Assessing Social Vulnerability to Riverbank Erosion across the Vietnamese Mekong Delta

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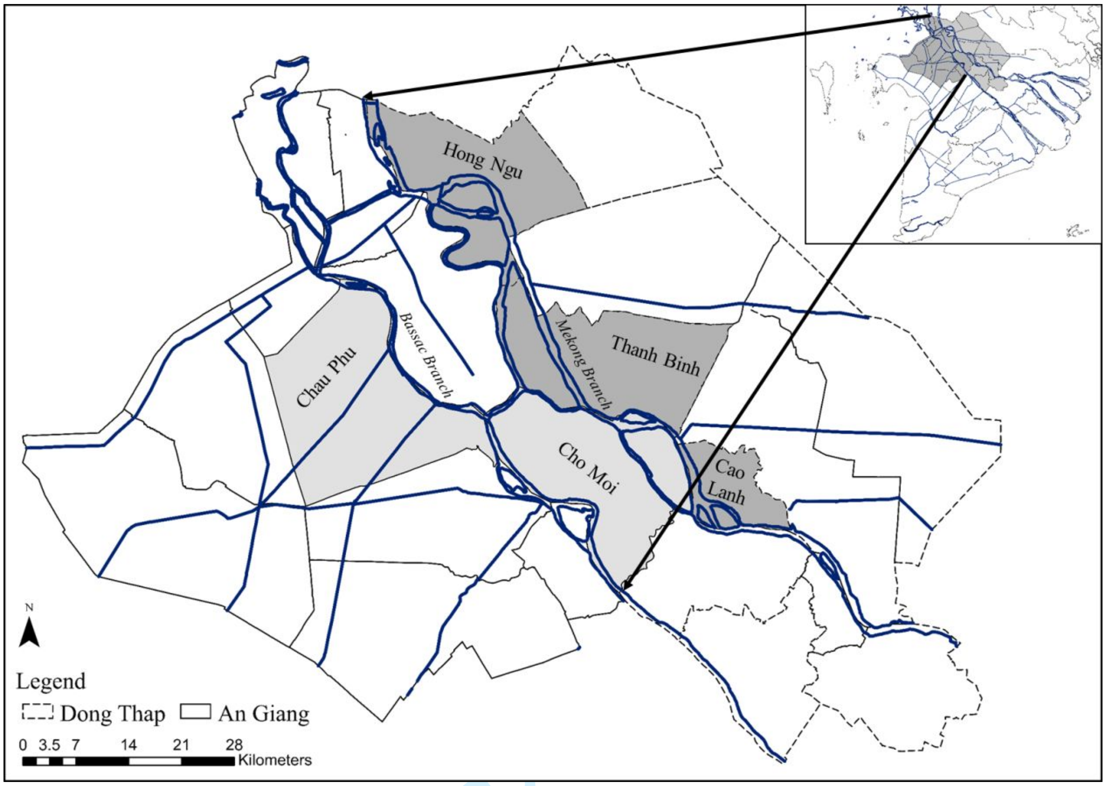

Figure 1: The studied districts within the VMD

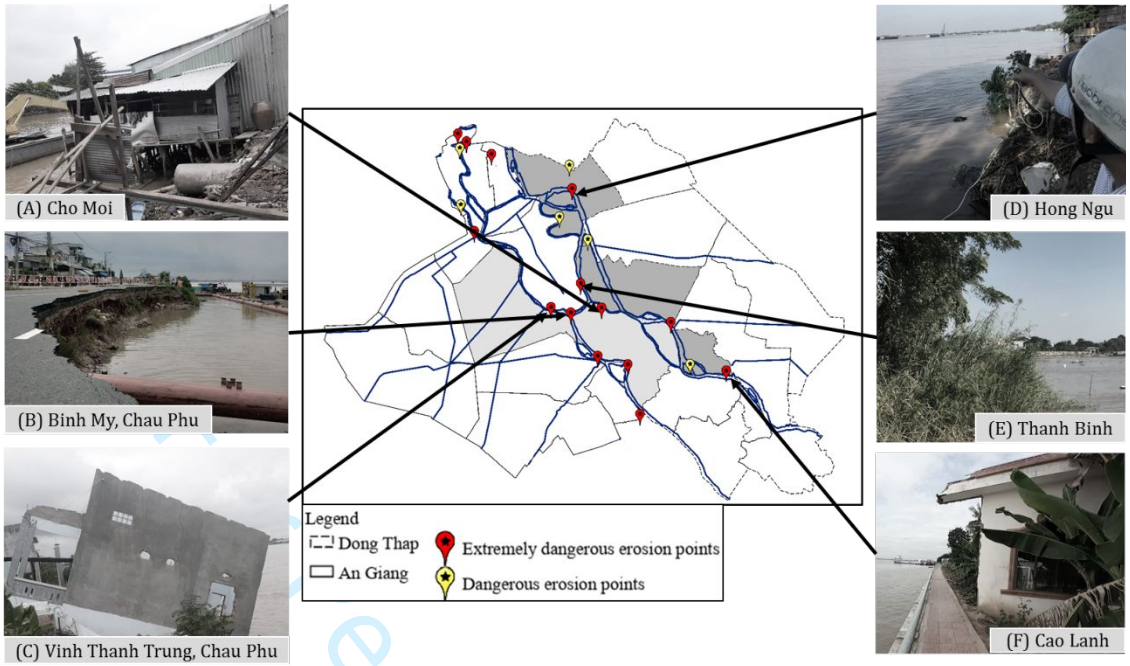

Figure 1: Locations of riverbank erosion in An Giang and Dong Thap (MARD, 2019)

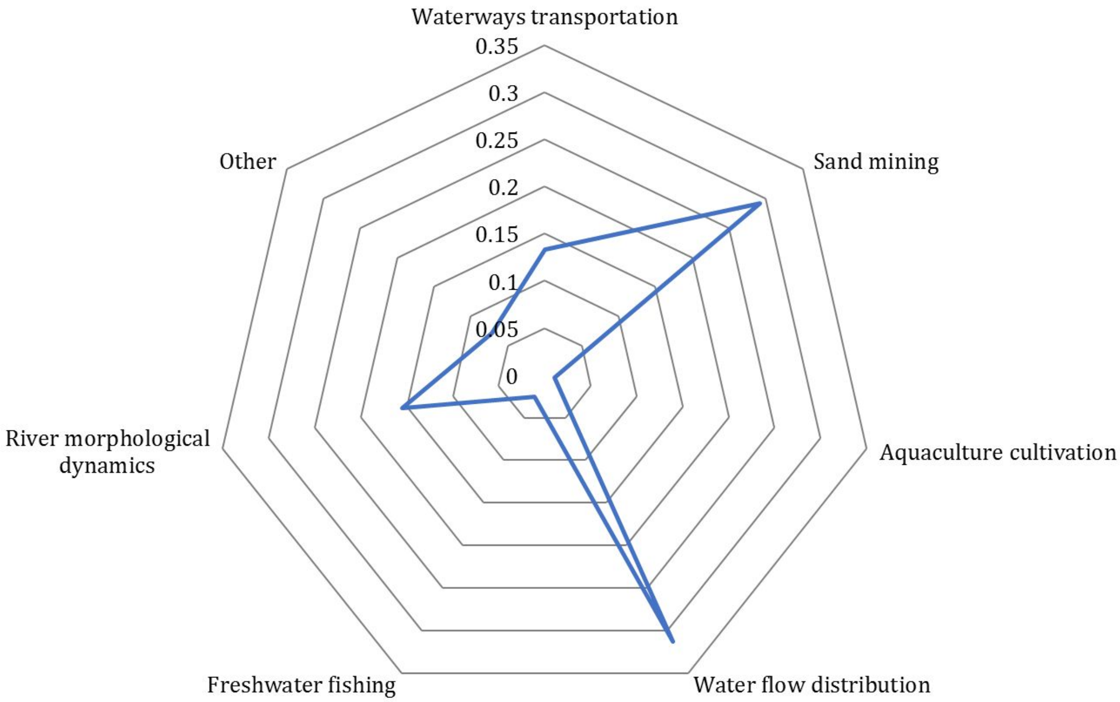

Figure 1: Drivers of riverbank erosion in An Giang and Dong Thap outlined from household surveys and KIP interviews

