THE SOCIALIST REPUBLIC OF VIETNAM

Data Collection Survey on Basin-based Comprehensive Sediment Management in River Systems of the Central Region in Vietnam

EXECUTIVE SUMMARY
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Japan International Cooperation Agency (JICA)

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1. Background and Objective

In recent years, coastal erosion has been amplified in many areas in Vietnam causing serious adverse impacts to dense inhabitants as well as rich ecological values along the shore. Of possible causes, a reduction of river-supplied sediment and changes of a longshore sediment transport pattern could be considered as chief culprits. The former is often caused by surface water diversion, soil reservoir storage, dam building and sand mining. Whereas, construction of man-made structures along the beach could disturb the along shore sediment transport flows, and accordingly, it affects the position and shape of coastal lines. However, these issues are not well recognized and addressed properly in Vietnam. And as a result, to cope with coastal retreat issues, ad hoc hard counter measures are often implemented locally without any consideration of coastal sediment transport regime. These construction of coastal revetments or groins to stop beach erosion in Cua Dai beach of Hoi An, for example, do not help to stabilize the foreshore but in contrast, erosion still develops with increasing magnitude over the last few years. The lack of scientific evidences and solid understandings about changes of sediment transport in river systems and coastal areas attributes to this trend. In fact, recent lessons from coastal research community in Japan prove that coastal retreat problems could not be solved effectively without a proper and comprehensive consideration of sediment-related issues arising in various forms at the areas of mountain / foot of mountain, alluvial plain, and river mouth /coast in accordance with a so-called "flow of sediment".

In line with previous support from JICA for Vietnam to develop basin based plans for flood management ("Integrated Flood Management Plans (IFMPs") in the central region, it is expected that a similar concept with IFMP, namely "Comprehensive Sediment Management (CSM)"[1], can be effectively applied to deal with issues related to changes of sediment transport in river systems and coastal areas and it serves as the context for this survey. To support for the formulation of CSM, this survey project aims at 1) providing quantitative evidence of the changes of sediment transport in river system and coastal areas in central Vietnam; 2) identifying the cause that triggers the serious coastal erosion problems directly related to "sediment management" issues; and 3) proposing possible solutions as well as recommendation for the establishment of CSM's framework so as to solve these problems in an effective and sustainable way.

2. Survey Area

The targeted area covers six provinces in the central coastal region of Vietnam, such as Quang Tri, Thua Thien Hue, Quang Nam, Quang Ngai, Binh Dinh, and Phu Yen, where serious coastal erosion problems (especially Vu Gia-Thu Bon River Basin including Cua Dai Beach) are occurring.

3. Analysis Results of Sediment Management Issues

(1) Current Status of Human Activities Affecting Sediment Transport in Vu Gia-Thu Bon River Basin

According to a global scale study[2], coastal retreat is directly influenced by the reduction of river-supplied sediment. The increase of human activities such as dams/reservoirs construction, sand mining or construction of infrastructures that diverse river flow has caused various problems on coastal erosion by reducing the amount of sediment supply of rivers, blocking the movement of drift sand, and changing the direction of sediment flow. These intensive activities are also observed at Vu Gia – Thu Bon basin during the survey:

Dams/Reservoirs Construction: In Vu Gia-Thu Bon River Basin, the number of dams has increased since 2000 and will continue to have a huge influence on the sediment transport of river basins, thereby aggravate the river bank and coastal erosion in the future. Currently, the dam catchment area occupies nearly 50 percent of the entire catchment area.

Sand Mining: According to data received from Quang Nam's DONRE (2017), approximately 10 million m^3 of sand has been mined from river channels since 2008. However the actual mining volume

[1] The concept of "Comprehensive Sediment Management" includes data and information management, coordination with diverse stakeholders and comprehensive planning of human activities which directly or partly affects to "flow of sediment"

