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Conservation Challenges for Olive Ridley Sea Turtles in North Kerala: A Case Study of Kolavipalam Beach

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Indian coastal regions harbor diverse species of sea turtles, among which Olive Ridley turtles are prevalent and commonly encountered in the coastal waters of Kerala and the Lakshadweep Islands. These turtles exhibit a preference for nesting on expansive beaches and sandy areas situated at river mouths. Our study area, located in the Irringal village of Kozhikode district in North Kerala, overlooks the Arabian Sea and lies adjacent to the Kottapuzha River. Here, the local community has undertaken a conservation initiative known as Theeram Prakriti Samrakshana Samithi (TPSS) to safeguard Olive Ridley turtles during their nesting period. During this study, we investigated the status of Olive Ridley turtle nesting grounds and populations in Kolavipalam

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surveying beach from 2019 to 2023. We recorded the number of OliveRidley sea turtle nestings during this period, collected the eggs, and assessed the hatching success from the artificial hatchery. The mean annual number of eggs hatched was 54.4 ± 23.27 and the overall nesting success was 25.73%. The study revealed a significant decline in nesting turtles compared to previous years, with only 1-2 egg-laying turtles observed yearly. Median hatch success declined dramatically from 80.21% during the earlier period to 36.41% during this study period. Our analysis identified various challenges affecting turtle nesting, including the construction of sea walls, the development of beach areas for tourism, and changes in rainfall patterns. As a result, turtles were forced to nest closer to the shoreline, making their nests more vulnerable to waves and flooding. These findings emphasized the urgent need for increased conservation efforts to safeguard these endangered sea turtles, particularly in areas like Kolavipalam, which were once ideal nesting sites.

Keywords: Olive ridley; conservation; coastal erosion; community base conservation.

1. INTRODUCTION

Sea turtles are a crucial component of the global food web and play a vital role in maintaining the health of the world's oceans. However, the management of marine resources is increasingly challenging due to escalating pressures on marine biodiversity and existing gaps in our understanding of the biology of important species, such as sea turtles (Hawkes et al., 2009). Among the five species of sea turtles found in the Indian region, four—Olive Ridley (*Lepidochelys olivacea*), Green Turtle (*Chelonia mydas*), Leatherback Turtle (*Dermochelys coriacea*), and Hawksbill Turtle (*Eretmochelys imbricata*)—nest along the Indian coastline (Kar & Bhaskar, 1982). These marine turtles in the Indian Ocean are globally classified as Vulnerable (Olive Ridley turtle and Leatherback Turtle), Endangered (Green turtle and Loggerhead Turtle) and Critically Endangered (Hawksbill turtle) according to the IUCN Red List (IUCN, 2011). Olive Ridley turtles are particularly important for coastal and marine ecosystems. They contribute to the stability of the food web by regulating prey populations and transferring nutrients from feeding areas to coastal habitats. Additionally, their shells serve as a habitat for various epibionts, which provide food for fish and shrimp, thereby supporting a diverse range of marine species (Bjorndal & Jackson, 2003).

The Olive Ridley turtle (*Lepidochelys olivacea*) is currently classified as Vulnerable on the IUCN Red List (Abreu-Grobois et al., 2008) and is also legally protected under Schedule I of the Indian Wildlife Protection Act (1972). These turtles are known to nest along the eastern coast of India, with their breeding season extending from November to May, during which mating, egg-laying, and hatching occur (Behera et al., 2010). The species is reportedly in decline across its geographical range, primarily due to pollution, habitat loss, mortality resulting from unsustainable fishing practices, and exploitation for food (Limpus, 1995). Mortality during the nesting season can lead to severe population declines, as mature individuals are permanently lost (Bhupathy & Sarvanan, 2002).

Olive Ridley turtles are commonly found in the coastal waters of Kerala (South India) and the Lakshadweep Islands. They typically prefer nesting on large beaches and sandy areas near river mouths. Kerala, with its 590 km coastline bordered by the Arabian Sea to the west and the Western Ghats to the east, encompasses approximately 6,250 km² of brackish water habitats, including marshes, backwaters, mangroves, and intertidal zones. These areas are vital feeding and nursery grounds for various commercially significant marine species such as fish, prawns, and crabs, and they also support inland transportation.

