Socio-economic assessment of riverbank erosion from heavy boat traffic: A case study at the Cho Gao Canal, Tien Giang, Vietnam

H H Anh¹ and N N Thuy²*
¹Faculty of Economics, Nong Lam University, Ho Chi Minh City 720400, Vietnam
²Office of International Cooperation, Nong Lam University, Ho Chi Minh City 720400, Vietnam

*Corresponding author: nnthuy@hcmuaf.edu.vn

Abstract. Cho Gao canal is the only inland waterway channel for river transport with large tonnage transporting rice, agricultural products, and goods from the Mekong Delta to Ho Chi Minh City. However, big waves from heavy boat traffic have been gradually wearing away the riverbanks, creating severe erosion and affecting local communities livelihood and safety. This study assessed the vulnerability of riverbank erosion in the Cho Gao canal using a quantified erosion index and the contingent valuation method. The data was collected from 120 households living along the canal. The calculation revealed that 76.67% of the households had moderate erosion vulnerability, which will become higher in the future unless government interventions are made. Besides, this paper also examined people willingness to accept (WTA) to compensate for the losses from riverbank erosion. On average, each household along the canal accepted 503.4 million VND (around 21,872.78 USD) of compensation to pay for their suffered losses. Factors influencing people's WTA were erosion affected levels, income, and age. People living along the Cho Gao canal have been experiencing damages from riverbank erosion since 2009, so there is a demand for state interventions to alleviate the problem and re-stabilize local communities' livelihood.

Keywords: Cho Gao Canal; contingent valuation method; erosion index; riverbank erosion

1. Introduction
Vietnam's Mekong Delta has a natural dense river system. Therefore, before road traffic systems were developed, the waterway was the primary method for transportation in the region. The Cho Gao canal in Tien Giang province, whose length is 28.5 km, is the arterial waterway of the Mekong Delta and the only inland waterway channel that provides access for large ships of more than 80 gross registered tons to transport agricultural products and other goods from the Mekong Delta to Ho Chi Minh City. The canal's traffic volume has been increasing continuously to more than 1500 ships per day, exceeding its carrying capacity. In restricted waters, because the river's size is relatively small, waves from boats have a massive amount of energy that can significantly erode the riparian zone [1–3]. For years, big waves from heavy boat traffic have been gradually wearing away 2 to 3 meters of both sides of the riverbanks of Cho Gao canal. The most affected areas are the communes of Binh Phan and Binh Phuc Nhut, where 4 meters of riverbanks collapse per year. In some places, the riverside road widths were narrowed down to only 1 meter or even impassable. There were accidents, injuries, and even deaths because people fell into the river while driving through eroded riverside pathways. Moreover, bank erosion washed away the soil, causing many lands and houses to be swept into the river. It is so dangerous that local people are afraid to move around during the night-time. Despite the risk, people along the canal have not migrated to another area because of their limited finances, the same reason that kept people in the erosion-prone Bhola district in Bangladesh staying in the village [4].
The local government has made many attempts to control the problem and minimize damages. In 2018 and 2019, the district invested 3.5 billion VND to strengthen the embankments in Binh Phan and Binh Binh Nhut communes. In 2020, the district continued to reduce landslides and floods in Binh Khuong 1 hamlet, Binh Thuong Nhut commune, with a cost of 9.6 billion VND. Local authorities and people living along the canal here expect that interventions will soon be implemented to stop the erosion hazard.

Studies on erosion in the Mekong Delta tend to concentrate on the coastal areas and aim to understand the natural and anthropogenic causes [5–7]. The erosion hazard in inland rivers and canals has limited attention compared to the coastal areas [8]. Few studies have examined this topic, especially the effects of waves generated by boats on riverbank erosion [9]. Erosion is not only triggered by natural factors such as flow, tides, waves, storms, floods, or sea-level rise, but human activities can also jeopardize the situation [10,11]. Erosion caused by waves hitting shorelines is among the six major causes of riverbank and canal erosion in the Mekong Delta [12]. Thang et al. [9] reported that erosion of riverbanks and canals in the Mekong delta is positively correlated with the height and weight of waves from boats.

