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Effectiveness Of Nylon Net Fencing In Enclosing And Safeguarding Protection Area Of Sundarban Tiger Reserve

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Abstract

Context: The Sundarban Tiger Reserve (STR), a UNESCO World Heritage Site and the world's largest tidal flat, had faced intense human-wildlife conflict, primarily involving the Royal Bengal Tiger (Panthera tigris tigris). Tigers' encroachment into adjacent human settlements triggers this conflict, leading to human deaths and tigers' retaliatory killings. In response, the management of the Sundarban Tiger Reserve (STR) is critical, with 108 km of nylon net fencing being installed at the forest-village interface, especially along the tidal river banks and along the forest edge.

Aims: This study evaluates the effectiveness of this low-cost nylon net fencing physical barrier in mitigating HWC and safeguarding the designated protection areas by restricting tiger movement.

Methods: Data suggests a dramatic reduction in tiger straying incidents in villages (from approximately 25–30 cases per year to nearly 0) following the widespread implementation of nylon net fencing.

Key Results: The fencing, often supported by bamboo or more durable cement concrete posts, functions as a psychological and physical deterrent.

Conclusions: However, challenges persist regarding the long-term maintenance of the fence in the dynamic estuarine environment, such as community engagement and alternative livelihood programs.

Implications: The study concludes that the nylon net fencing is a highly effective, cost-efficient, and critical intervention in the STR's integrated conservation strategy, provided it is supported by a rigorous maintenance protocol and community cooperation.

Keywords: Sundarban, Tiger, Wildlife, Nylon Net, Fencing, Conflict, Estuarine Ecosystem, Mitigation.

INTRODUCTION:

Southern Bangladesh and the Indian state of West Bengal host the Sundarbans, a UNESCO World Heritage Site (Jamal et al., 2022). The total forest area of the Sundarbans in India is 4,263 km². Of this, 2,588.89 km² is the Sundarbans Tiger Reserve, (STR 2023-24) (STR 2024-25) which has now expanded by 1,044 km² to 3,628.89 km², making it the second largest tiger reserve in India. The Sundarbans is the world's largest mangrove forest and is home to the Royal Bengal Tiger (Panthera tigris tigris). The high population density

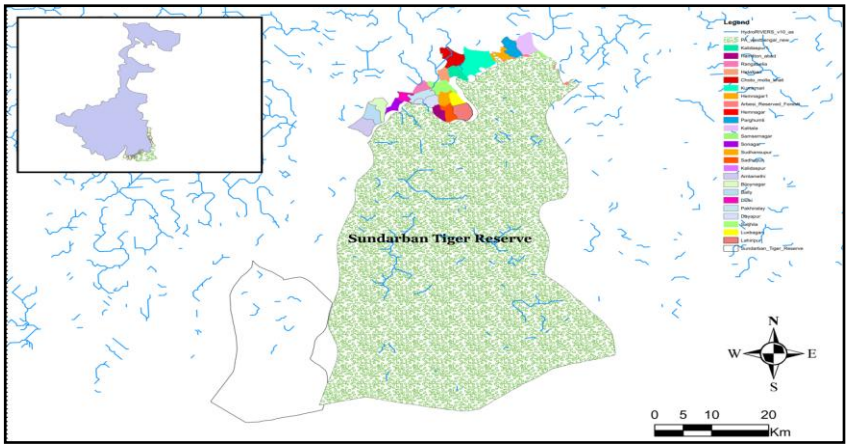
around the reserve also presents a unique challenge for tiger conservation. The core and buffer zones adjacent to the STR are also highly vulnerable to anthropogenic pressure. In the past, tigers often came to villages in search of food and attacked livestock in the villages (Debnath, 2020). There have been reports of many deaths of people along with livestock in the past. The primary concern for the management of this reserve is human-tiger conflict, which is exacerbated by the proximity of tiger habitats to human settlements, the unique behavioural adaptations of the Sundarban tigers and the dependence of local communities on forest resources. Historically, local communities and the planning of the Sundarban Tiger Reserve used plant fences, but these proved to be inadequate and unsustainable (Das, 2012). Later, a significant system of physical barriers was developed by the Sundarban Tiger Reserve to demarcate forest boundaries and prevent tigers from crossing natural waterways and entering villages. This significant system is a buffer forest covering an area of 108 km with nylon net fencing to address the human-wildlife conflict problem. Its low cost and effectiveness have been adopted as an easily deployable and environmentally sensitive solution.
Keeping these in view, an attempt has been taken to study the effectiveness of Nylon Net Fencing in enclosing and safeguarding protection area of Sundarban Tiger Reserve.

