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Anthropogenic stresses on nesting habitat of olive ridley sea turtles (*Lepidochelys olivacea*) with special reference to technical ammonium nitrate plant at rushikulya rookery of ganjam coast, Odisha, India

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Abstract
Olive ridley sea turtles (*Lepidochelys olivacea*) are flagship icons for the conservation of coastal and marine ecosystems having a circumtropical distribution in a wide variety of habitats. Odisha coast has the world's largest rookeries for Olive ridleys namely Gahirmatha, Devi and Rushikulya. Olive ridleys and their habitat along Odisha coast very often face natural and anthropogenic stresses leading to failure of mass nesting and population decline. The present study aims to assess the impact of anthropogenic stresses on the nesting habitat of olive ridleys at Rushikulya river mouth with special reference to Technical Ammonium Nitrate Plant and to suggest mitigative measures for the conservation of sea turtles and their habitat. Present work reveals the threats associated with the nesting beach to be beach erosion, tidal inundation, developmental projects, sand mining, predation of eggs and hatchlings, vehicular movements, plastic litter, exotic plantation, artificial illumination fisheries in the off-shore water.

Keywords: Olive ridleys, nesting beach, rushikulya, *arribada*, ganjam coast

Introduction
Olive ridleys (*Lepidochelys olivacea*) are considered as the most abundant sea turtles in the world and are the most abundant species to nest along the eastern coast of India. They are a group of marine reptiles having a circumtropical distribution in more than 60 countries (Abreu-Grobois and Plotkin, 2008) [1]. This species occupies unique ecological niches and exhibit intra-specific variation in population sizes, reproduction and morphology (Wallace *et al*., 2010) [2]. It is the only species that exhibit two types of reproductive behaviour: female can either emerge in mass nesting events called *arribadas*, or they emerge solitarily or in small groups without synchrony (Kalb, 1999) [3] In India Olive ridley turtles' nest along the east and west coasts, with major mass nesting beaches in Odisha state. The 480 km length of Odisha coast harbours has three mass nesting beaches, which are the Gahirmatha rookery near the mouth of rivers Brahmani and Baitarani along the northern Odisha coast, the rookery near the mouth of river Devi, located 100km south of Gahirmatha and the Rushikulya rookery, located 320km south of Gahirmatha near the mouth of river Rushikulya along the southern Odisha coast (Pandav *et al*., 1998) [4] (Fig-1). Though the mass nesting of olive ridleys at the Rushikulya rookery in the Ganjam district of Odisha was discovered in 1994 (Pandav *et al*., 1994) [5], sporadic nesting can be observed throughout the coastline of Ganjam district (Pattnayak and Prusty, 2022) [6] (Fig-2). The coast of Andhra Pradesh, lying in continuation to the south Odisha, also provides sporadic nesting habitats to olive ridley sea turtles (Tripathy, 2005; Raja Sekhar *et al*., 2009) [7, 8]. The Olive ridleys population are prone to decline over the last several decades because of their low intrinsic growth rate coupled with natural and anthropogenic stresses (Pattnayak and Prusty, 2022; Tripathy and Rajasekhar, 2009) [6, 9]. Such pressure is mounting year after year on turtle fauna at Rushikulya rookery (Pattnayak and Prusty, 2022) [6]. This paper deals with the impact of anthropogenic stresses on nesting habitat of o live ridleys with special reference to Technical Ammonium Nitrate Plant at Rushikulya rookery of Odisha coast in India. Olive ridleys are placed under Schedule-I of Indian Wildlife (Protection) Act, 1972 (Amendment 2022) that provides the highest level of protection, by prohibiting hunting, poaching and egg destruction. Despite their widespread global distribution, olive ridley sea turtles are listed as vulnerable by the IUCN Red List and as per CITES it is prohibited for trade of any kind.