Since the Mekong delta is the most critical agricultural and fishery producer of Vietnam, increases in riverbank erosion threatens rural communities’ sustainable livelihoods [13]. Hence, it is essential to have a clear understanding of this issue to make appropriate interventions. Previous studies usually utilized remotely sensed satellite data [7] and hydrologic models [5,14] to analyze the consequences of erosion. Moreover, the canal is also the place of residence of thousand people. Families living along the canal is directly affected by the disaster more and more severely. Losses of properties, land, lives have occurred, and the impacts significantly disrupted their livelihoods. Therefore, an assessment of the erosion from a socio-economic perspective is needed. The novelty of this study is to provide insights into the socio-economic aspects of the erosion problem. Specifically, our objective is to assess the vulnerability of riverbank erosion in the Cho Gao canal using a quantified erosion index and the contingent valuation method.

2. Material and methods

2.1. Study site

Cho Gao canal is a tributary connecting the Tien river and Vam Co river to create a waterway from Ho Chi Minh city to the Southwest of Vietnam. The French initiated the construction in 1876. Before it was built, boats had to take very long routes. Some routes had to travel along the coastal line, which was not suitable for every boat. Thus, the Cho Gao canal construction helps boats travel safely and saves time and transportation costs. Initially, the canal was dug 30m wide and 12 km long. About 11,000 Vietnamese people mobilized for the construction; the volume of the excavated soil was about 900,000 m³. It took 676 workdays to complete the canal. Over the years, bank erosion has made the canal three times wider than during the French colonial period. Although the present width is 80m, boat traffic can only operate in the middle of the canal due to the shallow depth of the rest of the canal.

2.2. Data collection

The primary data in this study was collected by interviewing 120 local households living on both sides of the canal. The investigation method used a structured questionnaire to collect information on the erosion situation, suffered damages, the vulnerability of the erosion, and local government’s assistance and solutions to respond to the hazard. Selected sites for the survey encompassed Binh Phan and Binh Binh Nhut communes. Both communes are located adjacent to the Cho Gao canal, and their riparian areas are intensively eroded.

2.3. Methodology

2.3.1. Assessing the willingness to accept for compensation of damages from bank erosion. This paper employed the contingent valuation method (CVM) to examine the damage that local people suffered from bank erosion. CVM is a common method in environmental economics to infer people’s preferences
for public goods and environmental quality [15,16]. In this study, local households were asked to state their willingness to accept (WTA) for a compensation program. WTA was also utilized in many papers, such as the payment that farmers would accept to adopt environmental management practice in watershed regions in the United States [17], the compensation for land fallowing in Northern China [18], or people's acceptance of improved ecosystem services in Hebei province, China [19]. Regarding studies about erosion in the Mekong Delta of Vietnam, earlier papers focus on the hydrologic evaluation and the physical interaction between the waves and the banks more than the social vulnerability and losses that farmers have to bear [5,9,13].

The critical component of the CVM application is the survey questionnaire, in which households were presented with a hypothetical program, and the monetary compensation is the only attribute that varies based on the respondents' answers. An open-ended question was used for the respondent to state their desired compensation. Before the WTA question, participants needed to answer some questions regarding the condition of the riverbank erosion where they were residing and how they were affected by it. The wording of the WTA question is as follows:

Because of heavy boat traffic, both sides of the Cho Gao canal have been eroded severely. Therefore, the Ministry of Transport approved a program to compensate and support affected people in the area. The program requires each household to estimate the damage suffered due to bank erosion and provide the monetary value you want to receive as a one-time compensation. After completing the statistics, the head of the hamlet will collect and submit them to the People's Committee of Cho Gao district under the supervision of the Provincial People's Committee. The compensation amount will be directly given to households by local authorities. Therefore, how much is the compensation you are willing to accept to restore the economy and stabilize your family's lives?