METHODS:

• Study Area:

The study was focused on the buffer zone area of the Sundarbans Tiger Reserve. Special attention was paid to the 108-kilometer stretch along the riverbank towards the forest, surrounded by nylon net fencing and the study was conducted in the villages adhered to the Nylon Net Fencing on the other side.

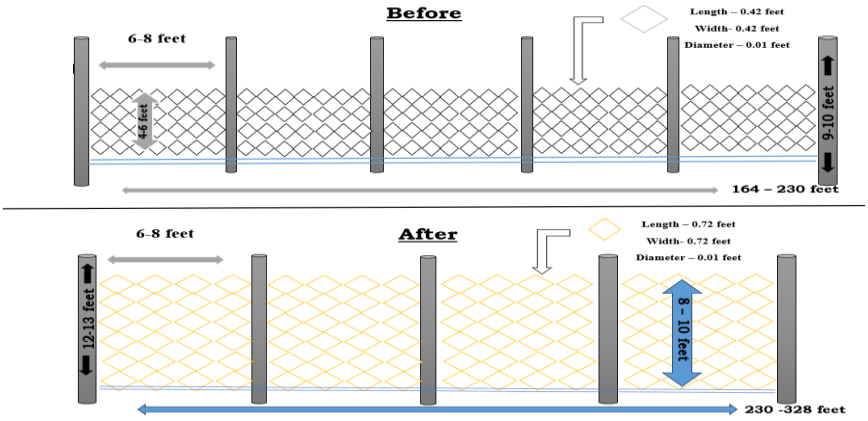
Fig No.-1: Sundarban Tiger Reserve with conflict-prone zones (Villages)



• Fencing Intervention:

Nylon net fencing is made of UV-protected plastic, which is very light and does not get damaged easily in the river's saltwater. It is situated at a height of 8 to 10 feet along the forest edge (nylon net mesh size: length - 0.504 feet; width- 0.412 feet; diameter-0.012 feet). The structure is built on bamboo poles which are placed 6-8 feet apart from each other. The lower part of the fence is 0.4-0.5 feet below the ground level and is reinforced with a “Kapa” barrier, which is made using Goran (Ceriops decandra) and Bain (Avicenna officinalis) wood so that no wildlife like deer can burrow under or through the fence line (STR 2022-23). Thereafter, this installation is mostly done on the edge of the forest near the village and wherever there is a risk of human-wildlife conflict.

Fig No- 2: Before and After drawings of Nylon Net Fencing

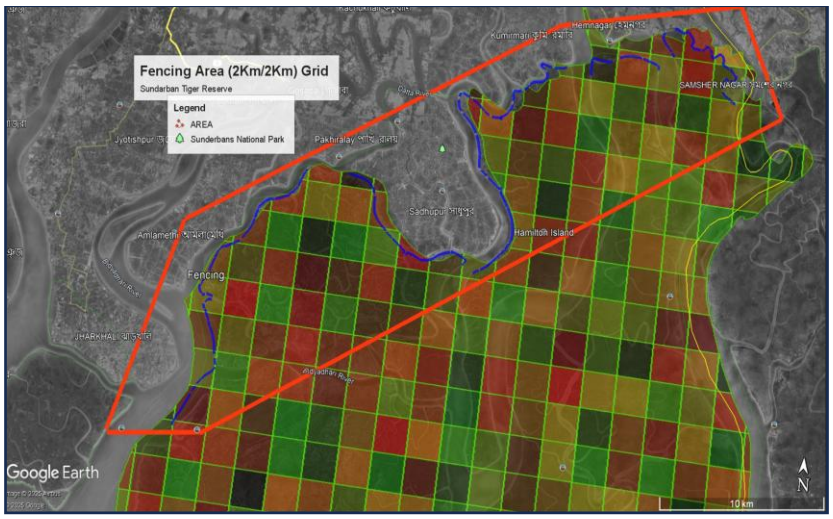


• Data Collection and Analysis:

GPS Mapping:

The perimeter of the forest enclosed by nylon net fencing was measured using Locus Map. Later, those were spatially analysed, and geospatial representations were merged using Q-GIS and Arc-GIS software. Thus, all the locations were presented in a unified and visual way.

