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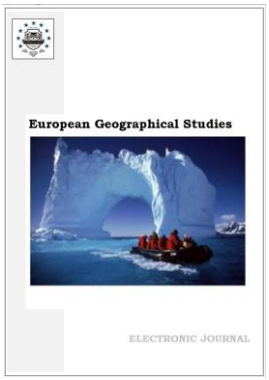

Shoreline Changes and Their Impacts on Tourism: A Case Study of Sam Son City, Thanh Hoa Province, Vietnam

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Abstract

Sam Son has over 17 kilometers of coastline, making it advantageous for marine tourism and resort tourism. However, various types of research have confirmed that climate change has impacted on tourism activities. The change in shoreline can have a significant impact on tourism infrastructure, as it can alter the accessibility, safety, and attractiveness of coastal destinations. The aim of the paper is to analyze the shoreline change rate over 33 years (1989–2022) and its impacts on tourism in Sam Son. Multi-temporal satellite images were used to extract shorelines, and Digital Shoreline Analysis Systems (DSAS) was used to detect the rate of shoreline change. The results indicated that the shoreline change of Sam Son can be divided two parts, including the Hoi estuary zone and the Do River estuary area. In the Hoi estuary, the erosion rates range from -2.22 m/yr to -40.32 m/yr. Buiding FLC Sam Son for tourism is one of the causes of loss of sedimentation in this area. Additionally, in the Do River estuary, the rate of accretion has significantly increased, reaching to 9.7 m/yr. This phenomenon of sediment accumulation is the foundation for building resorts to serve tourism in Sam Son.

Keywords: shoreline change, tourism, DSAS, and Sam Son.

1. Introduction

Coastal areas are some of the most popular tourist destinations worldwide, attracting millions of visitors every year. However, climate change is causing significant and ongoing changes to coastlines (Duong, 2021), which are having a range of impacts on tourism in these areas. Climate change is also leading to an increase in the frequency and severity of extreme weather events, such as hurricanes, tropical storms, and flooding, which can cause significant property damage and disrupt tourism activities. This can have serious economic consequences for tourism-based communities and small businesses.

Moreover, changing weather patterns and temperatures can also have indirect effects on tourism activities, such as water sports, hiking, and wildlife viewing, which may become less predictable, more difficult to access, or be impacted by changes in wildlife behavior due to changes in the environment.

The sea level rise caused by global warming, and coastal erosion (Zhang et al., 2004) is leading to the loss of shoreline infrastructure. This loss can make it more difficult for visitors to enjoy the beach and can reduce the overall attractiveness of coastal areas as tourist destinations.

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Additionally, coastal erosion can damage businesses that rely on tourism, such as hotels and restaurants, and can make it harder for them to operate effectively. (Paterson et al., 2010). In the erosion studies, there is a persistent debate regarding the extent to which coastline erosion is influenced by natural versus human factors, including tourism development and urban growth (Nguyen et al., 2020).

Thanh Hoa is a province located in the North Central Coast of Vietnam, and it is home to a well-known seaside resort called Sam Son. The resort is situated approximately 15 km from the provincial capital (Nguyen Xuan Hai, Thanh, 2020). Despiteits popularity as a tourist destination, Sam Son's beach tourism industry is facing major challenges due to unsustainable exploitation and development practices, compounded by the effects of climate change. According to a study by Cong Quan Nguyen and V.H. Pham in 2016, the cumulation rate along the northern and southern coast of Hoi river mouth reaches 5 to 10 m/year, while the erosion at the Hoi estuary is weaker, only about 3-5 m/year (Cong Quan Nguyen, Pham, 2016). The narrowing of Sam Son town's administrative boundaries caused by coastal erosion has resulted in direct impacts on human life, tourism resources, infrastructure, historical and cultural relics, seasonality, and all tourism activities in the area (Nguyen Xuan Hai, Thanh, 2020).

This study addresses the current status of coastal erosion and accretion for the beaches of Sam Son, which were selected for their popularity as tourist destinations and the likelihood of significant anthropogenic influence on shoreline change. The shoreline changes were detected using Landsat images. Remote sensing techniques for shoreline detection include extracting the ratio Green/Near Infrared (Lan et al., 2013), Histogram thresholding on band 5 (Alesheikh et al., 2007), and NDWI (Kuleli et al., 2011). In this paper, the NDWI was used to extract shorelines, and continuing coastal erosion and accretion rates were calculated using the Digital Shoreline Analysis System (DSAS) (Baig et al., 2020).