Surveys of nesting beaches are often the most practical and cost-effective method for assessing and monitoring sea turtle populations over extended periods (Schroeder & Murphy, 1999). Continuous monitoring is essential for understanding the population dynamics of sea turtles and evaluating the success of conservation initiatives (Wallace et al., 2001). This study assessed the status of Olive Ridley turtles and their nesting populations in Kolavipalam, North Kerala, in collaboration with Theeram Prakriti Samrakshana Samithi (TPSS). It focused on nesting populations, hatching success, and identifying threats to nesting sites, providing insights for future conservation efforts.

2. MATERIALS AND METHODS

2.1 Study Area

The survey was conducted in the Kolavipalam area, precisely located at approximately 11°29'38.634'' N and 75°36'54.316'' E in Kozhikode, Kerala, India (Fig. 1), during the period from 2019 to 2023. This coastline is characterized by gently sloping beaches composed of medium to coarse quartz sand. The supra-littoral zone of the beach is distinguished by dunes that rise over 10 meters in the northern region and gradually descend to a lower beach platform towards the south. The prevalent beach vegetation includes species such as *Ipomoea* spp*, Sporobolus virginicus* and Cyperaceae spp with coconut plantations predominating the central portion of the study area. The climate reflects that of a typical tropical maritime coast, with the pre-monsoon season extending from February to May, the southwest monsoon season from June to September, and the post-monsoon season from October to January. The region experiences heavy to moderate rainfall during the southwest monsoon season, while the post-monsoon season brings additional precipitation due to the influence of northeast monsoon winds. On average, the area receives 300 cm of rainfall annually, with 60% occurring during the southwest monsoon (June–September) and 30% during the northeast monsoon (October–January). Coastal processes in the region are predominantly shaped by the action of waves, currents, wind, and tides.

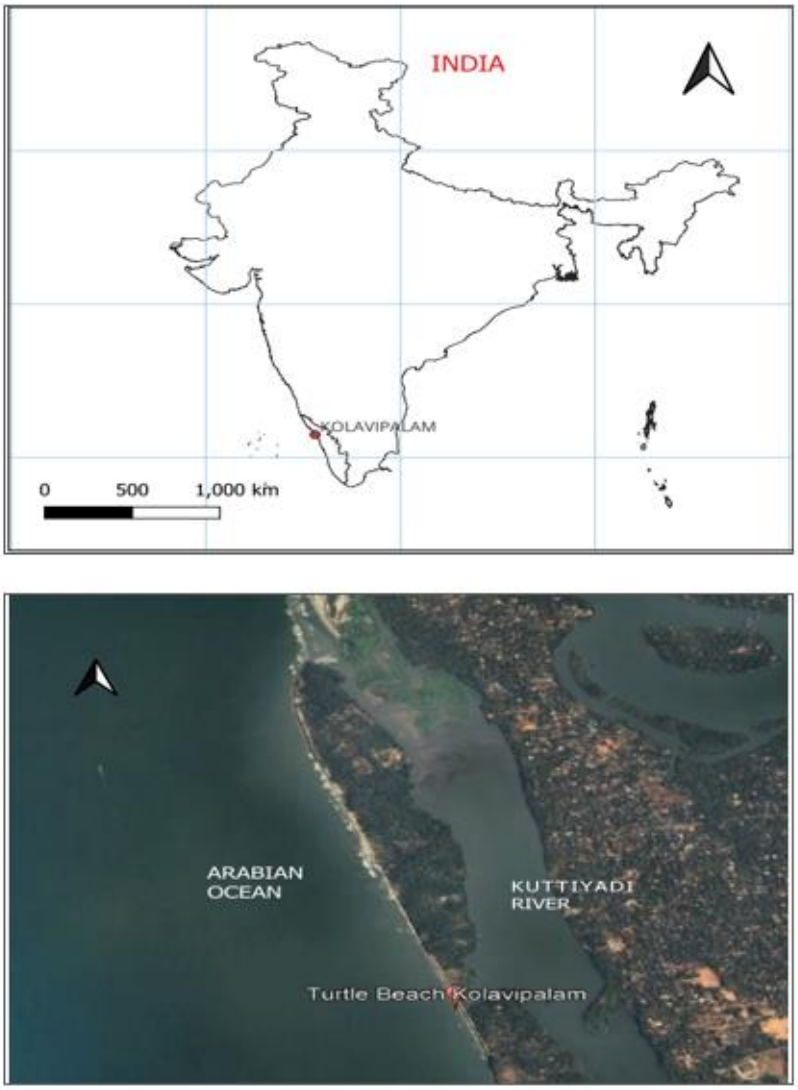

Fig. 1. Study area

2.2 Study Species

The Cheloniidae family of turtles includes the Olive Ridley (*Lepidochelys olivacea)*, often known as the Pacific Ridley. Its name comes from the olive-green hue of its carapace, which is its heart-shaped shell. When thousands of female turtles congregate on the same beach to lay their eggs, a phenomenon known as arribadas occurs, and this species is especially well-known for it (Abreu-Grobois & Plotkin, 2008). The Olive Ridley turtle, one of the seven species of sea turtles found worldwide, is one of the smallest and most abundant, yet it is threatened in a number of regions and has experienced particularly sharp population decreases in the western Pacific (Shanker et al., 2021).