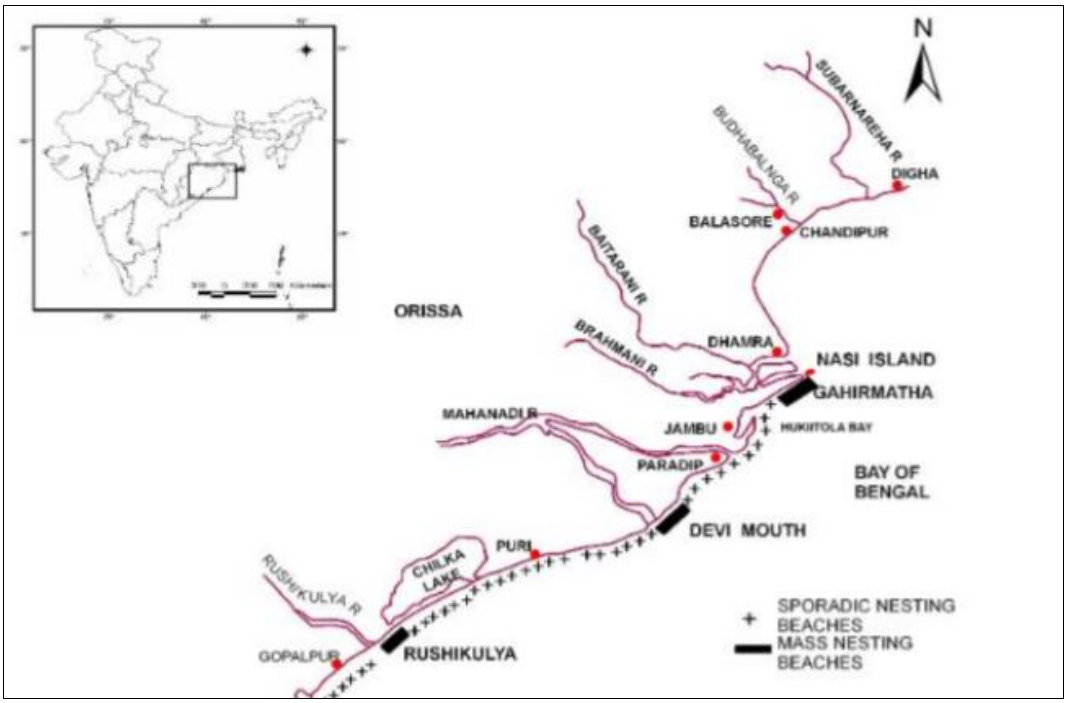

Fig 1: Mass nesting beaches of Odisha and major sporadic nesting sites along Ganjam coast