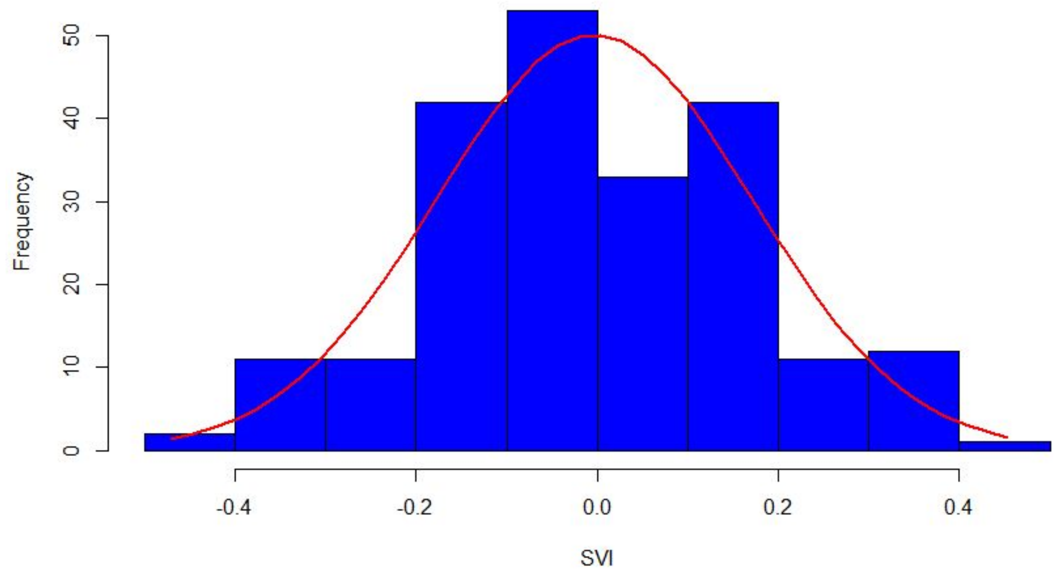

Figure 1: The distribution of the SVI

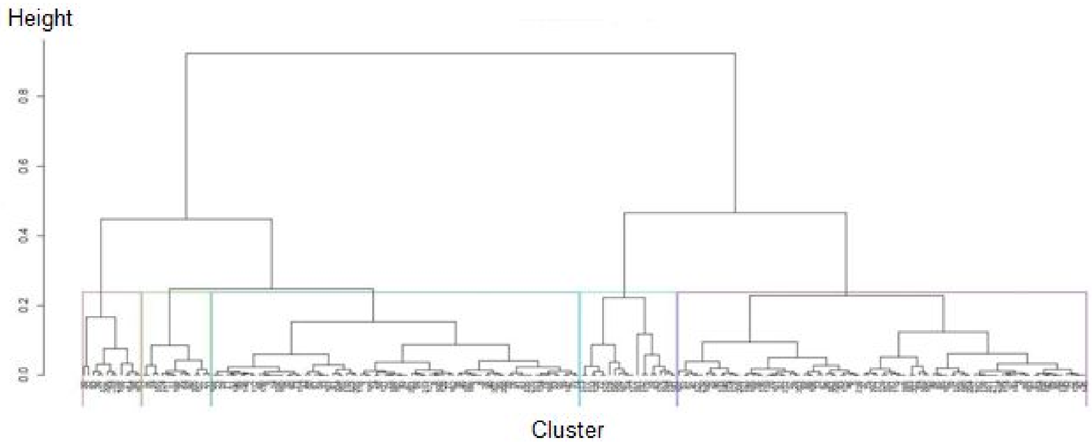

Figure 1: Cluster analysis

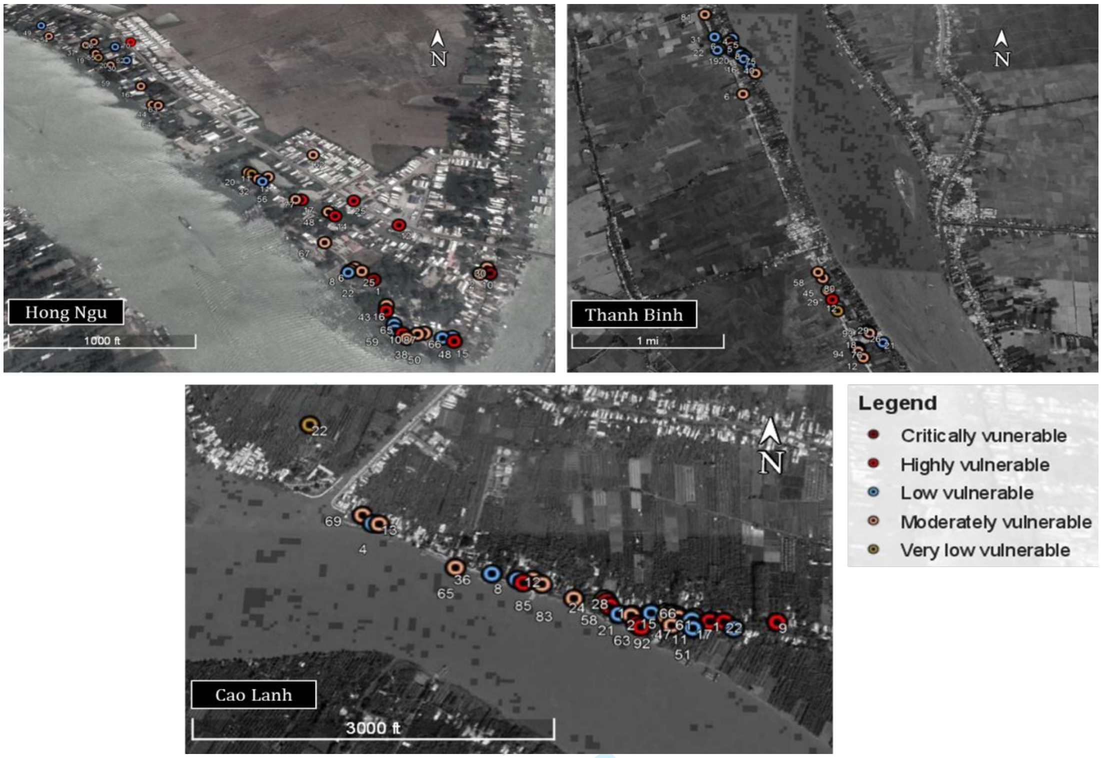

Figure 1: The SVI of survey households in Dong Thap province

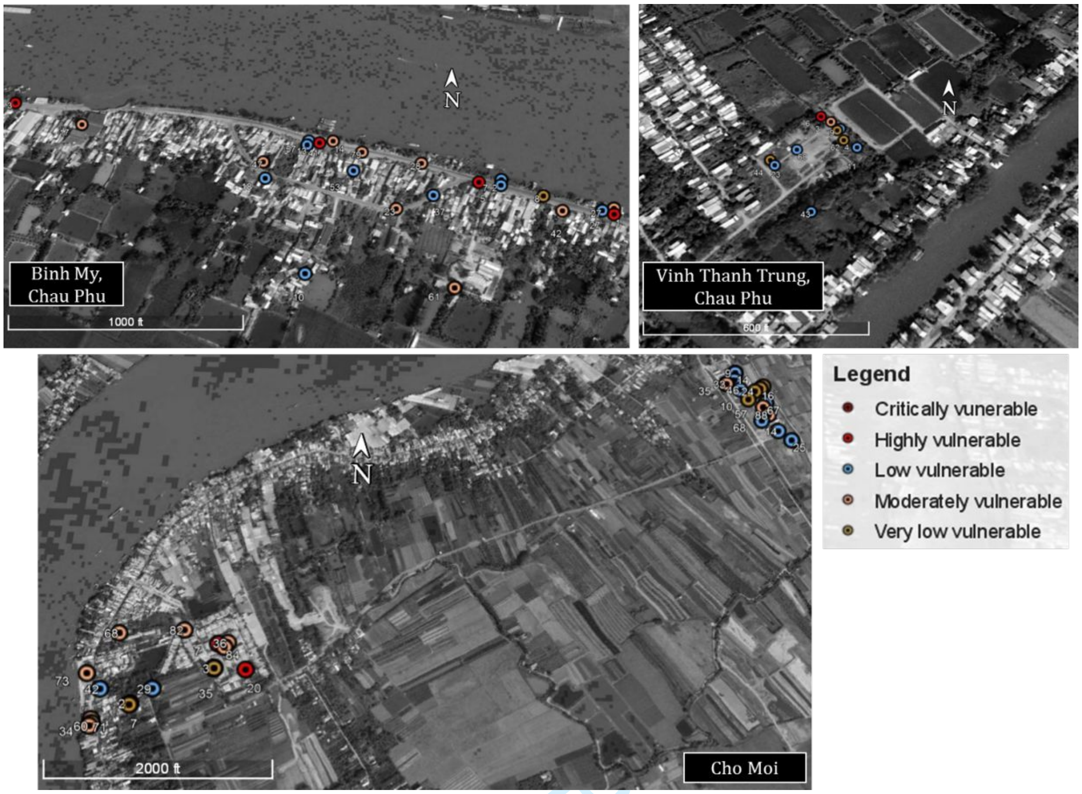

Figure 1: The SVI of survey households in An Giang province

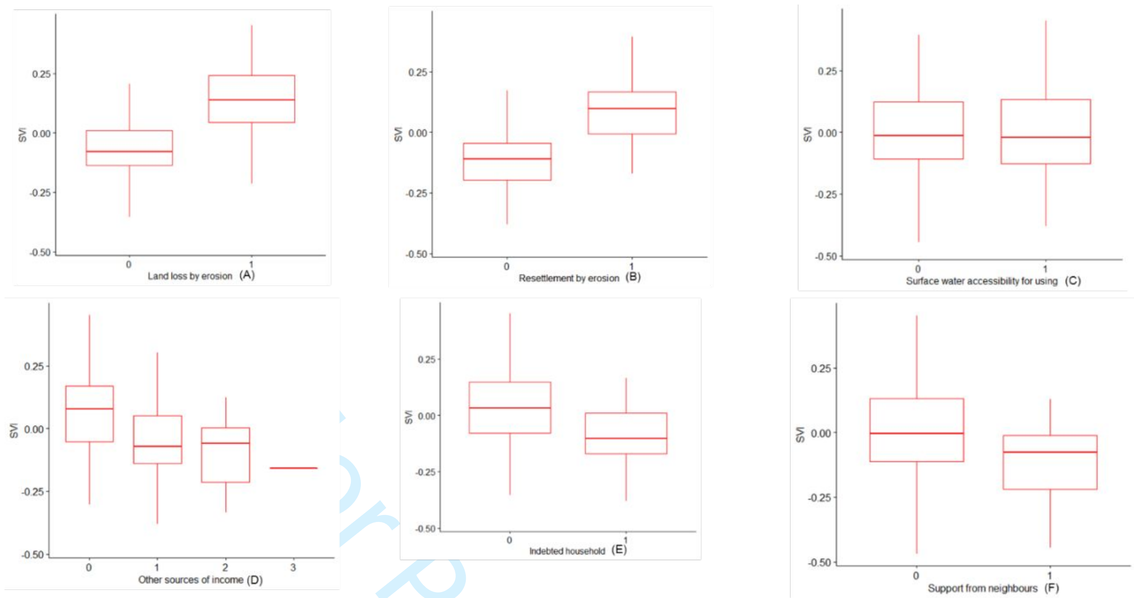

Figure 1: ANOVA analysis results of the SVI and different household characteristics

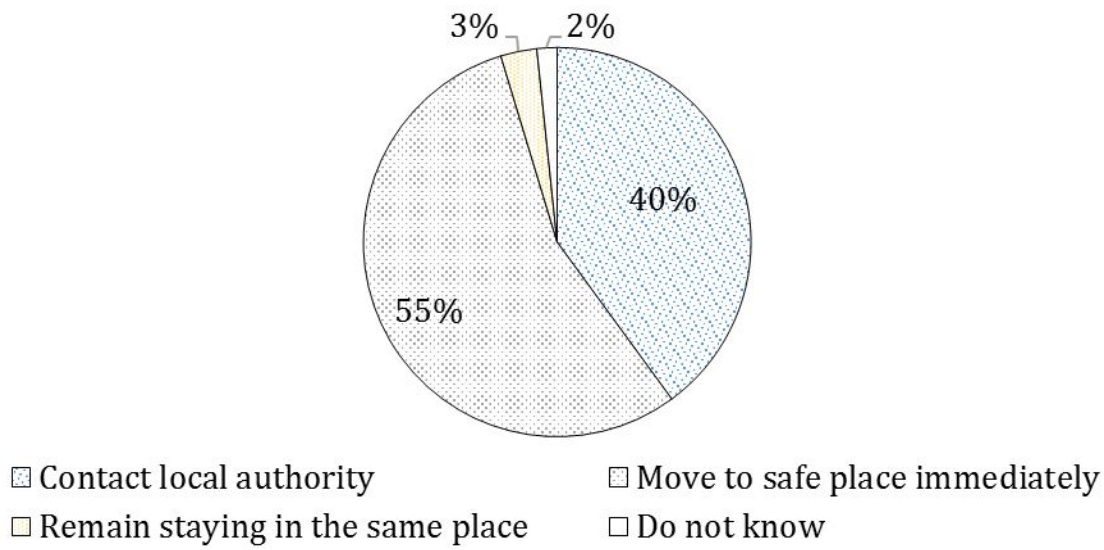

Figure 1: Responses of households to riverbank erosion

Table 1: Indicators for household survey questionnaire

Vulnerability factor	Component	Indicator
Exposure	*Characteristics of riverbank erosion hazard (frequency and magnitude)*	Frequency of riverbank erosion % of HHs reporting land degradation during last 30 years % of HHs experienced displacement in last 30 years Average number of others natural calamity during last 30 years
Sensitivity	*Health sensitivity*	Average time to reach the nearest health centre % of HHs who do not have toilet and poor hygiene status
	Food and agricultural sensitivity	Average food insufficient month % of HHs that collect water directly from river, streams, pond
	Demographic sensitivity	Dependency ratio % of female-headed HHs Average family member in a HHs
Adaptive capacity	*Economic capacity*	% of household dependent solely on agriculture as income source Average number of households who have burden of loan % of HHs who have access to financial services to any financial institution % of HHs who have a family member working outside the village at relatively developed place Household income
	Social network and communications	% of HHs who have received any kind of support from neighbour % if HHs who have supported and helped to neighbour % of HHs where a family member is affiliated with any organization % of HHs have communicative devices (TV, radio, mobile etc.) at home Years of residing in the village/commune
	Education and skills	Education index

Table 1: Predictor variables description

Predictor variables	Description
Erosion frequency (X1)	Frequency of riverbank erosion at each erosion hotspot
Land loss (X2)	The total land area lost to riverbank erosion by each household
Resettlement (X3)	Whether affected households have resettled to another locality to
Other suffered disaster (X4)	Other natural disasters households suffered
Time to the medical station (X5)	Time to the nearest emergency medical station
Chronically ill member (X6)	Number of household members chronically ill
Poor hygiene status (X7)	Access to safe and clean hygiene system
Insufficient food (X8)	Any period without access to sufficient food
Surface water access (X9)	Whether affected households rely on surface water for living and working
Average household size (X10)	Average household size
Other sources of income (X11)	Additional income sources
Financial services access (X12)	Access to local financial services
Debt / Loan (X13)	Total debt of affected households
Migrated family member (X14)	Number of household members moved to another place to live or work
Main income (X15)	Income households have from the main occupation