2. Study area

Sam Son City is a coastal city situatedin Thanh Hoa province, located in the North Central Coast region of Vietnam (Figure 1). It is located approximately 16 kilometers from the center of Thanh Hoa City and 170 kilometers from Hanoi, the capital city of Vietnam. Sam Son City is well-known for its beautiful beaches, which attract many tourists from both Vietnam and other countries. Sam Son has several attractions, including Truong Le Mountain, which offers a beautiful panoramic view of the city and surrounding areas. Additionally, there is Hon Trong Mai and Doc Cuoc Temple, both of which are situated at the top of Doc Cuoc Mountain.

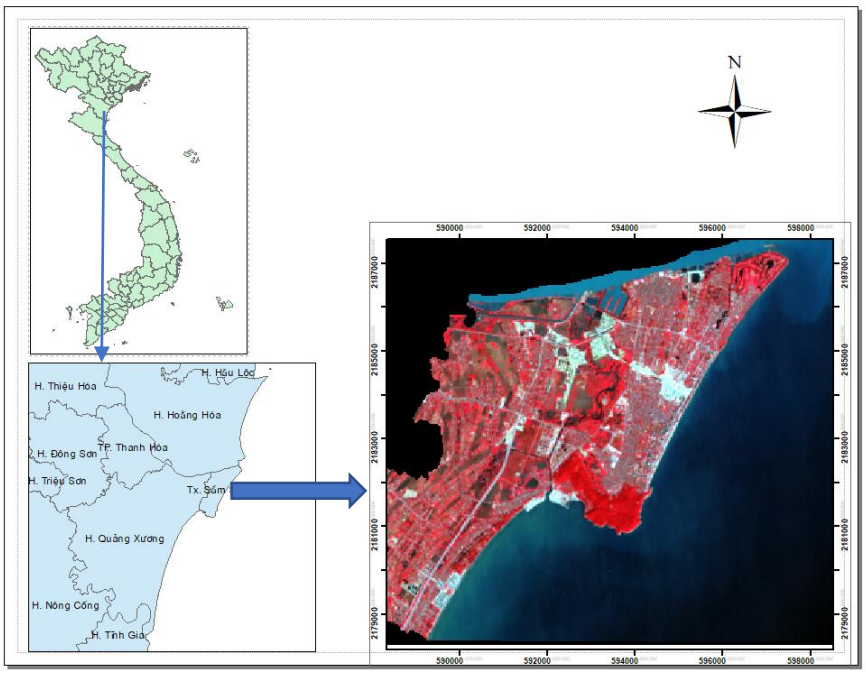

Fig. 1. Study area

The shoreline of Sam Son Cityhas experienced significant changes in recent years due to natural and human-induced factors. Coastal erosion, sea level rise, land subsidence, as well as human activities like sand mining and coastal development have all contributed to alterations in the shoreline. The loss of beach area and changes to the shoreline can significantly impact tourism in Sam Son City since the area's beaches are a major attraction for tourists. Furthermore, coastal erosion can cause damage to infrastructure and properties along the coast, resulting in economic losses.

In conclusion, shoreline change in Sam Son City is a complex issue that requires a multifaceted approach to address. It is crucial to monitor the the shoreline continually and implement appropriate measures to ensure the long-term sustainability of the coastal environment and the local economy.

3. Materials and methods

Multi-temporal Landsat satellite data were downloaded from the USGS website (https://earth explorer.usgs.gov/) for 1989, 2001, 2013 and 2022. The satellite images that have been downloaded are in UTM projection, specifically in zone 48N and using the WGS 84 datum. The details of the satellite data used and its details are shown in Table 1.

Table 1. Landsat image list (L7 – Landsat 7 ETM+; L8 – Landsat 8; L5 – Landsat 5 TM)

Sensor	Acquisition date	Tidal level (m)
L8	20221017	3.21
L8	20131227	3.01
L5	20010929	2.61
L5	19891123	2.5

To analyze the shoreline change along the coastal tract of Sam Son, a process has been followed as given in Figure 1. The shorelines were extracted from Landsat in 1989, 2001, 2013 and 2022. The multi-date shoreline was also given as input in Digital Shoreline Analysis System (DSAS) tool to calculate the shoreline change statistics.

