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The Dual Nature of Wildlife of Indian Sundarbans: Cooperation and Conflict

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Abstract:

The Sundarbans act as home to diverse groups of wildlife and provide livelihoods for millions of people present in Sundarbans. The wildlife and human populations are closely associated with each other in this vulnerable ecosystem that is marked by complex ecological interactions with dependencies and conflicts. This article provides a brief overview of the dependencies of the local people of Sundarbans and the conflicts associated with it. Local people are involved in various types of activities like fishing, crab collection, honey collection, firewood collection, etc. Human activities are the major causes of the conflicts with wildlife in this area. The major focus of conflict is the Royal Bengal Tiger and crocodile being a potential threat to human life. The dependencies and conflicts between humans and wildlife need a balanced approach to conservation and development.

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Introduction:

A delta formed by the Ganges, Brahmaputra, and Meghna rivers in the Bay of Bengal forms the Sundarbans. It has a vast area of forest and saltwater swamp forming the largest delta in the world and includes wide mangrove forest spread over 10200 km². Sundarbans contains a total of 102 islands; among those, 54 islands are inhabited by humans (Dey, 2019). The largest contiguous mangrove forest in the world comes under two adjacent countries, India and Bangladesh. The Sundarban mangrove wetlands have been disappearing since 1770. Near about 5364 km² area of tidal forest was converted into agricultural land that comes under 19 police stations of North and South 24 Parganas of West Bengal. Now, the Sundarban wetland area consists of about 4262 km². According to the 2001 census, the reclaimed areas of Sundarbans contain 3.76 million human populations with an average of 845 people per km² area. The local people of Sundarbans lead their lives depending upon fishery, forestry, handcraft, etc (Das, 2017; Chakraborty and Ghosh, 2019; Chakrabarti et al., 2024). Sundarbans are also known for their rich biodiversity due to the presence of a diverse array of flora and fauna. The presence of many endemic species makes Sundarbans unique biogeographically. The diversity of mangrove plants itself helps to keep the huge biodiversity of Sundarbans. The competition for resources like food, water and space are the obvious reasons for the conflict. Humans are modifying nature depending upon their never-ending needs. As a result, an increase in human population is invading, modifying and destroying the natural habitats of native species. In Sundarbans, human-animal conflict is so significant, especially human-tiger conflict (Das, 2017). People who live in Sundarbans exclusively depend on the mangrove ecosystem of Sundarbans for their livelihood. The people who are so close to the mangrove Forest face snake bites, tiger attacks, etc. The residents of Sundarbans who are living at the forest boundary are affected by tiger straying. Poachers take advantage of this presence of the human population to fulfil their unethical money-making purposes (Sardar et al., 2016; Das, 2017). Humans depend on natural resources, and that increases the exposure of wildlife towards anthropogenic practices, which can be one of the main drivers for human-wildlife conflict.

Study site:

Sundarbans is present in between India and Bangladesh. The area occupies approximately 10000 sq. km. area, of which 62% is located in Bangladesh and the remaining 38% is located in India. The forest covers 6,017 sq. km in the Khulna region of Bangladesh and an additional 4,267 sq. km in the North 24 Parganas district of West Bengal, India. The area is situated within the latitudes of 21°30' N to 21°30' N and the longitudes of 89°00' E to 89°55' E. The UNESCO site resides at the delta of three rivers, namely Ganga, Brahmaputra, and Meghna, along the Bay of Bengal (Jamal et al., 2022). The Sundarban Biosphere Reserve (SBR) spans over an expanse of 9630 sq.km, with the uninhabited portion of the Indian Sundarbans accounting for 4263 sq.km. Under the current administrative division, this area is further divided into the Sundarbans Tiger Reserve (STR) covering 2584.89 sq. km and the South 24 Parganas forest division encompassing 1678.11 sq. km (Chatterjee, 2023). Sundarban Biosphere Reserve spreads over 963000 ha area

that is further divided into three zones such as Core area, Buffer zone and Transition zone. Out of 963000 ha area Core zone takes about 169200 ha, Buffer zone takes about 223300 ha and Transition zone takes about 570500 ha area. The Indian Sundarban is surrounded by river Muriganga on west and on the east, it is surrounded by Harinbhahga and Raimangal rivers. Other well-known rivers are Saptamukhi, Thakuran, Matla and Goasaba, flowing through this exceptional ecosystem (UNESCO, 2018).

LOCATION MAP

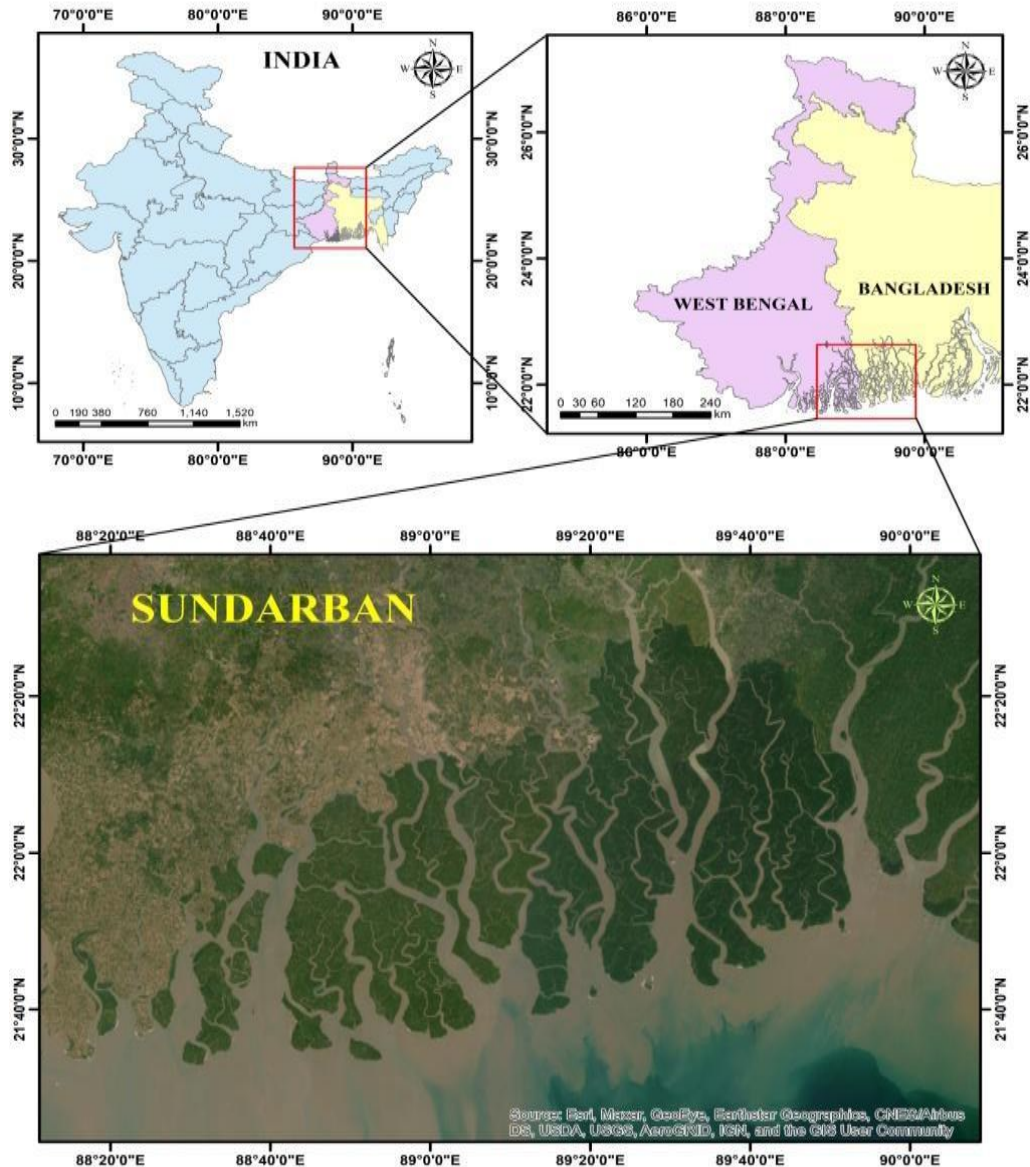


Figure 1. Sundarban Biosphere Reserve (SBR) in undivided Sundarban(Source: ArcGIS 10.4.1).

ZONATION OF SBR IN INDIA

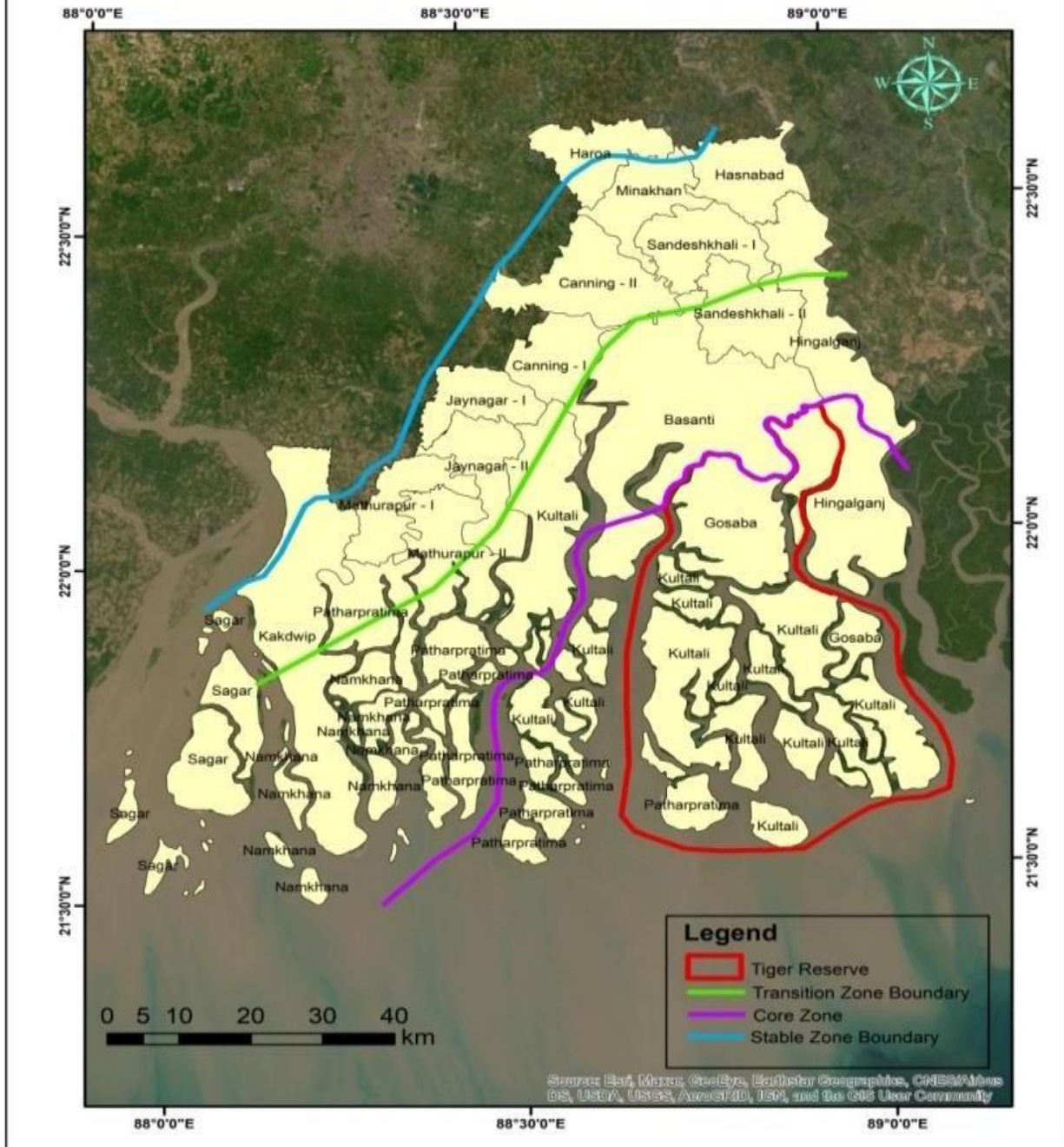


Figure 2. Indian part of Sundarban Biosphere Reserve with distinct zones(Source: ArcGIS 10.4.1).

Result and Discussion:

Flora and fauna of Sundarbans:

The Sundarbans are famous for their rich biodiversity, boasting a remarkable variety of flora and fauna. The ecosystem is a treasure trove of biological diversity, from dense mangrove forests to endangered Bengal tigers. Sundarban is the largest delta that contains funnel-shaped estuaries that have tidal domination and form mess-like structures by the intervention of rivers, channels, and creeks (Biswas et al., 2023). The transitional habitat in Sundarbans provides a suitable environment for the mangroves to grow prominently. More than 300 species of plants have been found in Sundarbans. Out of 300 species, only 28 species are true mangroves. The names of true mangroves are listed below in Table number 1 (STR, 2021).