Support from neighbours (X16)	Whether affected households have received support from neighbours relating to riverbank erosion events
Support to neighbours (X17)	Whether affected households have provided support to neighbours relating to riverbank erosion events
Member of any organisation (X18)	Number household members belonging to local formal organizations
Communicative devices (X19)	Total devices/approaches households had to reach out to riverbank erosion information
Education index (X20)	Number of educated years of adults in affected households

Table 1: Description of riverbank erosion classifications according to MARD

Serial	Classification	Description
1	Extremely dangerous areas	a) Closely located to the river dyke system threatening the dyke safety; b) Directly risk urban and/or residential areas, headquarters of governmental organizations at districts level and above; c) Already directly affected crucial infrastructures including airport, railway, highway, national road; national port; high voltage system from 66 KV and above; school and hospital from district and above.
2	Dangerous areas	a) Potential to affect the river dyke system, but still under control; b) Potential to affect urban and/or residential areas, governmental organizations at all levels; c) Potential to affect crucial infrastructures including airport, railway, highway, national road; national port; high voltage system from 66 KV and above; school and hospital from district and above.
3	Manageable areas	Other potential erosion areas, which do not relate to the first two types.

Table 1: Status of riverbank erosion impacts at surveyed locations

Serial	District	Affected households	Total economic loss (billion VND)	Total land loss (ha)
1	Cho Moi	30	0.48	0.17
2	Chau Phu	16	25.13	0.23
3	Hong Ngu	14	1.4	0.7
4	Thanh Binh	1415	5.6	2.81
5	Cao Lanh	21	0.8	0.40

Table 1: The statistic description of input predictor variables:

Predictor variables	Mean	Variance	Std. Dev	Min	Max	Range
Erosion frequency (X1)	2.2661	18.325	4.28079	1.00	57.00	56.00
Land loss (X2)	0.3349	0.224	0.47303	0.00	1.00	1.00
Resettlement (X3)	0.5413	0.249	0.49944	0.00	1.00	1.00
Other suffered disaster (X4)	0.8440	0.962	0.98068	0.00	4.00	4.00
Time to the medical station (X5)	12.7431	88.109	9.38663	1.00	45.00	44.00
Chronically ill member (X6)	0.4495	0.249	0.49859	0.00	1.00	1.00
Poor hygiene status (X7)	0.7982	0.162	0.40229	0.00	1.00	1.00
Insufficient food (X8)	1.9862	1.802	1.34226	0.00	8.00	8.00
Surface water access (X9)	0.3991	0.241	0.49084	0.00	1.00	1.00
Average family member (X10)	4.5642	7.141	2.67227	0.00	34.00	34.00
Other sources of income (X11)	0.6284	0.327	0.57162	0.00	3.00	3.00
Financial services access (X12)	0.3303	0.222	0.47139	0.00	1.00	1.00
Debt / Loan (X13)	0.3119	0.216	0.46435	0.00	1.00	1.00
Migrated family member (X14)	0.6651	1.450	1.20398	0.00	8.00	8.00
Main income (X15)	7.7E+06	1.7E+17	1.3E+09	4E+05	1.20E+09	1.2E+10
Support from neighbours (X16)	0.1835	0.151	0.38796	0.00	1.00	1.00
Support to neighbours (X17)	0.1009	0.091	0.30191	0.00	1.00	1.00
Member of any organisation (X18)	0.0963	0.106	0.32540	0.00	2.00	2.00
Communicative advices (X19)	2.2844	0.960	0.97991	0.00	7.00	7.00
Education index (X20)	6.2752	9.767	3.12525	0.00	14.00	14.00