Fig No -3: Fencing of the Sundarban Tiger Reserve: 2km x 2km Grid Area



Direct Field Observation:

Field observations were made along the entire nylon net fence, which was held in place for seven consecutive days at each transect using a (2 × 2 km) grid typically produced with ArcGIS and controlled by Locus Map. The main aim of these observations was to record patterns in wildlife movements, instances of attempted fence crossings, incidences of fence structural failure, and the condition of fence maintenance (mainly repairs). During the observation, I systematically recorded location data, including GPS coordinates, photographic evidence, and other information.

Photographic Documentation

Visual evidence of fence condition, animal movement, had been systematically recorded.

Photo No-1: Seven days of continuous nylon net fence monitoring to assess its condition and Wildlife Movement (Range)

Photo No-2: Fencing the Sundarban Tiger Reserve: Before and After

RESULTS:

• Human-Wildlife Conflict Incidents Before and After Fencing

Earlier, tigers used to enter villages in search of food and hunt cattle, deer, and wild boars coming from the forest, the ratio of which has decreased from 85% to 95% due to the provision of Nylon Net Fencing.

The cases here show the financial and social trauma suffered by the forest department and the local peasants because of a tiger straying episode.

Financial resources (approx.) involved in managing a single tiger straying incident:

Data based on Primary and Secondary Observations:

A single tiger straying incident lasts for 3–4 days before it is either trapped or tranquillised.

The straying tiger incident does not cause any injury to humans or cattle.

1.) Mobilisation of tiger straying response resources, such as nylon net fencing to enclose the tiger within the village, bamboo, transport vehicles, trap cages, forest department staff, JFMC members, and other necessary manpower, to the site of the straying incident

a. Hiring of boat and fuel for 4 days – Rs. 40,000
2.) Hiring labour for installing nylon net fencing, providing night watch and ward services, moving equipment and cages to the installation site, transporting the cages after tiger capture, and removing the fencing.
3.) Approximately 100 man-days over 4 days at Rs. 330 per day, amounting to about Rs. 132,000.
4.) Veterinary drugs and other tranquilisation-related equipment – Rs.20,000
5.) Arrangements for lighting, a generator, food, and other incidental expenses at the site for labour, night watch, and crowd control management will cost Rs. 30,000.
6.) Using speedboats to mobilise the tiger rapid response force and veterinary team as well as related equipment, including fuel – Rs. 60,000.
7.) The number of man-days required for crowd control measures during the straying tiger's ailments is estimated to be 3 to 4 days. Per man-day, the number of man-days = 20. The cost for 20 man-days = ₹330 per man-day = ₹6,600.
8.) Transporting the captured tiger, treating it, and releasing it in the wild by creating safe barriers for staff.
a. Hiring of boat and fuel – Rs20,000
The cost of 40 man-days, each valued at Rs. 330, adds up to a total of Rs. 13,200.
9.) In total, neutralising any stray tiger incident used to incur a financial cost of Rs. 321,800.
Additionally, the normal life in the village where the tiger incident occurred is disrupted, resulting in economic losses for the villagers, such as damage to croplands from resource mobilisation, disruption of tourism, and interference with daily activities, none of which are included in the previous calculation.
So, correlating the data until 2012, when the number of tiger straying incidents per year was on average around 25-30 per year, the total financial cost of handling such situations used to be approximately Rs. 321,800.
The installation of the nylon net fencing has significantly reduced this burden. In addition to that, the reduction in the number of days in straying incidences has brought stability among the local villagers, which has resulted in boosted tourism in the past 10 years. Tourism in the adjoining areas has increased 5-fold in the past 10 years.
The above calculations are based on the assumption that the human- or livestock-related damage is not a part of the tiger straying incident. Including the costs mentioned below will significantly increase the cost of a straying tiger incident.
Compensation to Affected Families –
i. Cattle Loss: Rs 25,000 to Rs 30,000 per animal.
ii. Human Death: Rs 5,00,000 per person.
iii. Average Annual Compensation Cost (Before Fencing)—Over Rs 600,000.

