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Tiger Prawn Seed Collection in the Indian Sundarbans: Environmental, Livelihood, and Occupational Implications

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Abstract

The Sundarbans recognized as a global biodiversity hotspot, support the livelihoods of approximately 95% of the local population through activities such as agriculture, aquaculture, and fisheries. The present study investigated the socio-economic conditions, environmental implications and occupational hazards faced by tiger prawn seed collectors in the Basanti and Hingalganj blocks of the Sundarbans. Blocks were purposively selected as notable tiger prawn seed collectors found in this region. A simple random sampling method was used to survey 60 monodon seed collectors from four villages with semi-structured interviews conducted to gather data on their socio-economic status and occupational risks. The data analysis incorporated mixed method approach, employing descriptive statistics, and thematic analysis. The study utilized the (SPE) Risk Assessment Model to evaluate the risks associated with physical, ergonomic, biological, and psychological hazards. Study reveals that Income from tiger prawn seed collection exhibits significant seasonal variation. Maximum income is recorded from April to July with monthly income of ₹11,400. Study on occupational hazards indicate that physical hazards pose the highest risk (0.68), followed by ergonomic (0.65), psychological (0.46), and biological hazards (0.35). These risks highlight the urgent need for improved safety measures and alternative livelihood opportunities. The research underscores the necessity of balancing economic sustenance with ecological conservation, suggesting future interventions that include protective gear, ergonomic tools, and government support to ensure the well-being of the collectors and the sustainability of the Sundarbans ecosystem.

Keywords: Tiger prawn seed collection, conservation, occupational risks, socio-economic

Introduction

Estuaries are extremely productive, dynamic, and distinctive ecosystems that provide food, transportation, and recreation. The ecosystem services of estuaries are extensive and intricately linked to the livelihoods of the surrounding populations (Ramachandra *et al.*, 2022) ^[23]. The Sundarbans estuary, one of the most productive, is regarded as global biodiversity hotspot (Sarat Babu, 1999; Sayer *et al.*, 2000) ^[27, 29]. The Indian Sundarbans spread over a vast area of (9660 sq.km) with a human population of over 4.5 million inhabiting 52 islands. Approximately 95 percent of the population is directly or indirectly dependent on the Sundarbans ecosystem for their livelihoods, engaging in occupations such as agriculture, wild honey harvesting, aquaculture, and fisheries (Chowdhury *et al.*, 2016) ^[9]. Shrimp farming in the Indian Sundarbans area was initiated during the 6th Five-Year Plan, spanning from 1980 to 1985. This initiative was part of a broader effort to develop coastal aquaculture, and it received support from the World Bank along with other development agencies (Wood *et al.*, 1992) ^[31]. The extensive shrimp aquaculture farms are increasingly mushrooming along this coastal zone taking advantage of the nutrient-rich brackish water situation in Sundarbans area especially *P. monodon*, the largest Indian marine penaeid