Table 1. list of true mangroves in Sundarbans(Source: Sundarban Tiger Reserve)

Common name	Scientific name
Kalo Baine	<i>Avicennia alba</i>
Peara Baine	<i>Avicennia marina</i>
Jat Baine	<i>Avicennia officinalis</i>
Genwa	<i>Excoecaria agallocha</i>
Hental	<i>Phoenix paludosa</i>
Garjan	<i>Rhizophora apiculata</i>
Bhara	<i>Rhizophora mucronate</i>
Sundari	<i>Heritiera fomes</i>
Tora	<i>Aegialitis rotundifolia</i>
Khalsi	<i>Aegiceras corniculatum</i>
Hargoja	<i>Acanthus ilicifolius</i>
Kankra	<i>Bruguiera gymnorrhiza</i>
Bakul Kankra	<i>Bruguiera parviflora</i>
Jat Garan	<i>Ceriops tagal</i>
Jhamti/Jele Garan	<i>Ceriops decundra</i>
Chak Keora	<i>Sonneratia caseolaris</i>
Karanja	<i>Pongamia pinnata</i>
Habli	<i>Thespesia popul</i>
Manda	<i>Viscumori entale</i>
Baro Manda	<i>Dendrophthoe falcate</i>
Kripa	<i>Lumnitzera racemose</i>
Gol Pata	<i>Nypa fruticans</i>

Son Champa	<i>Bruguiera cylindrical</i>
Pashur	<i>Xylocarpus mekongensis</i>
Tak Keora	<i>Sonneratia apetala</i>
Hoya	<i>Hoya parasitica</i>
Goria	<i>Kandelia candel</i>
Kalak Kambing	<i>Finlaysonia obovata</i>

Mangrove ecosystem gives a suitable environment for a wide range of animal communities to assemble. The mangrove forest of Sundarbans is home for many animals where they live, but several other animals come here for foraging or breeding. In Sundarban Tiger Reserve a total of 1586 faunal species have been found, among them 15 species of mammals, 8 species of birds, 17 species of reptiles belong to Schedule I (rare) and II (endangered) of the Wildlife Protection Act, 1972. Sundarbans is the only mangrove ecosystem in the world possessing tigers. There are several other mammals found in Sundarbans that contribute to the rich biodiversity of Sundarbans. Recent investigations have shown that more than 300 species of bird are present in Sundarbans, including several migratory birds who visit the area especially in winter season. Sundarbans is famously known as “Kingfisher’s Paradise” due to the presence of 10 out of 12 species of kingfishers found in India. Several species of reptile, amphibian and fish are present in this region. Most common macro invertebrates are also abundant in number in this area. Table no.2 represents the faunal diversity in Sundarbans (STR, 2021).

Table 2. Faunal diversity of Sundarban (Source: Sundarban Tiger Reserve).

Mammals	Tigers
	Other mammals: Gangetic Dolphin, Irrawady Dolphin, Cheetal, Rhesus macaque, Wild boar, Fishing cats, Leopard cats, Small Indian civet, Common otter, Black finless porpoise
	Extinct species of Sundarban: Javan Rhino, wild buffalo, barasingha, barking deer and leopards
Birds	The waders: Sandpipers, Spoonbills, Whimbrels, Stilts, Thick knees, Curlew, Green shanks
	Some important raptors: White-bellied sea eagle, Osprey, Brahminy kite, Shikra, Crested serpent eagle, oriental honey buzzard (occasionally), short-toed eagle
	Hérons: Pond herons, Grey heron, Purple heron, Night-heron

	Other common birds: Cormorants (little and intermediate), Indian shag, Yellow-footed green pigeons, Seagulls, Egrets, Sunbirds, Cuckoos, varieties of ducks, Geese and Storks (especially the Lesser Adjutant stork)
	Rare: The Goliath heron, Buffy Fish Owl
Reptiles	Saltwater Crocodile, Water monitor lizard (<i>Varanus sp.</i>)
	Snakes: King cobra, Common cobra, Russell's viper, Common Krait, Rat snake, Chequered keel back, Green whip snake
	Turtles: Water turtles -Indian soft-shelled turtle, Spotted Pond turtle, Flapshell turtle Sea turtles - Olive ridley, Green sea and Hawksbill turtle
	Endemic: River terrapin (<i>Batugar baska</i>)
Amphibians	The amphibious mud skipper, Periphthalmus, Boleophthalmus, various frogs
Fish	Shark and Rays: Ganges shark, white spotted shovel-nosed guitarfish, Pondicherry shark, Indian dog shark, Bull shark, Hammer headed shark, Black tip shark, Pale edged sting ray, Black edged sting ray
	Edible fishes: Hilsa, Bhetki, Pomphret, Parshey, Gurjali, Amude, Ram fita, Churifita, Topshey
Invertebrates	Crabs and shellfish: Tiger prawns, Hermit crabs (<i>Clibnarius spp.</i>), Fiddler crabs (<i>Uca spp.</i>), Red ghost crabs (<i>Ocypod sp.</i>)
	Trilobites: Horseshoe crab (endangered)

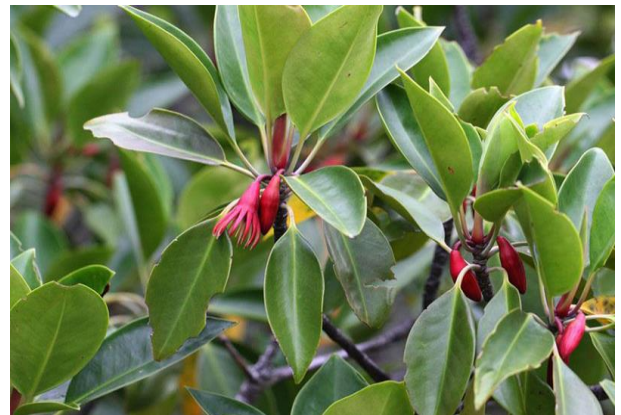




Figure 3. Flora and fauna of Sundarban (Source: Sundarban Tiger Reserve).

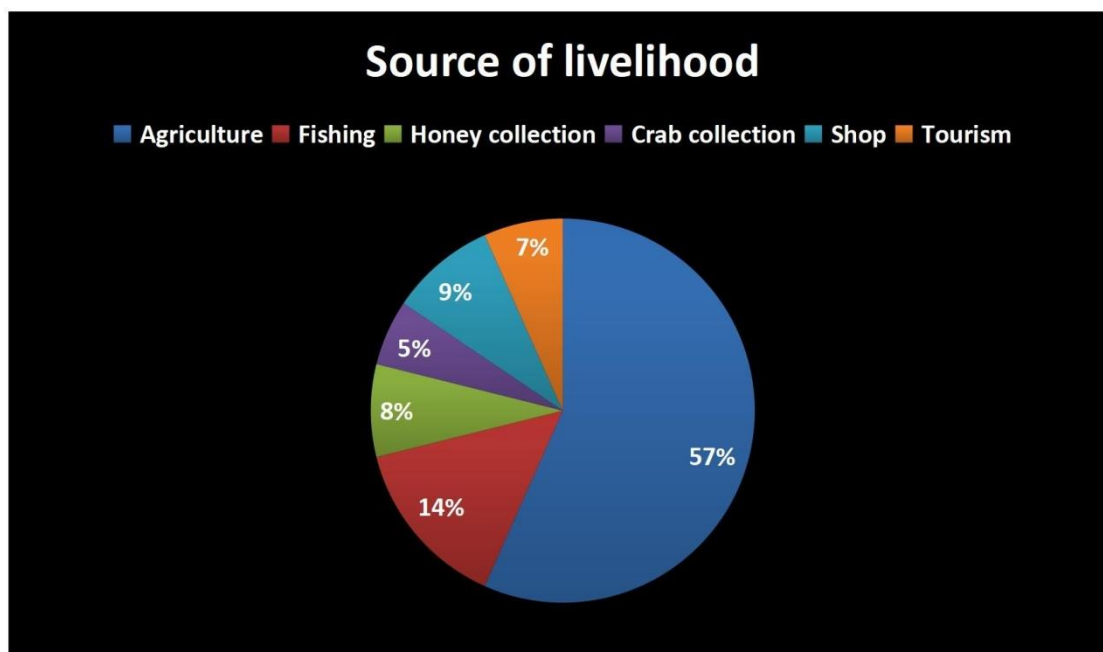


Figure 4. A major source of livelihood for the local people of Sundarbans.

People dependencies:

Human survival and economic wellbeing solely depend on biodiversity. After 1970, people of Sundarbans migrated towards safer islands like Ghoramara due to submerging of farmlands of surrounding Islands. After 2015 people started to move to Sagar Island when Ghoramara started to disappear due to the rise of water level. The people of Sundarbans have been constantly facing catastrophic cyclonic events throughout the year for many decades. These catastrophic

events adversely affect the livelihood of local peoples of Sundarbans. Most of the local people of Sundarbans come under Below Poverty Line (BPL) having acute poverty, illiteracy, poor health, unemployment in that region. So they have to depend on the natural resources of Sundarbans for their survival. They enter into the forest for honey collection, wood cutting, fishing and other activities and ultimately get involved in conflict with wildlife (Jamal et al., 2022).

Tourism

Every year, thousands of tourists come to visit Sundarbans from different parts of the world. Tourism is one of the major sources of income for local people and there are several small handmade indigenous product-based businesses have been developed during last few decades. There are so many unique attractive things present in Sundarbans that encourage eco-tourism and give more power to local small businesses, especially to local women, to get involved in tourism-based businesses. The main attractions for the tourists are wildlife especially Royal Bengal Tiger, bird watching, dense mangrove forest, village life, local food and many other things. The tribal cultures of Sundarbans attract the attention of tourists and it is one of the major sources of income for the tribal people of Sundarbans. Tourists from West Bengal, outside of West Bengal and abroad visit here and generate massive employment for the local people of Sundarbans (Jamal et al., 2022).

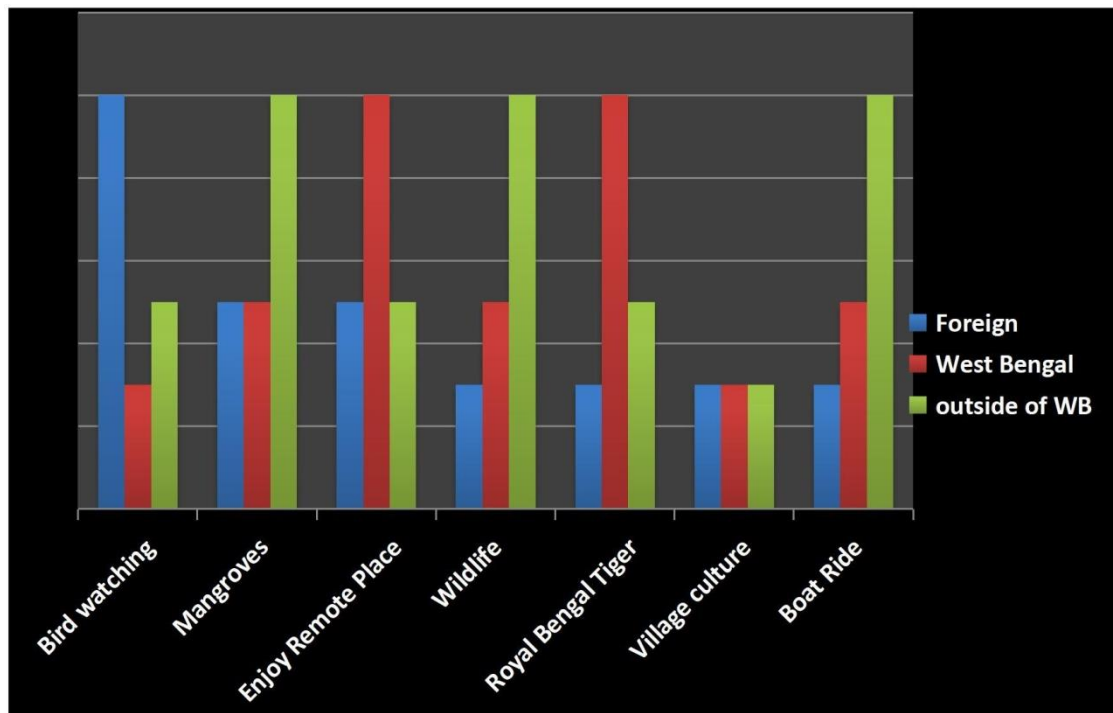


Figure 5. Tourists visit for different tourist attractions in Sundarbans.