3.1. Shoreline extraction

Shoreline extraction using satellite images is a process that involves separating land and water bodies. One of the indicators that is sensitive to changes in water content and can be used to detect water-related objects is the normalized difference water index (NDWI), which is derived from the near-infrared (NIR) and short-wave infrared (SWIR) channels of remote sensing data (Gao, 1996). The NDWI can also be derived from NIR and green channels in remote sensing data (McFeeters, 2007). The NDWI is considered one of the most commonly utilized water indices for extracting shorelines (Liu et al., 2017). In this study, the NDWI value was derived by Gao (1996) for Equation 1.

$$NDWI = \frac{NIR-SWIR}{NIR+SWIR} \quad (1)$$

Where NIR is the near-infrared band of Landsat; SWIR is the short-wave infrared channel of Landsat.

Multi-temporal satellite imageries areíused to extract shoreline data through online visual digitization in vector format using ArcGIS10.1. Shorelines are manually and individually digitized from each satellite image for the purpose of extraction. The shorelines were added to a personal geodatabase with following five attributes: ObjectID, Shape, Shape_Length, Date_, and Uncertainty. The shorelines extracted at different times were combined into a single feature in the attribute table, resulting in a single shapefile.

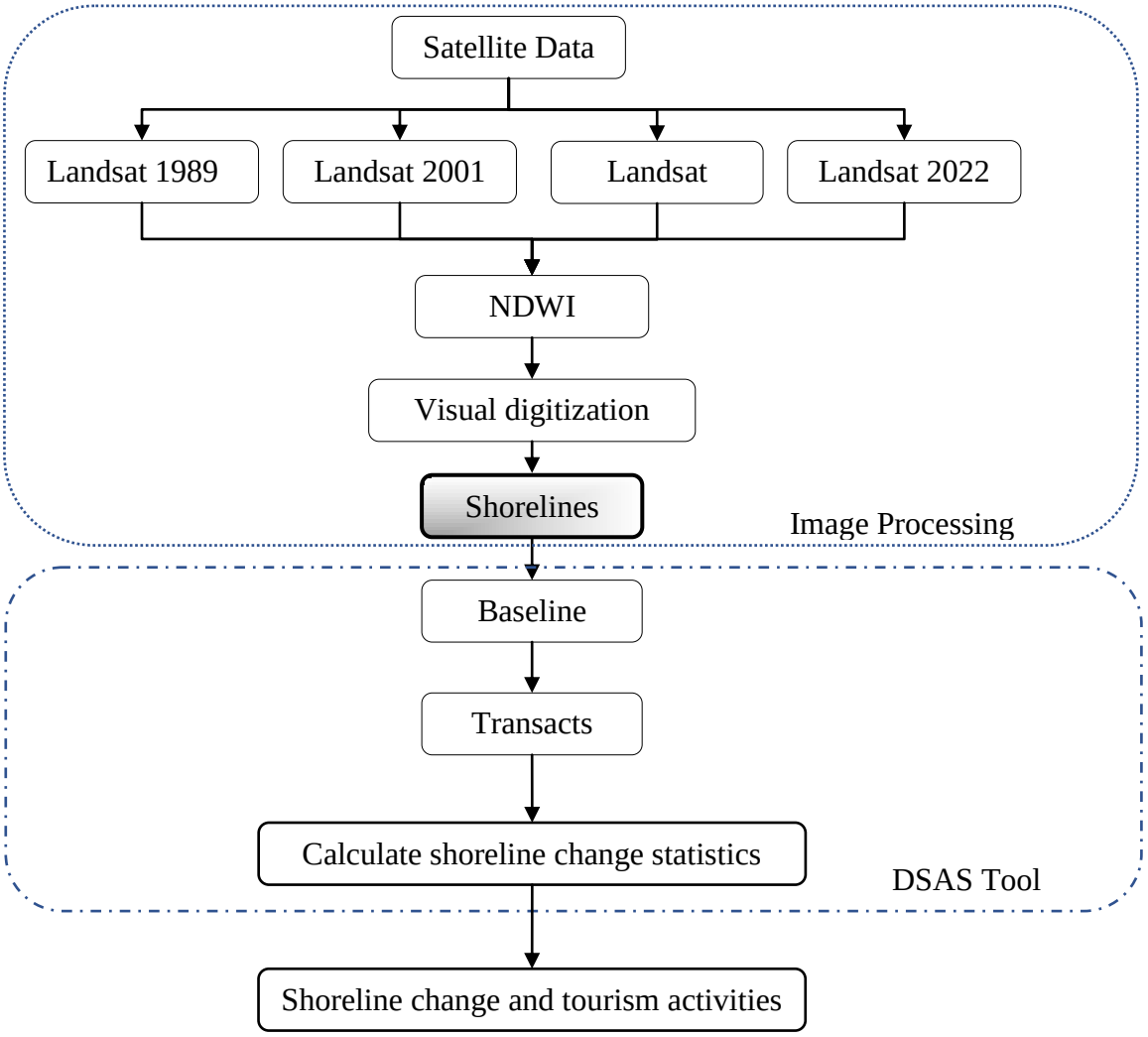

Fig. 1. Flow chart of the methodology

3.2. Shoreline change

In this study, the DSAS tool was used to estimate shoreline change. The changes to the shoreline were determined by incorporating the shoreline positions referenced to the established baseline. The variation in the coastline was determined by the intersections of