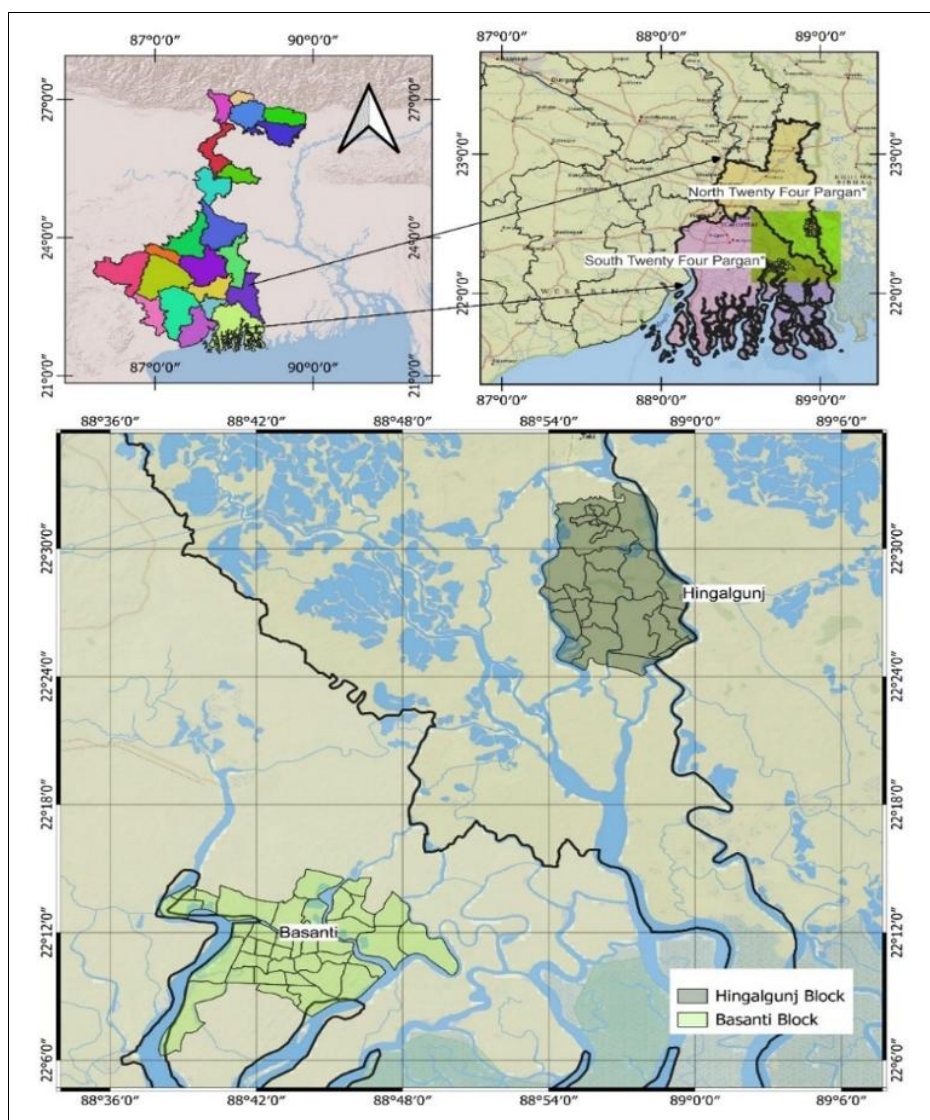
prawn (Kurian and Sebastian, 1982) ^[21], is the most preferred species for shrimp farming in the Sundarbans area because of high market demand and rate in the international market but the artificial hatching of *P. monodon* is hampered by inadequate physicochemical conditions, particularly low salinity levels (30-32%), necessitating the importation of tiger prawn seed stock. However, this practice is beset by challenges including seasonal availability, microbial risks, high mortality rates during transport, variable conditions, and substantial costs, collectively impeding the region's ability to meet the escalating demand for tiger prawn seeds in its expanding fish farms. (Sarkar and Bhattacharya, 2003) ^[28] The increasing demand for *P. monodon* seeds from expanding fish farms along the Sundarbans' coastlines has enticed impoverished coastal fishers to engage in wild prawn seed collection as a means of earning a livelihood (Banerjee and Singh, 1993) ^[2]. The Sundarbans estuarine area supplies large quantities of naturally available tiger prawn seeds (Bhowmick, 1993; Chokroborti *et al.*, 1987) ^[6, 7]. In the Sundarbans region, tiger prawn collection, locally known as "meendhara," engages individuals across all demographics, including men, women, and children. Notably, women play a predominant role in the prawn seed collection process.