Table 1: The description of the ANOVA analysis

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.826	20	0.291	79.177	.000
	Residual	0.725	197	0.004		
	Total	6.550	217			

Table 1: The description of predictor variable coefficients

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.036	0.022		-1.633	0.104
	Erosion frequency (X1)	0.004	0.001	0.109	4.411	0.000
	Land loss (X2)	0.159	0.010	0.434	16.661	0.000
	Resettlement (X3)	0.155	0.009	0.446	17.532	0.000
	Other suffered disaster (X4)	0.042	0.005	0.239	9.208	0.000
	Time to medical station (X5)	-0.001	0.000	-0.037	-1.420	0.157
	Chronically ill member (X6)	0.020	0.009	0.059	2.268	0.024
	Poor hygiene status (X7)	0.026	0.011	0.060	2.301	0.022
	Insufficient food (X8)	0.004	0.004	0.031	1.100	0.273
	Surface water access (X9)	0.013	0.010	0.036	1.294	0.197
	Average family member (X10)	0.001	0.002	0.013	0.512	0.609
	Other sources of income (X11)	-0.082	0.008	-0.270	-10.907	0.000
	Financial services access (X12)	-0.065	0.010	-0.177	-6.464	0.000
	Indebted / Loan (X13)	-0.079	0.010	-0.211	-7.676	0.000
	Migrated family member (X14)	-0.009	0.004	-0.063	-2.295	0.023
	Main income (X15)	-1.017E-10	0.000	-0.075	-2.895	0.004
	Support from neighbours (X16)	-0.085	0.012	-0.190	-6.947	0.000
	Support to neighbours (X17)	-0.085	0.016	-0.148	-5.387	0.000
	Member of any organisation (X18)	-0.045	0.014	-0.085	-3.207	0.002
	Communicative advices (X19)	-0.006	0.005	-0.036	-1.328	0.186
	Education index (X20)	-0.005	0.001	-0.096	-3.667	0.000

Table 1: The description of household SVI categories

Level of vulnerability	Range	Description
Critically vulnerable	-0.47 - -0.445	Households were strongly vulnerable to riverbank erosion. Very high risk to local residents' life and livelihoods;
Highly vulnerable	-0.38 - -0.17	Households suffered moderate levels of vulnerability. Resources and capacities for dealing with riverbank erosion were insufficient and inefficient;
Moderately vulnerable	-0.164 – 0.02	Households earned the SVI at the centre of the range. Households had available capacities for short-term dealing with riverbank erosion;
Low vulnerable	0.024 – 0.191	Households were slightly vulnerable to riverbank erosion. Socio-economic capitals and potential risks on this group should be paid attention to;
Very low vulnerable	0.247 – 0.454	Households had sufficient strengths and capacities to adapt with /reduce riverbank erosion vulnerability.

Assessing Social Vulnerability to Riverbank Erosion across the Vietnamese Mekong Delta

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Assessing Social Vulnerability to Riverbank Erosion across the Vietnamese Mekong Delta

Climate change and trans-boundary development in the major deltas of the world, including the Vietnamese Mekong Delta have exacerbated environmental risks. Land subsidence, riverbed sand mining, and intensive groundwater extraction have all contributed to lower channel bed levels, resulting in riverbank erosion and the loss of assets and livelihoods for local residents. This study investigated the drivers, and classified the social vulnerability of local communities affected by riverbank erosion along two main branches in the Vietnamese Mekong. Direct interviews were conducted with 218 erosion-affected households along the Mekong and Bassac rivers in Dong Thap and An Giang provinces in order to create a social vulnerability index. More than 70% of the total surveyed households belonged to the highly, moderately, or low vulnerability groups, suggesting a range of affected communities within the sample, some of whom had the ability to cope with its short-term impacts. However, the estimated social vulnerability index revealed significant geographical heterogeneity, with communities along the Mekong branch being more vulnerable than those along the Bassac. The recommendations from our investigations include the establishment of community awareness programs, as well as policy changes that ensure and support local residents' livelihoods adaptation. Stakeholder participation and enhanced community engagement was found to be the most important tools available in terms of aiding local people cope with the complex impacts of riverbank erosion.

Keywords: Riverbank erosion; Social vulnerability; Vietnamese Mekong Delta

Introduction

Riverbank erosion has the potential to cause a wide range of socio-ecological effects throughout the world (Hutton & Haque, 2004; Sharma, 2013; Bhuiyan et al., 2017), putting local populations at danger (Cutter et al., 2003; Flanagan et al., 2011; Tate, 2012). Vulnerability assessments can be used to establish understanding of how water hazards, such as riverbank erosion, potentially affect ecosystems and communities. The risk-hazard framework is the most widely used method for assessing natural hazards-induced vulnerability (Mafi-Gholami et al., 2016). It comprises the risk assessment characterized by the erosion possibility, frequency and extremeness of physical event changes (Wilhelmi & Morss, 2013) and the exposure determined by spatial distribution of the vulnerability index (Mafi-Gholami et al., 2019).

The Vietnamese Mekong Delta (VMD), located in the downstream portion of the Mekong River, is one of the world's three most vulnerable deltas to climate change, while also playing a critical role in the global food security balance (IPCC, 2014; Nguyen et al., 2015; Smajgl et al., 2015; Minderhoud et al., 2018; Jordan et al., 2020). Climate change has resulted in changes in precipitation, temperature, and natural catastrophes, particularly increases in the severity and frequency of water-related hazards, all of which have exacerbated complex threats to the delta's socio-ecological systems (Parker et al., 2019; Smajgl et al., 2015; Witjes, 2018).

Riverbank erosion in the VMD is caused by significant changes in hydrological regimes in the Mekong River Basin as a result of global climate change and inappropriate socio-economic developments inside the delta (Vaidyanathan, 2011; Yong & Grundy-Warr, 2012; Anthony et al., 2015a). Upstream hydropower and water-related infrastructure projects along the Mekong River's main channels and tributaries have exacerbated the physical and socio-ecological conditions downstream in the VMD. Both flow volumes and sediment transport have reduced, leading to significant degradation of surface water quality and sediment deposition, as well as the weakening of river banks (Hackney et al., 2020; Kondolf et al., 2018). Furthermore, as a consequence of Vietnam's recent economic growth and building boom, sand mining for construction has increased dramatically, notably along the Mekong and Bassac rivers, particularly in the upstream provinces of An Giang and Dong Thap (Bravard et al., 2013), resulting in exaggerated riverbank erosion due to changes in river morphology (Vasilopoulos et al., 2021).

According to the Riverbank and Coastal Erosion Prevention Plan (Ministry of Agriculture and Rural Development, 2019), the VMD is at risk of riverbank erosion, with hundreds of sites (representing hundreds of kilometres of riverbank) classified as significantly serious, serious, and site of concerns. This study was implemented specifically to evaluate the social vulnerability to riverbank erosion of affected communities at household level, and to identify the opportunities and challenges of potential mitigation solutions.

The Mekong and Bassac branches are two major tributaries of the Mekong River that flow along the provinces of Dong Thap and An Giang in the upstream section of th e Vietnamese Mekong Delta (Figure 1). Dong Thap and An Giang have a total administrative area of 338,385 ha. and 353,680 ha. and populations of 1.6 million and 1.9 million, respectively (GSO, 2020). In both An Giang and Dong Thap provinces, 48 and 52 bank erosion sites respectively, along the Mekong and Bassac rivers were recorded in 2019. The total bank erosion length in An Giang was 3.7 kilometres, which affected 146 homes while in Dong Thap it was 28.5 kilometres affecting 6,297 homes.. Riverbank erosion has caused complicated socio-ecological risks and implications to both p provinces. In 2019, the Cho Moi and Chau Phu districts of An Giang province suffered the most intense riverbank erosion, with 46 families affected, and an land loss of 0.4 ha, whereas in the Hong Ngu, Thanh Binh, and Cao Lanh districts of Dong Thap province 1,547 houses were affected and an area of 3.78 ha lost to erosion (GSO, 2020).

Figure 1: The studied districts within the VMD

Methodology

Data collection

Secondary data

Secondary data employed included grey literature, unpublished reports and spatial data obtained from the provincial authorities of An Giang and Dong Thap. Reports of the most updated water infrastructure planning (in the year 2019) and annual disasters and risks (from 2015 to 2020) were obtained from the Division of Irrigation (DoI), a sub-unit of the Provincial Department of Agriculture and Rural Development; a state management unit responsible for water hazards and disasters, including riverbank erosion hazards. In addition, the most updated water infrastructure maps (for the year 2020) consisting of sluice gates, waterways, river dyke systems were also provided by DoI.

Primary data

Key informant panel (KIP)

Four KIP interviews were conducted in An Giang and Dong Thap in collaboration with local officials from both the provincial- and district levels of the Department of Agriculture and Rural Development to gain an understanding of their concerns, the context of in-situ riverbank erosion and its consequences for the local communities. The findings were then used to identify erosion hotspots for later household surveys and to provide local state officials with policy guidance for riverbank erosion mitigation.