After the survey, a linear regression model was used to examine factors influencing households' WTA. The proposed explanatory variables were age, gender, average income, the affected level, and the erosion rate. The model is expressed as following:

\[
WTA = \beta_0 + \beta_1 Age + \beta_2 Gender + \beta_3 Average Income + \beta_4 Affected level + \beta_5 Erosion rate + \epsilon \quad (1)
\]

### Table 1. Variables in the regression model.

| Variables          | Definition                                                                 |
|--------------------|-----------------------------------------------------------------------------|
| **Dependent variable** | WTA of the households (million VND)                                       |
| **Independent variables** | WTA of the households (million VND)                                       |
| Age                | Age of the household head (years)                                          |
| Gender             | Gender of the household head. Dummy, 1 if male; 0 if female                |
| Average income     | Monthly average income of the household. 1 if below 5 million VND/month; 2 if from 5 to 10; 3 if from 10 to 15; 4 if from 15 to 20; 5 if from 20 to 25; and 6 if 25 or over |
| Affected level     | The affected level due to bank erosions, presented by a 5-points scale with 1 is not affected and 5 is seriously affected. |
| Erosion rate       | The erosion rate judged by the respondent using a 5-point scale with 1 is no erosion and 5 is very fast. |

2.3.2 Estimating the livelihood vulnerability to riverbank erosion. To understand the susceptibility of local households to the erosion, this paper attempted to quantify the livelihood vulnerability index of
the erosion hazard (LVI-Erosion). Livelihood vulnerability is defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of natural variability and extremes. It is a function of three major components: exposure, sensitivity, and adaptive capacity [20]. Each major component contains one or more sub-components which are explained by a variety of indicators. The livelihood vulnerability was widely examined in similar studies about the erosion hazard [21–23].

| Major components | Sub-components | Indicators | Unit |
|------------------|----------------|------------|------|
| **Exposure (e)** | Bank erosions (SC₁) | The household has no access to warnings and information about bank erosions at Cho Gao canal (I₁-1). The household has to relocate its houses and properties due to erosion (I₁-2). The household suffers damages on properties and houses due to the erosion (I₁-3). There are abnormal and adverse changes at the bank where the family is living (I₁-4). | 1: yes, 0: otherwise |
| **Sensitivity (s)** | Minimum standards of living (SC₂) | The household lacks clean water for living (I₂-1). The household has to use unstable water sources (I₂-2). The household produces its own food for daily life (I₂-3). | 1: yes, 0: otherwise |
| | Basic standards of living (SC₃) | The household finds it difficult and inconvenient to go to local health facilities because the riverside roads were eroded (I₃-1). The household uses the canal as the primary mode of transportation (I₃-2). Children in the household have to drop out of school because of the eroded pathway (I₃-3). The household does not have electricity for daily life (I₃-4). | 1: yes, 0: otherwise |
| **Financial capability (SC₄)** | The household is not supported to borrow capital for production and business (I₄-1). The household has debt at the bank (I₄-2). The household has no alternative financial resources (I₄-3). | 1: yes, 0: otherwise |
| **Demographic characteristics (SC₅)** | The number of dependent people in the household (children under 15 years old, female over 55 years old, and male over 60 years old) (I₅-1). The number of years that the household have lived in the area (I₅-2). | People, Year |
| **Adaptive capacity (a)** | Livelihood strategies (SC₆) | The household has livelihoods related to agriculture (I₆-1). The household’s livelihood is susceptible to risks of climate and erosion (I₆-2). The household has no stable income source (I₆-3). Unemployment people (I₆-4). | 1: yes, 0: otherwise |
| | Social networks (SC₇) | The local authorities support households to find jobs (I₇-1). Households do not have access to information channels on local policies and guidelines (I₇-2). The household does not receive any support from the government (I₇-3). | 1: yes, 0: otherwise |
Exposure is the degree of disturbance or stress on a system [24]. It includes the characteristics of the hazard and the system’s affected elements [25]. Thus, local households’ exposure in the Cho Gao canal was described by the bank erosion hazard. There were four indicators selected to explain the exposure: the inaccessibility to warnings and information about the bank erosion, the households had to relocate their houses and properties due to the erosion, the households had damages on properties and houses due to the erosion, and there were abnormal and adverse changes at the bank where the family were living.