This occupation is particularly prevalent in South 24 Parganas, where many are involved in tiger prawn seed collection. A similar situation is observed in North 24 Parganas. Tiger prawn collection is a highly profitable venture allowing them to earn hard cash at the end of the day (Mondal and Bhaduri, 2010) ^[22]. However, the dependence of these communities on tiger prawn collection for their livelihood presents a "double-edged sword" scenario, as it caters to both the seed supply and economic sustenance needs. Despite its economic benefits, tiger prawn collection has caused severe biodiversity loss and ecological damage in the region, prompting significant concerns (Das and Sarkar, 2009; Bhatka *et al.*, 2021) ^[15, 1]. Government regulations have been implemented restrictions on collection of tiger prawn seeds in the region. However, the absence of alternative livelihood opportunities and support from government organizations for other employment prospects leaves these communities heavily dependent on this practice (Ahmed *et al.* 2012). Tiger prawn seed collection is fraught with numerous occupational hazards, significantly impacting the safety and well-being of the collectors. These hazards include frequent human-animal conflicts, where collectors are at risk of snake bites, tiger attacks, and crocodile attacks. Such encounters place them

in perilous situations, particularly in certain geographic regions where these predators are prevalent (Das, 2017). It is crucial to note that tiger prawn seed collection represents one of the most lucrative occupations in the Sundarbans region. Despite the inherent risks and ecological damage associated with this practice, local communities persist in this occupation out of necessity. Consequently, it is imperative to balance the protection of these collectors' livelihoods with the conservation of the delicate ecosystem. On this background, the present paper attempts to capture an in-depth view of the socio-economic conditions of the people involved in tiger prawn seed collection, the occupational hazards they face, and the impact of prawn seed collection on the Sundarbans ecosystem. By examining these interconnected aspects, the study aims to provide a comprehensive understanding of the challenges and implications associated with this practice. Through detailed analysis and highlight the urgent need for sustainable solutions that address both the welfare of the prawn seed collectors and the conservation of the unique and fragile ecosystem of the Sundarbans.

Methodology

Study Area



The study was conducted in the Basanti Block of South 24 Parganas district and Hingalganj blocks of the North 24 Parganas district of the Indian Sundarbans, West Bengal.

Sampling method: Collection of prawn/shrimp seed from natural resources is an age-old practice among the farmers in coastal areas of three coastal districts. The exact number of wild prawn seed collectors in the Indian Sundarbans has not been comprehensively assessed. However, the Fishermen's Association estimates that approximately 25,000 individuals (7,000 men and 18,000 women) are engaged in this activity. Notably, about 8,000 of these collectors (6,000 women and 2,000 men) operate within the core areas of the Sundarbans. Three blocks in the Sundarbans with significant numbers of tiger prawn seed collectors are Hingalganj, Basanti, and Gosaba.

A simple random sampling method was employed to survey 60 monodon seed collectors from two selected blocks Basanti and Hingalganj blocks. These blockswere purposively selected due to the high number of tiger prawn seed collectors found there. A semi-structured interview schedule was used to gather information on their socio-economic status and the occupational hazards they face from January 2024 to August 2024.

Data Analysis: The data analysis for this study involved mixed method approach. Focused group discussion was used for the identifying different occupational hazards faced by tiger prawn seed collectors, after identify the occupational hazards, it is very important to assess the risk from particular hazard to understand the damage of it. the SPE Risk Assessment Model (Shadizadeh and Ataallahi, 2015)^[30] was adopted to evaluates risks for specific hazards by calculating risk as a function of Severity, Probability, and Exposure, represented as $Risk = f(SPE)$. However, for the purposes of this analysis, we employ an alternative method to calculate risk. Instead of using the multiplicative approach, we have chosen to average the factors and then normalize the result. This method is expressed as: $Normalized\ Risk = 1/3(Severity + Probability + Exposure)$.

Justification for Averaging Method: This method offers a balanced metric by assigning equal weight to each factor and averaging their combined impact. Although this approach differs from traditional multiplicative models, it presents distinct advantages, such as simplifying the analysis and aligning with specific study objectives. Additionally, since the data is normalized, applying a multiplicative model could have a negative effect on the results, making the averaging method more appropriate for this analysis.

Severity is rated on a scale from 1 to 5 as follows: 1 = None or Slight; 2 = Minimal; 3 = Significant; 4 = Major; 5 = Catastrophic. Probability is also rated from 1-5 thus; 1=Impossible; 2=Unlikely in normal circumstances; 3= 50%; 4= Greater than 50%; 5=Vey likely and Exposure is rated from 1-4 thus; 1=None; 2=Average; 3=Above average; 4= Great. Normalisation method was used to classify the risk score as Low risk (0 to 0.33), Moderate Risk (0.33 - 0.66) and High risk (> 0.66).