transects oriented perpendicular to the shoreline (Kuleli et al., 2011). It is essential to establish the baseline adjacent to the series of shoreline positions. Transects should be cast perpendicular to this baseline at a spacing defined by the user to intersect the shorelines and establish measurement points. The position of the baseline plays a significant role in determining the orientation of the transect through the shorelines.

In this study, 521 transverse transects, each 1700 meters long and perpendicular to the offshore baseline, were generated at 50-meter intervals along the coastline (Figure 2). The DSAS methodology was used to evaluate the erosion and accretion rates of shoreline positions by utilizing the end point rate (EPR) and linear regression (LRR) techniques. To determine the end point rate (EPR), the distance of shoreline movement is divided by the time elapsed between the oldest and most recent shoreline positions. The LRR approach has encountered issues when fitting a least squares regression line to all shoreline points along a specific transect to determine the slope of the line, which represents the rate of shoreline change. The LRR method assumes a linear trend between the earliest and latest shoreline dates to calculate the rate of shoreline change. The metadata files for long- and short-term transects contain information about the two fields associated with the linear regression rate calculation. Instead of a single shoreline point, the LRR

method involves fitting a least squares regression line to multiple shoreline position points for a particular transect (Figure 3).

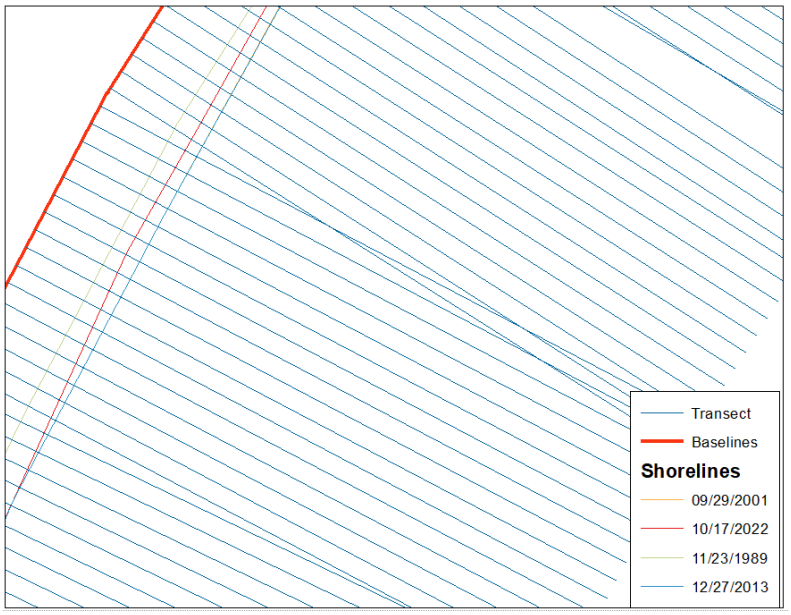

Fig. 2. Launching of transects from the baseline parallel to the shoreline vectors