Sensitivity is the characteristic that makes a system weak against stresses [26]. We categorized it into three sub-components: minimum standards of living, basic standards of living, and the household’s financial capability. The first sub-component had three explanatory indicators, the second had 4, and the final had 3.

Adaptive capacity is the capability of a system to adjust to stresses [27]. It reveals the efforts to cope with the bank erosion hazard. These efforts can come from the family or social networks of the area [28]. Thus, there are three sub-components of adaptive capacity: the household’s demographic characteristics, livelihood strategies, and social networks.

The calculation of LVI-Erosion followed the approach of Hahn et al. [29]. Firstly, all of the selected indicators were standardized because they were varied in terms of measurement units, using the formula:

\[ \text{Indicator}_{ri} = \frac{S_i - S_{\text{min}}}{S_{\text{max}} - S_{\text{min}}} \] (2)

Where Si is the collected value of the indicator i of the sub-component r, Smin and Smax are the min and max value of the indicator, respectively. After being standardized, the value of each sub-component is the average value of its corresponding indicators.

\[ SC_{ri} = \frac{\sum_{i=1}^{n} \text{Indicator}_{ri}}{n} \] (3)

Where SCri is the value of the sub-component r, indicatori is the standardized indicator indexed by i, n is the number of explanatory indicators of the sub-component r. Then, the major components were calculated using balanced weights and their corresponding estimated sub-component.

\[ MC = \frac{\sum_{i=1}^{n} W_Mi \times SC_{ri}}{\sum_{i=1}^{n} W_Mi} \] (4)

Where MC is one of the major components (exposure (e), sensitivity (s), and adaptive capacity (a)); WMi is the balanced weights, determined by the number of sub-components that make up each major component. Finally, the LVI-Erosion were calculated using the equation:

\[ LVI - Erosion = (e - a) * s \] (5)

Where e is exposure, s is sensitivity, and a is adaptive capacity. In this study, LVI-Erosion ranges from -1 to 1 with -1 is the least vulnerability, -1 < LVI-Erosion < -0.5 means very low vulnerability; 0.5 ≤ LVI-Erosion < 0 means low vulnerability; 0.5 ≤ LVI-Erosion < 1 means moderate vulnerability; and LVI-Erosion = 1 is the highest vulnerability.

3. Results and discussion
3.1. The riverbank erosion hazard at Cho Gao canal
Since 2015, erosion in the canal has become more severe, mainly attributed to the narrow channel flow with high traffic density (figure 1). About 80% of the traffic are vessels and barges carrying super-heavy sand from 500-1,000 tons and often cruise simultaneously, leading to very large waves hitting the
riverbank banks. In addition, traffic congestion and stranded boats often occur in un-dredged sections, which accelerates the erosion rate on both sides of the canal.

Another artificial cause of the hazard is the prevention and management of salinity in Go Cong and Cho Gao districts. Various sluice gates to control seawater intrusion and high tides were built to meet water demands for irrigation. Thus, the natural flows in small branches of the canal have been regulated without considering the heavy boat traffic and strong tidal currents in the main channel. Thus, in flood seasons or high tides, high-velocity flows go into the canal and create strong whirlpools that erode the embankments.

Since 2015, there have been hundreds of cases of landslides along the riverbanks. Many of which are deep inland from 2 to 20m, affecting the lives of thousands of households. Currently, there are 12 severe cases with a total length of over 12 km that need urgent treatment (Binh Phan commune has 10 places and Binh Nhut commune has 2 places). During the tide in early September (lunar calendar) in 2020, the rising water (water height from 30-50cm) flooded production land, causing flooding and damage to the property of crops for more than 140 hectares of agricultural production land of 410 households of Binh Phan and Binh Phu Nhut communes.

The erosion hazard caused many families to lose land, houses, and traffic roads, so they had to rebuild their houses and build embankments as countermeasures. The respondents said they had to spend hundreds of millions of VND per year to build embankments and to pack sandbags to prevent soil runoff. However, they were only temporary measures because strong waves from the heavy boat traffic kept hitting and washing away the riverbanks. The lives of households living along the south bank of the Cho Gao Canal (including the communes of Binh Phan and Binh Nhut Nhut, and Cho Gao town) are most severely affected. The entire road system along the south bank is almost lost, many houses are at risk of falling into the water, and business and production activities here have also been stalled. Through the results of the survey and the opinions of localities, the situation of erosions and landslides is very serious. About 42.5% of the surveyed households answered that the erosion rate in the area is very fast, and 38.33% thought that the erosion rate is fast.