Household survey

A questionnaire to evaluate social vulnerability at the household level in riverbank erosion hotspots was developed based on indicators by IPCC (2007) and the studies of Schneider et al. (2011) and Bhuiyan et al. (2017) (Table 1). In the year 2020, 218 households were surveyed across six identified hotspot areas in An Giang and Dong Thap (Figure 1). The selection of respondents, representing both indigenous knowledge and local experiences was based on five criteria: current livelihood, proximity to the river, gender, ethnicity, and length of residency.

Table 1: Indicators for household survey questionnaire

Data analysis

Quantitative analysis

Five steps were taken to assess the social vulnerability of the surveyed households. The raw data was first cleaned and encoded using data screening and encryption. Since the indicator values had a wide range and were on multiple scales, normalization was used to rescale each indicator before the analysis. *Natural Log* was used to normalize the eight continuous indicators (including: erosion frequency, time to the medical station, insufficient food, average family size, migrated family member, main income, communicative advice and education index) due to the wide range of obtained values. The remaining binary variables were coded into 0 and 1. The social vulnerability index (SVI) was carried out after the database had been cleaned, coded and normalized. Vulnerable levels of survey households were reflected through classifying the obtained SVI by applying the clustering analysis statistical approach. Thereafter, the household SVI was mapped to illustrate spatial distributions and correlations.

$$X' = \ln(X_i)$$

Three index components were calculated to formulate the social vulnerability index, including: exposure, sensitivity and adaptive capacity. Each component was created by summing up the predictor variables as shown in Table 2.

Table 2: Predictor variables description

Binary indicators were encrypted into 0 and 1, while continuous indicators were normalized to the range [0;1]. The number 0 indicates that there was no influence, whereas 1 indicates that there was a positive impact. The SVI was calculated using the three index components according the following formula:

$$SVI = (EI - AI) \times SI,$$

Where EI stands for exposure index, AI is the adaptive capacity and SI is the sensitivity index. The SVI was further normalised to the range of [-1,1] towards cluster analysis for classifying vulnerability levels by the formula:

$$X' = (b-a)\frac{X - \min(X)}{\max(X) - \min(X)} + a$$

Whereas b is the maximum and a is the minimum of the range. The formula for SVI conversion was:

$$X' = (2)\frac{X - \min(X)}{\max(X) - \min(X)} - 1$$

The relationship between predictor variables and estimated SVI could be either positive or negative. The greater the values in the former case (with the highest value of +1), the better the SVI and the smaller the numbers in the latter case (with the lowest value of -1) the worse the SVI. According to Cutter et al. (2003) and Mavhura et al.

(2017), each predictor variable in the SVI computation was treated identically, which is appropriate when weights are not applied.

Statistical modelling and Geographical information system (GIS)

A linear regression model was built, where the SVI was the dependent variable and indicators creating three SVI components were predictor variables. The study used the significant value (p-value of 0.05) to assess the statistical significance of the developed model and to identify which predictor variables statistically affected the SVI.

A geodatabase was developed to provide the spatial distribution of surveyed households using Quantum GIS software. This database included a layer that depicted the spatial distribution of social household vulnerability, as well as data for analysing the spatial correlation of the obtained SVI of five studied districts.

Results

Indigenous knowledge on the causes and impacts of riverbank erosion

According to the Prime Minister's Decision (Decision 01/2011/Q-TTg), riverbank erosion hazards are classified into three levels: extremely dangerous, dangerous, and manageable (Table 3). The field visits took place at areas classified as extremely dangerous, where riverbank erosion has been occurring since 2015. Figure 2 displays the fieldtrip sites, as well as associated riverbank erosion scenes, with certain areas (for example, Figure 2(F)) having previously been concreted according to the Ministry of Agriculture and Rural Development (MARD) guidelines to protect riverbanks from continuous erosion.

Table 3: Description of riverbank erosion classifications according to MARD

Figure 2: Locations of riverbank erosion in An Giang and Dong Thap (MARD, 2019)

According to data gathered from the KIP interviews and the annual natural disaster reports in An Giang and Dong Thap provinces, riverbank erosion caused a significant economic loss in 2019 (Table 4), amounting to ~ 1.2 million USD in An Giang and ~ 0.35 million USD in Dong Thap. The riverbank erosion in Chau Phu district, An Giang province, occurred near the national highway route that connects Long Xuyen, the province's largest city, with the remainder of the province, resulting in a much higher economic loss than in other locations. Furthermore, due to the high variation of population densities in each erosion site, the number of households impacted by riverbank erosion varied dramatically. According to officials from the DoI in An Giang and Dong Thap, the number of affected families could not adequately reflect the real consequences and losses caused by riverbank erosion, but household demographic factors, particularly economic capability and social networks may provide a better reflection.

Table 4: Status of riverbank erosion impacts at surveyed locations

Riverbank erosion is a natural phenomenon, according to the DoI officials from both provinces, although anthropogenic activities frequently have a major effect on the rate and location of morphological change. Riverbank erosion was particularly common around river intersections and along island banks, which is reasonable given significant changes in water discharge and flow velocities across time and space in those places. Furthermore, because An Giang and Dong Thap are upstream provinces of the VMD, fluvial morphology was a significant element, with strongly meandering rivers causing critical riverbank erosion.

Figure 3: Drivers of riverbank erosion in An Giang and Dong Thap outlined from household surveys and KIP interviews

There are a variety of anthropogenic activities that can speed up riverbank erosion at both regional and local scale. According to KIP interviewees, large-scale projects such as reservoir constructions and hydropower plant developments in upstream portions of the Mekong River may well contribute to the experienced local riverbank erosion. Household surveys revealed six major causes of riverbank erosion at the local level, including catchment land use changes, sand mining, river transportation, and intensive groundwater extraction (Figure 3). Climate change and upstream development were also mentioned by some respondents, accounting for 5% of the total survey.

The social vulnerability to riverbank erosion of effected households

Table 5 shows the statistical descriptions of twenty the predictor variables acquired from the household survey and used to build the linear regression model. The large standard deviation of variables X1, X5, and X15 suggested that respondents' input values for those indicators differed more from the remainder of the dataset. Because the X1, X5, X8, X10, X14, and X15 variables were defined as continuous variables, their maximum values were substantially higher than their mean values, resulting in a large discrepancy in range between those continuous variables and the remainder of the variables. Indicators with notable variances in range and similarity were also reflected of individual household socio-economic features, resulting in response variety in disseminating the data acquired.

Table 5: The statistic description of input predictor variables:

A linear regression model was found to have an R-squared value of 0.889, indicating that the regression model was useful in explaining nearly 90% of the variance in the obtained SVI. The regression model was statistically significant, as shown by the p-value of the F statistic (Sig.=.000). As a result, the model was deemed to be suitable for detecting the SVI (Table 6).

Table 6: The description of the ANOVA analysis

A total of 15 statistically significant variables were found. Their p-values were less than 0.05 in this case, therefore any changes in those variables resulted in changes of the calculated SVI. Furthermore, the Coefficients (Beta) found described six positive and nine negative correlations between predictor factors and the SVI ().

Table 7: The description of predictor variable coefficients

The Shapiro-Wilk's normality test yielded a p-value of 0.3416, which was higher than 0.05, indicating that the SVI followed the normality distribution law. The histogram (Figure 4) revealed that the majority of the SVI values were in the –0.2 to +0.2 range, with a total frequency of 160, indicating that 75% of the questioned households (160 out of 219 total households) were vulnerable, with the most vulnerable and least vulnerable households accounting for about a quarter of the total.

Figure 4: The distribution of the SVI

Five types of households SVI were discovered as a result of the cluster analysis (Figure 5). There was statistical significance between five susceptible clusters. since the ANOVA analysis showed the p-value was 0.00, lower than 0.05. As indicated in Table

8, each group reflected a distinct degree of household SVI, with values ranging from -1 to 1. The lower the calculated household's SVI was, the more vulnerable the household.

Figure 5: Cluster analysis

Table 8: The description of household SVI categories

Figure 6 and Figure 7 show the SVI spatial distribution of surveyed households in Dong Thap and An Giang provinces, respectively. Levels of vulnerable gradually decreased from moderately (44%) to low (31%), highly (13%) to very low (11%) and finally critically (1%), indicating that most affected households had available capacities to deal with riverbank erosion impacts, though these capacities may only be available for a short time. Houses located close to a river were clearly found to be more vulnerable. A significant number of susceptible households were found along the Mekong River, whereas those examined along the Bassac River were less vulnerable (55% and 35%, respectively). Riverbank erosion affected communities close to river confluences, more than those further inland.

Figure 6: The SVI of survey households in Dong Thap province

Figure 7: The SVI of survey households in An Giang province

Land loss, resettlement, other sources of income, indebtedness, financial services evaluation, support from neighbours, and support to neighbours were all found to be statistically significant predictors with the calculated p-values of 0.00 (less than

0.05). Those were adaptive capacity components that showed that households had a wide range of resources and capacities to deal with erosion, and variables strongly affected the SVI. The major drivers of the final SVI's diversity were land loss, resettlement, revenue sources, loan, and financial accessibility (Figure 8).

