
Shifting Trends of Estate Sand Dunes and Effects on Population Activities in The Cua Dai Area, Quang Nam Province Vietnam

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ABSTRACT: The movement of estuarine dunes is a complex process, attracting a lot of attention from scientists. Since its second visible appearance in 2018, many scientists with specialized methods have sought to understand the causes and mechanisms of dune formation in front of Cua Dai. Some studies have shown that the dunes in front of Cua Dai tend to move north and are associated with the dunes on the north bank of Cua Dai. However, these studies only evaluate based on natural laws and ignore the impact of people's development activities. Using general research methods of geographical science, the article has shown the current and future movement trends of dunes in front of Cua Dai: expanding to the west, moving inside Cua Dai, down south, and tending to connect with the sand bar on the southern shore of Cua Dai.

KEYWORDS: displacement, estuarine dunes, Cua Dai

1. INTRODUCTION

Estuarine dunes are dynamic and fascinating ecosystems that play an important role in the coastal environment. This unique landform is formed at the intersection of rivers, estuaries, and oceans. Although there is still much debate about the origin and formation of estuarine dunes, most people believe that estuarine dunes are formed due to the impact of river water flow sediment factors, and river activity. Wave movements and tidal currents (V.N, 1966) (Nishikawa & Ito, 1998) (Quentin H.T. Smith, 2010). There are three modes for estuarine dunes to form and exist: estuarine dunes are formed and are stable for a long time, estuary dunes are formed and then destroyed, and no underground dunes are formed (Gao W., 2018). However, to form estuary dunes, it must go through three stages: the estuary underground dune formation stage, the estuary dune formation stage, and the morphological change stage (Vu Van Phai, 2023). The life cycle of estuarine dunes goes through three periods: dunes originally existed inland (during the last glacial maximum), global warming caused rapid marine invasion, combined With a typical terrain height, it has separated into dunes from the mainland, dunes are connected to the mainland under the impact of the sea reclamation process combined with the phenomenon of flooding at the river mouth (Helmut Bruckner, 2017). The formation of estuarine dunes in each country not only has an impact on the economic and social development of the region but also plays an important role in maintaining the ecosystem and providing vitality for many people. flora and fauna. Therefore, they attract the attention of researchers, especially researchers on river and sea dynamics with traditional and modern methods. Edmonds and Slingerland (2007) used the Delft3D hydrodynamic model combined with morphodynamics to synthetically simulate the estuarine dune formation process (DA Edmonds, 2007). William Nardin and Sergio Fagherazzi (2012) used the sediment transport model combined with the Delft3D-SWAN wave model to clarify the role of waves in the formation of dunes blocking estuaries (William Nardin, 2012).

Dunes in front of Cua Dai, Quang Nam province, Vietnam, after appearing clearly in 2017 after the 2016 historic flood that took place in the Thu Bon river basin, have received the attention of many scientists. (including scholars around the world) to explain the causes and mechanisms of the formation and development of this dune. However, the formation and transformation of dunes outside Cua Dai is completely different from the mechanism of formation of dunes in front of delta estuaries (Vu Van Phai, 2023)), so there is still a lot of inconsistency. in views. Nguyen Kim Dan and Huynh Cong Hoai (2019) based on field measurement data to calculate hydrodynamic regime using the Croco-3D model, Telemac system, and Litpack system. The results show that under the influence of coastal currents, Northeast and Southwest monsoons have formed dunes in front of Cua Dai (Nguyễn Kim Đan, 2019). Vu Van Phai and colleagues (2019) using the method of coastal morphodynamic analysis combined with the remote sensing mapping method, believe that the formation and evolution of dunes outside Cua Dai is a natural phenomenon, depends on the long-term and complex interaction between the dynamics of the Thu Bon River and the outer sea, including the Cu Lao Cham archipelago; At the same time, the research team has initially pointed out the material source of formation and evolution of dunes in front of Cua Dai (Vu Van Phai, 2023).