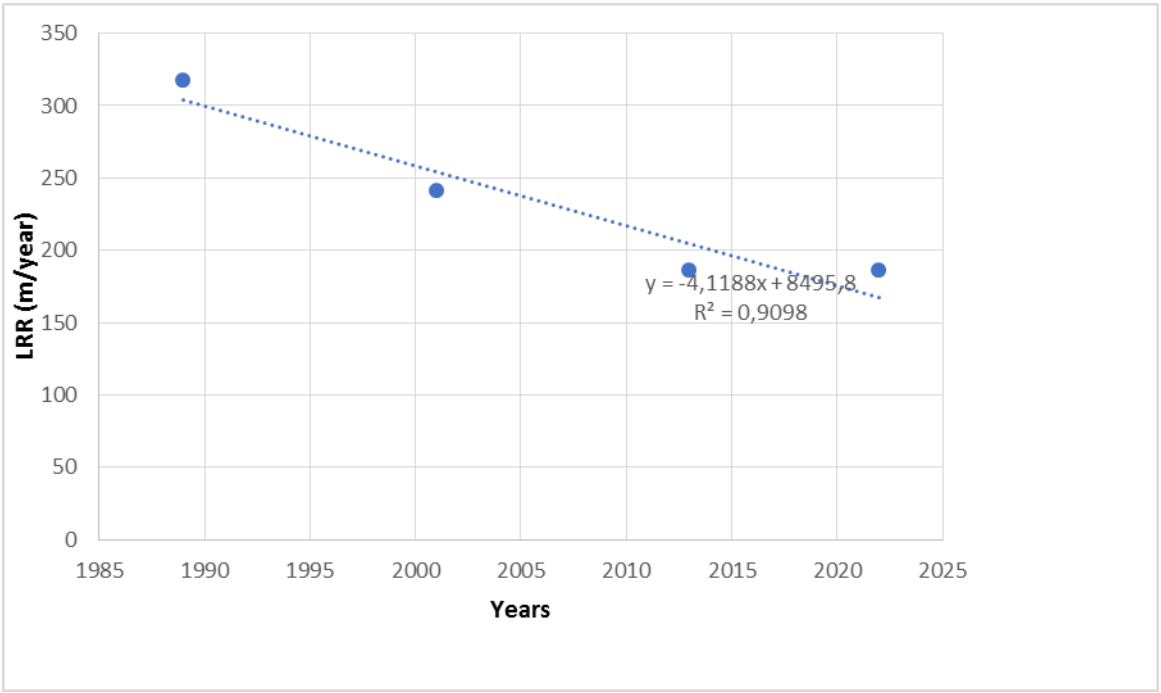

Fig. 3. Representation of a typical cross-plot showing LRR for shoreline change in Sam Son City

4. Results and discussion

4.1. Shoreline state

The geomorphological features of the coastline play a crucial role in detecting beach conditions, specifically those related to coastal erosion. The shoreline is a dynamic system that responds quickly and continuously evolves, with trends monitored through mapping on various dates through data collection in the field or satellite imaging (Mendonça et al., 2020). The rate of shoreline change for Sam Son has been analyzed using the LRR method. The study shows that Sam Son experienced both erosion and accretion. The rate over 521 transects, erosion rates ranged from

-0.77 m/year to -40.32 m/year, while the accretion rate along the coast ranged from 0.68 m/year to 9.7 m/year. Moreover, the LRR indicates that stable and insignificantly changing shoreline areas are concentrated in the Trung Son, Bac Son, Truong Son, Quang Vinh, Quang Hung, and Quang Dai regions (Figure 4).