Honey collection:

The rich mangrove diversity provides a suitable habitat for the formation of Bee hives. The major Non-Timber Forest Produce (NTFP) includes prawn collection, fish collection, firewood collection, crab collection, wild honey collection, and bee wax collection, which are the major sources of livelihood for forest-dependent populations in Sundarbans. Honey collection is one of the risky and profitable livelihoods for the local people. *Apis dorsata* is commonly known as chak moumachi in Sundarban makes beehives in mangrove forests and produces pure wild honey which has huge demand in the market. The honey and wax from these bee hives have so much economic importance as they are quite expensive. But honey collection in Sundarbans is a life-challenging occupation and uncertain business due to the attacks of tigers, snakes and several other factors (Table 3). Honey collection is traditionally practiced in Sundarbans as it requires so much experience (Bhattacharyya & Mitra, 2018).

Table 3. Cost of honey collection in Sundarbans (2012-2022) (Source: Prepared by the author, Sundarban Tiger Reserve).

Sl. No.	Year	Target inKg.	Achievement inKg.	Collection cost per Kg.	Incidental cost per Kg.	Total cost inRs.	+ Wastage 1%
1.	2012-13	25,000	24,750	50	13	15,59,250	
2.	2013-14	20,000	20,950	75	15	18,85,500	
3.	2014-15	60,000	47,412	100	15	54,52,380	54,524
4.	2015-16	75,000	33,515	110	15	41,89,375	41,894
5.	2016-17	20,000	19,050	115	15	24,76,500	
6.	2017-18	15,000	15,000	115	15	19,50,000	
7.	2018-19	15,000	15,000	125	15	21,00,000	
8.	2019-20	18,000	17,800	135	15	26,70,000	
9.	2020-21		389	150	15	64,185	
10.	2021 - 22	30,000	3649.7	160	17	6,45,997.00	



Figure 6. Honey Collection in Sundarbans (Picture courtesy: Sundarban Tiger Reserve).

Fishing

Fishing is one of the major sources of income for the local people of Sundarbans. They used to catch fish from November to January but some other fishing activities also have seen during March to June. More the 80% of the tiger victims belongs to fisherman community that includes tiger prawn collector and crab collector (Das, 2017).

Fisherman generally go out fishing for several days and carry their essential accommodations like food and water. They find a suitable place to halt and make temporary base camps, which are locally known as “Tong”. They set up the fishing net for optimal fishing and stayed there for a few days. Although fishing is a life-threatening job in Sundarbans as crocodile and tiger attacks are a major concern in those remote areas. The local people not only catch fish for their livelihood but also for their own consumption to fulfill their essential nutritional demands (Jamal et al., 2022).

After cyclonic storms, the saline water invaded the farmlands and made agricultural fields unfertile to produce crops. So, the local people have no option left for their survival other than fishing and collecting Non-Timber Forest Produce. They involve their family members in this fishing activity, and they use smallboats for daily fishing activities. Creeks of the Sundarban Delta are foraged by fishermen for sustainable fishing that helps to balance the stability of the ecosystem and maintain the biodiversity of Sundarbans.

Joint Forest Management

Joint Forest Management (JFM) is an initiative toward sustainable development and biodiversity conservation, started under National Forest Policy in 1988 where state forest departments support local people to protect and manage forest resources. Local communities earn money from forest resources and share the benefits with them. JFM has potential outcomes towards eco-friendly sustainable development where a potential source of livelihood is provided by forest resources such as Non-Timber Forest Produce (NTFP), fuel wood, fodder and other economically important products from the forest. These forest products are sold by local communities, generating livelihood and prevent the degradation of forest that provide local, national and International environmental benefits.



Figure 7. Fishing activities including crab collection and prawn seed collection (Source: Sundarban Tiger Reserve).

A total of 26 JFMC are active in various locations of Sundarbans. Both male and female participants have taken part in this initiative. The following resources of Sundarbans are collected and maintained in buffer zone of STR sustainably and utilized to generate livelihood for JFMC beneficiaries (Robbins, 2014).

1. Honey collection by local people with the permission of the forest department.
2. Fishing – BLC, forest department gives permission to the fisherman.
3. Prawn and crab collection.
4. Eco-development activities such as fisheries, crab fattening, prawn cultivation, etc.
5. Infrastructure facilities like building community centres, brick-selling pathways, jetties, embankment maintenance, etc.
6. Water treatment plants – installation and supply of water treatment plants.
7. Livelihood support activities like goat rearing, duckery and conduction of veterinary camps in various areas of Sundarbans by forest department.

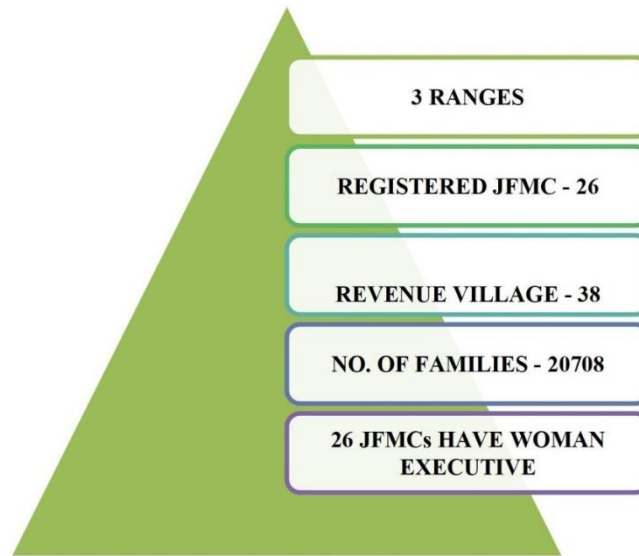


Figure 8. Status of Joint Forest Management (JFM) in Sundarbans (Source: Sundarban Tiger Reserve).

Share money from JFM is distributed between the government and local people. This share money from JFM attracts more people to come and join in this holistic sustainable development. More than 40% of the share money comes from the eco-tourism, and this helps to generate livelihood in the local community. Due to the generation of alternative livelihood in Sundarbans, fewer people enter the forest and tiger attacks will be reduced. The share money from JFM is distributed among JFMC beneficiaries, and from 2012 to 2019, an increase in share money distribution has been seen. But from 2019 to 2022, the trend has been falling. Last year (2022), a sharp fall in share money from 120.4 lac to 89.04 lac was seen, and this indication poses a significant threat to local people as well as the forest department. We can assume that this decreasing trend may be due to the negative impact of the pandemic caused by COVID-19.

Mangroves play a crucial role in ecosystem by helping in carbon sequestration, giving shelter to coastal areas from devastating cyclones, maintaining the rich biodiversity and acting as a source of livelihood for local people of Sundarbans. Mangroves and wetlands are sharply decreasing throughout the world due to anthropogenic activities and sea level rise. The world's largest single block of mangrove forest is rapidly declining at an alarming rate due to overexploitation of natural resources, changes in land use patterns and agricultural practices. Studies have shown that nearly 76% area of mangrove species named *Heritiera fomes* has declined between 1959 to 2005 in Sundarbans. Other abundant species of mangrove such as *Ceriops decandra*, *Excoecaria agallocha* and *Xylocarpus mekongensis* have been declining dramatically (Sahana, 2023).

From 1982 to 2022, a significant change in vegetation cover outside the STR is evident, which is shown in Fig.11. The change has been more prominent in the last decade. The probable reason for this change is the implementation of JFM in Indian Part of Sundarban Biosphere Reserve. Sustainable development with JFM is responsible for the rapid plantation of

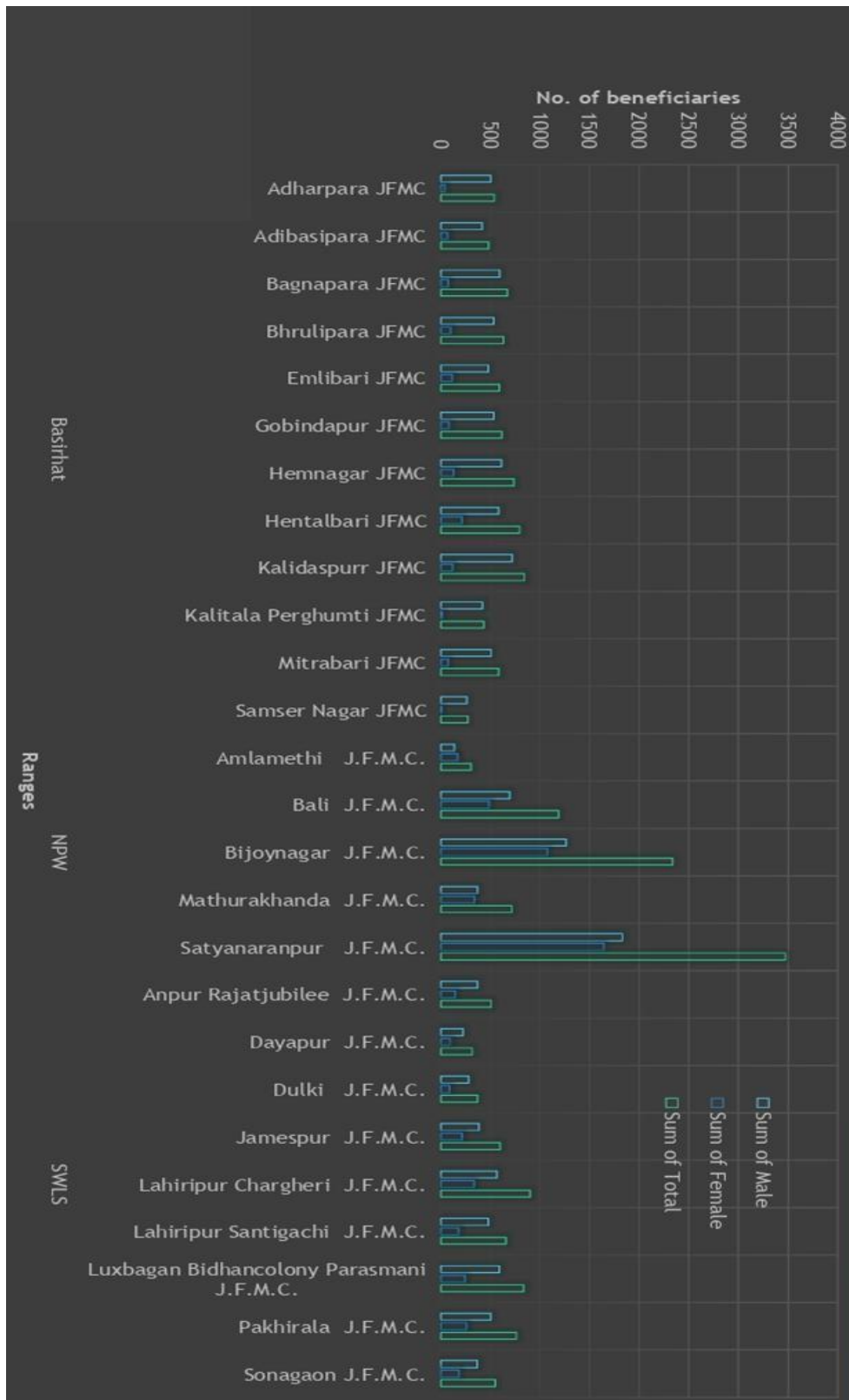


Figure 9. Demographic dividend of JFMC beneficiaries in different Ranges under STR (Source: Sundarban Tiger Reserve).