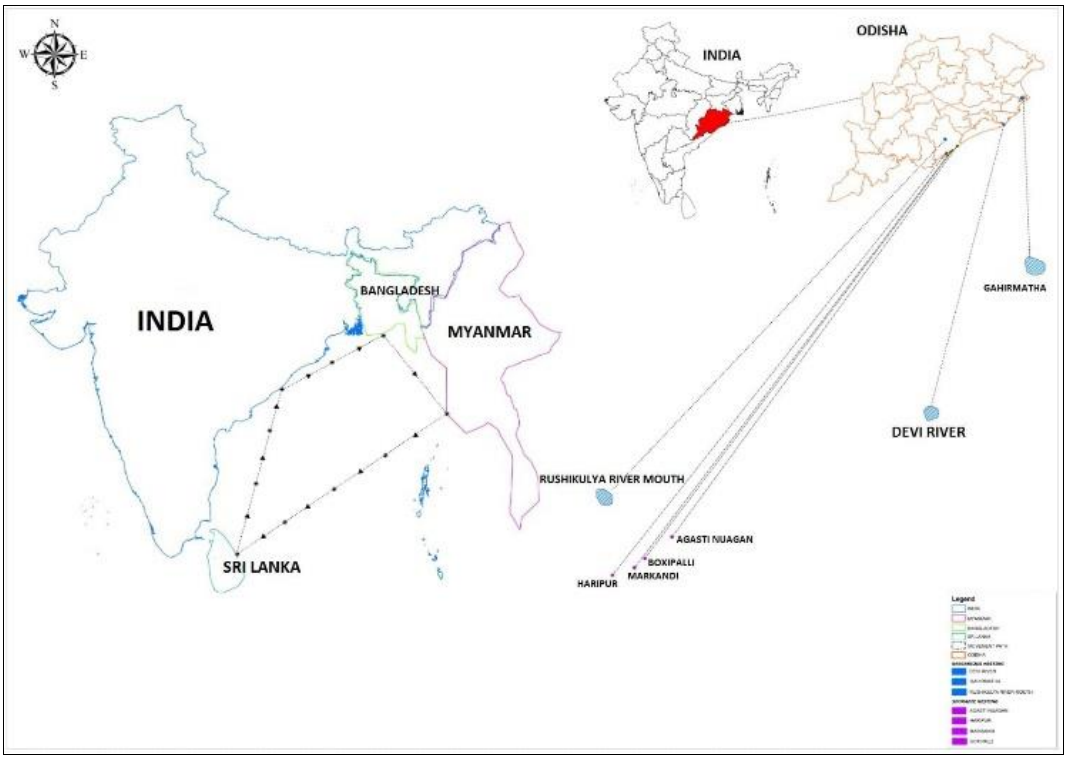

Fig 2: Mass nesting beaches of Odisha and major sporadic nesting sites along Ganjam coast.

2. Materials and Methods

2.1 Study area

The coastline of Odisha measuring 480km length with sandy beaches are suitable and conducive habitat for nesting of olive ridleys. Ganjam district is the southernmost coastal district of Odisha comprises 60km of coastline which is around 12.5% of the state's coastline that is bordered on the north by Chilika Lake and south by Bahuda river estuary extending up to Andhra Pradesh. The coastline of Ganjam is characterized by variety of land forms including sand dunes, estuaries of Rushikulya and Bahuda and other features like *Casuarina* plantations and fish landing centers. There are 28 fishing villages and 20 fish landing centers (Scariah *et al*., 1987) [10]. About, 20% of the population of total fishing households in Odisha belongs to the Ganjam district (Pattnayak and Prusty, 2022) [6]. The common landform in the study area is bestowed with coastal sand dunes.

2.2 Field Survey

Field surveys were conducted along the beach in three phases *i.e.*, pre-nesting season (February), nesting season (March) and post-nesting season (May) during 2022. The survey was

conducted on foot with other team members walking along the stretch of the beach to record the presence of olive ridley sea turtles and to study the topographic features. Presence of beach vegetation were identified after Haines [11]. Other activities like human interventions along the beach and threats such as presence of stray dogs, jackals, mongoose; proximity of fishing villages and fish landing centers; presence of marine debris (plastics and others), artificial lighting were recorded during the study. Interactions with the villagers (senior citizens, local youths, ladies) were conducted to ascertain the observations and collection of other information pertaining to beach condition, egg laying, mortality, egg predation and also impact of *Casuarina* plantation, artificial lighting and plastic debris on the mass nesting beach with structured questionnaire.

2.3 Observation

Gopalpur is a coastal town in the state of Odisha along Bay of Bengal. M/s Tata Steel was acquired 1214.083 Ha. of land including 3.792 Ha. of forest land in village Chamakhandi of Chhatrapur Tahasil in Ganjam district and allotted an area of 16.285 Ha. to M/s Smartchem Technologies Ltd. (STL) for installation of Technical Ammonium Nitrate (TAN) Plant. The topography of the site as observed ocularly was a levelled terrain having elevation ranging between 3 to 7m above msl and belonged to eastern ghat hill ranges. The project area was bounded by latitude $19^0$17'45.90'' N and longitude $84^0$55'3.02" E.

From available information it was revealed that artefacts like NH 216 was located at a distance of 3.74 km north and NH 516 at a distance of 0.8km south-east. Railway Station Jagannathpur was located at a distance of 6.0 km north-west and Gopalpur Port at a distance of 4.9 km east. Villages like Uppulaputty and Badaputty were located at a distance of 1.45 km south-south west and 2.27 km north-east respectively. Natural features like Kharinala was passing through the Zone of Influence (ZOI) at a distance of 0.40 km in north-west direction. Bay of Bengal was located at a distance 2.58 km south-south east whereas Surya River at a distance of 8.19 km west. Besides, Rushikulya rookery was located at a distance of 17 km from the project site. This site was not within the Coastal Regulation Zone (CRZ) area and very often subjected to the furry of cyclones and storms originating from Bay of Bengal.

Technical Ammonium Nitrate (TAN) plant would produce 900 MT of weak Nitric Acid per day to manufacture 1143 MTPD Ammonium Nitrate solution. It would also generate 14.6 MW power from waste heat turbo generator (4.6 MW) and coal fired boiler (10.0 MW) for Ammonium Nitrate plant and captive power plant respectively.