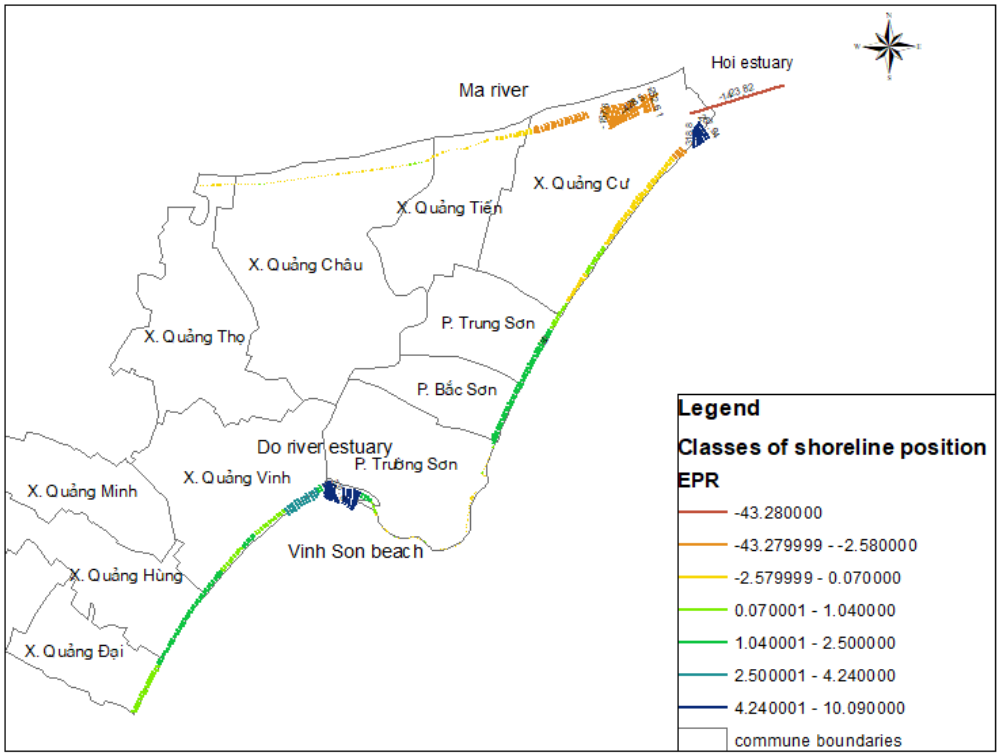

Fig. 4. Shoreline accretions and erosion of Sam Son coast with LRR

4.2. Shoreline change and tourism

Sam Son is one of the beautiful beaches in Vietnam that attracts many tourists. However, in recent years, Sam Son has been strongly affected by climate change, which has significantly impacted tourism activities. Climate change affects various tourism activities, including tourism resources, infrastructure and technical facilities serving tourism activities, and touristic operations. Specifically, climate change indirectly impacts tourism resources (20 %), tourism infrastructure (30 %), and tourism technical infrastructure (15 %) and affects seasonality in marine tourism (35 %). Additionally, climate change indirectly impacts tourism services, such as resorts, passenger transfers, and sightseeing activities, as entertainment depends heavily on weather conditions (Nguyen Xuan Hai, Thanh, 2020). Due to the impact of climate change, Sam Son City in Thanh Hoa Province has experienced unusual patterns of activity, such as an increased frequency and intensity of storms. These storms arrive earlier and last longer than average in many years, which has seriously affected the overall tourism development, as well as the technical infrastructure and tourism facilities of Sam Son City in particular (Le, 2022). One of the impacts on the technical infrastructure material factor for tourism in Sam Son is shoreline change and tourist accommodation facilities.

The rate of shoreline changes is strongest in two areas, namely the Hoi estuary (Figure 5) and the Do river estuary (Figure 6).

The accretion process is concentrated only in the southern part of Hoi estuary with rates ranging from 4.97 to 9.7 meters per year. Hoi estuary is the downstream area of the Ma River system, which annually discharges millions (approximately 5.17 million) of tons of sediment into the sea (Van Cu Nguyen, Pham, 2003). The amount of sediment is formed through the process of accumulation at river mouths, such as that of the Hoi estuary. On the other hand, the area to the north of the Hoi estuary experiences severe erosion, with erosion rates ranging from -2.22 m/yr to -40.32 m/yr. The strongest erosion, which reaches a rate of -40.32 m/yr, is associated with the

most complex erosion-accretion activity. In this area, coastal erosion is caused by both natural factors and land exploitation activities. The natural factors include climate events such as storms, rising sea levels, and waves (Viet Cuong Ho, Le, 2012; Manh Hung Le, Ho, 2013). The activities of land exploitation cause depletion of sediment supply, leading to erosion. One of the most prominent land exploitation activities is the construction of tourism accommodation facilities such as Sam Son FLC complex and Van Chai resort. 8. As a result, sand mining in this tourism area has led to the loss of the source of sediment deposition and this activity also creates a swirling current of waves that washes away the sediment, leading to coastal erosion.