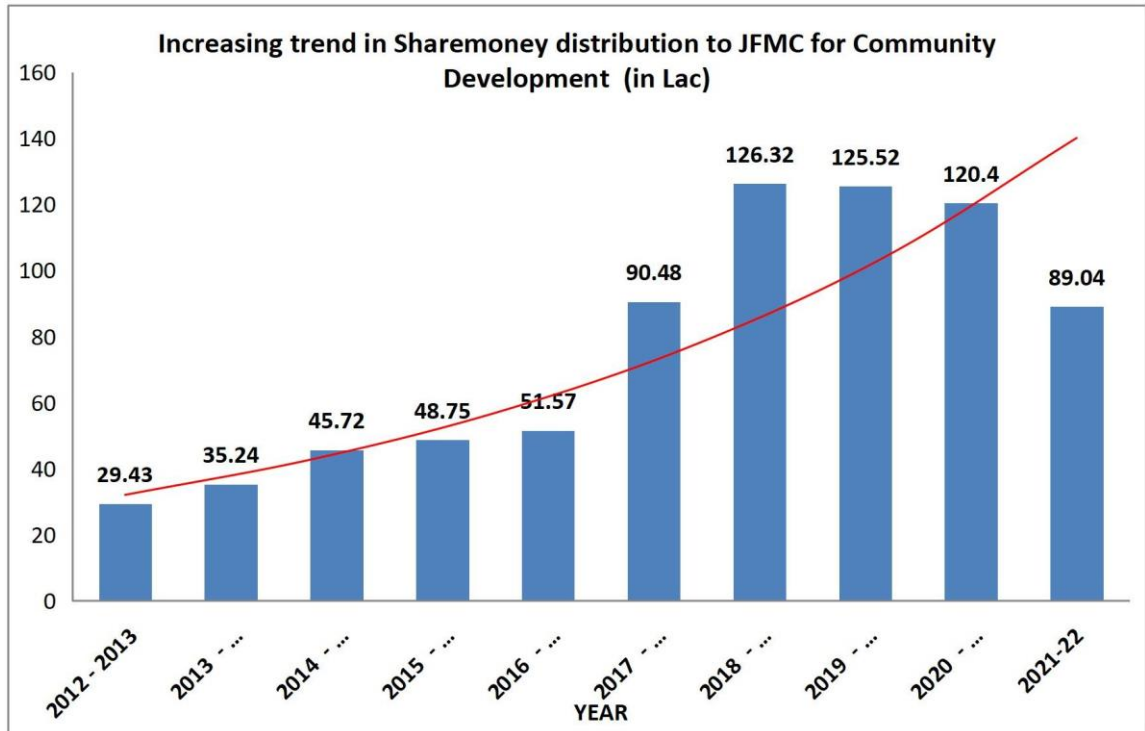


Figure 10. Share money distribution among JFMC from 2012 to 2022 (Source: Sundarban Tiger Reserve).

trees, generating alternative sources of firewood. So, the wood cutting from core mangrove forests is prohibited strictly, thus saving the mangrove ecosystem in Sundarban Biosphere Reserve. The mangrove forest cover in the core area of SBR has been quite stable throughout the last four decades. The major changes have been evident in human-inhabited areas.

Conflict with wildlife:

Conflicts are so obvious when the presence of a species in an area is a threat to human welfare. Co-existence can be stable or unstable for two neighbouring species occupying the same niche. The history of human-wildlife conflict started from the origin of humans when they had to depend on the biodiversity around them for survival. These dependencies have increased with human evolution. There are some conditions responsible for human-wildlife conflicts – (i) when human activities have negative impacts on wildlife. (ii) When the activities of wildlife negatively affect human welfare. (iii) When wildlife-friendly activities of some people are misinterpreted by some other group of people, it creates controversy, and this will ultimately affect wildlife (Das, 2017). Indian Sundarbans include protected ecological habitats and human habitation around them. So human and wildlife are intensely connected with each other in Sundarbans. Due to the increasing human population in Sundarbans, land use patterns have changed during the last few decades. Mangrove vegetation has reduced during the last few decades.

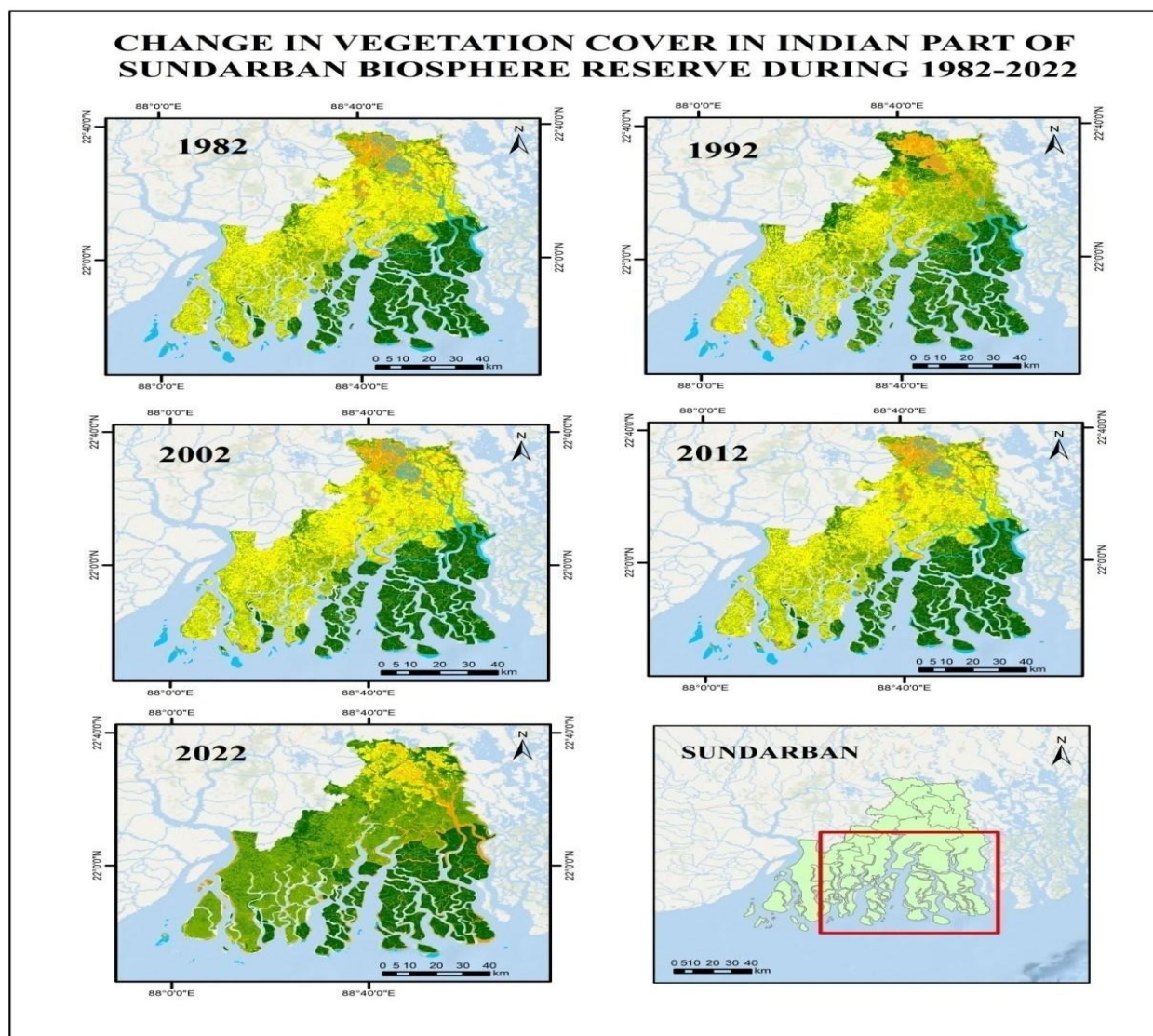


Figure 11. Change in vegetation cover in the Indian part of Sundarban Biosphere Reserve from 1982-2022.

Human-tiger conflict:

The human-tiger conflict in Sundarbans has increased with time due to human interference in the tiger's habitat. The only mangrove ecosystem in the world that has tigers is constantly facing conflict between humans and tigers due to the increasing needs of the local people of Sundarbans. The human-tiger conflict arises mainly because of the invasion of humans into the territory of the tigers and the straying of the tigers into human habitation. The Royal Bengal Tiger is so special for its unique adaptation to mangroves. This unique adaptation makes them different from any other tiger population in the world. The tigers of Sundarbans generally rely on deer, wild boars and monkeys. They also feed on fishes and crabs when food is scarce. They can cross the river by swimming at a speed of 16km/hr, drinking saline water and climbing trees. Tigers cannot be easily visible in Sundarbans, although pugmarks of tigers can be found everywhere. They can

tolerate harsh environments with the fluctuation of a wide range of physicochemical parameters. The tiger victim data shows four most vulnerable forest blocks. From 1985 to 2009 total 789 persons was attacked by tigers (Das, 2017). During 2012-2022 total 18 deaths have recorded in different blocks of STR. Compensation has been provided by the government to the family of tiger attack victims. During these years highest official number of deaths has seen in 2021 and during 2015-2018 no death has officially recorded.

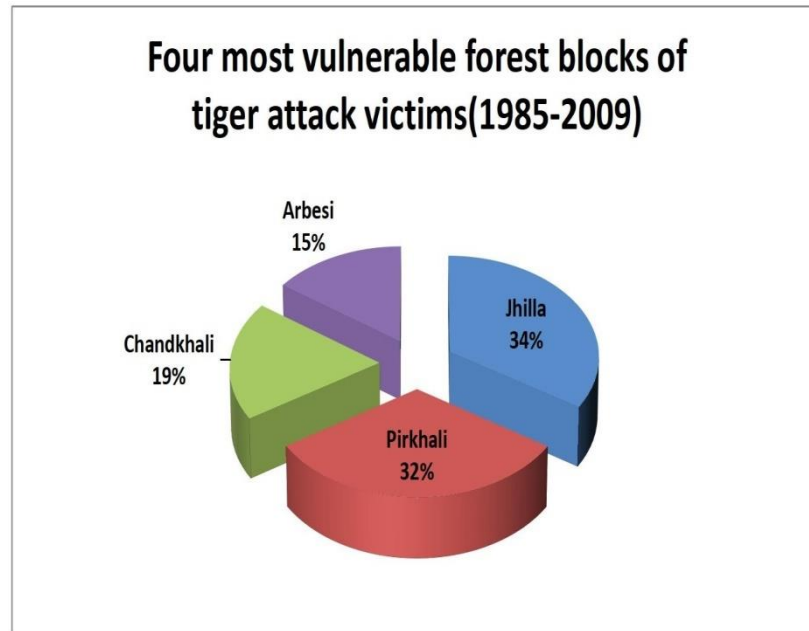


Figure 12. During 24 years four most vulnerable forest blocks of tiger attack victims (1985-2009).

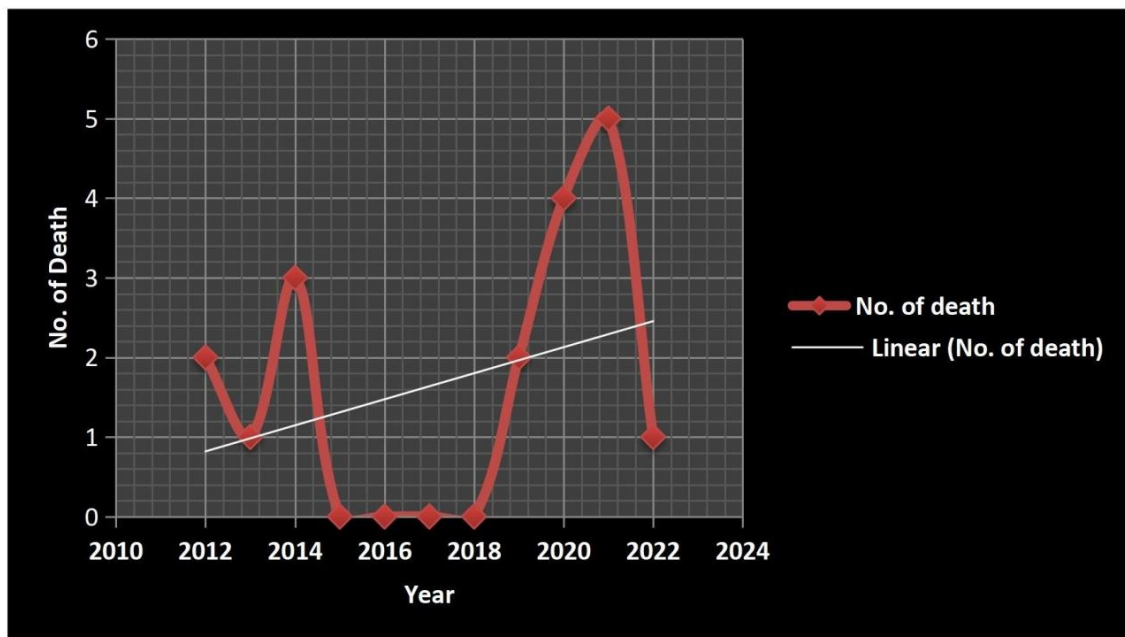


Figure 13. No. of deaths by tiger attack during 2012 to 2022 (Source: Sundarban Tiger Reserve).

Honey collectors, fishermen, and crab collectors who enter the deep forest mostly in the early morning and afternoon create disturbance by making smoke or lighting fires for honey collection. Tiger attacks are often seen when the intruding groups are not well connected. It is evident that tiger attacks are mostly seen in groups of four or less than four people. During the span of 24 years (1985-2009), the most affected community by the tiger attacks was the fisherman community. A total of 501 victims of fishermen, including 523 deaths and 78 injuries. The fishermen enter into the small creeks to collect tiger prawns and fix fishing nets to get more fishes. Sometimes they have to get down into water from their small boats to fix the fishing nets. Tiger comes to the edges of creeks to drink water and to feed on crabs and fish. The high mortality of fishermen during 24 year shows a direct conflict between tiger and fisherman. The second and third most affected communities are crab collectors and honey collectors, respectively. A total of 128 victims of crab collectors, including 108 deaths and 20 injuries, and for honey collectors, the total number of victims is 108, which includes 92 deaths and 16 injuries during 24 years. Honey collection is more prone towards tiger attacks, although the number of victims is still less than the other two professions due to the exposure time of honey collectors towards forests being only two months in a year (Das, 2017). From 1999 to 2014, a total of 368 deaths and 63 injuries were recorded by the death registry office of STR (Das, 2018).