Thus, studies have shown that the dunes in front of Cua Dai appear for many different reasons, and tend to move and change significantly due to the influence of many factors. Using general research methods of geographical science, this article will

Shifting Trends of Estate Sand Dunes and Effects on Population Activities in The Cua Dai Area, Quang Nam Province Vietnam

clarify those shifting trends and their impact on economic development in the Cua Dai area, contributing to the development of management strategies, and planning for this area.



Fig 1: Research area

2. DATA AND RESEARCH METHODS

- Data collection and analysis methods: research data related to estuary dunes in the form of articles are collected and analyzed to evaluate the role of estuary dunes in the scientific environment. At the same time, data on the terrain of the Cua Dai area in the past was collected to clarify the shifting trend of dunes in front of Cua Dai. Economic and social data related to the research area were also collected during the process of completing this article.

- Field survey method: seabed topography data, and dune topography in the Cua Dai area were measured during a field survey in August 2023 to build a bottom topography map of Cua Dai area scale 1/10,000 and determine the area and height of dunes in the East, North, West, and South directions.

- Mapping, remote sensing, and GIS methods: to clarify the shifting trend of dunes in front of Cua Dai over 35 years (from 1988 to 2023), data in the form of maps and satellite images. In the past, field measurements were processed using GIS.

3. RESULTS AND DISCUSS

Some studies have shown that, in the past, dunes in front of Cua Dai once existed as underground dunes in front of the river mouth (Vu Van Phai, 2023) (Cham, 2019) (Fig 2). However, this article does not discuss the process and causes of dune formation but only discusses its shifting trend from its apparent appearance until the present time.



Fig 2: Cua Dai area in 1965 (topographic map of Cua Dai area at 1/50,000 scale) (Vu Van Phai, 2023)

Observations on a series of satellite images from 1988 to 2023 show that dunes in the area in front of Cua Dai have appeared clearly in 02 periods. Through the processes of sediment transport, topographic conditions, and mixed river-sea impacts, materials can be brought to accumulate in front of the river mouth, forming sandvouches and underground dunes. then gradually developed

Shifting Trends of Estate Sand Dunes and Effects on Population Activities in The Cua Dai Area, Quang Nam Province Vietnam

into an alluvial ground in front of the river mouth. The bottom terrain of the Cua Dai area was strongly accreted. The sedimentation process formed a long sand bar that emerged from the water to form a dune in front of the river mouth.

The first time it appeared (starting from 1988 to 1992), the dunes in front of Cua Dai had a crescent shape, distributed on the northern bank of Cua Dai. During this period, the marine dynamic regime prevailed, the flow in the river was small, the amount of sediment and sand carried from the river to the sea was an average of 80,000 m³/year (Figure 4), the coastal current due to waves directed upward North (Cham, 2019). Therefore, the dunes have been connected to the sand bars on the North coast of Cua Dai and the area has tended to gradually shrink since 1990. Although during this period the effects on people's activities in the Cua Dai area have not been recorded, received by information sources, but it can be seen that the dunes have blocked 2/3 of Cua Dai, losing the entire channel on the North bank, and somewhat hindering the sea travel activities of ships.