• Cost of Nylon Net Fencing Installation

Nylon net fencing is mainly planted with bamboo poles. The Sundarbans Tiger Reserve provides nylon ropes to the women of the villages, enabling them to weave nylon nets. Each nylon bundle weighs 57 to 58 kg, and the women willing to weave nets in the village are paid 17 taka per kg by the Sundarbans Tiger Reserve for their work (17×57/17×58 = 969/986). Many of these women have happily chosen weaving as their alternative occupation. The women weave the fencing nets with this nylon rope. Each net has 17 to 18 loops, and the women use a special wooden stick to weave it. Taking into account the costs of bamboo poles, weaving, and rope, the total estimated expenditure per bundle of fencing material is around 1,200–1,300 Taka, which provides one complete fencing unit ready for field installation.

• Nylon Net Fencing in Preventing Zoonotic Disease Transmission from Wild Animals

Tigers (Panthera tigris), wild boar (Sus scrofa) and spotted deer (Axis axis) share habitats with people in regions such as the Sundarban. These interactions not only result in increasing human–wildlife conflict but also pose the risk of zoonotic diseases, i.e., the pathogen spillover from wildlife to humans (Blenkinsop & Trompiz,2018) (Depner et al.,2017). For instance, wild boar can transmit diseases like leptospirosis or swine fever to humans by directly infecting water and soil. Tick-borne diseases, including Lyme disease, infect spotted deer carrying ectoparasites like ticks. While tigers rarely have direct disease transmission, some bacteria and parasites can be transmitted by tigers, for example, Mycobacterium Bovis (bovine tuberculosis), which can spread through carcass consumption or dogs. One of the major achievements of this work was that the installation of nylon net fencing has reduced them on a significant scale, and it creates a physical barrier to prevent wildlife from entering farmlands and water bodies in villages. This in turn far lowers the chance for disease transmission (Mysterud A, et al.2018) (dropping communicable faecal, urine or biting wildlife infection rates). Furthermore, with a reduction in livestock predation events, people are no longer as likely to interfere with injured wildlife—a leading cause of transmission of disease in the past. The resulting reduced contact between domestic animals and wildlife also greatly reduces the prominence of interspecies disease transmission.

• Wildlife Movement Patterns near Fenced Areas

Patterns of wildlife movement near the nylon net fencing were observed in the field as well as in traditional GPS tracking studies from the Forest Department. I observed wild boars and spotted deer many times moving along beside the fence, but none have crossed it. Here, sometimes even forest personnel and local villagers have noticed tigers walking beside the fencing or resting near it, but the tigers didn't go any further, indicating that the fencing acts as a barrier not only physically but also psychologically.

• Maintenance and Durability Observations

Six months of continuous monitoring revealed that nylon net fencing demonstrates considerable durability; it has sustained localised damage in cyclone-prone zones, primarily due to persistent tidal currents and the impacts of climate change. The STR undertakes prompt maintenance and repair operations in remote locations whenever the fencing is torn or compromised, particularly in cases of riverbank collapse during extreme weather events. Excessive vegetation overgrowth, flooding, or other mechanical factors are responsible for most structural damage. Cost-effective maintenance measures are systematically implemented with the active participation of STR and trained community members, while Joint Forest Management Committees (JFMCs) play an important supportive role in ensuring the long-term functionality of the barrier.

Fig No- 4: Co-relation between Increasing Nylon Net Fencing and Tiger Straying in