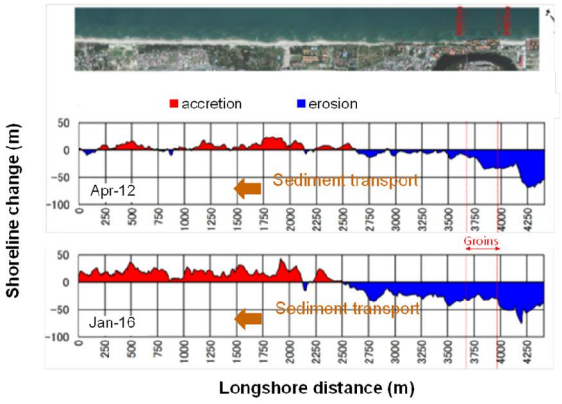
[2] Syvitski, J.P.M., Vorosmarty, C.J., Kettner, A.J. and Green, P., 2005. Impact of humans on the flux of terrestrial sediment to the global coastal ocean. Science, 308(5720): 376-380

cannot be estimated accurately because most of sand mining has been done illegally. If this trend continues, it is likely that the amount of the sediment transport in the river basin will continue to decrease.

River Flows Diversion: Major structures that diverse sediment flows in Vu Gia-Thu Bon River Basin are: Cua Dai Bridge, Dai Loc Weir. Cua Dai Bridge crosses Thu Bon River at 1.5 km upstream of the estuary, and has an abutment on the left bank that has been partially reclaimed. Since the river cross-section is narrowed down on the left due to construction of this abutment, river main stream might have been diverted to the right bank. As a consequence, it could lead to a reduction of sediment supplied to the left coast of Cua Dai while sediment volume distributed to the right side could increase significantly.

Dai Loc Weir was constructed in 2009 at a point where water is diverted from Vu Gia River to Thu Bon River to ensure enough water discharge to Han River (downstream part of Vu Gia River). This artificial structure has changed the timing of run-off, i.e, reduces the discharge volume to Thu Bon River during dry season but it has caused overflow and increased water supply to this tributary during flood season. As the nature of sediment movement, most of fluvial sand is carried to the coast during the flood season, one part (finer bodies) is transported further offshore, but the other part (coarser sand) will be kept at the estuary in the form of sandbars. The migration of these sand bars down along the coast under wave actions during winter/summer times might protect the beach from erosion. The significant increase of flood discharge might wash away the nearshore sandbars to offshore area and therefore put the beach at Cua Dai under a vulnerable situation.

Part of coastal morphodynamics processes is sediment transport. The changes of gradients in sediment transport rates lead to erosion or accretion, which in turn alternate the nearshore morphology. For practical approaches, littoral sediment movement in the nearshore zones is usually divided into a cross-shore and alongshore process. Alongshore sediment transport is generally associated with alongshore currents which are induced by oblique incident waves. It is considered as a chief mechanism causing long term evolution of beach. Whereas, short term seasonal changes (i.e, scale of few days or weeks) are closely resulted by cross-shore sediment transport as a consequence of wave orbital motions and cross shore currents. In the Cua Dai coastal area, erosion prevention measures, such as sea dikes, revetments or groins, etc.., have been implemented for the past few years. However, since these measures were designed without consideration of longshore sediment transport, they do not bring any minor improvements but in contrast cause adverse impacts on the adjacent areas. For instance, private coastal dikes to protect the property from coastal erosion have been constructed locally by owners of the resorts along Cua Dai Beach while waiting for proper actions by local authorities for a synchronized solution. Additionally, in 2015, a system of groins, which uses geotextile, was built in front of several resorts to mitigate the erosion. However, these structures themselves are disturbing the long-shore sediment transport, and then aggravating the coastal erosion. The analyzed result of shoreline change and topographic change indicates that erosion has still proceeded to the adjacent areas even after the construction of these structures (see **Figure 2.1**).