To assess the environmental impacts of tiger prawn seed (TPS) collection in the Indian Sundarbans, a systematic

literature review was conducted and data base such as publish or perish and key words ("tiger prawn seed collection" OR "TPS collection") and ("environmental impact" OR "environmental effects") used and important papers are reviewed and thematic analysis was conducted to identify emerging themes for environmental impact of tiger prawn seed collection.

Results and Discussions

Mode of Catching of TPS

Tiger prawn seeds, or "meens," are typically found in large quantities during high tide when the pressure from the sea pushes them upstream (Raychaudhuri, 1980)^[24]. The number of fish rises as the water level increases, particularly around the new moon and full moon phases. However, the actual collection of these seeds occurs during low tide. Additionally, the summer season is observed to be the most productive time for collecting prawn seeds, while the winter months yield the least amount.

There are primarily two methods for collecting prawn seeds: dragging a net and spreading a net. Each day, prawn seed collectors engage in two main activities: dragging the net forward or backward, and collecting the seeds. Due to financial constraints, they cannot afford large nets, so they primarily use small, hand-operated nets. These nets are dragged through 1 to 2 feet of thick, sticky mud and salty water. Collectors drag their small hand-operated nets either forward or backward, covering long distances of approximately 6 km per day. This process takes long hours each day, during which they navigate the challenging conditions of mud and salty water to gather prawn seeds.

Methods of collection Tiger prawn seed

The collection of prawn seeds involves the use of several simple implements. These include *nets*, *aluminium pans*, *ropes*, *enamel trays*, and *bivalve shells*. Each tool plays a specific role in the collection process.

Their catching nets are of mainly two types:

- Hand operated scoopnet (Chakni jal)
- Shooting net (Naukar jal)

Hand-operated scoop netnet locally known as (*Chakni jal*, *tana jal*) typically made from durable nylon or polyethylene, *tana jal* features a fine mesh size, often ranging from 10 to 20 millimeters, which is effective in capturing small fish and prawn species, including the highly sought-after tiger prawn seeds.

Shooting netlocally known as (Naukar Jal) meaning the boat's net. It is almost triangular In shape. The three sides of the net arc bound to three bamboo poles providing structure and support, the size of the net was diameter 25 m, length 26 m. It is a long funnel-shaped net tied at the tail end of the shoot ne and set against tidal water to filter seed from the estuarine water.

In some places set barrier net (Char pata jaal) is also used to collect the tiger prawn seeds. It is well known that the young ones of prawn and fish have a tendency to settle among the mangrove vegetation for feeding and shelter. Taking advantage of this habit, an easy and efficient method is in vogue for trapping and collection of. Seeds of *P. monodon* and mullets from the mangroves covered by inter-tidal mud flats.



Fig 1: shooting net operation from boat



Fig 2: Hand operated scoop net

Sorting of Tiger shrimp (Bagda) and other post-larvae is done by hand with the help of small watch-glasses, plastic plates or shells of bivalves. Slightly grown up Tiger shrimp juveniles settle on the bottom of the containers. Sorting of early juveniles and post-larvae of *P. indicus* is a difficult task, since these are very much sensitive to handling.

Bivalve shells

These are collected from the river. The shells are used to pick out the meen. The prawn seeds are also sorted by floating them on the valve. Additionally, the shells aid in the separation process during sorting

Enamel tray

The post larvae of Tiger shrimp, *P. monodon* (commonly known as Bagda) are seen to swim in the containers and sometimes they also hang or cling on the wall of the containers. Since the bagda fry are pink-reddish in colour it become easier to sort out it from the collection particularly

against white background i.e. when the sample is displayed on white enamel tray for sorting.

Aluminium pans

The local name is Handi. It is priced at Rs 150 and purchased from the market. An aluminium pan is used for keeping the meen alive in saline water.