3.2. Characteristics of the surveyed households

The number of male household heads accounted for 61% of the sample. In terms of age distribution, nearly all the household heads were middle-aged as the ages from 35 to 65 amounted to more than 80% of the sample. More than 77% of the interviewed households had less than 5 members. Besides, the

| Places              | Number of affected households | Average area of a house (m²) | Needed area of the resettlement zone (m²) |
|---------------------|-------------------------------|-----------------------------|------------------------------------------|
| Binh Pham commune   | 125                           | 100                         | 15,000                                   |
| Binh Phuc Nhut commune | 109                          | 180                         | 11,520                                   |
| Cho Gao town        | 50                            | 100                         | 600                                      |
| Cho Gao district    | 284                           | 380                         | 32,520                                   |

Figure 1. The eroded banks at Cho Gao canal.
number of dependent people is responsible for 21% of the population. The total people within surveyed families were 466 people, in which the numbers of children under 15, women over 55 and men over 60 were 40, 35, and 21 people, respectively.

Nearly all of the surveyed families were native people, especially the ones living at the riparian areas of the canal, as 98% of the sample has lived in the study area for more than 35 years. The longer they reside, the more they are aware of the erosion hazard and understand its underlying causes. At the same time, more years of living in the riparian areas also mean they must face greater risks and damages.

The income of interviewees in the study area was relatively low as each household only earns 5 to 15 million VND per month. The more employed members in the family, the more they are affected by disturbances from the threat. People reported that they hope the bank erosions can be resolved so that they can safely work again. The primary livelihoods in Cho Gao district are related to agricultural production activities, including fruit trees, livestock, and poultry. There were 48.33% families earning income by doing business, small trade, work as workers in factories, or day labors, and 13.33% had livelihoods related to fisheries, such as shrimp and fish fishing, to make a living or to serve for daily meals.

3.3. Willingness to accept to compensate for the erosion hazard

The average amount of the stated WTAs was 503 million VND/household (around 21872.78 USD). Compensation amounts from 10 to 200 million VND had the largest share at 39.17%. The highest WTAs were more than 1 billion VND. Some households with WTAs over 1 billion VND were responsible for 9.17% of the total survey. These households mostly suffered very high losses since they possessed large-scale manufacturing facilities that were stalled because of the erosion. Hence, they need capital to find alternative production sites and recover income. In the river erosion-prone district Bhola, Bangladesh, local households suffered economic losses due to disrupted economic activities, ranging from 1.15 USD to 588 USD [30]. In the case of riverbank erosion in the southern edge of the Pannonian Basin in Serbia and the Republic of Srpska, it takes 7.91 million Euros and 2.54 million Euros to protect the banks of Bosna River and Kolubara River, respectively [31].

Seventy-nine households answered that they were willing to accept compensation because they wanted the family to have a better life, and also thought the hypothetical program in the questionnaire was the obvious thing that the government should do and should be done as soon as possible. Also, 59 families reported that the asked scenario is a good plan. Therefore, it could be seen that the main reason households agreed to receive compensation from the project was that they wanted to have an improved

![Figure 2. WTA of the surveyed households.](image-url)
Table 4. Reasons to accept the compensation.

| Reasons                                              | Number | Share (%) |
|------------------------------------------------------|--------|-----------|
| I think this is a good plan.                         | 59     | 51.30     |
| I accept because I wanted to have a better life for my family. | 79     | 68.70     |
| I think it's the government's responsibility.        | 74     | 64.35     |
| I accept because I'm worried about my future generations. | 32     | 27.83     |
| Others                                               | 10     | 8.70      |

Table 5. Estimated linear regression model.