Figure 8: ANOVA analysis results of the SVI and different household characteristics

Resources to deal with riverbank erosion

More than 90% of respondents urged their neighbours to escape to safer areas immediately in the event of erosion occurring, and the local People's Committee was contacted for additional assistance. Only a small percentage (3%) remained after the erosion occurred far from their homes, at a distance of more than 40 meters, while the remaining 2% had no idea what to do and barely moved. This small group was unusually composed of elderly and destitute people who were experiencing significant erosion.

Figure 9: Responses of households to riverbank erosion

Following an erosion incident, the majority of impacted households sought immediate assistance funds. Overall, 64% of households reported having difficulty mitigating the effects of riverbank erosion, particularly in obtaining an adequate budget for resettlement and the financial means to start over in a new job. While the affected households were frequently given one-time small relief funds from the Central Government to help with housing maintenance or resettlement, they discovered that unstable livelihoods and income sources were long-term hardships. The remaining 36% of surveyed households received help in terms of emergency remittance payments

302 directly from family members who had already migrated for work either permanently or temporarily. This was a highly valued source of help which allowed easy access to funds to those affected and really in need of fast access to cash.

305 In addition, respondents mentioned the neighbourhood's great potential and readiness to assist each other in overcoming the economic consequences of riverbank erosion. In total, 28% of respondents said they would consider receiving and/or offering financial assistance to their neighbours, while the remaining 72% said they would not. People seek help from their neighbours for a variety of reasons (Figure 10), including a budget for housing repairs and upkeep, assistance with relocating precious belongings out of harm's way, and psychological support. Respondents placed a high value on their neighbourhood because they were important first contacts in an event of an emergency, particularly in the case of riverbank erosion, which placed not only assets and livelihoods at risk, but also lives.

Discussion

Fundamental characteristics of social vulnerability to riverbank erosion in the mainstreams of the Vietnamese Mekong Delta

The provinces of An Giang and Dong Thap experienced a wide range of effects as a result of riverbank erosion. Those findings massively aligned with previous study focusing on the physical changes of the river system (Bravard et al., 2013; Darby et al., 2016) as well as the fluctuation of water flows and sedimentation seasonally and temporally(Darby et al., 2016; Hackney et al., 2020). The VMD was formed by the alluvial deposition, thus the sediment from the Mekong River played the survival role for the delta's living ecosystems. The degradation of sediment, especially the alluvium, has resulted in a great deal of negative impacts, which riverbank erosion is notably highlighted (Anthony et al., 2015; Jordan et al., 2020). The surveyed communities were characterized by low-income, a high elderly population, low-educated, and "highly economic dependent" households with family members under 15 or over 65 years old without sufficient qualifications to contribute to household income. These groups are commonly recognised as marginal groups by previous studies of Mavhura et al., (2017); Mustafa et al., (2011); Pham et al., (2018); and Tran et al., (2018). This study discovered a strong link between marginal groups and vulnerability, with the majority of them falling into the highly vulnerable (5^{th}) and relatively vulnerable (4^{th}) categories. This implies that these groups are already facing already complex vulnerability relevant challenges for survival. Additionally, regarding the reliability of the data obtained from the elderly and low-educated, the research considered this aspect right at the beginning of developing the study's structure, the questionnaire, the progress of household survey and data analysis. Specifically, at the survey phase, questions were asked based on the "normal conversation" approach by interviewers, which allowed respondents to understand all questions without academic or professional knowledge prerequisites. A wide range of qualifications of interviewees was taken into account, from their capacity of communication, their Vietnamese understanding (as it might be difficult for the ethnic minority, then the local language translator needed). Furthermore, the study tested all obtained data to investigate whether there were any confounding values and variables. These steps were taken to assure that the obtained data were reliable and suitable for analysis.

Despite the fact that the majority of the afflicted communities were located near major rivers, the SVI revealed significant variances. Households with high vulnerability are prevalent in Hong Ngu, Cao Lanh, and Chau Phu, where minor ethnic groups and unstable occupations coexist. Households with more secure occupations, including landowners, and long-term residents who have previously experienced riverbank erosion, were found to be the least vulnerable. Furthermore, households that had lived in the same place for a long period of time had lower levels of vulnerability. They consisted of "old" households who had resided in the surveyed villages for at least 40 years. Their views and positions were highly appreciated and listened to by others in the community.

Dynamics of the social vulnerability

The assessment of vulnerability was carried out to investigate a range of social dimensions in this study. These dimensions strongly defined themselves by the spatial and local demographical contexts. The SVI was developed based on these conditions to strongly explain the impacts of riverbank erosion. It was otherwise found that the obtained SVI was remarkably unique in some aspects, where local socio-ecological components, consisting of *demographic sensitivity, economic capacity, social network and communications* were highlighted. *Remitted income, financial accessibility, potential support from/to neighbours* were especially crucial in driving the vulnerability and adaptive capacity of affected households. The assessment of vulnerability in this study was done by looking at a range of social variables. These elements were greatly influenced by regional and local demographical considerations. Because these factors explain the impacts of riverbank erosion, the SVI was built with them in mind. Furthermore, the created SVI was found to be extremely unique in a number of ways, particularly when it comes to local socio-ecological components including demographic sensitivity, economic capability, social network, and communications. Remitted income, financial accessibility, and potential support from/to neighbours were important factors in determining a household's overall vulnerability and adaptive capacity. Those signs pointed to a long-standing regional culture in which family and community members were well respected within a community. As a result, impacted families received remitted income in the form of emergency assistance from family members or neighbourhood assistance.

The spatial analysis indicated the instability of the SVI spatially in comparison to previous evaluations in other regions. Riverbank erosion resulted in significant changes in land use practices and livelihoods (Anthony et al., 2015b; Jordan et al., 2020; Kondolf et al., 2018; Sharma, 2013).Yet, the resettlement and migration as a direct result of riverbank erosion, became more of a concern in our research. Significant losses to household assets and living space, placed a strain on livelihoods. The study produced a new indicator – residence time – which demonstrated the influence of total years that a household had resided within the study area. This indicator was developed in response to findings from earlier VMD research (Le et al., 2016; Nguyễn et al., 2012; Pham et al., 2015; Tran et al., 2017), which showed the relevance of local understanding, experiences and social networks. The findings of the linear regression model results also revealed that the residency duration and the SVI had a high statistical correlation.

The SVI must be explained in relation to the socio-ecological context (Adger, 1999; Cutter et al., 2003; Duc et al., 2021; Tate, 2012, 2013; Tran et al., 2019). Previously, there was no consistent framework or standard method for quantifying the effects of a particular water-related hazard on impacted communities. A framework needs to be dynamic and reflect acutely the current situation in investigated areas. The instability of the SVI was demonstrated in this study, which backed up previous findings.

Towards enhancing resilient capacity to riverbank erosion, what should be done?

The assessment of vulnerable households at various levels is critical as it provides the decision-makers, local authorities, and the community with crucial information for selecting and implementing the most appropriate vulnerability reduction pathways. To carry out pre-event mitigation actions, the vulnerability assessment helped target the most affected among communities with their identities, including demographic, socioeconomic conditions, and the drivers of vulnerability. Previous research on water hazards-induced vulnerability in general, and riverbank erosion in particular (Atteridge & Remling, 2018; Nguyễn Thanh Bình et al., 2012; Rickless et al., 2020; Wiréhn, 2017) have highlighted these aspects.

This study persuaded local stakeholders of the impacts and vulnerability of riverbank erosion through a variety of social dimensions that were used as survey indicators. As a result, actions should be shaped by taking high-risk indicators into account. For example, the research revealed education level, dependent rate, income and forms of urgent help all had a substantial influence on the SVI. Thus promoting riverbank erosion awareness and facilitating livelihood flexibility are important short-term activities to focus on.

With the participation of key stakeholders within the case study areas and a great deal of effort from central to local government as well as the affected communities themselves, solutions have been put into action. Immediate financial assistance from the Central government; and technical assistance from local governments reduced impacts-induced vulnerability. These immediate reliefs may not be effective in the longer term, as riverbank erosion is expected to continue due to reduced upstream sediment loads and unsustainable socio-economic development in the VMD (Anthony et al., 2015a; Chapman & Darby, 2016; Li et al., 2017).

According to the findings, communities already inherently have a high degree of ability to cope with riverbank erosion, which governments could strengthen and consider when making decisions. The education level, household income, unstable livelihoods and occupations, and financial accessibility to immediate support were all seen as major drivers of the high levels of vulnerability in affected communities. Here, the local government and decision-makers should keep these factors in mind when implementing policies. More initiatives should be developed to improve community knowledge of water hazards, dangers, and susceptibility, especially riverbank erosion. By equipping the community with the essential knowledge and skills, they will be better prepared to deal with possible episodes of erosion in the future. In addition, improving livelihoods and financial access schemes to make them more flexible and adaptive is critical for increasing community resilience through a variety of pre-sources. Stakeholder involvement and participation should be enabled in either riverbank erosion mitigation methods or actual execution, since social networks were also identified as a major source of vulnerability reduction. This covers the functions of local unions such as Farmer Unions, Women Unions, and Youth Unions, which act as representatives of local communities.