In addition, based on consultations with stakeholders in the field, it has been identified that the severe impact of evaluation results has affected tourism infrastructure (Nguyen Xuan Hai, Thanh, 2020), such as shoreline change. The services in marine tourism that are affected by shoreline change (erosion) in Sam Son are shown in Table 2.

Table 2. Matrix analysis of limitation, and factors affecting marine tourism in Sam Son

Areas	Tourism activities	Limitations
Along the coast of Ho Xuan Huong	Hotels, Public swimming beaches, Shopping, Restaurant	Infrastructure has not fully invested, Sea level rise, Planning is not synchronized
Quang Cu commune		Natural disaster risks; erosion; Environmental pollution; Infrastructure is low; Services are not yet developed; Landslide.

Source: Nguyen, Tran, 2020

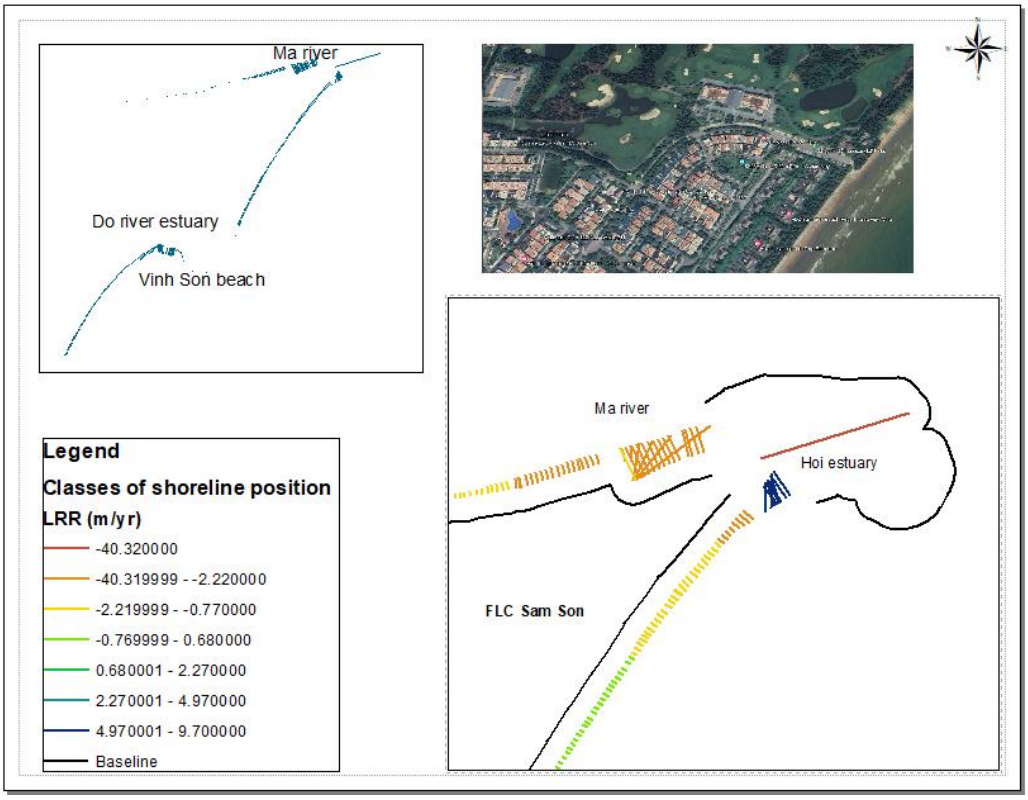

Fig. 5. The rate of shoreline change in Hoi estuary (LRR)

The Do river estuary is where the process of sedimentation and formation of Vinh Son Beach and Nam Sam Son Beach take place. This area is located to the west of the Truong Le mountain range.

Therefore, sediment and sand are deposited by the action of waves and tides. Leading to accumulation rate of up to 9.7 m/yr (Figure 6). The deposition of sediment at the mouth of the Do River serves as the foundation for developing resort areas that cater to tourism. Currently, this area has been filled with additional sand and built boundaries for the purpose of building resorts and hotels.