|                      | Unstandardized Coefficients | Standardized Coefficients | Sig. | Collinearity Statistics |
|----------------------|-----------------------------|---------------------------|------|-------------------------|
|                      | B               | Std. Error | Beta |            | Tolerance | VIF |
| (Constant)           | -1224.111       | 398.506    |      | 0.003       |           |     |
| Age                  | 13.277          | 5.362      | 0.209 | 0.015       | 0.956     | 1.046 |
| Gender               | -72.874         | 117.877    | -0.053 | 0.538       | 0.936     | 1.068 |
| Income               | 205.989         | 48.752     | 0.360 | 0.000       | 0.937     | 1.067 |
| Affected level       | 157.643         | 76.193     | 0.214 | 0.041       | 0.638     | 1.567 |
| Erosion rate         | -28.809         | 78.501     | -0.038 | 0.714       | 0.624     | 1.602 |

living which reduces the dangers from landslides for their families and communities, and were very interested in the proposed support program.

Of the 120 interview households, five were unwilling to receive from the project. The main reason for their rejection was because they were not affected by the hazard. Also, they expected more impoverished families to receive compensation. Some commented that the likelihood of the project being implemented is relatively low or their financial capabilities were good enough to not depend on the compensation.

We employed linear regression to examine factors influencing the households’ WTA. The estimated model could explain 19% of the variation of the households’ WTA. Durbin Waston test was 1.5, and all VIF values were lower than 10 moreover there was no autocorrelation and multicollinearity. Gender and the erosion rate showed no influence on the stated WTA. From the survey, both male and female household heads showed great care for their families, they have deep concerns for the safety of family members and expressed concerns about bank erosion that will adversely affect their daily lives, so there was no difference in their WTA. In addition, the coefficient of the erosion rate was also inconsistent with our initial expectation because most of the interviewees reported that the erosion rates where they were living were fast or very fast. Therefore, the data of this explanatory had slight variation, leading to an insignificant correlation with the dependent variable.

There were three statistically significant variables: age, income, and the affected level. All of these factors showed positive correlations with WTAs. Specifically, if the average income increases by 1 unit, the required compensation will increase by 205.989 million VND (around 8,952 USD). Households with higher income often possess valuable assets, so their costs from the damages were high, leading to corresponding higher WTAs. In a similar study in the river Padma of Bangladesh, many wealthy farmers became marginal farmers or even landless because of the erosion hazard [21]. Besides, if the affected level increases by 1 unit, the required compensation will increase by 157.643 million VND (around 6,851 USD); finally, if the age of the household head increases by one year, the WTA will increase by 13.277 million VND (around 577 USD).

3.4. Livelihood vulnerability to riverbank erosion

The mean and standardized values of selected indicators were presented in table 6. The exposure indicators revealed that 60.8% of the sample had to move their houses and properties away due to the erosion as the suffered damages were relatively high.
The living conditions in the study area had both advantages and disadvantages. Only a few households lacked electricity or clean water for living, educational conditions were improved, and the number of households whose children had to abandon their schooling was relatively low. Besides, medical conditions have not been effectively addressed when quite a few families feel inconvenienced while going to the local health facilities as the road traffic is not safe anymore. The families' financial capability was another problem as 63% of the sample had no secondary or alternative income source. The number of households wishing to receive loan support was quite high at 91%. Regarding social networks, there were 45% of the households reported not receiving any support from the local government. Therefore, it can be seen that the government needs to pay more attention to people's lives here. There should be policies to support people before the landslide situation in the area is officially resolved. Policy initiative was also highly recommended in the study of Shariar [32].

The standardized indicators were used to calculate the sub-components and major components of LVI-Erosion. The sub-component with the highest value was SC\textsubscript{1} at 0.618, and the lowest value was SC\textsubscript{2} at 0.115. The average values of exposure, sensitivity and adaptive capacity were 0.618, 0.371, and 0.269, respectively. These figures indicate a community that was highly exposed to the erosion hazard but have a low ability to adapt and cope with it.