2.3 Methods

In our study area, the community-driven conservation effort known as Theeram Prakriti Samrakshana Samithi (TPSS) was introduced by residents to safeguard Olive Ridley turtles during their nesting season dates back to 1998, initiated through collaboration between local communities, the Kerala Forest Department, and WWF. A resident of Kolavipalam, Mr. Suresh Babu played a pivotal role in its establishment, prompted by the annual migration of Olive Ridley turtles, *Lepidochelys olivacea*, to his home town. They organized monitoring and educational initiatives involving local communities and coastal students to raise awareness about the significance of conserving turtles and mangroves. Additionally, they engaged in rehabilitating injured turtles caught by local fishermen. The Kerala State Forest Department oversees this program, aiming to establish a sustainable local turtle conservation effort and contribute to regional conservation strategies.

Systematic surveys were conducted during the nesting season (November to April) to record the number of Olive Ridley turtle nests. Night patrols were organized to identify nesting turtles, document nest locations, and ensure proper protection of eggs. Eggs from identified nests were carefully collected and transferred to a protected artificial hatchery maintained by the TPSS conservation initiative. The total number of eggs hatched was recorded for each nesting season. Hatching success was calculated as the percentage of successfully hatched eggs relative to the total eggs incubated. Data on unhatched eggs, including potential causes of failure (e.g., predation, flooding), were also documented. Historical data on nesting and hatch success (1998–2018) were obtained from published records and conservation reports for comparison. The data were divided into two periods: 1998–2016 (Period 1) and 2016–2023 (Period 2). A Mann-Whitney U test was conducted to compare hatch success rates between the two periods. Median values and interquartile ranges were calculated for both periods, and p-values were used to assess statistical significance. Boxplots were created to visualize the distribution and variation in hatching success over time. Anthropogenic and environmental factors affecting nesting and hatching success were identified through field observations, consultations with local communities, and reviews of environmental changes (e.g., sea wall construction, tourism activities, and rainfall patterns).

3. RESULTS AND DISCUSSION

3.1 Population Characteristics

A total of only seven adult turtles came for nesting in Kolavipallam Beach, North Kerala, India were observed from November 2019 to March 2023. The mean annual number of eggs hatched was 54.4 ± 23.27 and the overall nesting success was 25.73%. The maximum number of turtle eggs collected was in the year 2019-2020 and the least number of turtle eggs recorded during 2020-21 with total absence. These observations were compared with the historical data of the TPSS (Fig. 2 and Fig. 3). The seawall structures along the shore and increased tourism-related activities along the northern part of the Kerala coast could perhaps be the main reasons, and that caused this drastic decline. However from 1998- 99 onwards the arrival number of olive riddle sea turtles for nesting in the Kolavipalam region was regularly monitored. The maximum and minimum number of 5,508 and 36 sea turtle hatchlings were released into the sea during 1998- 99 and 2017-18 respectively. But in 2019-20, 136 eggs were hatched from 363 collected eggs. During our study 2020-21, there was a total absence of turtles visited for egg laying.

The findings of this study highlight a critical decline in the nesting and hatching success of Olive Ridley turtles in Kolavipalam, North Kerala, over recent years. Historically, this region has served as a vital nesting ground for Olive Ridleys due to its expansive beaches and sandy river

mouths, supported by local conservation efforts like the TPSS initiative. However, our data show a significant decrease in nesting numbers and hatching success compared to previous decades. From 2019 to 2023, only 1–2 nesting turtles were recorded annually, with a mean hatching success of 25.73% and an average of 54.4 ± 23.27 eggs hatched per year.