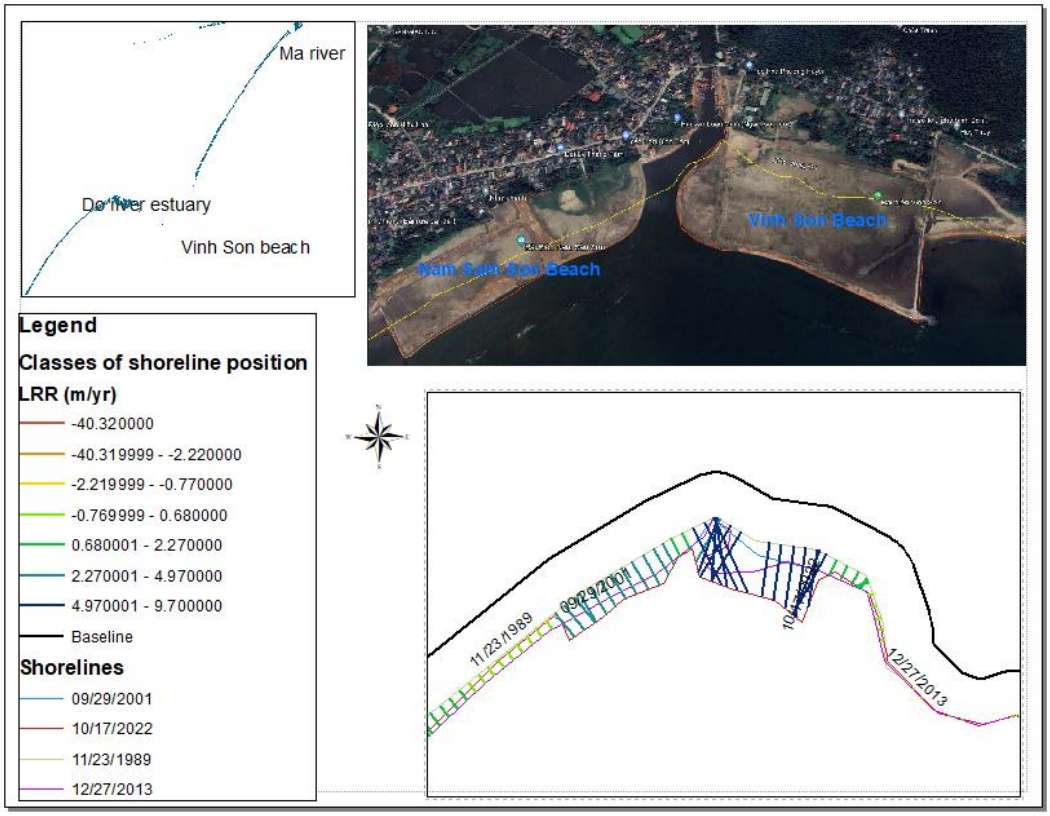

Fig. 6. The rate of shoreline change in Do river estuary

5. Conclusion

The impact of shoreline change on tourism in Sam Son City has been significant. The city's beautiful beaches are a major attraction for tourists, and any changes to the shoreline can have an adverse effect on the tourism industry in the area.

Coastal erosion and land subsidence have caused the loss of some beach areas, potentially reducing the number of tourists visiting Sam Son City. This could have a negative impact on the local economy, as tourism is a significant source of income for the area. In addition, the shoreline changes can also impact the availability of recreational activities, such as swimming and sunbathing, thereby decreasing the area's appeal to tourists.

To address the adverse effects of shoreline changes on tourism in Sam Son, Thanh Hoa, it is crucial to adopt sustainable and eco-friendly tourism practices. This can encompass initiatives like beach nourishment projects, the promotion of ecotourism, and the integration of measures to mitigate the effects of climate change. Furthermore, it is essential to involve the local community in tourism development and management to ensure that tourism benefits the local economy and promotes the preservation of natural resources.

Overall, addressing the problem of shoreline changes in Sam Son City is crucial to ensuring the sustainability of the local economy and the long-term viability of the region as a favored tourist destination.

6. Acknowledgments

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