The final estimation revealed that the average LVI-Erosion of people living along the Cho Gao canal was 0.064, which fell into the moderately vulnerable group. This value is equivalent to the result of Bhuiyan et al. [21] using a similar approach. The LVI-Erosion range from -0.153 to 0.260. Around 77% of the households were moderately vulnerable to bank erosion at the canal. Although the community was highly exposed to the hazard, low sensitivity helped lower the overall vulnerability to riverbank erosion. Nevertheless, this result still serves as an alert to the local authorities because unless

Table 6. Mean and standardized values of the selected indicators.

| Major components | Sub-components | Indicators | Mean | Standardized values |
|------------------|----------------|------------|------|---------------------|
| **Exposure (e)** | Bank erosions (SC\textsubscript{1}) | I\textsubscript{1,1} | 0.208 | 0.208 |
|                  |                | I\textsubscript{1,2} | 0.608 | 0.608 |
|                  |                | I\textsubscript{1,3} | 4.217 | 0.804 |
|                  |                | I\textsubscript{1,4} | 0.850 | 0.850 |
|                  | Minimum standards of living (SC\textsubscript{2}) | I\textsubscript{2,1} | 0.175 | 0.175 |
|                  |                | I\textsubscript{2,2} | 0.125 | 0.125 |
|                  |                | I\textsubscript{2,3} | 0.267 | 0.267 |
| **Sensitivity (s)** | Basic standards of living (SC\textsubscript{3}) | I\textsubscript{3,1} | 0.308 | 0.308 |
|                  |                | I\textsubscript{3,2} | 0.092 | 0.092 |
|                  |                | I\textsubscript{3,3} | 0.050 | 0.050 |
|                  |                | I\textsubscript{3,4} | 0.008 | 0.008 |
|                  | Financial capability (SC\textsubscript{4}) | I\textsubscript{4,1} | 0.908 | 0.908 |
|                  |                | I\textsubscript{4,2} | 0.117 | 0.117 |
|                  |                | I\textsubscript{4,3} | 0.633 | 0.633 |
|                  | Demographic characteristics (SC\textsubscript{5}) | I\textsubscript{5,1} | 0.800 | 0.200 |
|                  |                | I\textsubscript{5,2} | 35.580 | 0.474 |
| **Adaptive capacity (a)** | Livelihood strategies (SC\textsubscript{6}) | I\textsubscript{6,1} | 0.667 | 0.667 |
|                  |                | I\textsubscript{6,2} | 0.767 | 0.767 |
|                  |                | I\textsubscript{6,3} | 0.425 | 0.425 |
|                  |                | I\textsubscript{6,4} | 0.158 | 0.053 |
|                  | Social networks (SC\textsubscript{7}) | I\textsubscript{7,1} | 0.083 | 0.083 |
|                  |                | I\textsubscript{7,2} | 0.291 | 0.291 |
|                  |                | I\textsubscript{7,3} | 0.450 | 0.450 |
intervention is made as soon as possible, the livelihood vulnerability of the erosion will undoubtedly keep increasing as the hazard is anticipated to be increased in the future [11].

4. Conclusion
Cho Gao canal is one of the most important waterways in the Mekong Delta. However, continuous heavy boat traffic over the years has created numerous incidents of bank erosion on both sides of the canal. Adverse effects of the hazard have posed a risk to the localities' livelihood, assets, production, and transportation.

This study applied the CVM to appraise the damages from bank erosion through the compensation people want to accept. We discovered that each household along the canal received 503.4 million VND (around 21,872.78 USD) to cover their losses. Besides, when the household head's age or income is higher, they tend to answer a higher WTA. In addition, when the affected level due to riverbank erosion increases, the household is also willing to receive a higher payment from the hypothetical project.

The livelihood vulnerability of erosion of local households was also quantified and confirmed that the community living along the Cho Gao canal is moderately vulnerable to erosion. Notably, the local people were highly exposed but had low adaptive capacity due to poor living conditions, unstable incomes, and limited capital. The study found that local families urgently need support from the government to improve their capabilities to cope with and adapt to the risks. Although there are many limitations, this paper revealed and provided informative insights into the erosion hazards at the Cho
Gao canal in terms of social-economic aspects. Nevertheless, there are remain many potential opportunities for further research to be conducted in this area.

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