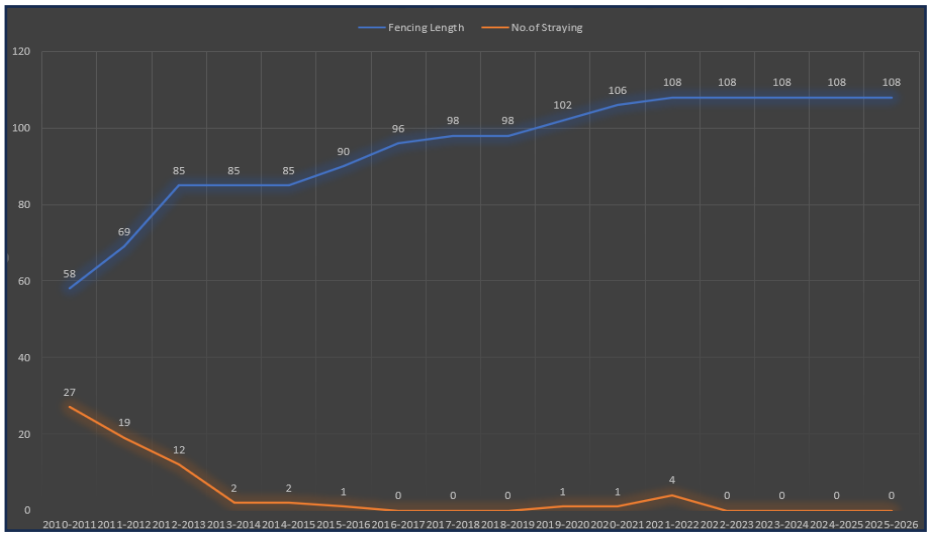


Fig No-5: No. of Tiger Strayed - Yearwise (1998-2025)

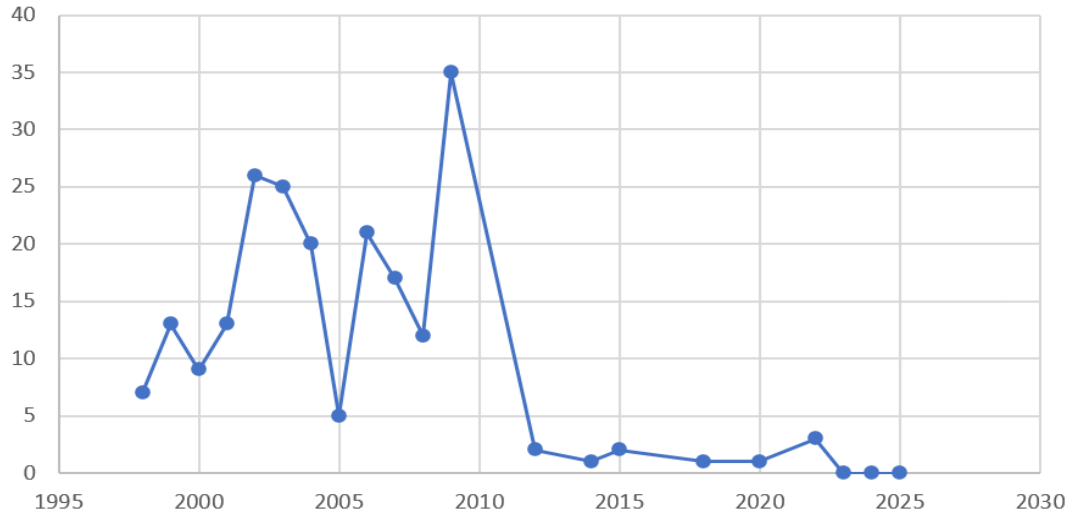
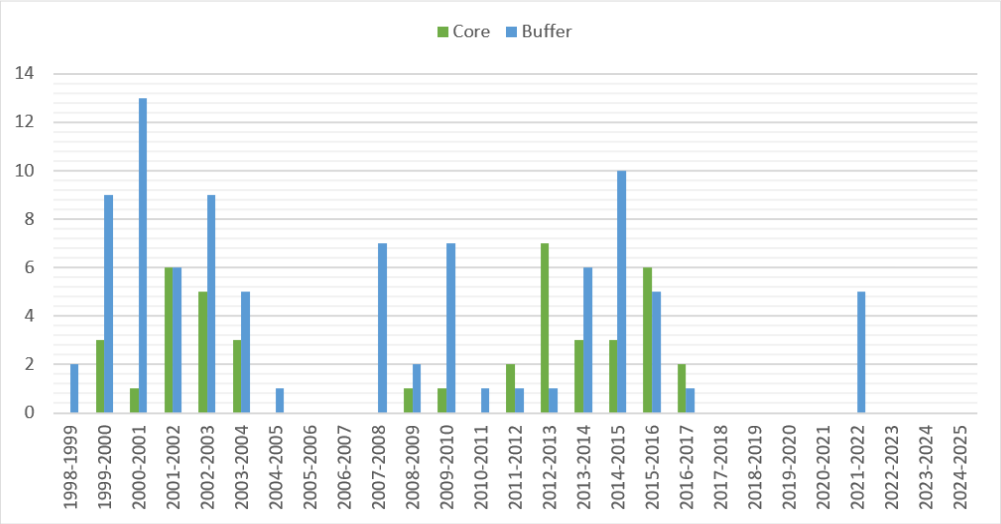