Fig 3: Sorting of *Monodon* seeds from bivalves

Seasonal Variation in Tiger Prawn Seed Collection in the Sundarbans Region

In the Sundarbans area, tiger prawn seeds are typically available year-round in varying quantities. Peak tiger prawn seed collection observed during the month of April to July. A group of people, locally known as "Meendhara," are typically involved in catching tiger prawn seeds.

The collection of tiger prawn seeds in the Sundarbans region exhibits significant seasonal variation, with approximately 1500 to 2,500 seeds collected from April to July, decreasing to around 500 to 1,000 from August to December, and further dropping to 500 and below from January to March given Fig 4. These fluctuations can be attributed to seasonal changes in environmental conditions such as water temperature, salinity, and monsoon patterns, which influence the breeding cycles and abundance of tiger prawns (Hossain *et al.*, 2004) ^[19]. Peak breeding periods, corresponding with higher temperatures and increased availability of phytoplankton, are prevalent from April to July, resulting in higher seed availability during these months (Bhattacharya *et al.*, 2003) ^[4]. Conversely, the monsoon and post-monsoon periods from August to December bring changes in water salinity and sediment loads, impacting seed availability. During the winter months from January to March, lower water temperatures reduce prawn reproductive activity, leading to a decline in seed collection (Islam *et al.*, 2014) ^[20].

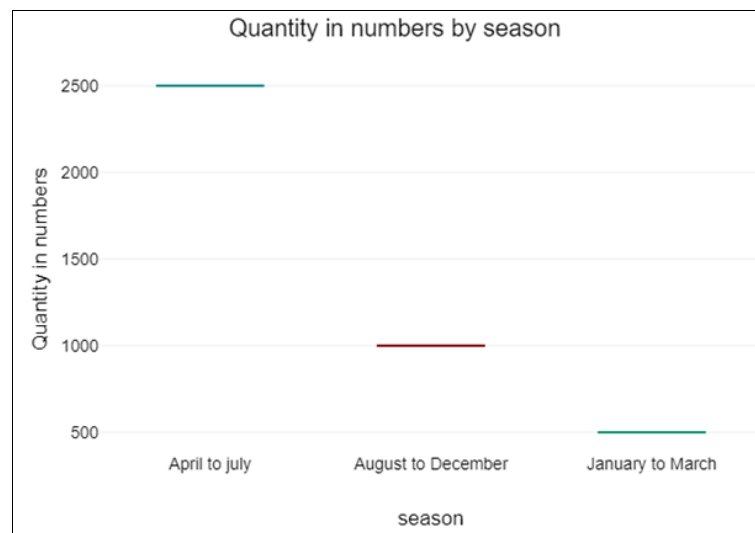


Fig 4: Seasonal Variation in Tiger Prawn Seed Collection

Size grade and average price

The size, grade, and average price of tiger prawn seeds vary. Mysis, locally known as "Pin," are priced between 250 to 500 Rs per 1,000 pieces. Post-larvae that are 10-15 days old, locally called "Chanti," are priced between 300 to 750 Rs per 1,000 pieces.

Peak Collection Period for *P. monodon* Post-Larvae During Lunar Phases

During the lunar cycle, from new moon (occurring before 1 day and after 6-8 days in every circle) to full moon (occurring before 2 days and after 4-5 days in every circle), *P. monodon* post-larvae collection reaches its peak. Similar type of result was found by Bhaumik and Mitra, 2013 that the fish seed availability during 1st to 7th days of the full moon and also new moon phases was significant in respect of the total numbers hauled and percentage of fin fish, shell fish and the tiger shrimps in seed collection nets

Environmental Impacts of Tiger Prawn Seed Collection

The collection of tiger prawn seeds in the Sundarbans has profound environmental impacts. This practice leads to the weakening and breakage of embankments, the destruction of social forestry saplings on riverbanks, and disruptions to the mangrove ecosystem and its food chain (Mondal and Bhaduri, 2010) [22]. Additionally, various fish species and other fauna are harmed, and the discarded non-target species further adversely affect the local environment.