Conclusion

Riverbank erosion in the VMD's upstream section is caused by a variety of factors, including transboundary hydrological development, previous unsustainable regional development practices, and ongoing climate change, all of which combined to have serious implications for human well-being and livelihoods. This study built a social vulnerability index for evaluating riverbank erosion vulnerability effectively by combining IPCC (2007) guidance as well as relevant past research (Schneider et al. 2011; Bhuiyan et al. 2017).

The calculated SVI reflected the demographic and socioeconomic circumstances of local communities well, with significant contributions from the three main factors of levels of education, residency time, and indigenous knowledge. Households' spatial distribution had a key role in defining riverbank erosion risks and distinguishing vulnerability levels, with households closer to the Mekong and Bassac's main streams experiencing higher degrees of vulnerability in terms of land loss. Furthermore, income sources and financial circumstances, such as debt, had a significant impact on the SVI, as it is related to the direct capacity to mitigate the impacts of riverbank erosion hazards. Social networks, such as family and neighbours, have been identified as critical resources for affected communities seeking immediate financial assistance and mental health support in response to riverbank erosion.

The findings were able to provide evidence-based results and urge local decision-makers to take them into account within the policy-making process. Going forward, the role of these social dimensions deserve more attention in the drafting of riverbank erosion mitigation measures. Furthermore, stakeholder engagement must be seen as a necessary component of mitigation strategies, such as leveraging affected communities' social connectivity, and promoting the role of local grass-root organizations.

Acknowledgement

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Gesellschaft für Internationale Zusammenarbeit GmbH) and a visiting researcher at Can Tho University for proofreading the final manuscript.

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Review rebuttal on paper entitled *Assessing Social Vulnerability to Riverbank Erosion across the Vietnamese Mekong Delta*

To whom it may concern,

Please see below our responses to the reviewers' concerns and queries, as well as the details of changes we have made. We have modified and improved our paper based on the very useful comments and in response to the reviewers' feedback.

The following are the primary revisions we have undertaken during review:

- The Methodology section has been significantly improved to provide the additional requested details as outlined by the reviewers and the editor. We have also taken the opportunity to clarify some aspects we provided. This has included the additional of a theoretical framework as requested:
- We have additionally made significant modifications to the language used in comparison to the original submission in order ensure that the paper is as comprehensible and digestible as possible.

Thank you very much for the reviewers' feedback, your comments, and the opportunity to publish in your prestigious journal.

Sincerely,
Van Pham Dang Tri (on behalf of all authors)

Reviewer 1

Comment /Question	Reaction
1. This study is relevant for local government. The statistical method sounds appropriate with sufficient data support (social part). Riverbank erosion is associated with human activity, existing river morphology and geotechnical properties of the bank, and river hydraulics including climate change impact. Data on these and related analytical methodology does not scientifically sound. I suggest removing this part (erosion drivers and related variables, investigation of drivers) in the analysis and keep only social part.	Thank you very much for your feedback. In our study, we aimed to understand the local drivers of riverbank erosion through indigenous knowledge. In particular in the first half of the results,, all of which were further explained and alluded to in the discussion section by referring to relevant past studies in the region. We have clarified this and your concerns in the revised text on Page 13 – 14, Ln 319 - 336.: "The provinces of An Giang and Dong Thap experienced a wide range of effects as a result of riverbank erosion. Those findings massively aligned with previous study focusing on the physical changes of the river system (Bravard et al., 2013; Darby et al., 2016) as well as the fluctuation of water flows and sedimentation seasonally and temporally (Darby et al., 2016; Hackney et al., 2020). The VMD was formed by the alluvial deposition, thus the sediment from the Mekong River played the survival role for the delta's living ecosystems. The degradation of sediment, especially the alluvium, has resulted in a great deal of negative impacts, which riverbank erosion is notably highlighted (Anthony et al., 2015a; Jordan et al., 2020). The surveyed communities were characterized by low-income, a high elderly population, low-educated, and "highly economic dependent" households with family members under 15 or over 65 years old without sufficient qualifications to contribute to household income. These groups are commonly recognised as marginal groups by previous studies of Mavhura et al., (2017); Mustafa et al., (2011); Pham et al., (2018); and Tran et al., (2018). This study discovered a strong link between marginal groups and vulnerability, with the majority of them falling into the highly vulnerable (5th) and relatively vulnerable (4th) categories. This implies that these groups are already facing already complex vulnerability relevant challenges for survival."

2. Clearly define "dangerous" and "extremely dangerous"!	We added the description on Page 7, Ln 171 - 173 and in Table 3. Extremely dangerous areas: a) Closely located to the river dike system threatening the dike safety. b) Directly risk urban and/or residential areas, headquarters of governmental organizations at districts level and above. c) Already directly affected crucial infrastructures including airport, railway, highway, national road; national port; high voltage system from 66 KV and above; school and hospital from district and above. Dangerous areas: a) Potential to affect the river dike system, but still under control. b) Potential to affect urban and/or residential areas, governmental organizations at all levels. c) Potential to affect crucial infrastructures including airport, railway, highway, national road; national port; high voltage system from 66 KV and above; school and hospital from district and above.
3. Clearly explain the physical process of each erosion driver? E.g. how intensive groundwater extraction can provoke riverbank erosion?	As discussed in the response to question No. 1, our paper focuses on the social sphere, and as such, the physical processes are not further described in detail herein – we have included additional references to these points.
4. The conclusion section is rather a summary from the result and discussion section.	The conclusions have been rewritten in much greater detail, to draw the main findings together, as well as provide brief policy implications. You can find the adjustment on Page 18 - 19 Ln 443 – 455: "Riverbank erosion in the VMD's upstream section is caused by a variety of factors, including transboundary hydrological development, previous unsustainable regional development practices, and ongoing climate change, all of which combined to have serious implications for human well-being and livelihoods. This study built a social vulnerability index for evaluating riverbank erosion vulnerability effectively by combining IPCC (2007) guidance as well as relevant past research (Schneider et al. 2011; Bhuiyan et al. 2017). The calculated SVI reflected the demographic and socioeconomic circumstances of local communities well, with significant contributions from the three

	main factors of levels of education, residency time, and indigenous knowledge. Households' spatial distribution had a key role in defining riverbank erosion risks and distinguishing vulnerability levels, with households closer to the Mekong and Bassac's main streams experiencing higher degrees of vulnerability in terms of land loss.", and Page 19 Ln 463 – 467: "the role of these social dimensions deserve more attention in the drafting of riverbank erosion mitigation measures. Furthermore, stakeholder engagement must be seen as a necessary component of mitigation strategies, such as leveraging affected communities' social connectivity, and promoting the role of local grass-root organizations". Thank you very much for your valid comments.
5. Table 1, 4, 8 may not necessary since they contain little information and you already described in text.	We fully agree with the reviewer's comments. These Tables have been omitted from the revised text. Thank you very much.
6. Photo D, E, F do not show the tracing of riverbank erosion or it is not clear?	Those photos were taken in three study districts in Dong Thap province, all of which have seriously suffered from riverbank erosion since 2015. The photos serve to provide the reader with an ideal of the local context and capture the riverbank erosion landscapes during the fieldtrip. Please find the addition we have made to this effect on Page 7, Ln 173 – 178: The field visits took place at areas classified as extremely dangerous, where riverbank erosion has been occurring since 2015. Figure 2 displays the field trip sites, as well as associated riverbank erosion scenes, with certain areas (for example, Figure 2(F)) having previously been concreted according to the Ministry of Agriculture and Rural Development (MARD) guidelines to protect riverbanks from continuous erosion.
7. Find a better way to present Figure 4 and 5! Number of household and economic loss should not be in the same axis because of different unit. What is the purpose of using such graph? Why not tabular form?	We switched the graph to a table to make it clearer and more understandable. Please see Table 4: Status of riverbank erosion impacts at surveyed locations for your reference. In this table, we systematize the actual impacts of riverbank erosion on the number of affected households, the economic loss and land loss.