The total allotted area of 16.285 Ha (40.24 Ac) would be utilized for installation of plant, construction of road, development of green belt, establishment of PV Solar system and rest area would remain vacant (Table 1).

Table 1: Distribution of Plant Area for different activities

Sl. No.	Activities	Area (Acres)	Percentage (%)
1.	Establishment of plant and road construction	24.00	59.64
2.	Green belt development	13.28	33.00
3.	P V Solar System installation	1.98	4.92
4.	Vacant Area	0.98	2.44
Total		40.24	100.00

It was observed that TAN plant area was well within 10 km radius of the prohibited area of Olive Ridley nesting beach i.e. Rushikulya river mouth (South of Prayagi to North of Arjipalli). Also, sporadic nesting was noticed to take place in Agasti Nuagaon, Boxipally and Markandi which were located within 10 km radius of Technical Ammonium Nitrate Plant of M/s Smartchem Technologies Ltd. (Fig-2).

Beach vegetation was dominated by Sea prinks (*Spinifex littoreus*), Horse shoe creeper (*Ipomoea pes-caprae*), Screw pine (*Pandanus fascicularis*), Sand binder (*Launaea sarmentosa*) although some other plant species also coexisted. Faunal species were identified from the beach were mostly crustaceans like Ghost crabs (*Ocypode ceratophethalmus*), Sand crabs (*Ovalepis australiensis*) insects such as mites, ants and maggot larvae. Avian fauna of this region was pond heron (*Ardeola grayii*), Sea gull (*Larus brunnicephalus*), House crow (*Corvus splendens*), Cranes (*Grus communis*) and mammals like Mongoose (*Herpestes edwardsii*), Jackal (*Canis aureus*), Fox (*Vulpes bengalensis*) and Otter (*Lutra perspicillata*) were also dwell in the area. Domestic dog (*Canis familiaris*) and Pig (*Sus scrofa*) were noticed in the area particularly where there was human habitation.

There were 53 species of trees (genera-49 and family-28), 12 species of shrubs (genera-12 and family-10), 8 species of herbs (genera-8 and family-8), 3 species of climbers (genera-3 and family-3) and 2 species of grasses (genera-2 and family-1) were listed within the core area of the TAN Plant whereas in its buffer area (ZOI) 47 species of trees (genera 37 and family 25), 13 species of shrubs (genera 12 and family 9), 9 species of herbs (genera 9 and family 9) 8 species of climbers (genera 8 and family 7) and 2 species of grasses (genera 2 and family 1) were identified.

Besides, 9 species of mammals (genera-9 and family-7), 7 species of reptiles (genera-7 and family-5) and 22 species of birds (genera-20 and family-15) were noted from the core area whereas 12 species of mammals (genera-12 and family-10), 9 species of reptiles (genera-9 and family-7) and 35 species of birds (genera-30 and family-23) were found present in the zone of influence (ZOI).

There are also other industries exists in the Special Economic Zone (SEZ) of industrial park, Gopalpur (Table 2).

Table 2: Other industries in the Special Economic Zone

Sl. No.	Name of Project	Product manufacturing
1.	TATA Steel Ltd.	Manufacturing of High Carbon Ferro Chrome through Electric Arc Furnace.
2.	Odimit (P) Ltd.	Resources Refractory Mixes/Chromite Sand/ Foundry Sand-AFS via granular Technologies, crushing serving and blending process.
3.	East Coast overseas (P) Ltd.	Resources Refractory Mixes/Chromite Sand/ Foundry Sand-AFS via granular Technologies, crushing serving and blending process.
4.	Andros System (P) Ltd.	Assembling of Aerial Target Systems for Indian Army
5.	TATA Consumer Product Ltd.	Food Processing Units- Tea Packaging and Bagging Unit.

Besides these, industrial complexes like Grasim Industries, Odisha Sands Complex (OSCOM) as well as *Casuarina* plantations, fish landing centers and Gopalpur Port are other notable features along the coast.