Significant bycatch is a major issue in tiger prawn seed collection. It is estimated that to obtain only 0.25-0.27% of tiger prawn seeds, 70-75% of other shrimp larvae, 20-25% of finfish larvae, and 4% of macrozooplankton are destroyed (Sarkar and Bhattacharya, 2003) [28]. The peak period for seed collection per day per shoot net is in June, while bycatch loss peaks in August before sharply declining. From November to February, both seed collection and bycatch loss decrease significantly. Seasonal variability is stark, with an estimated loss of 130 billion organisms as bycatch during the peak season compared to 2 billion during the lean season (Das and Sarkar, 2009) [15].

The extensive destruction of shrimp fry bycatch is highlighted in various studies. The bycatch includes

commercially important fish and shrimp species such as *Metapenaeus brevicornis*, *Metapenaeus ensis*, *Parapenaeopsis sculptilis*, *Penaeus penicillatus*, and finfish including *Hilsa ilisha*, *Hilsa toli*, *Stolephorus* spp., *Lutjanus* spp., *Pama pama*, *Johnius coitor*, *Glossogobius giuris*, and *Glossogobius rubicundus* (Banerjee and Singh, 1991) [2]. A study by Bhaumik *et al.* (1992) [5] revealed that around 181.4 million undersized finfish and shellfish seeds were destroyed during the collection of tiger prawn seeds in a 40 km stretch between Kulpi and Namkhana of the Hooghly estuary.

Non-selective fishing gears, primarily nets with small or zero mesh sizes, are highly destructive. These methods not only capture the targeted species but also result in significant bycatch of non-targeted species, leading to widespread destruction of aquatic seed populations (Bhakta *et al.*, 2021) [3]. It has been observed that an average of 313 juveniles of 37 species of finfish are destroyed for every 17 tiger prawn seeds collected. Furthermore, the use of nets by fry catchers along intertidal mudflats often results in the uprooting of mangrove seedlings and salt marsh grass (*Porteresia coarctata*). These plants provide crucial ecosystem services, such as erosion control, beach stabilization, bioremediation, and carbon sequestration. Consequently, the disruption caused by net dragging undermines these important ecological functions (Chowdhury *et al.*, 2017) [8].

While it is understood and recognized that the use of drag nets damages riverbanks, the impact on the ecosystem and the resulting loss of biodiversity are often not acknowledged by collectors. The full extent of this ecological damage remains unclear (Danda, 2004). The reduction in the abundance of key species through bycatch can lead to major and unpredictable changes in food chains, affecting the ecosystem similarly whether the removal is due to targeted catch or bycatch. "Cleaned" upper slope grounds result in a loss of predators (Gillett, 2008) [18].

The maximum loss of bycatch was recorded in July, with 115 kg per day, while the minimum loss of 2.64 kg was recorded in March. The highest quantity of bycatch was estimated for *Acetes* species (25.54% of the total quantity), followed by *Esculanta thoracata* (16.73%), *Stoloforous*

commersonii (12.98%), and *Therapon jharbua* (10.83%). The minimum quantity of bycatch was recorded for fish species like *Setipinna phasa* and *Nandus nandus* and also

quantify the Economics of the by catch (Ekka *et al.*, 2020)^[16].