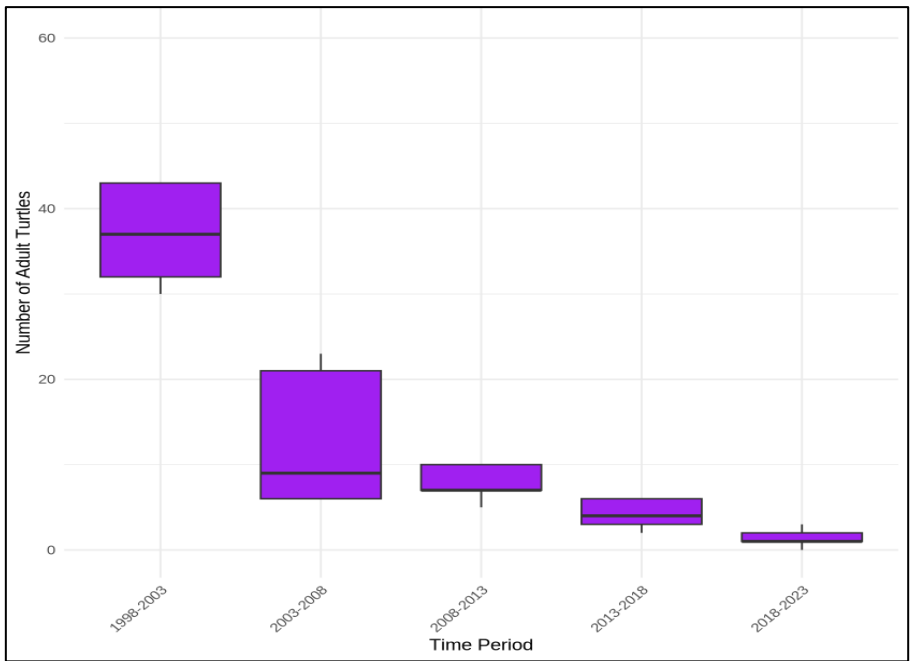

Fig. 2. Total number of adult females who came for egg laying at Kolavipalam from 1998 to 2023

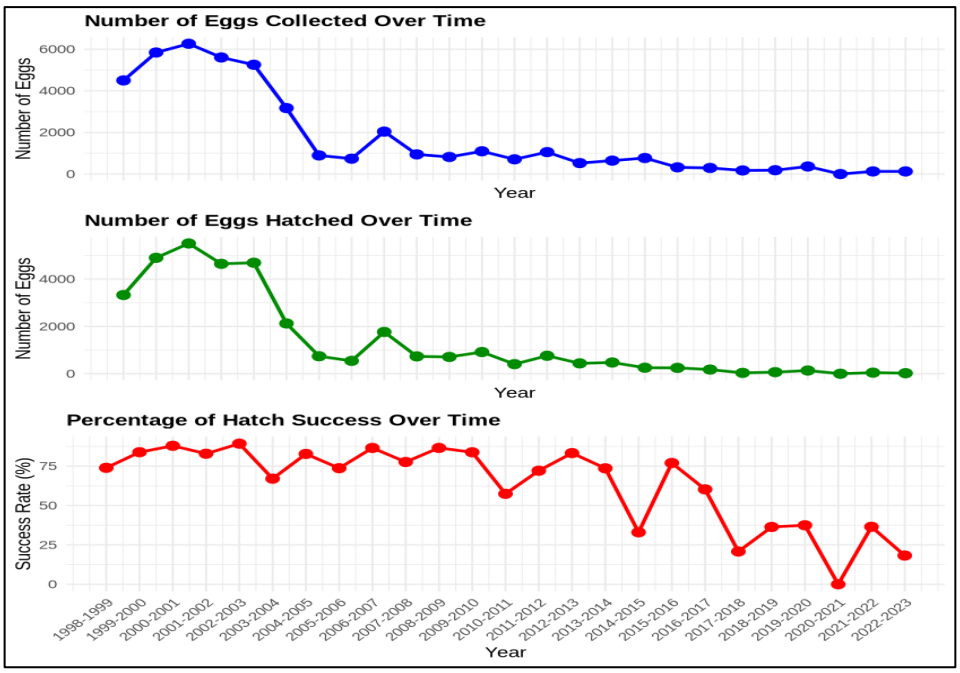

Fig. 3. Total no of olive ridley turtle eggs and hatchlings released in Kolavipalam beach from the year 1998-99 to 2022-23 in comparison with percentage hatching success of collected turtle eggs

Statistical analysis corroborates these findings, with a Mann-Whitney U test revealing a significant difference in hatch success rates between two periods (1998–2018 and 2019–2023). The p-values for both tests are less than 0.05 (Eggs Collected: p = 0.02544, Eggs Hatched: p = 0.01876), indicating statistically significant differences between the two time periods. The lower median values in the 2019-2023 period show a substantial decline in both egg collection and hatching success compared to the 1998-2018 period. Median hatch success declined dramatically from 80.21% during the earlier period to 36.41% in the latter, a drop of approximately 43.8 percentage points. Visual analysis of boxplots further illustrates this decline, showing reduced variation and consistently lower success rates in recent years, with extreme values like 0% in 2020–2021 highlighting potential external stressors.