Source: JICA Study Team

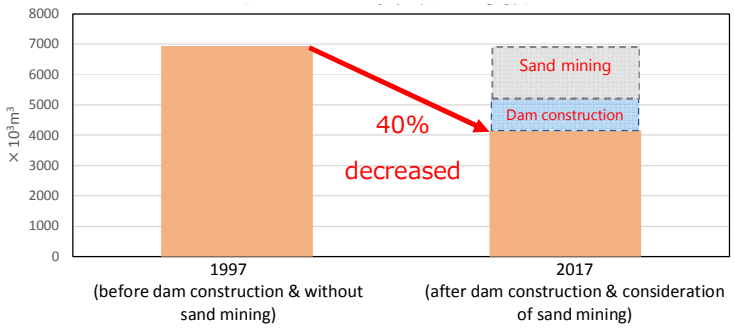
Figure 2.1 Shoreline Change Before and After Construction of Groin (Ref. year 2004)

(2) Quantitative Analysis of the Impact of Human Activities on Erosion

This part presents the quantitative analysis of the coastal erosion due to aforementioned intensive human activities in Vu Gia-Thu Bon River basin:

a) Quantitative Analysis on Reduction of Sediment Supply from River

Since the sediment loads are proportional to river discharges, sediment flux over times can be estimated quantitatively if river discharges are known. Historical data of flow discharges and water levels at various stations in Vu Gia-Thu Bon basin were collected to provide the input for the calculation of sediment supply from these rivers. In order to investigate the impact of human activities, annual sediment discharge from river is estimated and compared for two reference years, 1997 and 2017, respectively. These years represent the period before and after dam construction. It is noted that during this period, sand mining activities were intensified and thus it was also accounted in our estimation. The impact of dam construction and sand mining was estimated based on the following assumptions:



Source: JICA Study Team

Figure 2.2 Reduction of Sediment Supply

- ✓ Since long term observations of suspended materials in Vu Gia-Thu Bon basin are not available, the effect of dam construction is considered by setting the amount of sediment output behind the dam equal to zero after the construction of the dam. This assumption is based on the fact that sediment moves through river channel as bed load (coarse sand) and suspended load (fine sand, mud). While dams have trap efficiency of 100% for coarse materials, not all suspended materials are kept behind the dam. However, a case study in Yangtze River of China has shown that more than 90% of suspended sediment has been efficiently trapped after the construction of Three Gorges Dam[3]. Therefore, our assumption appears to be reasonable and it represents for the worse scenario.
- ✓ The effect of sand mining is considered by using the sand mining volume provided by Quang Nam Province without consideration of the illegal sand mining volume.

The result shows that the sediment supply to Cua Dai estuary has decreased by about 40%, from approximately 6939x10^3 m^3/year in 1997 to merely 4,146 x 10^3 m^3/year in 2017. (**Figure 2.2**). Specifically, the sediment discharge has reduced by approximately 14% (~ 963 x10^3 m^3/year) due to dam construction and by 26% (~ 1830 x 10^3 m^3/year) due to sand mining. The significant reduction of sediment supplied to the Cua Dai beach supports an assumption that severe erosion at Cua Dai Beach is directly related to these activities and it shall be further discussed below.

b) Coastal Erosion caused by Reduction of Sediment Supply from River

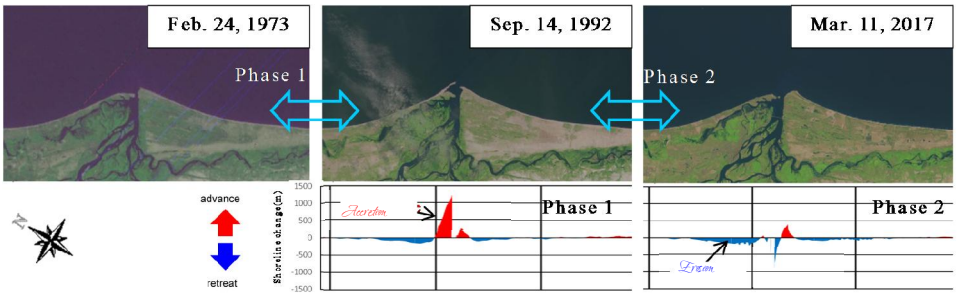
Long term evolution of Cua Dai beach was studied by analyzing satellite images. Then numerical simulation by mean of 1-Line model were performed to reproduce the past shoreline changes. By varying the model input, i.e, reduction of total alluvial sediment volume and changes on direction of river sediment supplied to the coasts, impacts of these factors to the coastal erosion can be quantified and analyzed. The reliability of the model prediction can be satisfactorily achieved by calibrating with actual shorelines change observed from our image analysis results. The outcomes are as follows:

Long-term Shoreline Changes from Image Analysis Technique: Consistency with discussions in section 3.(1), the advance and retreat of sand bar in front of Cua Dai estuary appears to be closely related to erosion in Cua Dai coast. As the decay of sand bar has happened since 1993, the erosion has been observed clearly. From 1973 to 1992, the coastline near the Thu Bon River mouth had advanced over 1,000m. During this period, it is estimated that the Thu Bon River could have supplied the abundant sediment volume. From 1993 to 2017, the coastline had retreated by approximately 200m and it is presumed that it is due to the combined effects of significant drop of sediment supply from the river as well as profound changes in river flow patterns (**Figure 2.3**).