8. The analysis of drivers of riverbank erosion (Figure 6) by people perception only is not convincing. Physical process analysis should be considered. I think the most feasible method is the use of a river hydraulic model. Moreover, it is very difficult to relate a particular erosion event to one or some particular drivers.	We are a little confused by this comment, as it seems to contradict the reviewer's earlier suggestion (see comment 1), as well as comment 10 (below) that we should not focus on the physical processes in this paper. Here we reiterate our earlier response to that comment, namely that this paper focused on indigenous knowledge rather than the physical processes of riverbank erosion.
9. Definition of all predictor variables (Table 6) should be well described.	Clear definitions have been added in the relevant table (e.g. Table 2 in the revised manuscript): Predictor variables description. Twenty predictor variables were coded from X1 to X20 and defined separately.
10. I suggest the study focusing on social vulnerability as the title reveals. It is better to remove the analysis that includes drivers of riverbank erosion (investigation of drivers). The related data and methodology is not sufficient. If the terms "vulnerability" is then not appropriate, you may consider another one like "adaptive capacity and exposure". Consequently, you need to alter the objective statement in Line 33-36, Page 4. The two specific objectives are OK.	The specific objectives were altered. We have adopted the reviewer's suggestion. The updated objectives can be found in Page 3, Ln 71 – 74: "This study was implemented specifically to evaluate the social vulnerability to riverbank erosion of affected communities at household level, and to identify the opportunities and challenges of potential mitigation solutions." As the objectives were revised, we have focused the study on the social vulnerability, which we believe that the obtained data from the field survey and the methodology of statistical analysis and GIS application have been sufficient to answer the research questions.
11. Please provide the settlement characteristics in the study area! You may plot a representative cross section showing river centerline, river's right of way, house, etc. Besides readers' comprehension on the study area, such illustration will give chance to include definition sketch of some predictor variables.	As we have included pictures showing the facts of riverbank erosion in the study area (Figure 2). Readers are able to basically find the characteristics of surrounding features in the vulnerability maps (Figure 6 and Figure 7). We had carefully discussed this comment, which we supposed that it would be good to keep the current shape. Thank you for the nice suggestion and your later engagement with our response would be appreciated.
12. You mentioned about the elderly and low educated people. How do you justify the reliability of interview data from those people?	We added the clarification for this question on Page 14 Ln 335 – 346: "Additionally, regarding the reliability of the data obtained from the elderly and low-educated, the research considered this aspect right at the beginning of developing the study's

	structure, the questionnaire, the progress of household survey and data analysis. Specifically, at the survey phase, questions were asked based on the "normal conversation" approach by interviewers, which allowed respondents to understand all questions without academic or professional knowledge prerequisites. A wide range of qualifications of interviewees was taken into account, from their capacity of communication, their Vietnamese understanding (as it might be difficult for the ethnic minority, then the local language translator needed). Furthermore, the study tested all obtained data to investigate whether there were any confounding values and variables. These steps were taken to assure that the obtained data were reliable and suitable for analysis.”
13. Please justify the consideration of normalization range [0;1] and [-1,1]! Why not the same? Why not other, like normalize by standard deviation.	We considered the scale of each predictor variable and the normalizing of the predictor variables (at a suitable scale) allowed us to miniature the range. The range [-1,1] simplified how the positive and negative relationships will result in the value 1 and -1 in respectively for predictor variables. The normalization range [0,1] indicated that there was no impact for the number 0 and positive impacts for 1. We have added more details on Page 6 Ln 143 - 144 and Page 6-7 Ln 157 – 159, to outline our selection and our rationale. The normalization by standard deviation works well for a standard normal distribution dataset, while our SVI dataset did not have that distribution type, therefore our normalization approach was used to prevent this biasing.

Recent comment from reviewer 1

Comment /Question	**Reaction**
The methodology needs to be relooked.	The reviewer provides no details about the specific ways in which the methodology should be updated, so it is very difficult to provide a specific response to this reviewer’s concerns. However, many of the changes made in response to comments of reviewer

	1 are focused on methodological aspects and we are therefore confident that our revised paper does fully set out a robust methodological approach

Reviewer 2

Comment /Question	Reaction
1. Framing (Theoretical)	We have revised the methodology to include an outline of the theoretical frame. Thank you for your comment.
2. Review	We have added more a range of further information into the literature review based on the comments – we included these changes as part of the contextual framing in the introduction. Thank you for your comment.
3. Methodological	We have revised the details of the methodology according to comments of the reviewers. We think we have covered all the outstanding elements they requested. Thanks for your consideration.

Recent comment from reviewer 2

Comment /Question	Reaction
1. It is clear that the authors have made significant alterations to the manuscript and, as a result, the manuscript is both clearer and improved. I therefore think that the manuscript is in a shape now to be accepted.	Thank you the reviewer for your kind words and approval.

Reviewer 3

Comment /Question	Reaction
1. Was there any randomness in the selection of the households that were chosen for the surveys? Or were the households selected purely based on the criteria listed in the manuscript? I think more information as to why these criteria were chosen is needed to demonstrate that no bias has been introduced by this selection process.	We applied the criteria listed in the manuscript for the surveyed community selection. This is because we had no prior knowledge of the study areas. At the survey stage, we selected respondents randomly in all affected communities so there were no biases established in the survey phase.
2. More details as to how each component of the Expose, Sensitive and Adaptive capacity were scored is needed. In the manuscript (P6 Ln 22) it is stated that "each component [was] created by summing up contributed values" and was then normalized. But how were these original components values scored and on what ranges were the scores given? How does the range of scores use affect the resulting AI, EI, SI and ultimately SVI scores? For example, values between 0 and 10 may place more emphasis on higher values that a range of, say, 0 to 40. This bias will then be exacerbated by the normalization process and artificially dampen or enhance the survey results.	All of components were calculated by summing up all predictor variables of each component (post-normalization). To minimize potential bias, the range [0,1] was used to normalize the raw data of predictor variables. The value deviation of each predictor variable was retained in the post-normalized SVI, with the value size adjusted, so neither the Probability density function, nor the variable distribution law was changed.
3. Can the authors explain in more detail why a linear regression model was built between the SVI and the three component indicators? SVI is, as defined by the authors, already a function of the three indicators so is this not circular in assessing predominant functions based on an a priori relationship between the SVI and the indices?	Social vulnerability to riverbank erosion is highly dependent on spatial and temporal circumstances. However, not all component indicator relationships in social vulnerability assessment studies are the same. Furthermore, because the predictor variables were based on specific riverbank erosion events in the study areas, the linear regression model assisted in re-determining and confirming the relationship between component indicators and predictor variables with the SVI in terms of their relationship dimension (negative or positive for i.e.).
4. P2 Ln 17: the use of the word inappropriate is confusing, would 'unsustainable' be a better option?	Well spotted. The wording has been changed.
5. P2 Ln 24: Slight conflation over the scales of interest (transboundary to 'downstream	This text passage has been rephrased.

in the VMD') here that could be solved with some rephrasing.	
6. P3 Ln 10: Should risky, simply be risk?	The wording has been changed.
7. P3 Ln 31: Specify the type of vulnerability being assessed.	This information was added.
8. Intro - it would be good to cross-reference here to figure 1 at some point to point the reader to the locational information being discussed.	The comment was taken into consideration. Please see Page 3, Ln 79 - 92.
9. P5 Ln 56: I am guessing that Logart Nepe is a Vietnamese translation of Natural Log? Correct to the English, or explain its significance.	The wording has been adjusted.
10. P7 Ln 30: What is the household vulnerability layer? This has not previously been defined or discussed in the manuscript.	The writing was rephrased on Page 8 - 9 Ln 172 - 175.
11. P7 Ln 55: What are the definitions used to classify 'dangerous' and 'extremely dangerous'? How sensitive is the subsequent analysis to these definitions? Are they based on physical rates of bank erosion or are they based on perceptions of areas of risk?	We used those terms in accordance with the Vietnam Government's guidance in Decision 01/2011/Q-TTg on 04/01/2011 and the classification of Ministry of Agriculture and Rural Development in 2021, which divided the riverbank erosion risks into three levels. Please see Table 3 on Page 9.
12. In the results and discussion section, why the sudden change of formatting to italicize the components listed, when previously this has not been the case in the earlier sections. Please be consistent throughout.	We were following the available template, which the components will be formatted in italic from level 2 (Heading 2).
13. Table 8 - are all the P values 0? Do you need to include more decimal places or change the way these are written?	This table has been deleted as the information was illustrated in text.
14. Figures 4 and 5 - Is it appropriate to have the number of households (count) and economic loss (billion VND) grouped into one y-axis? It makes for very disproportionate reading between the two sites, especially judging the differences as a 25 billion VND difference appears equivalent to 25 households. This could imply that a household is equivalent to 1 billion VND (is this the authors intention)? Also the secondary y-axis on Figure 4 needs attention as several ticks have the same label.	These graphs have been converted into a table, which can be found as Table 4 on Page 11. We all agreed that the way they were displayed as graphs added to the complexity and confusion.

15. Figure 6 - What is the central axis of the rose diagram representing?	Already revised as per Figure 3. The central axis of the rose diagram represented the normalized value with the scale [0;1] of drivers causing riverbank erosion according to the results of the household survey.
16. Figure 8 - X-axis is illegible.	The X-axis of Figure 8 (was revised as Figure 5) and was updated.
17. Figure 11 - what do the binary x-axis on this graph represent?	Figure 11 was modified to Figure 8, where the X-axis represents the adaptability of affected households.

Recent comment from Associate Editor

Comment /Question	**Reaction**
Dear Authors, Thank you very much for having worked on your manuscript. However, as you can see from the reviewers' feedback, the text requires still major changes to be scientifically sound. Please go again through all the comments received in the past rounds of revision, and provide more detailed point-by-point answers to the reviewers' questions.	Dear Associate Editor, Our research team took comments from you and reviewers' into consideration. We have made changes to the paper and answered previous questions in detail in this updated rebuttal.