3.2 Threats

3.2.1 Habitat destruction

Habitat destruction caused by various human activities posed a significant threat to sea turtle nesting. It reduced the availability of suitable nesting sites, disrupted natural beach dynamics, and increased the vulnerability of nesting females and their offspring to various threats. From our study, we have identified the following threats currently disturbing the nesting grounds of Olive Ridley at Kolavipalam.

A. Sand Mining: Sand mining involves the extraction of sand from beaches and coastal areas, which significantly alters the natural landscape and decreases the availability of suitable nesting sites for sea turtles. It can also disrupt beach dynamics and contribute to erosion.

B. Coconut Plantations: Coconut plantations often replaced natural coastal habitats, such as mangroves and sandy beaches, with monoculture plantations. This loss of natural habitat reduced nesting opportunities for sea turtles and disrupted their life cycle.

C. Coastal Erosion and Sea Wall Constructions: Kolavipalam has been identified as an area highly susceptible to coastal erosion (Noujas & Thomas, 2015). To address this issue, various coastal protection strategies have been implemented, including the construction of seawalls and groins, which are among the primary measures used to protect the coastline. These structures help dissipate wave energy, thereby reducing the impact of erosion on vulnerable coastal zones. While seawalls are typically constructed to shield coastal areas from erosion and storm damage, they can disrupt the natural dynamics of beaches and negatively affect nesting habitats. By obstructing access to suitable nesting sites or creating physical barriers, seawalls can interfere with the nesting behaviors of sea turtles. A significant portion of the coastline has been fortified with seawalls to prevent erosion, rendering these beaches less suitable for turtle nesting. Coastal erosion can directly reduce available nesting grounds by eroding sandy beaches where sea turtles typically lay their eggs, thereby diminishing suitable areas for nesting and disrupting nesting behaviors.

As coastal regions grapple with erosion, a range of strategies has been employed to mitigate the effects of beach loss or storm damage. Hard stabilization techniques, such as groins, jetties, and seawalls, are effective in safeguarding property but often lead to the narrowing or complete loss of beaches (Beatley et al., 2002). The Indian coastline is increasingly vulnerable to coastal erosion due to sea-level rise and other unprecedented atmospheric events associated with climate change. Over the past decade, the Kerala coast, located at the southern tip of India's western coastline, has experienced significant changes. The increase in shoreline alterations is likely due to several factors, including the rise in cyclonic activity in the Arabian Sea, the formation of swell waves, variations in wave energy, and rising sea levels linked to climate change. Additionally, the slow rate of sediment discharge by rivers, the construction and spacing of groins, the length of these structures, longshore currents, and the predominant northward sediment transport all contribute to the creation and erosion of beaches along the western coast of India (Pradeep et al., 2022).

D. Private Road Construction: The construction of private roads near nesting beaches led to habitat fragmentation and disturbance. Increased human activity associated with road construction and maintenance deterred nesting females and increased the risk of nest destruction.

E&F. Waste Dumping: Waste dumping, especially near coastal areas, can pollute nesting beaches and marine environments. Pollution directly harmed sea turtles, their eggs, and their

food sources, leading to decreased nesting success and population decline.

3.2.2 Tourism

The estuarine region, surrounded by lush Mangrove forests, holds a natural allure for tourists. However, the lack of adequate amenities has transformed it into a hotspot for drug use and criminal activity. Indiscriminate disposal of plastic waste and other litter poses a significant threat to the Mangroves. Agha et al. (2022) highlights in their review about how plastic pollution affects the health and survival of sea turtles including physical entanglement, ingestion, and the disruption of their habitats. Understanding these impacts is crucial for developing effective conservation strategies and mitigating the growing threat of plastic pollution in marine ecosystems. Development projects geared towards tourism are causing harm to the delicate coastal ecosystem. The control of coastal areas by private entrepreneurs under the guise of tourism and development exacerbates these issues. Despite the risks, 50% of the local population derives financial benefits from selling goods to tourists, leading them to support tourism despite its detrimental effects. Referred to by many tourists as "Mini Goa,"(longitude and latitude) the estuarine area is increasingly being tailored solely for tourism, resulting in escalating waste accumulation due to the influx of visitors.