Shoreline Change and Sediment Transport Rate from Numerical Simulation: Reproductions of shoreline changes using 1-Line model demonstrate an accretion trend in the northern area of Cua Dai

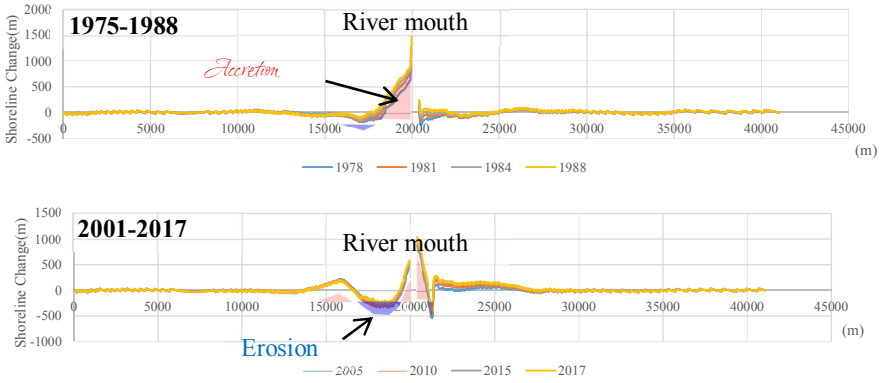
[3] Kondolf, G. M. et al. (2014), Sustainable sediment management in reservoirs and regulated rivers: Experiences from five continents, Earth's Future,2,256–280,doi:10.1002/2013

estuary between 1975 and 1988, while they illustrate an accretion trend in the southern area and an erosion trend in the northern area of Cua Dai estuary between 2001 and 2017 (**Figure 2.4**). In the latter case, the reduction of sediment supply (due to sand mining and dam construction) and changes of river flow regime (due to flow diversion) were concerned.



Source: JICA Study Team

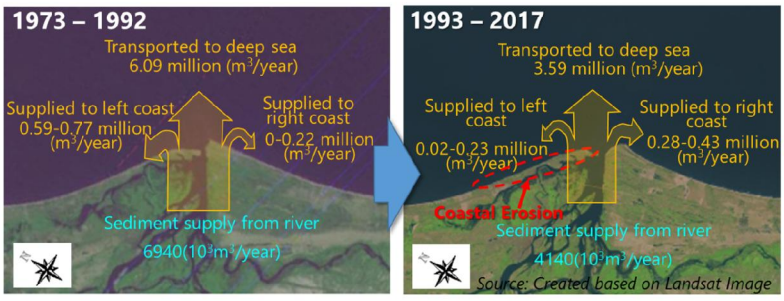
Figure 2.3 Shoreline Change during 1973-2017 (Reference year: 1973)



Source: JICA Study Team

Figure 2.4 Numerical Simulation Result of Shoreline Change during 1975-1988 and 2001-2017

Main Causes of Coastal Erosion: the numerical simulation results show that between 1973 and 1992, the amount of the northward sediment transport was larger than that of the southward sediment transport (**Figure 2.5**). However, this trend was reversed between 1993 and 2017. Additionally, the sediment supply from river decreased during this period.



