more dissemination of information on the consequences of sand mining, and use of alternative materials in construction are feasible solutions for improved sand mining management in Cau River.

REFERENCES

Ab. Ghani, A., H. Md. Azamathulla, C. K. Chang, N. A. Zakaria, Z. A. Hasan. 2011. Prediction of total bed material load for rivers in Malaysia: A case study of Langat, Muda and Kurau Rivers. Environmental Fluid Mechanics, 11:3. pp. 307-318.

Bac Ninh Newspaper. 2007. Sand mining on Cau River. www.baobacninh.com.vn accessed on 25 Jul 2010.

Bac Ninh Provincial People Committee. 2006. Decision No. 96/2006/QD-UBND on sand and gravel mining on the rivers in Bac Ninh province. www.bacninh.gov.vn/ accessed on 15 Oct 2010.

Baomoi Newspaper. 2010. Illegal sand mining in Bac Giang: Impossible for controls. www.baomoi.com accessed on 20 Feb 2011.

Bruce, Melton P.E. 2009. In-stream gravel mining impacts and environmental degradation feedback associated with gravel mining on the Rio Tigre of the OSA Peninsula, Costa Rica, and the proposed ADI Jimenez Gravel Mining Concession. Melton Engineering Services Austin, 8103 Kirkham Austin, Texas 78736.

Bull, W.B. and K.M Scott. 1974. Impact of mining gravel from urban stream beds in the Southwestern United States. Geology, 2:171–174.

Collins., B.D. and T. Dunne. 1990. Fluvial geomorphology and river-gravel mining: A guide for planners, case studies included. California Department of Conservation, Division of Mines and Geology Special Publication 98. 29 pp.

De Lange, Willem, Anton Nahman, and Andre Theron. 2009. External costs of sand mining in rivers: Evidence from South Africa**.** Environmental and Resource Economics Group, Council for Scientific and Industrial Research, South Africa, PO BOX 320, Stellenbosch, 7599, South Africa.

Doi Song and Phap Luat Newspaper. 2009. Illegal sand mining on rivers: Impossible for controls? www.doisongphapluat.com.vn accessed on 10 Jul 2010.

Erskine W.D, P.M Geary, D.N Outhet. 1985. Potential impacts of sand and gravel extraction on the Hunter River, New South Wales. Australian Geographical Studies, 23:71–86.

Geological Survey of India. A model document on impacts and methodology of systematic and scientific mining of the river bed material. Website: http://www.portal.gsi.gov.in/gsiDoc/pub/ accessed on 15 June 2010.

GSO (General Statistic Office). 2010. Statistical Year Book 2009. Statistical Publishing House. Hanoi, Vietnam.

Hanoimoi Newspaper. 2008. Day river in Hatay province: Until when do illegal sand mining activities continue? www.hanoimoi.com.vn accessed on 25 Oct 2010.

Industry Department of Bac Ninh Province. 2001. Plan on river sand exploration and exploitation in Bac Ninh province. An internal report.

Kharel, B.D., A. Koirala, D. Neupane, and S.N Chaudhari. 1992. Preliminary evaluation of the problem concerning sand extraction in the Kathmandu Valley. A report submitted to Department of Mines and Geology.

Kondolf, G.M. 1997. Hungry water: effects of dams and gravel mining on river channels. Environmental Management, 21:533–551.

Kondolf, G.M. 1994. Geomorphic and environmental effects of in-stream gravel mining. Landscape Urban Plannning, 28:225-243.

Kondolf, G.M., M.W. Smeltzer, and S. Railsback. 2001. Design and performance of a channel reconstruction project in a coastal California gravel-bed stream. Environmental Management, 28(6):761-776.

Lu, X.X, S.R Zhang, S.P Xie, P.K Ma. 2007. Rapid channel incision of the lower Pearl River (China) since the 1990s as a consequence of sediment depletion. Hydrology and Earth System Sciences, 11:1897–1906.

Mensah, J.V. 1997. Causes and effects of coastal sand mining in Ghana. Singapore Journal of Tropical Geography, 18:1, pp. 69–88.

MONRE (Ministry of Natural Resources and Environment), Malaysia. 2009. River sand mining management guideline. Department of Irrigation and Drainage (DID), 50626 Kuala Lumpur, Malaysia.

MONRE-Vietnam Environment Administration. 2009: Review report on environmental status in industrial zones of Vietnam. http://vea.gov.vn. Accessed on 25 Jul 2010.

OWRRI (Oregon Water Resources Research Institute). 1995. Gravel disturbance impacts on salmon habitat and stream health. A report for the Oregon Division of State Lands. Vol 1: Summary Report. 52 pp. Vol 2: Technical background report. 225 pp.

Padmalal, D., K. Maya, S. Sreebha, and R. Sreeja. 2008. Environmental effect of sand mining: A case from river catchment of Vembanad lake, Southwest Coast of India. Environmental Geology, 54:879–889.

Pauley, G.B., R. Risher, and G.L. Thomas. 1989. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) - sockeye salmon. U.S. Fish Wildl. Serv. Biol.Rep., 82:11.116. U.S. Army Corps of Engineers, TR EL-82-4. 22 p.

Ranjana, U.K. Piyadasa and C.M. Naverathna. 2009. River sand mining in southern Sri Lanka and its effect on environment. http://printfu.org/read/ accessed on 15 Jul 2010.

Rivier, B. and J. Seguier. 1985. Physical and biological effects of gravel extraction in river beds. In: J. S. Alabaster, ed. Habitat Modification and Freshwater Fisheries. Food and Agric. Organ. U.N., Rome. 278 pp.

Rundquist, L.A. 1980. Effects of gravel removal on river hydrology and hydraulics. In: Woodward-Clyde Consultants, ed. Gravel removal studies in arctic and subarctic floodplain in Alaska - technical report; pp. 67-140. U.S. Fish Wildl. Serv., Biological Services Program, FWS/OBS-80/08.

Vietnam Laws and Lives Newspaper. 2010. Illegal river sand mining: impossible to stop? http://www.doisongphapluat.com.vn accessed on 20 June 2010.

VietNamNet Bridge. 2009. Sand dredging "a problem on all the Vietnam's largest rivers." http://english.vietnamnet.vn/reports/2009/. accessed on 18 June 2010.

Wu, G., JD Leeuw, AK Skidmore, HHT Prins, Y. Liu. 2007. Concurrent monitoring of vessels and water turbidity enhances the strength of evidence in remotely sensed dredging impact assessment. Water Res, 41:3271–3280.

Xaydung Newspaper. 2010. Estimate of sand demand for construction in Vietnam. www.xaydung.com accessed on 22 Feb 2011.

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