3.2.3 Climate change

Kerala's main rainy seasons are the South-West Monsoon (June to September) and North-East Monsoon (October to December). Over the past few years, Kerala has experienced fluctuations in its rainfall patterns, particularly during the South-West and North-East Monsoon seasons. Rainfall patterns, particularly in regions influenced by monsoons, can significantly impact local ecosystems and communities. In 2019, the pre-monsoon rainfall was normal, but during the southwest monsoon, the state received above-normal rainfall, with Kozhikode District recording the highest. The northeast monsoon also brought excess rainfall to Kerala. In 2020, pre-monsoon rainfall remained normal, with the southwest monsoon seeing normal rainfall overall, again with Kozhikode experiencing excess rainfall. However, the North-East Monsoon in 2020 was deficient. In 2021, Kerala faced below-average rainfall during the South-West Monsoon but saw record-breaking rainfall during the North-East Monsoon and unprecedented rainfall in winter. The following year, in 2022, both monsoon seasons were within the normal range but below the long-term average. Notably, over the past 122 years, there has been a decreasing trend in seasonal rainfall. In 2023, India experienced below-average seasonal rainfall, with Central and South India receiving 100% and 91% of their long-term averages respectively, according to the Indian Meteorological Department. Climate change predictions for transitional tropical regions suggest scenarios of more restricted rainfall seasons, prolonged dry periods, and intensified rainfall patterns, although the specific direction and magnitude of these changes may vary regionally (Cubasch et al, 2001). In Kerala, coastal erosion primarily occurs during the southwest monsoon season when the waves are rough. There is now ample evidence of the impacts of global climate change on marine environments. Regional changes are more relevant in this context.

Thus the dramatic decline in the number of nesting turtles and hatchlings could be attributed to several anthropogenic and environmental factors. One of the primary factors appears to be the construction of seawall structures along the shoreline. Seawalls and other coastal armoring structures are known to alter the natural dynamics of the beach environment, causing habitat loss and modifying nesting sites, which can deter turtles from coming ashore to lay eggs (Mazaris et al., 2009; Fish et al., 2005). The presence of these structures at Kolavipallam Beach likely obstructs access to suitable nesting sites, forcing turtles to relocate or abandon nesting attempts altogether. Additionally, increased tourism-related activities along the northern coast of Kerala may further exacerbate the decline in nesting activities. The presence of tourists, artificial lighting, and other human disturbances on nesting beaches are well-documented threats to sea turtles, causing disorientation and reducing nesting success (Witherington & Martin, 2003). Artificial lighting can deter females from coming ashore to nest and can lead to hatchling disorientation, where hatchlings move towards artificial lights instead of the ocean, increasing their risk of predation and mortality (Salmon, 2003). The notable absence of nesting during the 2020–21 season may be partly due to these disturbances, combined with other unfavorable environmental conditions or stochastic events.