Fig No-6: Diagram Showing human killing in the Core and Buffer zone of the study area



DISCUSSION:

- **Effectiveness of Nylon Net Fencing in Conflict Reduction**

The installation of yellow nylon net fencing at forest peripheries in the Sundarbans presents a highly effective bio-social and technical solution for mitigating human-wildlife conflict. This intervention has led to a significant and visible decline in village incidents, substantiated by field observations and local interviews, showing a reduction in depredation by tigers, deer, and wild boars. The fencing functions as both a physical barrier and a psychological/behavioural deterrent—its lightweight yet durable nature disrupts the natural movement patterns of animals like tigers and wild boars KAZA-TFCA (2016). The scientific significance of the yellow colour (570–590 nm) enhances its effectiveness; it offers high visibility as a prominent warning signal (akin to aposematic colouring), triggering an alert or panic response in animals that causes them to avoid human habitats. Furthermore, the bright hue serves as a crucial visual cue for local villagers to mark restricted areas and allows Forest Department officials to quickly spot and repair damage, with some designs including retro-reflective elements for enhanced night-time visibility and collision prevention (Das & Bandyopadhyay, 2012). This evidence confirms that yellow nylon net fencing is a robust and multifaceted tool for reducing conflict events in hotspot areas.

Table-1: Comparison of Nylon Net Fencing (Colour) Materials

Colour	Scientific Properties	Animal Response	Effectiveness	Remarks
Yellow	This is the highest Wave length of visibility (570-590 nm) that is easily detected by the eye.	Helps create alertness and helps change direction.	Excellent	The most effective colour.
Red	Less attention-grabbing. Its Wave length (620-750nm)	Some animals don't see this colour well.	Poor	It is not effective at night.
Orange	Highly visible and used in many warning signs	Most animals avoid seeing it.	Good	It could be used as an alternative.
White	Bright but reflects light	Some animals don't recognize	Poor	Low visibility at night

		the colour it as an obstacle.		
Green	Blends perfectly with the natural environment	Becomes less of warning signal for animals	Bad	Not effective
Blue	Animals generally rarely see the colour blue.	Has very little impact on animals	Bad	Seeing this colour while avoiding

Table-2: Comparison of Fencing Materials

Fence Type	Wildlife Resistance	Salt Resistance	Sun / UV Resistance	Lifespan	Eco-Friendliness	Cost
Nylon Net Fence	High	High	High	3-5 years	No	Low
Recycled Marine Plastic Rope	High	Excellent	Good	5+ years	Moderate	Medium
HDPE Net or Rope	High	Excellent	Excellent	5-10 years	No	Medium
Composite Natural Fiber Rope	Moderate	Low	Low	1-2 years	High	Low
Solar Electric Fence	Very High	Good	Excellent	5+ years	Mixed	High
Bamboo + Hybrid Rope	Low	Low	Low	6-12 months	High	Very Low
GI Wire Mesh	High	Moderate	Good	3-5 years	No	High

Table No-3: Comparison of Bamboo and Alternative Materials in Fencing Installation

Material Type	Cost	Durability (Lifespan)	Resistance (Salinity, Insects, Moisture)	Maintenance Need	Suitability in Sundarbans	Remarks
Bamboo	Very low	1–2 years	Poor – rots quickly, termite-prone	High (Frequent replacement)	Moderate (short-term use)	Economical, locally available, but unsustainable in wet conditions
Concrete Poles	Moderate –High	10–15 years or more	Excellent – resistant to salinity, insects, and waterlogging	Very low	High (long-term use)	Sustainable, strong, but higher installation cost