On shore threats to the Olive ridleys were noted to be the developmental projects and their impacts, predation of eggs and hatchlings, presence of stray dogs and mongoose, marine debris, artificial lighting and proximity to fishing villages. One of the major threats that contributes to loss of eggs during *arribada* was the previously laid nests were inadvertently dug up and destroyed by other nesting females. Incidental capture due to intensive fishing operations with mechanized crafts was also identified to be a major threat in offshore waters. Presence of *Casuarina* plantations also pose threats to the eggs as the nests laid within are immediately predated by the Jackals and Dogs and also it provides shade to the nests that lowers the incubation temperature.

3. Discussion

In the present-day scenario, the coastline of Ganjam district is witnessing the gradual developmental activities which are encouraging the influx of more people, construction of infrastructure, and provision of road, housing and lighting facilities. The immediate effect of these activities are generation of sewage and industrial effluents, noise, air and water pollution, more vehicle intensity, more disposal of solid wastes and more requirement of water. As a result, there will be loss of biodiversity and much pressure will be exerted on the habitat, more particularly on the nesting habitat of Olive ridley sea turtles.

Both permanent and episodic threat factors have been taken into consideration in the present study, that is responsible for the nesting and mortality of Olive ridleys. Industrial developments, vehicular movements, solid wastes, pollution of air, water and noise contribute towards indirect threat whereas fishing, predation and artificial lighting are some of the direct threats associated with the declining of sea turtle population. Cumulative effect of all these factors may facilitate the sites unsuitable for sporadic nesting of sea turtles and Rushikuliya beach located at a distance of 17km may also be negatively impacted. Presence of industries near the nesting sites may made the sites unsuitable for turtle nesting (Pattnayak and Prusty, 2022) [6].

Artificial illumination emanates from the fisherman villages located near the nesting beach, is detrimental to sea turtles as it disrupts critical behaviors including nest site choice and the nocturnal sea finding habit of both hatchlings and nesting females. Hatchlings when they emerge out of their nests in the beach are programmed to move towards a brighter horizon. When lights are not around, moonlight and starlight reflected off the sea, that guides them in the right direction. With artificial illumination the hatchlings get disoriented and end up moving landward rather than seaward. When they move towards land, they lose all their stored energy and get dehydrated when sun comes up, or are eaten by other animals, or even get run over by vehicles when there are roads next to beaches. Movement of hatchlings towards artificial light sources rather than sea and succumb to exhaustion, dehydration and predation has also been reported by many workers for loggerhead and hawksbill sea turtles (McFarlane, 1963; Philibosian, 1976; Mann, 1978; Peters and Verhoeven, 1994; Salmon and Witherington, 1995) [12, 13, 14, 15, 16]. Light sources that emit comparatively low levels of short wavelength (blue and green) light affect both hatchlings and nesting adults less than the sources emitting higher levels of short wavelength light (Witherington and Bjorndal, 1991; Witherington, 1992) [17, 18].

Vehicular traffic and human foot traffic have the potential to damage buried eggs and harm pre-emergent hatchlings (Johnson *et ai*., 1995) [19]. Vehicular movement on the nesting beach degrades the nesting habitat by making the substratum hard and compact rendering the beach unsuitable for egg laying (Prusty *et al*., 2017) [20].

Marine debris, especially plastics is considered to be a major threat jeopardizing the survival of turtles, as consumption of such debris can lead to gastrointestinal obstruction or perforation (Wilcox *et al*., 2018) [21]. From a study conducted by Marine Science Department of Berhampur University collaborated with the National Centre for Coastal Research, Chennai; the Union Ministry of Earth Science and the Academy of Technocraft, Berhampur over a stretch of beach from Gokharakuda to New Podampeta, the main mass nesting site on the Beach Clean Day, eight different types of solid wastes were collected during the course of beach cleaning, most of which were rubber, glass and non-degradable plastic. Basing on this finding it has been reported that Olive ridley turtles might not prefer to visit Rushikulya if accumulation of solid wastes increased there, which might spell doom for India's second biggest rookery (Mohanty, 2021) [22].

Predation of large number of nests by the mammalian species like Feral dogs and Jackals and avian species like House crow, Brahminy kites, Brown-headed gulls mostly at the morning hours during the present study is supported by Tripathy and Raj Sekhar (2009) [9]. This finding has also been corroborated by Stancyk (1982) [23] who has reported that nesting depredation by Feral dogs, Pigs, Foxes, Coyotes, Coatis, Mongooses and Dogs can destroy up to 100% of nests. He has further reported that trash and food remain left by humans attracts pests and animals and have a devastating impact on the success rates of sea turtle nesting beaches.