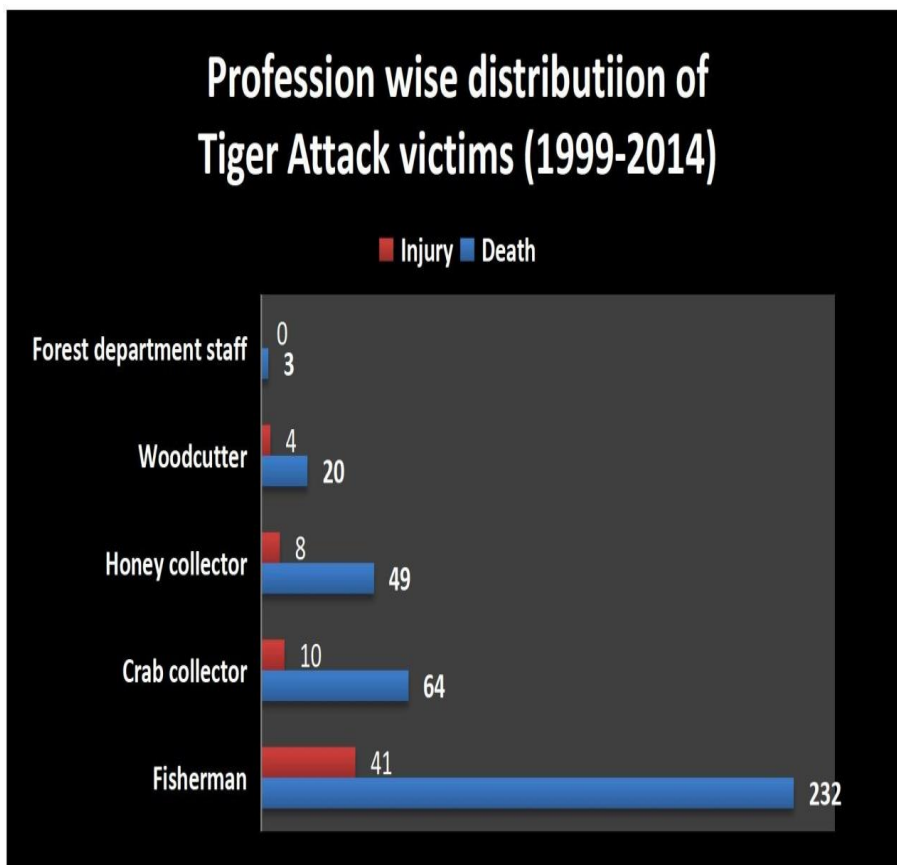


Figure 14. Profession wise, tiger attack victims during 1999 to 2014.

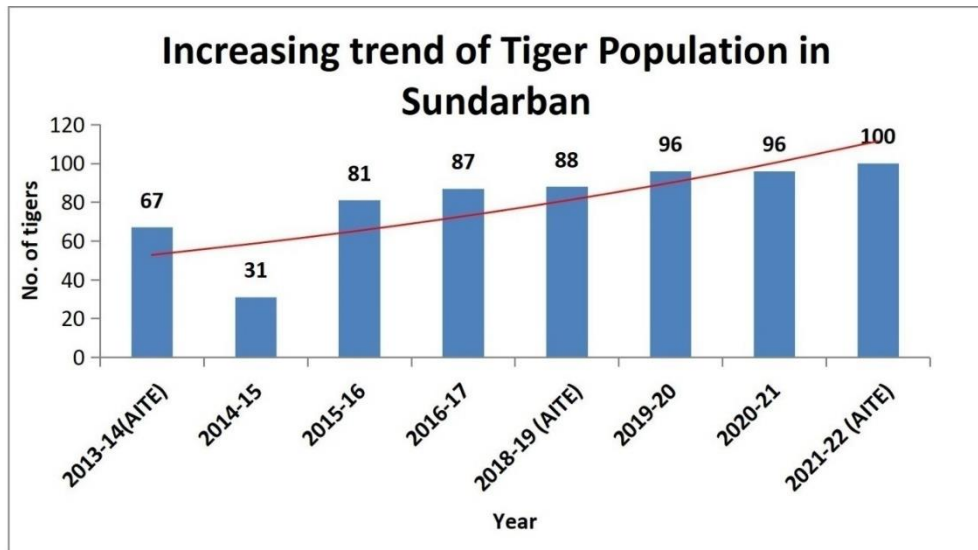


Figure 15. Increasing tiger population STR (2013-2022)(Source: Sundarban Tiger Reserve).



Figure 16. Tiger in Sundarbans (Picture courtesy: Sundarban Tiger Reserve).

Tiger population estimation has been carried out by NTCA (National Tiger Conservation Authority) and state forest department. All India Tiger Estimation (AITE) is conducted through several new techniques. In 2018, phase IV AITE was conducted by smart techniques such as the installation of the M-STriPES application in Android devices for patrolling and protecting tiger habitats and placing camera traps in various remote areas of STR for estimation of tiger population. The phase IV AITE in 2020-2021 shows that the numbers of endangered Royal Bengal Tiger are increasing in STR. A total of 96 tigers were estimated in the 2020-21 survey that includes 30 males and 52 females, and the sex of 14 tigers cannot be determined. 4 cubs are also found in this survey but they are not included in total estimation according to the

guideline of NTCA. The latest survey in 2021-22 shows an increasing rate of tiger population in STR (STR, 2021).

Table 4. Human death by tiger attack in Sundarban Tiger Reserve during 2012 to 2022 (Source: Sundarban Tiger Reserve).

Sl. No.	Date	Range	Zone of attack	Victim name (s)	Age	Gender	Compensation paid
1.	20/04/2012	SWLS	Inside	Rabin Sardar	54 years	Male	Rs. 1,00,000/-
2.	27/04/2012	Bashirhat	Indise	Krishnapada Mondal	39 Years	Male	Rs. 1,00,000/-
3.	30/10/2013	SWLS	Inside	Sri Samidh Mistry		Male	Rs. 1,00,000/-
4.	08/08/2014	SWLS	Not Inside	Smt. Bhagabati Mondal	49 years	Female	Rs. 2,50,000/-
5.	21/08/2014	SWLS	Not Inside	Sri Sekhar Biswas	28 years	Male	
6.	24/08/2014	SWLS	Not Inside	Sri Sannashi Mondal	35 years	Male	Rs. 2,50,000/-
7.	31/01/2019	SWLS	Not Inside	Sri Swapan Raptan	45 years	Male	Rs. 4,00,000/-
8.	08/12/2019	Bashirhat	Not Inside	Prabhas Munda	28 years	Male	Rs. 4,00,000/-
9.	28/07/2020	SWLS	Inside	Dharoni Mohan Mandal	57 years	Male	Rs. 4,00,000/-
10.	04/09/2020	Bashirhat	Inside	Rejaul Gazi	32 years	Male	Rs. 4,00,000/-
11.	06/09/2020	SWLS	Inside	Gopal Baidya	54 years	Male	Rs. 4,00,000/-
12.	02/10/2020	SWLS	Inside	Dinabandhu Jodder	55 years	Male	Rs. 4,00,000/-
13.	15/07/2021	SWLS	Inside	Dinabandhu Mondal	50 years	Male	Rs. 5,00,000/-
14.	18/08/2021	BHT	Inside	Anna Das	42 years	Male	Rs. 5,00,000/-
15.	04/09/2021	SWLS	Inside	Dwarik Mondal	63 years	Male	Rs. 5,00,000/-
16.	04/10/2021	BHT	Inside	Salim Sana	28 years	Male	Rs. 5,00,000/-
17.	05/10/2021	BHT	Inside	Asit Sarkar	56 years	Male	Rs. 5,00,000/-
18.	01/02/2022	SWLS	Inside	Chitta Ranjan Sarkar	55 years	Male	Rs. 5,00,000/-

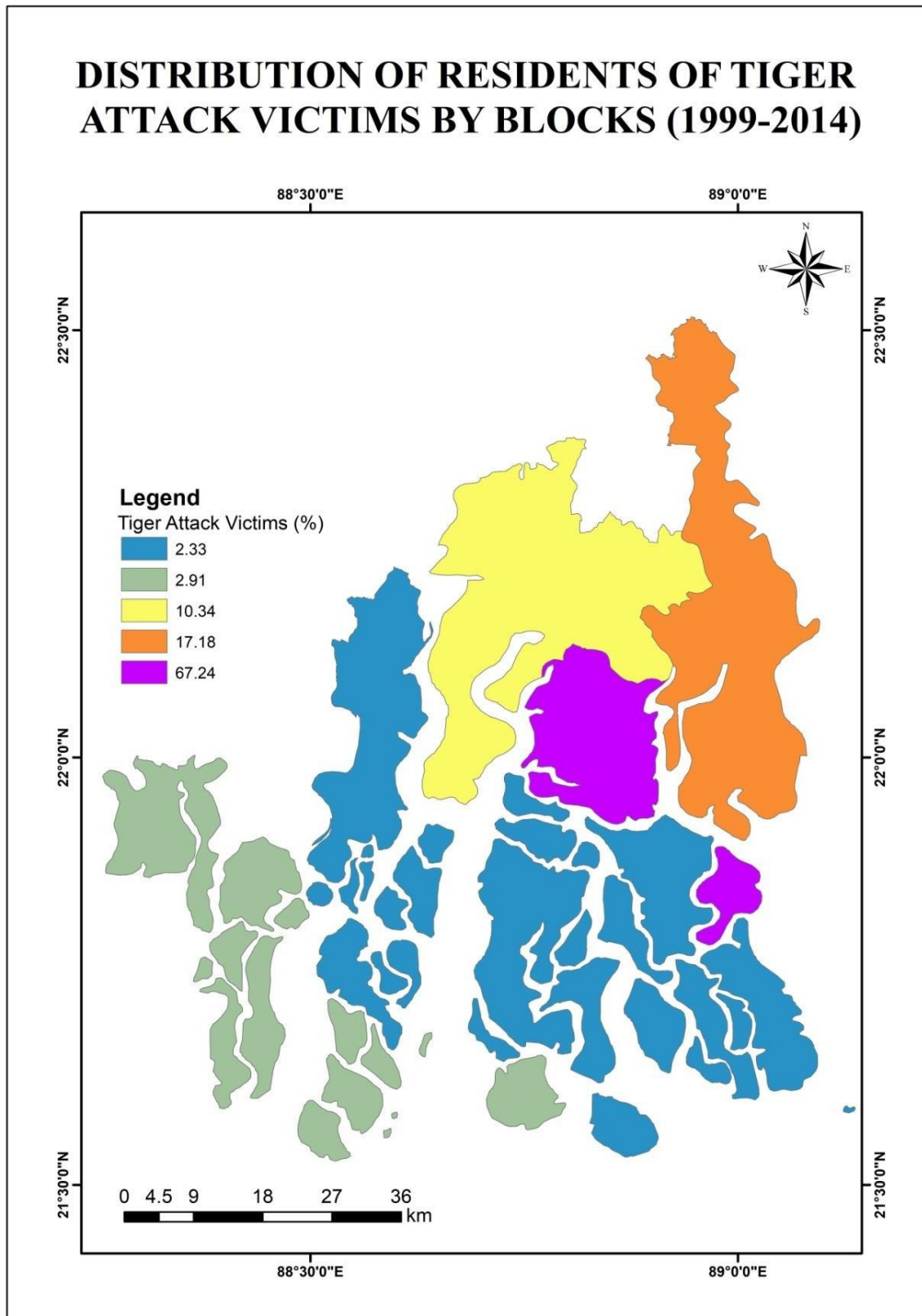


Figure 17. Residents of Tiger attack victims of different blocks (1999-2014) (Source: ArcGIS 10.4.1).