Source: JICA Study Team

Figure 2.5 Sediment Distributions to Coastal Area

According to the reproduction of the past shoreline changes by numerical simulation, the main causes of severe erosion at Cua Dai beach are as follows:

- ✓ Reduction of sediment supply from the river due to the dam constructions and sand mining
- ✓ Asymmetric distribution of the sediment supply from the river (river flow diversion)

(3) Current Issues with Sediment Management in Central Provinces of Vietnam

The quantitative analysis from the previous chapter clearly shows that the severe coastal retreat in the central provinces of Vietnam is mainly due to the intensified human activities that disturb the nature of sediment flow not at local but rather at a river basin scale. In this part, current issues with River Basin-based Sediment Management in Vietnam will be discussed which includes current status of: 1) coordination between related stakeholders to tackle with coastal erosion problems, 2) planning issue considering to the disturbance of sediment movement and 3) management of necessary data and information for erosion prevention measures.

a) Coordination Issues between Related Stakeholders

In Vietnam, the construction of dam and reservoirs, approval of sand mining activities and other infrastructures are controlled separately by different management bodies with different formulation procedures. However, in general it can be said that the institutions at central government level (ministries) are primarily responsible for the legal framework, coordination among ministries and local governments to get reviews and comments for the establishment of national master plans under their duties. Extended arms of these institutions at provincial levels (departments) are only in charge for the formulation and implementation of the planning of the administrative units under their management based on a master plan regulated by relevant ministries. The People's Committees of provinces (PPCs) are leading agencies in the State management in the localities who regulate the organizational structure, duties and powers of ministry affiliates at the province-level. There is a slight difference among provinces in task allocation for relative departments under their administration. However, most of cases the activities managed by related ministries are imposed on the provincial branches of those ministries. Currently, management of issues related to sediment transport in river basin and coastal areas are mostly under provincial branches of MONRE and MARD.

As a provincial branch of MONRE, DONRE is responsible for advising and assisting the PPCs on state management of natural resources and environment. They are in charge for collecting and accumulating the data for the analysis and assessment of the utilization of water resources and natural resources. However, data and information regarding the management of sediment transport in river basin such as: river cross-section, sediment grain size distribution, water discharge in entire river basin have not been collected continuously and systematically.

DARD, provincial agency of MARD, is responsible for advising and assisting the PPCs on administration of agriculture, forestry, aquatic, irrigation, rural development, flood and, disaster prevention. In all targeted provinces, DARDs are being allocated for river/ coastal erosion control. However, since they are not in charge of planning of sediment related disaster prevention; most erosion prevention measures are conducted after erosion has been occurred.

As discussed above, human activities such as dam and other infrastructure constructions, sand mining are managed independently by provinces in accordance with national master plans regulated by relevant ministries and there is no specialized agency dealing with integrated sediment management at the river basin level. In fact, initial efforts have been made to create a coordination board between local authorities for supporting integrated management of water resources and flood mitigation in the targeted river basin[4]. However as inter-provincial entities, they are not authorized to formulate planning for specific counter measures for coastal and river erosion problems. Therefore, coordination mechanism among ministries, their provincial departments as well as between administrative units based on the perspective of Comprehensive Sediment Management (CSM) at river basin level should be established to formulate an effective sediment management model so as to minimize the impacts of sediment-related disaster.

b) Planning Issues

A modern approach for large infrastructure development plans often includes a Strategic Environmental Assessment (SEA) during the master plan phase and during the implementation period of the projects; Environmental Impact Assessment (EIA) should be carried out. At present, EIA procedures in Vietnam are similar for all types of economic activities and mainly concentrate on qualitative/quantitative assessment of air/water/soil pollution but not sediment issues. In addition, the contents of SEA and EIA do not mention clearly the evaluation items, criteria, evaluation methods as

[4] A signing ceremony for the Establishment of the Coordination Board for Integrated Management of The Vu Gia-Thu Bon River basin and coastal area of Quang Nam-Da Nang was organized on August 21, 2017 among local authorities of Quang Nam and Da Nang provinces

well as requirements on experience and skill for assessment member(s) for different specific type of construction project. Therefore, it is advisable to describe such details for each specific type of economic activities. For instance, environmental regulations on hydropower dam construction project should include the impact assessment for changes of suspended sediment transport before and after dam construction and the evaluation process must be carried out by qualified river-basin sediment specialist(s).

c) Issues with Management of Necessary Data and Information for Erosion Prevention Measures

Regular data monitoring and comprehensive national guidelines are essential for study and management of coastal and river erosion problems. However, there are various shortcomings as follows:

- ✓ Basic data for investigation into the causes of erosion and for formulation of erosion prevention measures has not been collected / accumulated.
- ✓ Design standards of structures such as embankment and jetty are available, but guidelines for the evaluation / application process and applicable measures from the view point of CSM are not available at present.
- ✓ Control methods of coastal erosion are limited to hardware structures such as embankment, revetment and jetty. Measures to ensure the continuity of sediment transport such as beach nourishment and sand bypass are not sufficiently studied.