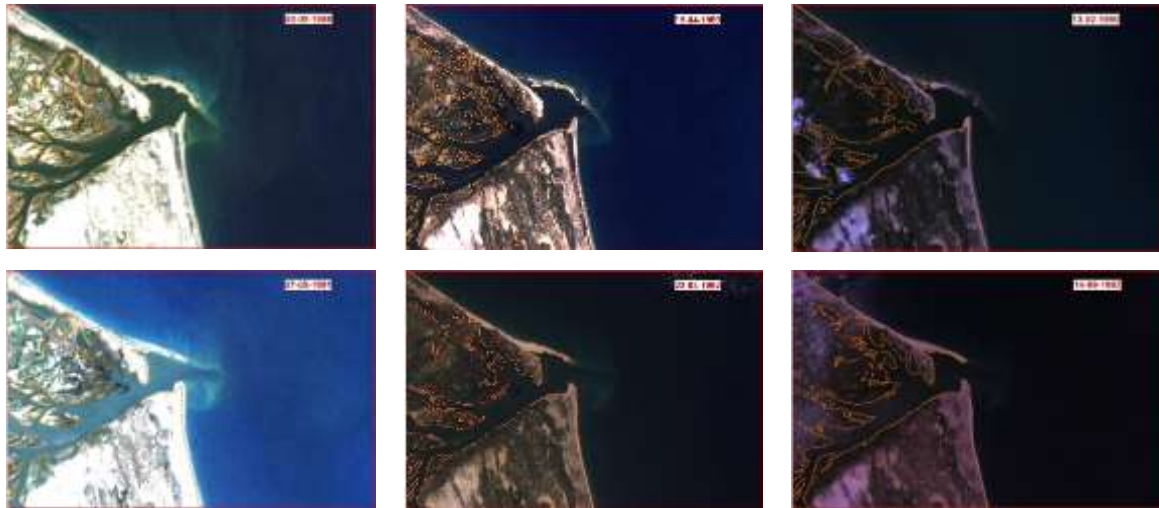


Fig 3: The first appearance of dunes in front of Cua Dai

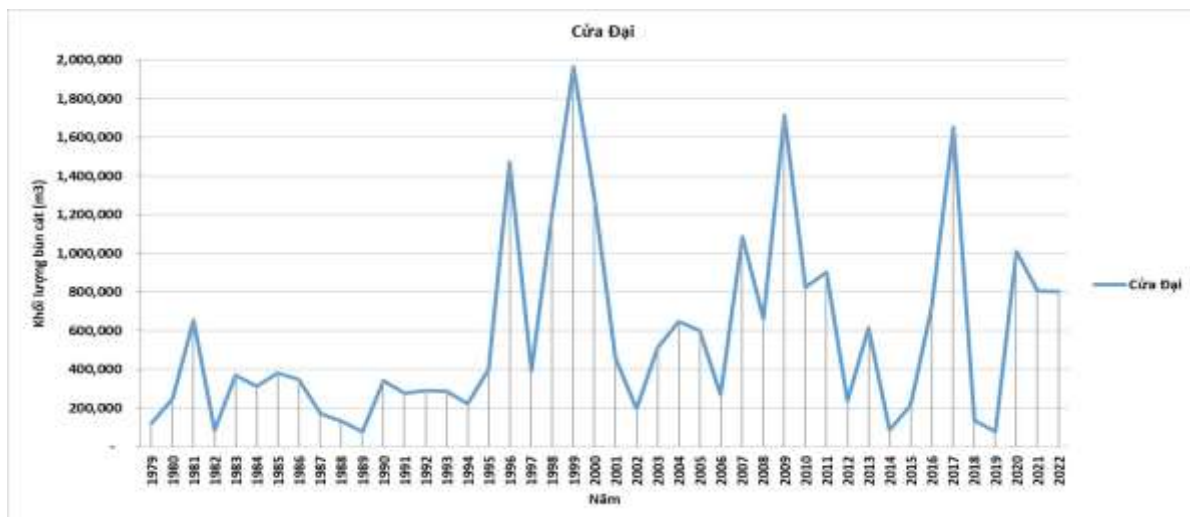


Fig 4: Volume of sediment and sand transported to Cua Dai from 1979 to 2022

From 1993 to 2017, the dunes attached to the sand bar on the North bank, under the influence of waves, moved into the river, partly pushed north by coastal currents. In the area outside the gate, stable, underground dunes exist with unclear shapes. During this period, civil activities continued to take place. However, at this time, the river mouth has lost its "natural breakwater", so under the influence of the dominant river dynamic regime, it has led to erosion in the coastal area, causing a significant impact on the river, coastal resources, and tourism business activities in the Cua Dai area. However, during this period, the bottom terrain was deposited with a fairly large volume of sand and mud from the river (especially in 1996, 1999, 2009, and 2017) with the material mainly being small fine sand, formed from sandbanks. This is the basis for the dunes in front of Cua Dai to appear for the second time.