The villagers of Gosaba and Hingalganj regularly visit the most vulnerable forest blocks except Chandkhali, those are known for tiger attacks. From the fringe villages of Gosaba and Hingalganj, people enter into forest for their livelihood. For this reason, Gosaba and Hingalganj are two major forest blocks from where the maximum number of people enter the forest and get attacked by tigers. The tiger attacks are less in several forest blocks such as Gona, Bagmara, Mayadwip, Gosaba and matla due to their location. Several areas of Canning I, Sandeshkhali-I and II, Namkhana, Kakdwip, etc., have been least affected by tiger attacks due to the less involvement of the residents of these areas in forest-related activities. The residents of several blocks such as Gosaba, Hingalganj, Basanti, Pathar Pratima and Kultali have been attacked by tigers. From 1999-2014, 67.24% of tiger attack victims were residents of Gosaba, 17.12% of Hingalganj, 10.34% of Basanti, 2.91% of Pathar Pratima, and 2.33% of Kultali. The vulnerable forest blocks for tiger attacks are present adjacent to several fringe villages of Gosaba and Hingalganj. Because of this the migration rate of these local people of fringe villages is higher than any other block (Das, 2018).

Deaths of humans by tiger attacks from 2012 to 2022 have been recorded by the STR forest department. Most of the attacks happened inside the Sundarbans Tiger Reserve, and some of the tiger attacks happened outside of the STR. The genders of killed persons were mostly males and females in this period. All the attacks were found to happen within three ranges such as SWLS, Bashirhat, and BHT. Compensations have been provided by the government to the tiger attack victims. During 2015-2018, no official death has been recorded due to tiger attacks.

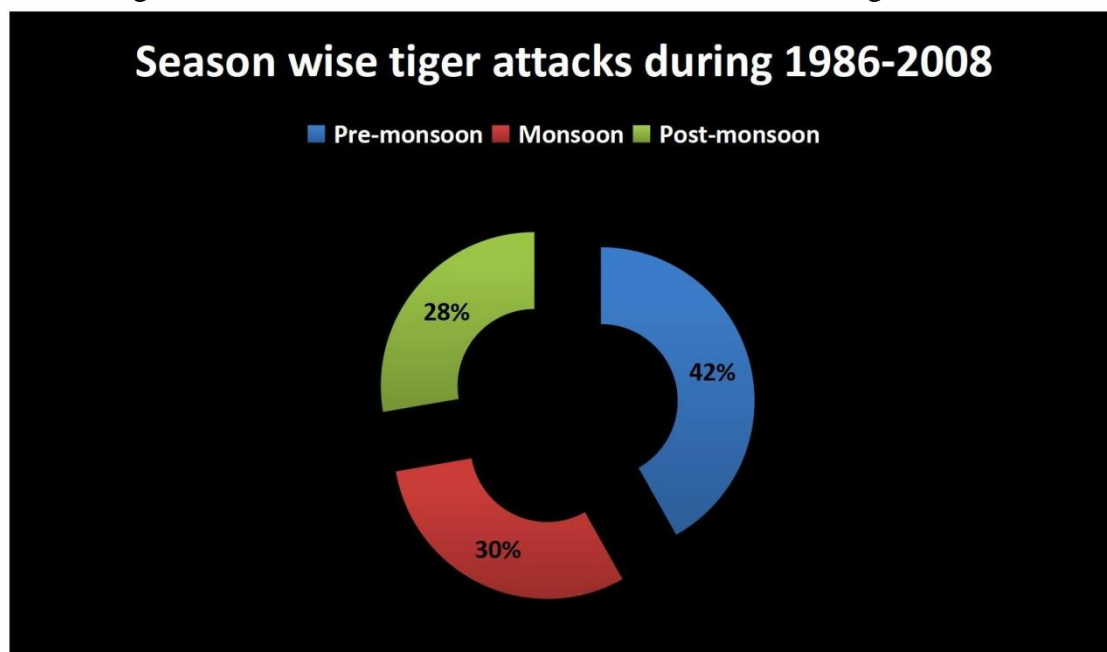


Figure 18. Season-wise tiger attacks from 1986 to 2008.

Tiger attacks on human have been happening throughout the year. Most of the attacks have been found to be happening in pre-monsoon season. From 1985 to 2009 total of 789 attacks took place, of which 20% happened in the month of April. Only 5.96% of attacks were recorded during

the month of October, which shows the lowest frequency of tiger attacks. From 1986-to 2008, out of a total of 789 tiger attacks, 157 tiger attacks happened in the month of April. If we divide a year into three seasons such as pre-monsoon, monsoon and post-monsoon, then the tiger attacks during 1986-2008 can be categorized into three parts. Most of the tiger attacks were found to happen in pre-monsoon season, and the second most tiger attacks happened in the monsoon season. But the second most tiger attacks have been seen in the month of January. 71 tiger attacks were recorded in the month of January during 1986-2008 (Das, 2017). Pre-monsoon season is more prone to tiger attack because local people enter the forest for their livelihood in this season. During monsoon people cannot access the forest due to the condition of rivers and creeks in rainy season.

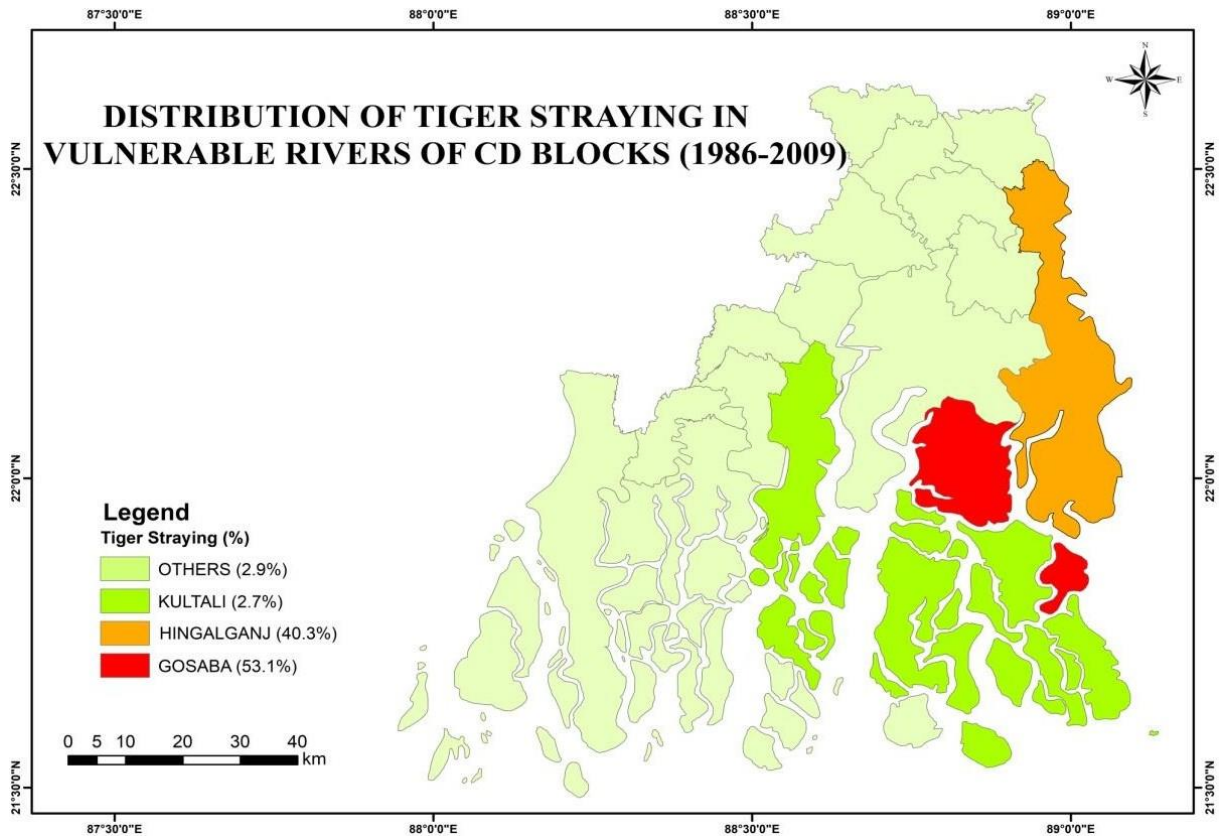


Figure 19. Distribution of tiger straying incidents in vulnerable rivers under different CD blocks.

Tigers need a large area for their straying and sometimes strayed tigers enter the human habitation in Sundarbans. Human-tiger conflict is so evident when tigers enter the human habitation or vice-versa. Tigers of Sundarbans can cross rivers and creeks by swimming. When tigers are turned into man-eater due to various reasons, the straying incidents increase frequently. During 1986-2009 the number of tiger straying incidents are 279 with an average straying incident 12 per year (Das, 2012). Several rivers and creeks are so vulnerable towards tiger straying such as Raymangal, Rangabeliya, Gumdi, Pirkhali, Kurekhali or Sakunkhali, Korankhali, kapura, Mokri and Thakuran. Among these rivers Raymangal has largest width of 800 meters and Kurekhali or Sakunkhali has smallest width of 25 meters. Due to the smallest width of Kurekhali or

Sakunkhali, 36.3% of all tiger straying incidents occurred through this river from 1986-to 2009. The second most vulnerable river towards tiger straying was Pirkhali with 33.6% tiger straying events in that time period. Pirkhali, Gumdi, Korankhali, Rangabeliya come under Gosaba, raymangal, Kapura, Kurekhali or Sakunkhali come under Hingalganj and Kapura, Mokri come under the Kltali CD block. The decreasing order of most vulnerable rivers containing CD blocks is Gosaba,Hingalganj and Kultali (Das, 2017).

Tiger straying has no fixed temporal pattern rather it can be seen throughout the year. The frequency of tiger straying incidents is higher in the winter season from December to February. The highest number of tiger straying incidents took place in the month of January during 1986-2008. Tiger straying least occurred in post-monsoon season. Out of 279 tiger straying incidents 36 occurred in the month of January and 4 occurred in the month of October during 1986-2008. Winter season is the season for littering. So, the female tigers need shelter to protect their cubs from males. Thus, the staying activity increases in the adjacent regions (Das, 2012). According to the local people, during floods and cyclones in Sundarbans, sometimes dead bodies of humans float into the river and settle down adjacent to the edges of creeks and rivers. During these disastrous events, the scarcity of food insists the tigers come out of the forest, and the consumption of human flesh turns them into man-eaters. (Jamal et al., 2022)

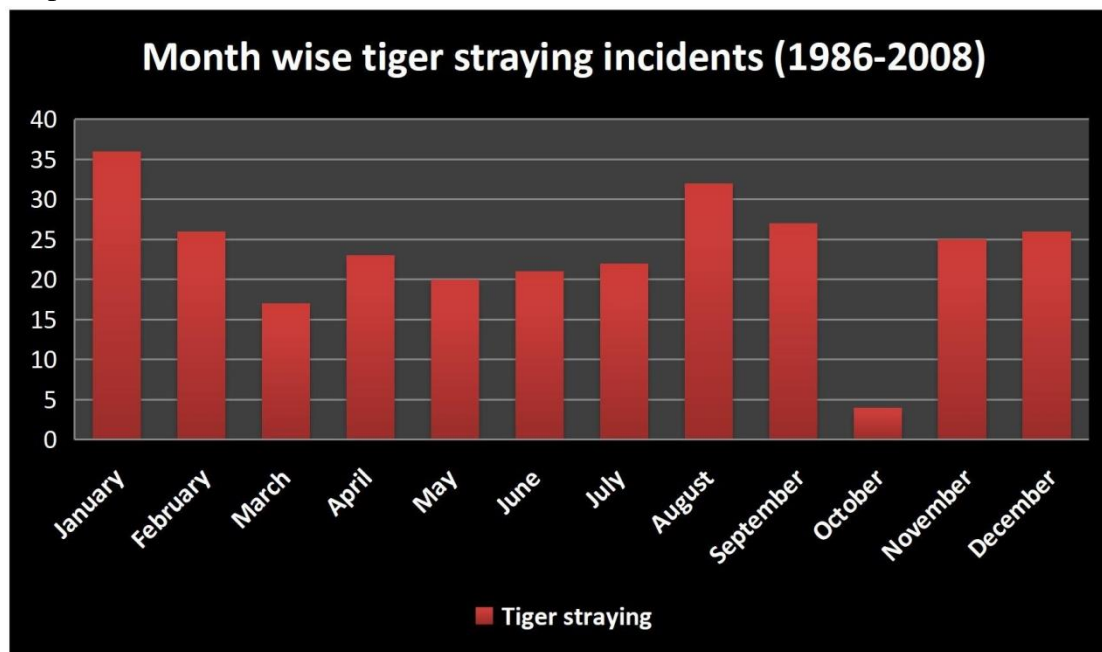


Figure 20. Temporal distribution of tiger straying incidents in a year during 1986 to 2008.