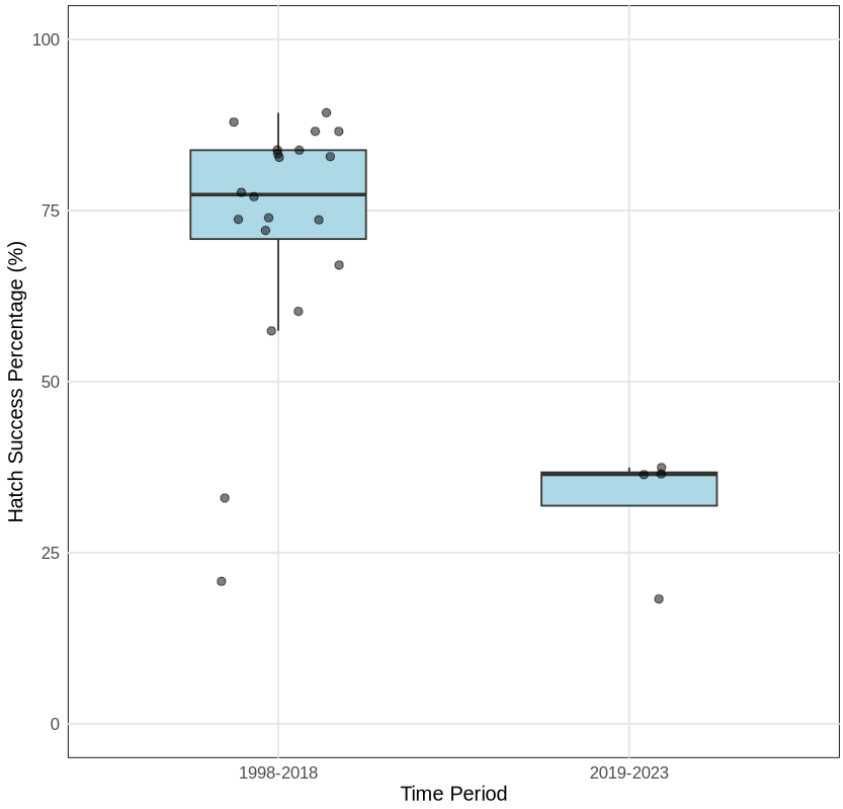

Fig. 4. Comparison of hatch success percentage

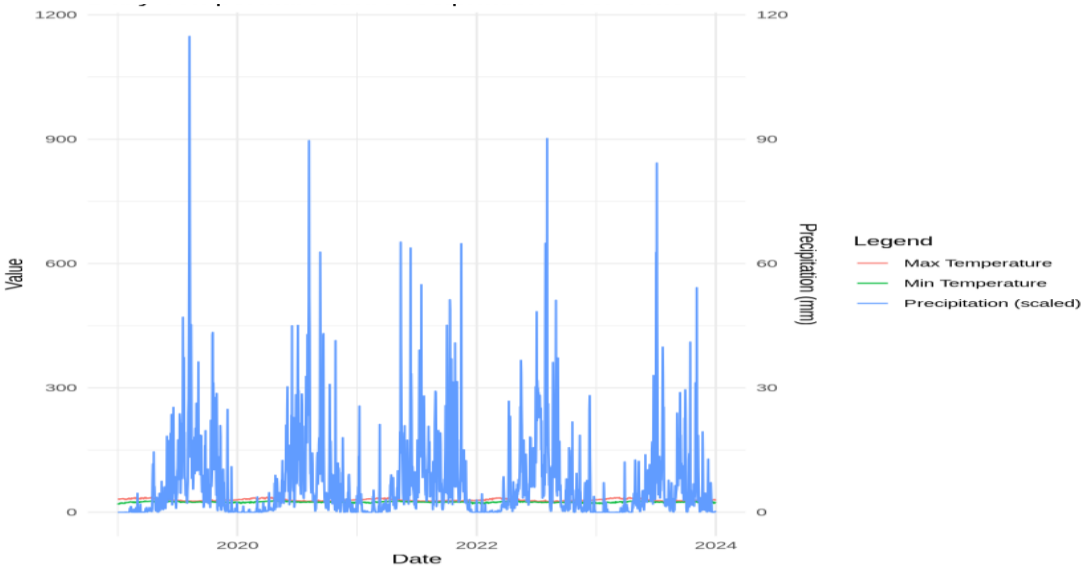

Fig. 5. Variation of precipitation and minimum and maximum temperature during the study

The historical data from 1998–99 to 2017–18 shows significant fluctuations in the number of hatchlings released, with a peak in the late 1990s and a sharp decline thereafter. This trend mirrors a global decline in Olive Ridley populations, largely attributed to incidental bycatch in fisheries, poaching, and habitat degradation (Spotila, 2004). Moreover, climate change impacts, such as rising sea levels and increased storm frequency, may further threaten the already dwindling nesting sites (Fuentes et al., 2010).