Shifting Trends of Estate Sand Dunes and Effects on Population Activities in The Cua Dai Area, Quang Nam Province Vietnam



Fig 5: Dunes exist as underground dunes, with unclear shapes

The second appearance (starting from 2018 until now), the dune appeared with a length of about 20m, about 230m from the coast, and was named "dinosaur island" or "dolphin island". From 2018 to early 2019, this dune continued to develop in three directions North, East, and South, while the west direction remained unchanged. Some studies have shown that the evolution of dunes can follow the trend of gradually moving closer to the northern shore of Cua Dai eroding over time and then disappearing in the absence of major floods in the area. The Thu Bon river system and wave and flow regime are normal as before 2017 (Cham, 2019; Vu Van Phai, 2023). However, the results of the process of combining field measurement data in 2009, 2019, 2020, and 2023 with images obtained from satellite images show that dunes tend to expand to the West, gradually moving inward and down south of Cua Dai.



Fig 6: The first appearance of dunes in front of Cua Dai (years 2018, 2019, 2021 and 2022)

The morphology, area, and height of dunes change over time. Measurement results in August 2023 show that the northern part of the dune is wide open with a height of approximately 1.7m, the southern part is small, approximately 1m high.

Shifting Trends of Estate Sand Dunes and Effects on Population Activities in The Cua Dai Area, Quang Nam Province Vietnam