Steel/Iron Poles	High	8–10 years (with galvanisation)	Good – strong but prone to rust in coastal climates	Moderate (anti-rust treatment required)	Moderate	Very strong, suitable where animal pressure is high, but costly
PVC/Composite Poles	High	8–12 years	Excellent – resistant to water, salinity, insects	Low	Moderate	Durable but expensive, less eco-friendly if not recycled
Treated Wooden Poles	Moderate	5–7 years	Improved compared to bamboo, but chemically treated	Moderate	Moderate–High	Longer-lasting than bamboo, but ecological concerns from treatment
Hybrid (Bamboo + Concrete Base)	Low–Moderate	3–4 years	Better than bamboo alone	Moderate	High (cost-effective compromise)	Balances affordability and durability

Although bamboo is a cost-effective and readily available alternative for installing nylon mesh fencing, its poor structural integrity has severely limited its lifespan, especially in saline or waterlogged environments. In contrast, stronger materials such as concrete, steel, PVC composites, and pressure-treated wood poles offer superior durability against outdoor stress. Concrete poles are the best choice for long-term use because they are the most cost-effective and perform the best over time. They also need very little maintenance. Steel poles offer exceptional structural strength but are highly susceptible to corrosion in water-based conditions. Lightweight PVC and plastic composite poles (Table No-3) offer excellent water resistance. But their high cost and eco-friendliness have made them less popular. Processed wood poles, however, offer a significantly longer lifespan than raw bamboo. I recommend adopting concrete pole or PVC fencing over bamboo-based alternatives for sustainable long-term human-wildlife conflict mitigation in environmentally sensitive areas like the Sundarbans, due to their superior literature and effectiveness in deterring predator attacks.

CONCLUSION:

The implementation of nylon net fencing has emerged as a significant and successful strategy in mitigating human–wildlife conflict within high-risk rural areas of the Sundarban Tiger Reserve. Prior to its erection by the Forest Department under challenging environmental and logistical conditions, the incidence of wildlife intrusion and livestock predation was high; however, a remarkable reduction in such cases has been sustained through continuous monitoring. Surveys of residents confirm the positive effects, including a greater sense of safety, less worry about wildlife threats, and a better view of human-wildlife coexistence. These changes are also supported by changes in wildlife movement patterns that have led to many species living in core forest areas. Despite these successes, operational challenges persist, primarily concerning long-term maintenance needs, the vulnerability of the nylon to UV radiation and salt-induced degradation, and the susceptibility of fencing along tidal areas to damage from storm surges.

Recommendations:
a) **Using Sustainable Materials**: Use Composite Natural Fibre/ Recycled Marine Plastic Rope or HDPE net / Rope together with or instead of nylon to add to the sustainable nature and message (Table No-2).
b) **Maintenance at Intervals:** Whenever cyclones or Monsoons are experienced, the integrity of fences has to be tested, and proactive repair and maintenance programs should be carried to implementation.
c) **Community involvement:** People living in the neighbourhood can be trained to inspect the fence, to make small repairs and to report incidences properly.

d) **Policy Integration:** Fencing strategies need to be integrated within the long-term conservation and disaster management plans for overall security of human and wildlife populations.
e) **Metal Poles:** Metal poles made of iron or steel are sturdy and can withstand tidal flow, but they are heavier and more expensive.
f) **Cement or Concrete Poles:** Cement or concrete poles have a long lifespan and require little maintenance, but they can be difficult to transport in some rural areas.
g) **FRP Poles/Fibreglass:** These lightweight, non-corroding and weather-resistant poles will cost you more at the outset.
h) **PVC/Plastic:** Poles with reinforcement support These poles are lightweight and termite-resistant, but they are not as strong as metal or concrete poles.
i)**Treated Wooden Poles (Non-Bamboo):** These may be readily available locally at a cost and create an inability to control decay and termites.
j) **Recycled Composites:** Recycled composite materials in shipping containers can be found in urban sectors.
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Declaration of Funding:
This research did not receive any specific funding.

Data Availability Statement:
The researchers have collected the primary data with the help of a structured interview schedule after taking due permission from the competent authority. He also took the help of secondary data during the analysis in the study.

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