Tiger straying is a threatening incident for local people. To protect humans from tiger attacks several initiatives have been taken by the government. JFMC members and forest department frontline workers together work hard to protect local people from tiger attacks. Nylon net fencing is one of the initiatives taken by the forest department to reduce tiger straying in the fringe villages of Sundarbans. JFMC members and forest department staff are regularly involved in

patrolling activities to keep their eye on poaching activities, tiger straying and the condition of nylon net fencing. Regular maintenance of nylon net fencing has shown fruitful results for preventing tigers from straying. A total of 108 km of nylon net fencing is taken care of by forest department staff and JFMC members during the financial year of 2022-2-23. RCC and bamboo post are used to erect the fencing at a height of 10-12 foot. The normal mesh size of “4x4” is used to avoid any strangulation of wild animals like deer. The nylon net is made up of 4mm, 3 strand IP-PARA yellow nylon rope. The nylon net fencing has proved to be very effective in preventing tigers from straying into fringe villages as well as preventing the entry of cattle from village to forest. A total of 108 km of nylon net fencing has shown a co-relation between tiger straying and nylon net fencing with a positive outcome.



Figure 21. Co-relation between Nylon net fencing and tiger straying in Sundarban tiger reserve.

Tiger poaching is a very well-known event in protected areas. In Sundarbans tiger poaching has been happening for many years. Culprits take advantage of human-tiger conflict and enter the forest illegally to poach the tigers. The actual number of poached tigers is unknown but according to the official entry during 24 years (1986-2009) at least 92 tigers were poached in Sundarbans. In 1995, according to official entry, the highest numbers of tigers were poached during those 24 years. These tiger poaching events were officially recorded based upon the seized tiger skin from Sundarbans. Poaching activities have been reduced with time due to the strict government policies and Wildlife Protection Act. (Das, 2012).

When tigers enter into the fringe villages of Sundarbans, local people try to kill them to show their frustration. Sometimes tigers are poisoned by the local people. During 1990 to 2001 ten tigers are presumably killed by the local people. During this period forest officials found many

tigers dead at different regions of Sundarbans. Out of ten tiger killing incidents eight happened in Gosaba block and other two incidents happened in Hingalganj block and Kulatali block (Das, 2017). Local people attack stray tigers when they come out of the forest due to various reasons. All the revenge killings happened due to the suffering of people by tiger straying. Tigers destroy livestock of local people and attack humans when they turn into man-eater. The fear of survival and the anger against the tiger make them aggressive towards tigers.



Figure 22. Nylon net fencing in Sundarban (Source: Sundarban Tiger Reserve).

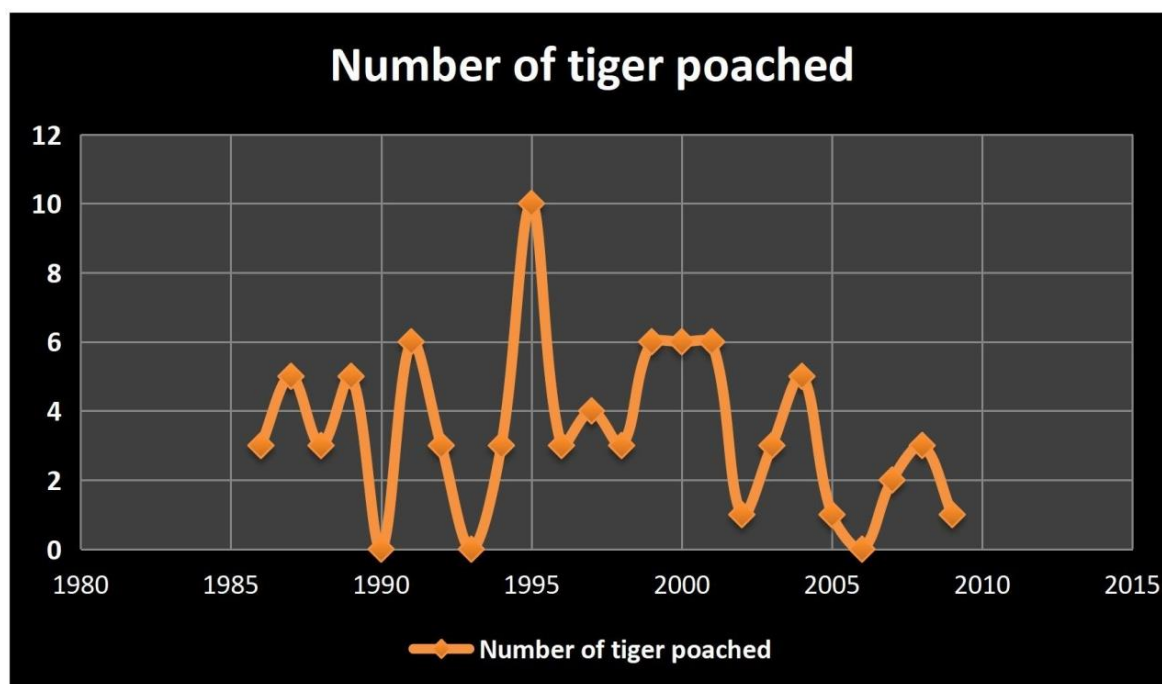


Figure 23. Number of tigers poached during in Sundarbans 1986 to 2009.

DISTRIBUTION OF TIGER KILLING INCIDENTS (BY VILLAGERS) DURING 1990-2001

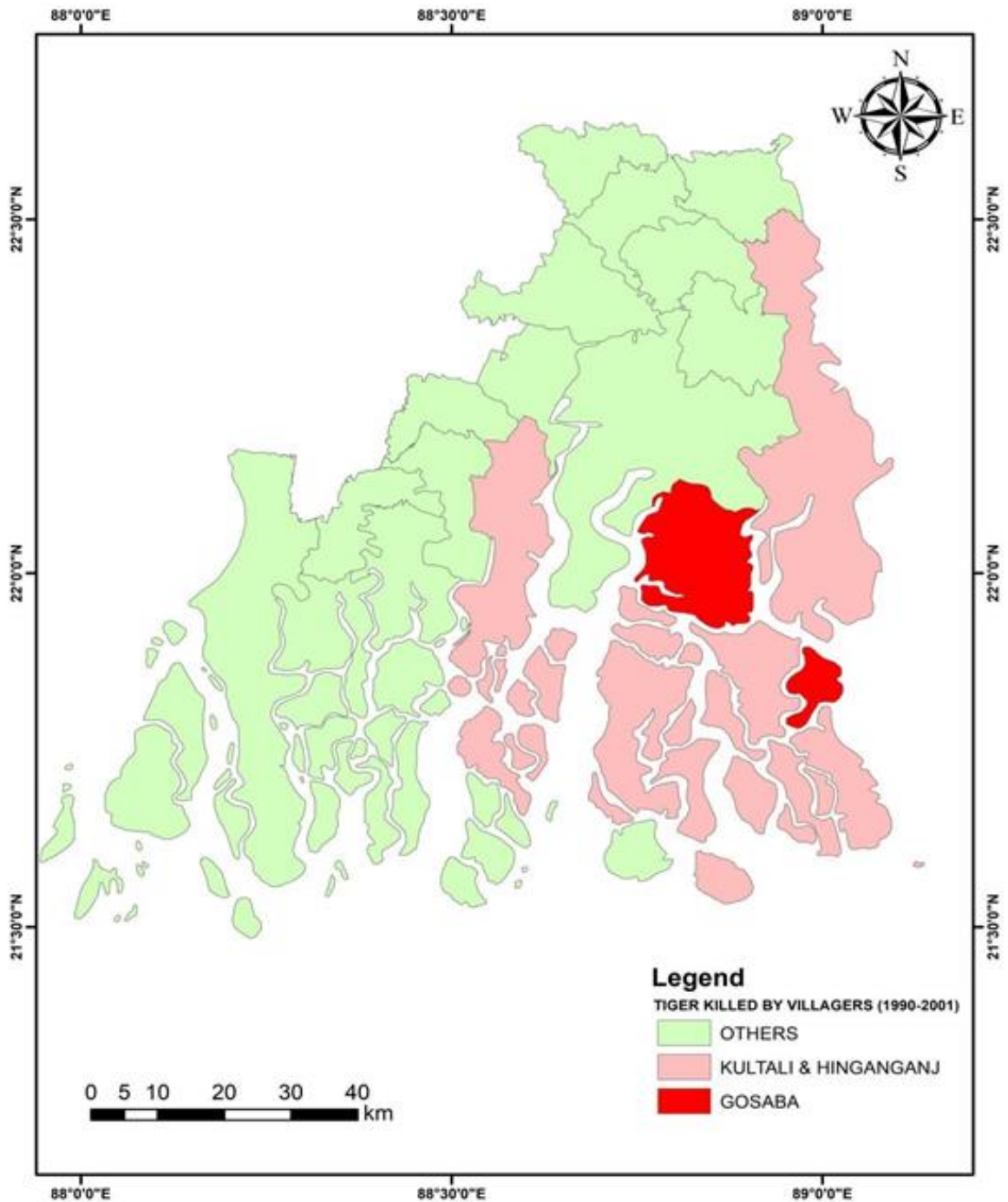


Figure 24. Tigers killed presumably by villagers during 1990-2001 (Source: ArcGIS 10.4.1).

Males, who were killed by tiger attacks in Sundarbans, left their wives as widow. Those women whose husbands died in tiger attack became tiger-widows. The life of tiger-widows becomes so difficult due to the social rejections. The socio-cultural stigma of Sundarbans obstructs them from marrying again. They are not allowed in social and religious events. On the other hand, the economic crisis makes their life so difficult and unsecure. They have to face mental and physical assaults from society (Debnath, 2020). This social condition of tiger widows is one of the keyfactors for enhancing human-tiger conflict.

Local people who enter the forest with traditional experience have directly evident the tiger attacks are called Target Group Respondents (TGR). There are eight attributes responsible for tiger attacks described by these TGRs. The eight attributes are conflict time, position of tiger attacks, nature of selection of prey, food habit of tiger, awareness of the forest intruders, selection of intrusion area, coordination among fish and crab collection team members and cultural understanding of intruders. According to the TGR the time of conflict is early morning or afternoon. Tigers preferably attack on the right side of the body. Most tigers prefer human flesh than any other food. There is a lack of awareness when native people enter the forest for their livelihood. During the process of boat licensing, there is no awareness program for survival in the forest. Fisherman prefer core zone for more collection of fish and crabs. As we know the core area is more prone to tiger attacks (Chatterjee, 2023). People solely depend on the local biodiversity such as they build their house with *Nypa* leaves. The collection of *Nypa* leaf is a risky task because to collect the leaves people have to enter into the forest. The way humans utilise the tiger's habitat is one of the primary responsible factors for tiger attacks.

Human-snake conflict:

Total 200 types of snake species belong to 11 families distributed throughout all over India. Among these only 52 species are venomous in nature. In Sundarbans several venomous species of snakes present that includes Indian Cobra, king Cobra, Indian Kraits, Banded kraits and Russell's viper. There are 17 common species of non-poisonous snakes present in Sundarbans that includes blind snake, beaked blind snake, Common wolf snake, green whip snake, rat snake, chequered keelback, striped keelback, Olive keelback, trinket snake, painted brown snake, Indian bronze back and dog faced water snake. The terrestrial, intertidal and aquatic environment provide ideal habitat for the snakes to live in Sundarbans. In Sundarbans, snake density is comparatively higher in southern part of the Sundarbans. Depending upon the frequency of sighting of poisonous snakes in Sundarbans a ranking can be made such as Common krait, Common Cobra, Banded krait, Russell's viper and King Cobra. Most of the deaths occurred in four blocks of Sundarbans such as Basanti, Canning I, Canning II and Gosaba due to fatal snake bites. During 1993-2005, a total of 527 deaths were recorded due to snake bites in these four blocks. In this time period out of 527 deaths 195 deaths in Gosaba, 146 deaths in Basanti, 101 deaths in Canning I and 85 deaths in Canning II were recorded. According to the vulnerability of snake bites in various blocks of Sundarban during 1993-2005, the most vulnerable block was Namkhana, with 272 deaths officially recorded, and the two second most vulnerable blocks were

Sandeshkkhali I and II, with recorded numbers of deaths were 188 and 189 respectively. Least vulnerable block was Minakhan with recorded number of deaths were 34. Total 2441 snake bites were recorded in 19 vulnerable blocks of Sundarbans during 1993 to 2005 (Das, 2017).