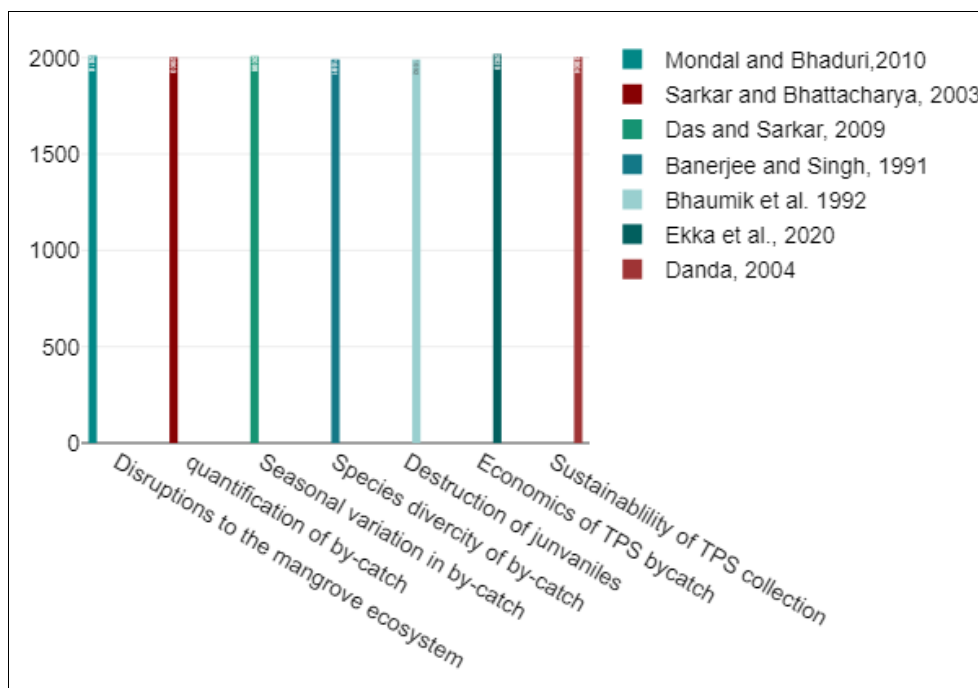


Fig 5: Research trends on environmental effects of TPSC

The research on the environmental effects of tiger prawn seed (TPS) collection highlights several critical areas. Key studies have focused on the disruptions to the mangrove ecosystem, quantification and seasonal variation of bycatch, and species diversity affected by this practice. Notably, there has been significant attention to the destruction of juveniles and the economic implications of TPS bycatch. Recent research has also examined the sustainability of TPS collection, emphasizing the need for more ecologically balanced approaches to mitigate the adverse impacts on the ecosystem. The timeline of these studies, ranging from 1991 to 2020, indicates a sustained interest in understanding and addressing the environmental challenges posed by TPS collection.

Socio-economic status of tiger prawn seed collection

The demographic analysis of individuals involved in tiger prawn seed collection reveals significant insights into gender, age, house type, Experience and family type distributions. The gender distribution indicates a higher participation rate among females (60%) compared to males (40%). Age-wise, the workforce is dominated by young (< 35) with 33.3% of respondents and middle (35 to 55) with 36.6% respondents and notable old aged group (> 55) with 30% of respondents also involved in TPSC. Education levels of the sampled tiger prawn seed collectors reveal that majority of the collectors (43.3%) are illiterates and 33.3% of the respondents are having primary level of education. Housing conditions of the participants show that a majority

live in semi-pucca houses (46.6%), followed by kuccha houses (41.6%), with a smaller proportion residing in pucca houses (11.6%). Regarding family structure, a predominant 65% belong to joint families, while the remaining 35% are from nuclear families. This demographic profile highlights a diverse and predominantly female workforce, with varied living conditions and family structures engaged in the activity of tiger prawn seed collection.

Seasonal Variation in Income from Tiger Prawn Seed Collection

Income from tiger prawn seed collection exhibits significant seasonal variation depicted in Fig 5. Maximum income is recorded from April to July, with an average collection of 1,500 seeds per month, reaching up to 2,500 seeds in June. During this period, the price per 1,000 seeds is lower due to higher availability, averaging around ₹380 for 10-12-day post-larvae. Collectors typically work 20 days per month, resulting in a monthly income of ₹11,400. From August to December, the average seed collection drops to 800 seeds per month, peaking at 1,000 seeds in August. Despite fewer collection days (18 days per month), the higher price per 1,000 seeds (around ₹450) leads to a monthly income of ₹6,480. The lean period from January to April sees minimal seed availability, with an average of 350 seeds per month, peaking at 500 seeds by the end of March. Due to high demand, prices peak at ₹600 per 1,000 seeds during this period. With an average of 14 collection days per month, the income during these months is about ₹2,940.