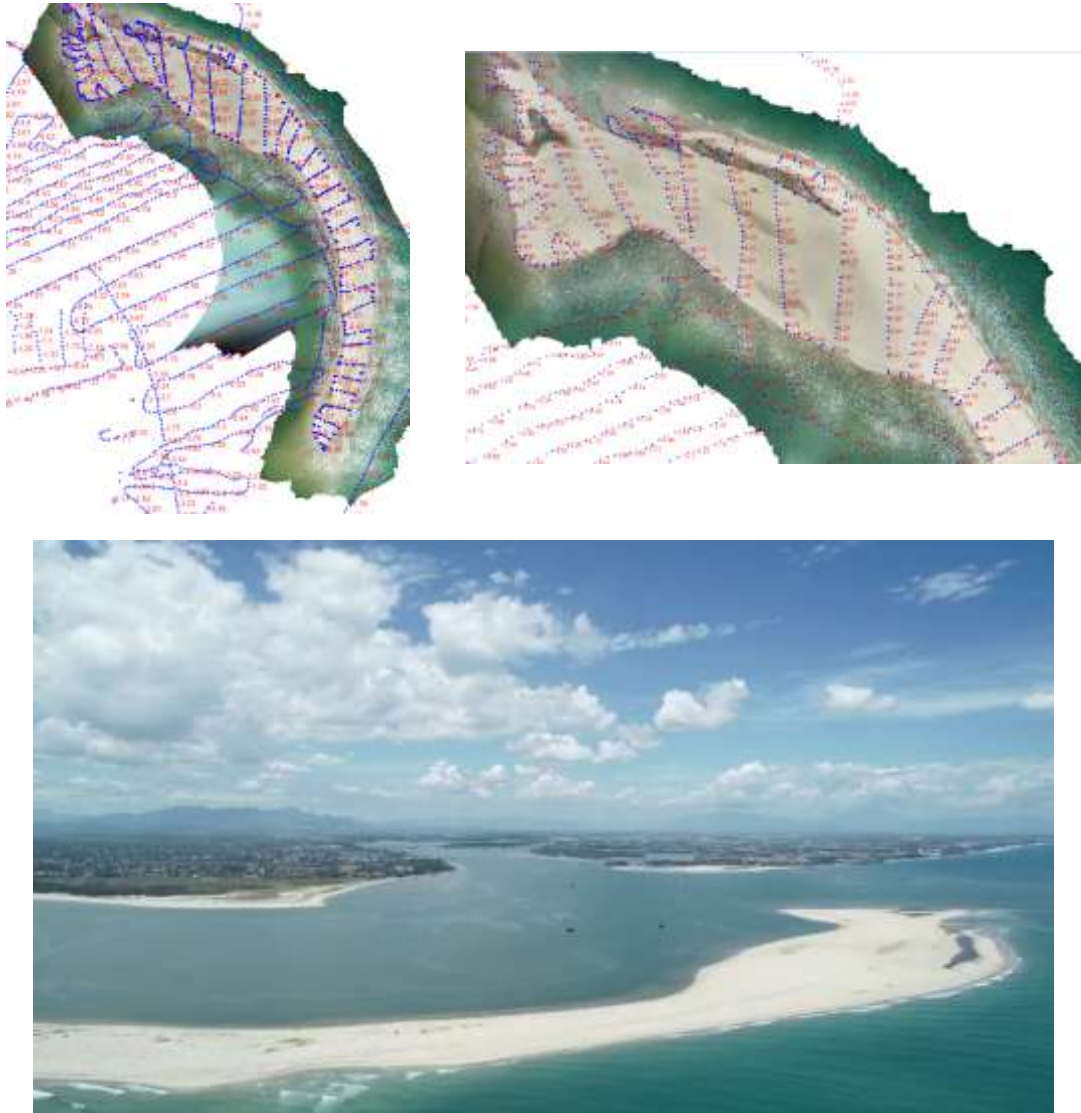


Fig 7: Dunes in front of Cua Dai in the current period

The appearance of dunes during this period had significant impacts on people's daily activities. Because the dunes are located on the shipping channel from Cua Dai to Cu Lao Cham, and the sediments tend to grow larger, the entry and exit of boats are very difficult. To solve the above problem, local authorities have used measures to clear the channel. However, the process of dredging the navigation channel in the Thu Bon River estuary area has affected the displacement and contributed to changing the morphology of the dunes in front of Cua Dai (Fig 8). In the future, under the combined impact of natural and social factors, the dunes will continue to move and connect with the sand bars on the southern shore of Cua Dai. At that time, this area once again lost its "natural breakwater", Northeast waves had the opportunity to advance strongly and perpendicular to the southern shore of Cua Dai, causing widespread erosion in this location.

Shifting Trends of Estate Sand Dunes and Effects on Population Activities in The Cua Dai Area, Quang Nam Province Vietnam