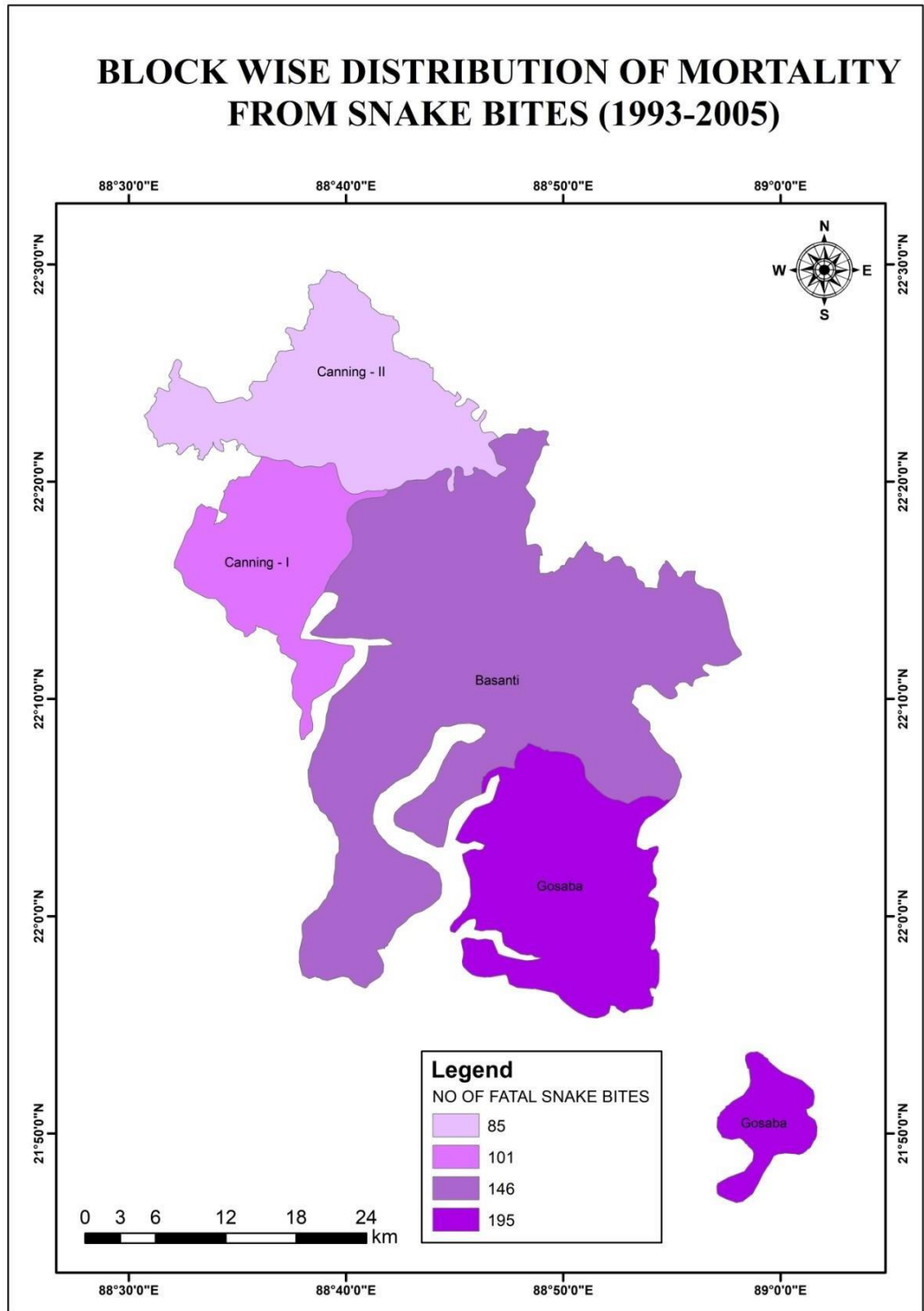


Figure 25. Block wise fatal snake bites during 1995-2005 (Source: ArcGIS 10.4.1).

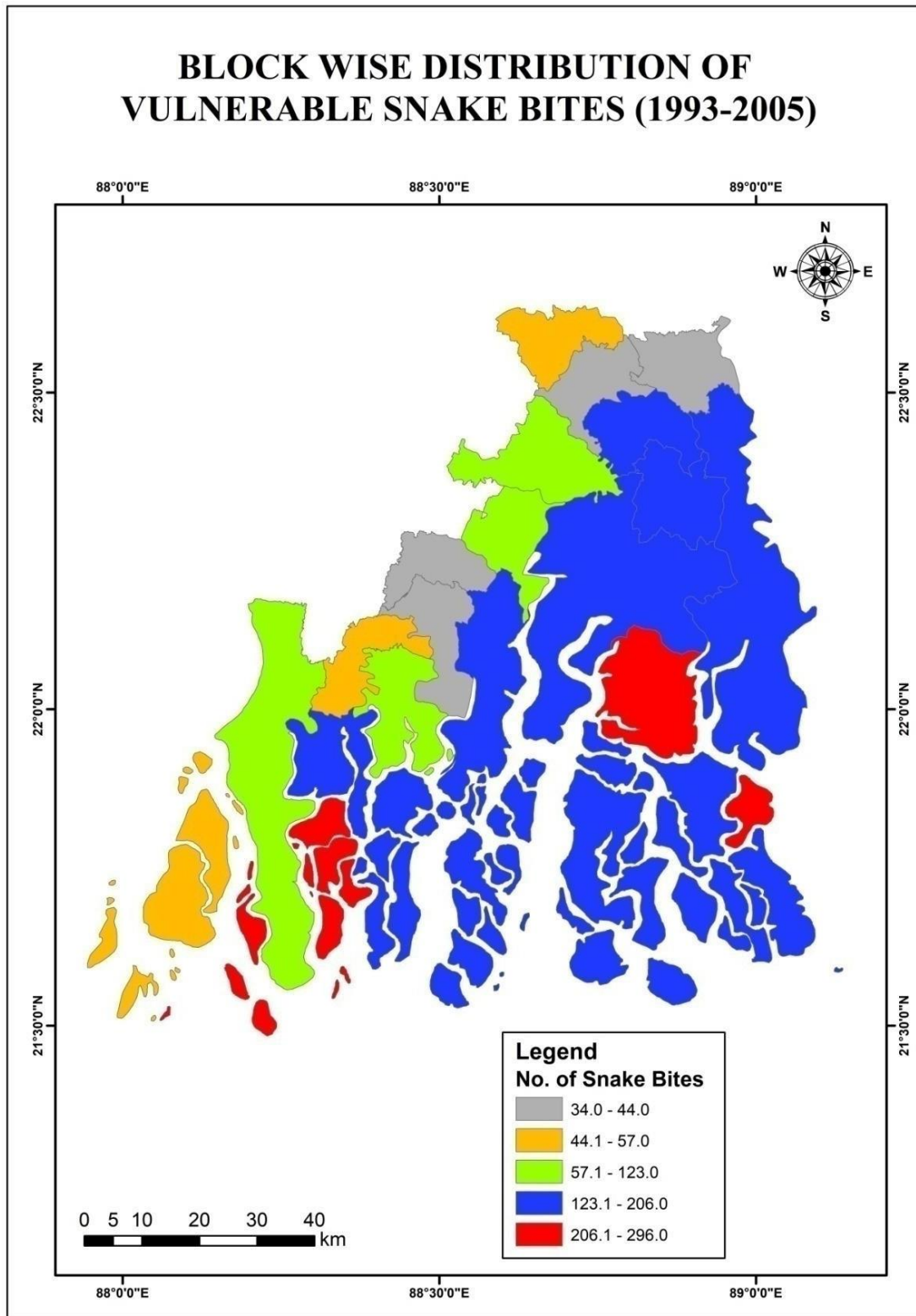


Figure 26. Block wise vulnerable snake bites in Sundarbans during 1993-2005 (Source: ArcGIS 10.4.1)



Figure 27. Crocodile in Sundarban (Source: Sundarban Tiger Reserve)

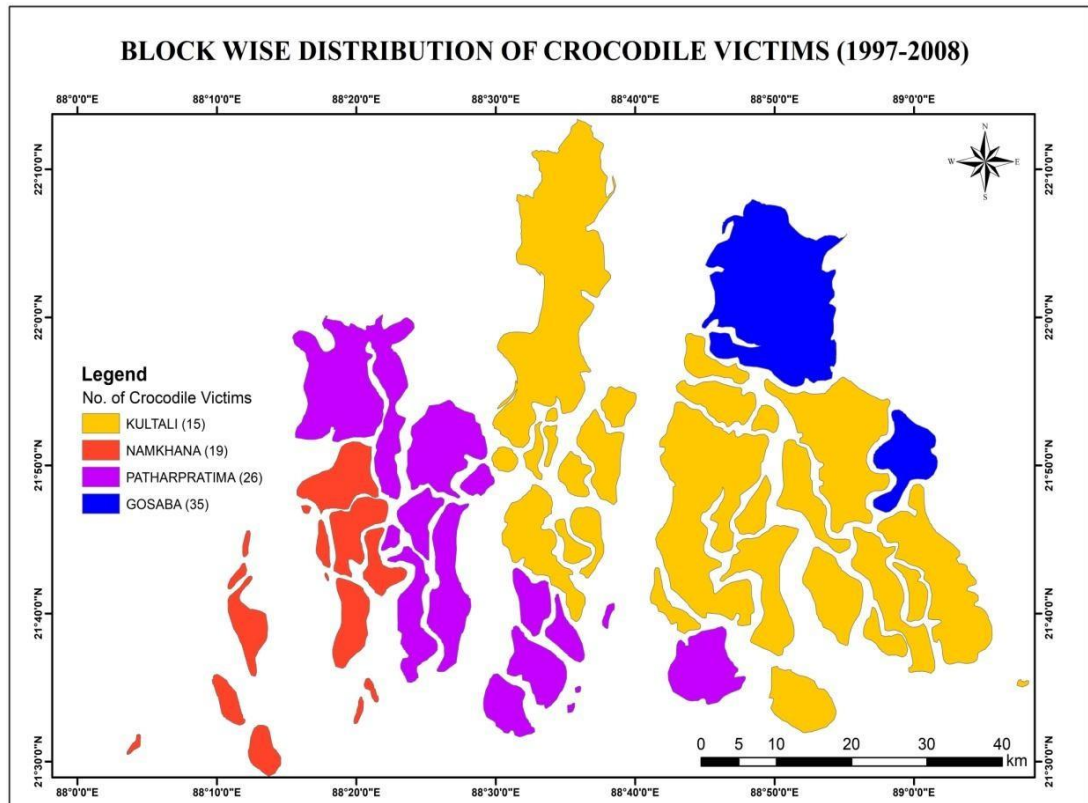


Figure 28. Block wise crocodile attack victims in Sundarbans during 1997 to 2008 (Source: ArcGIS 10.4.1)

Human- crocodile conflict:

Salt-water crocodiles are one of the apex predators found in Sundarbans. They inhabit coastal brackish near mangrove forests and can be seen while basking in the Sun over the mudflats. Saltwater crocodiles mate in the rainy season while the water level is highest in a particular time of a year. They show the courtship for mating during the month of September to October. During 2020-2021 the estimated numbers of saltwater crocodiles were 144 (Government of West Bengal, 2020). In Sundarbans, Crocodile victims can be two types such as the first category is fisherman and second one istiger prawn seed collector. In remote areas of Sundarbans, local people collect the spawn of shrimp using nylon net due to the lack of employment. During 1997 to 2008 a total of 103 people were attacked by saltwater crocodile. Most of the crocodile attack victims are prawn seed collector belongs to the age group of 11 to 50. Females are more affected than males against crocodile attacks. Total 103 incidents of crocodile attack happened in Sundarbans during 1997 to 2008, out of which 35 incidents happened in Gosaba, 19 in Namkhana, 26 in Pathar Pratima and 15 in Kultali. In Gosaba 28 deaths were recorded from 35 attack incidents. In namkhana, PatharPratima and kultali 10, 14 and 7 deaths were recorded respectively during 1997 to 2008 (Das, 2017).

Conclusion:

A complex web of dependencies and conflicts in Sundarbans highlights an obligatory relationship between humans and the natural environment. The unique ecosystem of Sundarbans, having dense mangrove forests, diverse wildlife, and proximity to the Bay of Bengal, has structured the life and livelihood of the local people. The fishing industry of Sundarbans is sustained depending upon the rivers and creeks as well as the rich biodiversity of Sundarbans. The mangroves also act as a protective barrier against cyclonic storms and prevent the submergence of land area under the water. However, the Sundarbans are facing various external challenges that accelerate the existing dependencies and conflicts. Climate change is one of the responsible factors that threaten the existence of the Sundarban ecosystem. Changes in environmental parameters lead to an increase in various natural disasters that destabilize the lives of local people. A sustainable holistic approach is required to address these dependencies and conflicts. Some initiatives have already been taken but more efforts should be made to address these crucial issues. As humans learn to appreciate the importance of the relationship between them and nature, it is possible to conserve human as well as ecosystem resources in a balanced way. The harmonious co-existence of humans and wildlife is essential to safeguard the livelihood of local communities and to give an eco-friendly environment to future generations.

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