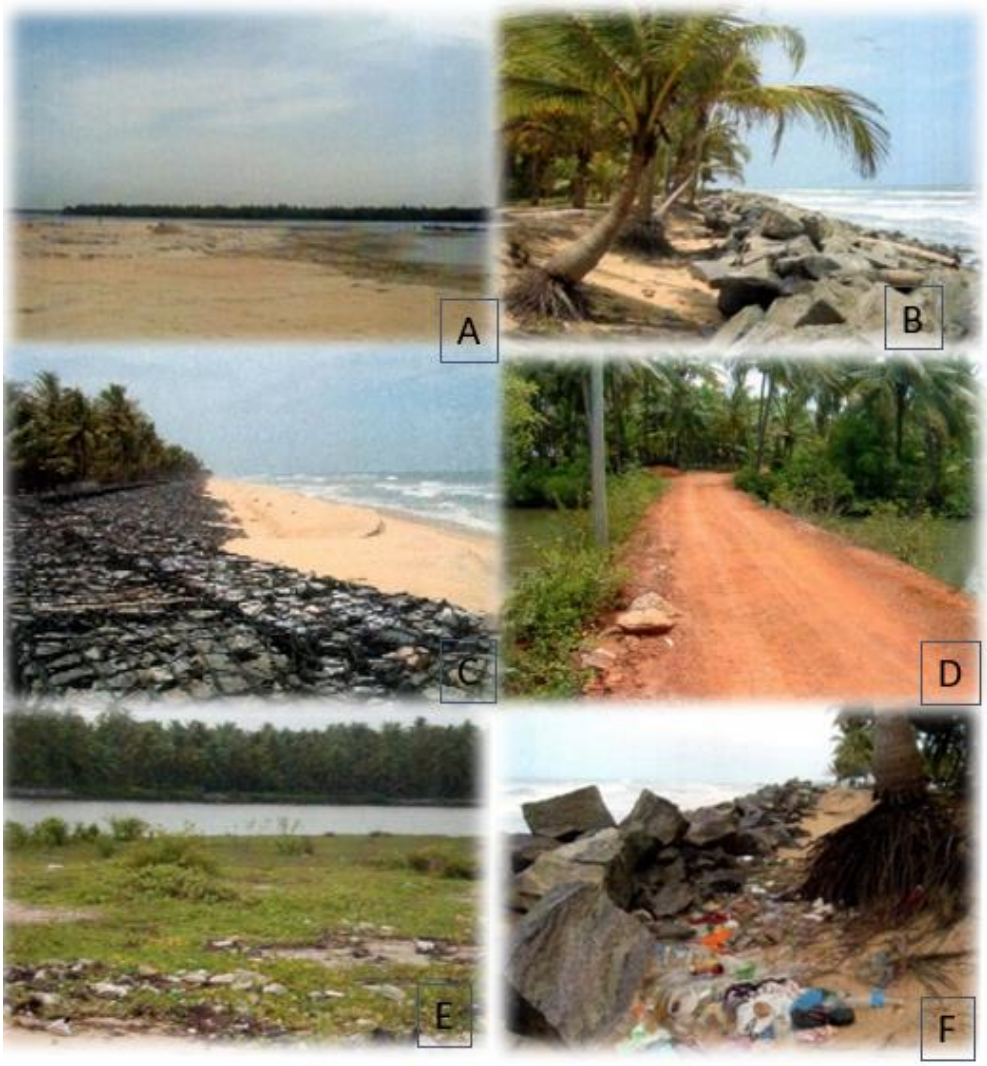

Fig. 6. Habitat Destructions: A. Sand mining B. Coconut plantations C. Private road construction D. Waste dumping E. Sea wall construction F. Plastic waste dumping

Our findings are consistent with other regional studies that have reported declining nesting trends for Olive Ridley turtles along the Indian coast. For instance, Shanker et al. (2004) reported significant declines in Olive Ridley populations along the eastern coast of India, particularly in Odisha, where mass nesting events, known as arribadas, have shown marked reductions in size and frequency. These declines have been linked to increased coastal development, habitat destruction, and other anthropogenic pressures similar to those observed in our study area.

4. CONCLUSIONS

The findings of this study emphasize the urgent need for increased attention and conservation efforts to protect the nesting habitat of vulnerable sea turtles, as the study area was once an ideal nesting site for them. Its conservation and survival are important because it is very much related to the conservation of coastal ecosystems. Along the seaside, olive ridleys face several dangers. As such, plantations, beach erosion, construction of touristic complexes, artificial illumination, and predation of eggs and hatchlings are factors largely damaging olive ridley ecosystems through the loss of their natural nesting habitats could further support these measures. Restricting or regulating coastal development, particularly the construction of seawalls, and managing tourism activities more sustainably are crucial. Additionally, implementing artificial lighting regulations and beach patrolling during nesting seasons can

minimize disturbances. Engaging local communities in conservation efforts and increasing awareness about the importance of protecting these critical habitats. The decline in Olive Ridley nesting at Kolavipalam Beach is indicative of broader regional and global trends threatening sea turtle populations. Continued monitoring, combined with targeted conservation efforts, is essential to mitigate these threats and ensure the survival of these vulnerable species. More proactive conservation measures as well as financial support are needed to protect sea turtles nesting places and rebuild their populations to healthy levels.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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