Due to tidal inundation eggs deposited on shifting beaches are prone to damage. Whitmore and Sutton [24] have reported that about 40-60% of the nests of Leatherbacks laid on shifting beaches have been lost due to the phenomena of beach erosion. Since long time shifting of Rushikulya river mouth from north to south and vice-versa has been reported (Rout and Behera, 2006) [25]. As a consequence of this shifting, there has been a substantial loss of nesting habitat at Rushikulya

rookery (Tripathy and Raj Sekhar, 2009) [9]. It has also been reported that three beaches namely Ramayapatana, Nalia Nuagaon and Patampetta-Purunabandha are actively eroding of which Nalia Nuagaon and Purunabandha are located close to Rushikulya estuary (Pattnayak and Prusty, 2022) [6], one of the major mass nesting sites of Odisha (Dash and Kar, 1990) [26]. As heavy loss of the post ovipositional eggs as a result of beach erosion at mass nesting site has been suggested by many workers (Dash and Kar, 1990; Choudhury *et al*., 2003; Mortimer, 1981; Cornelius and Robinson, 1986) [26, 27, 28, 29]; it is opined that there might be major loss of eggs as a consequence of beach erosion which may contribute towards the declining population of Olive ridleys.

Apart from developmental activities *casuarina* plantation is an immediate threat to the olive ridleys. *Casuarina* have been planted extensively all along the Odisha coast to act as a shelter belt for protecting the life and property of coastal inhabitants from the devastating effect of tropical cyclones, that hits the coastal area on regular basis. It has been reported by Tripathy and Raj Sekhar (2009) [9] that about 50% of the mass nesting beach of Rushikulya mouth is devoid of plantation whereas the rest areas are backed by the plantation of *Casuarina* and the nests laid within the plantation area are immediately predated upon by Jackals and Dogs. Besides this, high density of *Casuarina* plantation provides excessive shading to the nesting beach. From available report it is revealed that eggs laid in the shaded areas are subjected to lower incubation temperature that can alter the sex ratio of the population (Schmelz and Mezich, 1988) [30]. Male turtles are born if the eggs hatch at a temperature below 29ºC and above that the hatchlings are female (Jha, 2022) [31]. Declining of nesting activities of Loggerhead Sea turtles in Everglades National Park has been reported where the dense stands of *Casuarina* took over the native beach vegetation (Davis and Whiting, 1977) [32]. This is corroborated by other findings that *Casuarina* renders the beach unsuitable for turtle nesting due to its superficial root growth and thick litter fall (Pandav *et al*., 1998) [4]. Erosion of Gahirmatha turtle nesting beach is due to the presence of *casuarina* along the coast ((Dash and Kar, 1990) [26] and similar process of erosion has been occurred at Rushikulya rookery site affecting the nesting beach (Tripathy, 2005) [7]. The Central Empowerment Committee constituted by the Hon'ble Supreme Court of India has strongly recommended to restore the natural beach condition at three mass nesting sites of Olive ridleys along the Odisha coast by removing *Casuarina* (CEC, 2004) [33].

As per the minutes of the Environment Ministry's Forest Advisory Committee meeting (July 2018) while suggesting to grant clearance for diversion of 157.70 Ha of forest land to expand the mining lease of the OSCOM (Odisha Sand Complex), one of the production unit of IREL (Indian Rare Earth's Limited), an Indian Government undertaking, recommended the proposal with a series of general and specific conditions giving special emphasis on conservation of nesting beach of Olive ridleys along Ganjam coast (Aggarwal, 2018) [34]. As per the condition "an area of 2.5 km on either side of the river's mouth should be religiously conserved without any disturbance. The proposed compensatory land is found to be a natural habitat of peafowl and other shrub dwelling species; accordingly, the existing thorny/shrubby vegetation ecosystem should be maintained, without any attempt to alter by undue overplanting. However, soil moisture conservation should be given prime focus with possible creation of small water bodies and planting shall also be limited and confined to local thorny, fruit bearing species only."