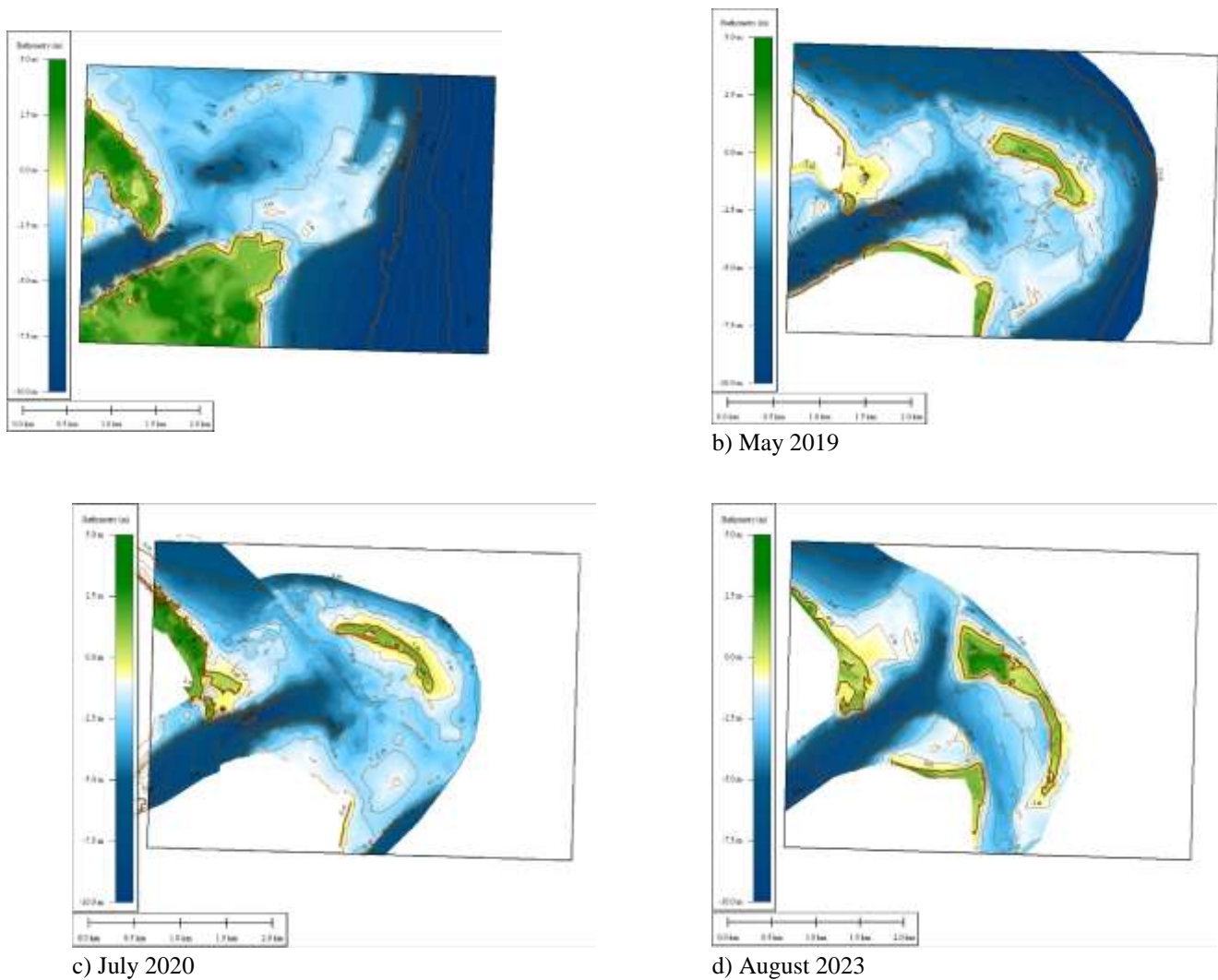


Fig 8: Terrain changes and dune deformation in the Cua Dai area

4. CONCLUSION

Using comprehensive geographical research methods, from traditional to modern research methods, it has been shown that the appearance of dunes in the Cua Dai area is a natural phenomenon. However, human economic development has increased and changed that natural development trend. If in the years before 2017, the dune in front of Cua Dai tended to move north and connect with the sand bar on the north bank of Cua Dai, then from 2019 to now, this dune tends to expand to the west, moving into the mouth, down south and possibly connecting with the sand bar on the south shore of Cua Dai.

The formation of dunes in front of Cua Dai next to it serves as a breakwater, helping to minimize wave energy hitting the shore, reducing erosion, and is a source of sand reserves used for beach nourishment in the surrounding area. It hinders navigation activities and hinders the marine livelihood activities of local people.

Clarifying the dune movement trend in front of Cua Dai is extremely important to be able to come up with effective prevention and management measures. This requires a combination of modern technologies such as GIS, remote sensing, and artificial intelligence along with natural and social science knowledge that will help respond to this phenomenon more effectively.

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Shifting Trends of Estate Sand Dunes and Effects on Population Activities in The Cua Dai Area, Quang Nam Province Vietnam

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