4. Conclusion and Recommendations

The survey's results clearly show that: 1) the severe coastal erosion in the central region of Vietnam is mainly due to economic activities that disturb sediment transport at river basin and coastal areas and 2) all the counter measures to prevent sediment related disasters are not really effective due to the lack of solid understandings on sediment transport matters. As mentioned in project background, CSM has currently been considered as a most effective strategy in many countries facing to serious sediment related disaster such as Japan and it is advised to adopt and implement CSM in Vietnam as a long term goal. Based on the study results of the current status of sediment management issues in Vietnam, 3) a proper framework to formulate CSM is proposed and as shown in **Table 4.1.**

In the meantime, due to the increasing magnitude and rapid speed of coastal retreats, some urgent solutions are proposed to mitigate the economic losses and threatening of human lives. These solutions are based on the concept of "sediment engine" which supply more sand to the left bank of Cua Dai beach by means of beach nourishment, sand bypasses or construction of water diversion flow structures to divert mainstream of the river to the left bank (See **Table 4.1**).

Table 4.1 Recommendations

Period	Purpose	Policy	Contents	Related Authorities
Urgent measures	Reduce the speed of erosion	Supply sand to eroded coastal zone to make up for reduction of sediment supply from river	・Conduct beach nourishment to directly supply the sediment to the left bank (about 400,000～500,000m^3/year) ・Construct sand bypasses to increase the sediment supply to left coasts: sand bypasses start from sand depositing points in river channel or right coast to the left coast	MARD, Quang Nam Province, Da Nang City
		Improve the direction of water flow to resolve asymmetric distribution of the sediment supply from the river	・Construct water flow control structures to increase water discharge to the left side of river mouth in order to restore the balance of the sediment discharge from the river	
Long-term measures	Create/ implement the comprehensive sediment management of river basins and coastal areas	Preparation of comprehensive sediment management plan	・Improvement of regulation/organization structure	MARD, MONRE, MOC, MOT, MOIT
			・Formulation of national sediment management policy/strategic program	
			・Preparation of guideline for sediment management planning	
		Implementation of comprehensive sediment management plan	・Formulation of comprehensive sediment control plan for major river basin/coast	PPC, DARD, DONRE
			・Detailed design of erosion control measures for major river basin/coast	
			・Review of approval procedure of sand mining and monitoring of the illegal sand mining	
		Human resources cultivation for comprehensive sediment management	・Establishment of organization for sediment control ・ Institution ・ Training system ・ curriculum	MARD, MONRE, Existing research institutions
			・Capacity building of the central government staff for comprehensive sediment management	
			・Guidance for municipal officials	
			・Capacity building of the local government officials for comprehensive sediment management	PPC, DARD, DONRE
	Create a data source for problem solving and measures evaluation / implementation	・Improvement of Observation system ・Continuous data observation ・Database construction and utilization	・Formulation of plans for measurement of weather, hydrology and oceanography	MARD, MONRE
			・Enhancement of numerical prediction/ data management capacity	
			・Improvement of meteorological, hydrological and oceanographic monitoring systems	
			・Improvement of database	
			・Implementation of meteorological, hydrological and oceanographic monitoring	PPC,

			· Monitoring of sediment volume (both approved and illegal sand mining volume)	DARD, DONRE
	Enhance scientific knowledge of comprehensive sediment management	Creation and improvement of relevant technical standards	· Formulation of technical standards related to sediment control (beach nourishment, sand bypass and sand recycling)	MARD
			· Dissemination of scientific knowledge (brochures, workshops)	
			· Implementation of specific projects and feedback on design and management based on technical standards	PPC, DARD, DONRE

Source: JICA Study Team