Present study reveals that during the manufacturing process of TAN by the Technical Ammonium Nitrate Plant not only noise will be generated due to the functioning of various machines but also fugitive emissions will be generated. As mitigative measures, the machines are to be provided with inbuilt appropriate control measures with insulation pad to limit the noise level and when required vent silencers are to be installed. Besides, green belt is to be provided along the boundary and planting is to be done at suitable vacant places within the core area.

Trees act as noise barriers reducing the pollution by a phenomenon called sound attenuation, which typically occurs when a sound wave travels a long distance until there is no energy to vibrate the air. Dampening of noise by trees occurs through absorption, distraction, refraction and masking. Thick, grainy bark and fleshy leaves are particularly effective in absorbing sound waves. Trees can absorb harmful air particles and gaseous pollutants. Toxins like nitrogen oxides, ammonia and sulphur dioxide pass through the leaves, bark and roots, apart from absorbing carbon dioxide and carbon monoxide. Presence of various species of vegetation around the industrial complex and within ZOI is a good sign which might contribute towards the improvement of microclimate of the region and for overall healthier and cleaner environment. It has been reported that noise interferes with animal communication, natural cycles, migration path, mating behavior, foraging behavior and spatial orientation on land and aquatic ecosystems. It even causes the extinction of animal species living in noise polluted environment as some of the species may be able to acclimate to these disturbances while others are less able to do so. Afforestation plays an important role in controlling the noise pollution preventing the animals from deleterious effects of noise. According to the World Health Organization, levels of sound less than 70 dB are fine to the living organisms and above this ranges it can harm them. The presence of trees and creation of green belt may absorb the noise so produce and may have a positive impact on the health and behavior of animals. However, the impact of air and noise pollution on plants and animals present in the area needs for intensive research.

4. Conclusion

Present work provides insights to the present scenario of turtle nesting beach of Rushikulya rookery and the impact of developmental activities along the Ganjam coast. The threats associated with the nesting beach that leads to the mortality of Olive ridleys are identified as beach erosion, tidal inundation, developmental projects, sand mining, predation of eggs and hatchlings, vehicular movements, plastic litter, exotic plantation, artificial illumination on the shoreline, besides pollution of water, and fisheries in the off-shore water. Wind action during March to May erodes the nesting beach and the sand layers get reduced depending upon the sites, which can be prevented by rehabilitating the native beach vegetations like sea pink, screw pines which act as sand binders. To prevent predation on nesting beaches intensive during nesting season by the vertebrate predators, regular patrolling of the beaches involving the enthusiastic local youths and fisherman community is to be organized more particularly during night, as long term conservation goals can be achieved by involving the local community. Site specific management initiatives like periodic beach cleaning and prohibition of lighting near

nesting beach need to be undertaken during *arribada*. Entry point activities like provision of incentives during the period of mass nesting and development of fresh water supply system to local residents who are mostly fisherman and suffering from water crises for their bona fide use should be encouraged. Glow-sign board with educative write-ups should be displayed at vulnerable locations for the awareness of visitors and local inhabitants. Protection of nests, eggs and hatchlings has to be undertaken with the involvement local fishing community during the reproductive period by providing them monitory benefits through organized awareness campaigns. Educational awareness campaigns and workshops are to be arranged in fishermen villages and in the schools and colleges on the importance of ecological significance of Olive ridleys. NGOs and conservationists are to be encouraged to participate in the design, funding and implementation of turtle conservation. Apart from this there is serious concern to keep watch over the developmental activities along Ganjam coast and their possible impact on Rushikulya rookery and sporadic nesting sites for effective management.

Olive ridley sea turtles are flagship icons for the conservation of coastal and marine ecosystem and females return to the beach they once hatched on to lay their eggs travelling over hundreds of kilometers. Odisha has an extensive history of conserving and protecting these keystone species. At present Olive ridleys and their mass nesting sites are exposed to so many threats both on-shore and off-shore. Thus, there should be a long term effective plan to take precautionary measures against the perceived threats to safeguard Olive ridleys and their nesting habitats including Rushikulya rookery. In addition, to address the issues of conservation a participatory approach needs to be developed by involving various stakeholders like State Wildlife wing of Forest Environment and Climate Change Department, Tourism Department, Port Authorities, Industries, Social Scientists, Environmentalists, local communities, fishermen etc. The developmental activities along the coast cannot be stopped altogether, but should be restricted with proper mitigative measures and the anthropogenic activities should be properly regulated.

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