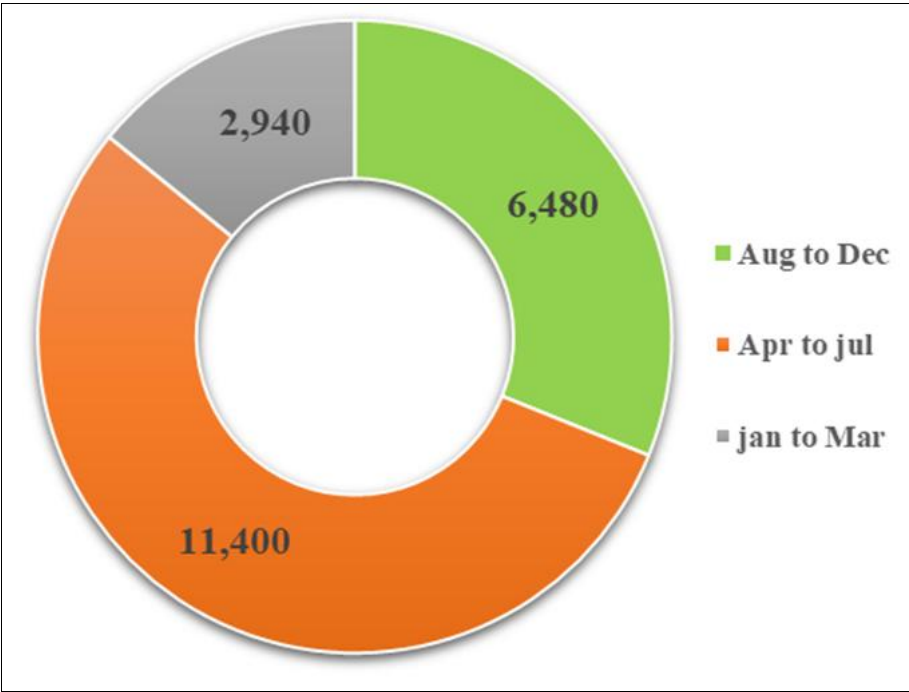


Fig 6: Seasonal variation of income (in Rs) from TPSC

Occupational hazards faced by tiger prawn seed collectors

Small-scale traditional fishers of Sundarbans are highly dependent on nature for lives and livelihoods and the majority of the populace in Indian Sundarbans depend on fisheries directly or indirectly for their livelihoods. (Ghosh *et al.* 2022) ^[17]. Although small-scale fishers gain many benefits from fisheries, they face health risks and safety problems (Zakia *et al.* 2010) ^[32]. Life in the Sundarbans is marked by severe difficulties, extreme poverty, lack of basic necessities, and constant challenges posed by the harsh geographical conditions. Occupational hazards related to fishery are also potential risk factors that lead to various morbidity, as perceived by the respondents (Roy *et al.* 2024) ^[25]. Especially tiger prawn seed collection being one of the lucrative and large employment generating occupation prone to several occupational hazards (Chowdhury *et al.* 2016) ^[9]. Although several studies have taken place which documented occupational hazards of tiger prawn seed collectors (Das *et al.*, 2016; Sarkar and Bhattacharya, 2003) ^[13, 28] but present study systematically comprehend the occupational hazard through Analysis of Occupational Safety and Health Administration (OSHA) 5 Workplace Hazards classification with suitable modifications and risk

associated with them.

Physical hazard

In this study, physical hazards are operationalized as environmental dangers that have the potential to cause physical injuries or health issues to workers, either through direct contact or due to the working conditions to which they are exposed. Shrimp seed collectors in the Sundarbans face significant physical hazards shown (Table 1) due to the challenging and hazardous working conditions. Collectors often wade in waist-deep water, encountering severe foot injuries from walking through soft mud densely populated with molluscs and glass pieces, with a risk score of 0.61. During the peak collection season from April to July, they endure continuous exposure to severe sun and UV radiation for 6 to 8 hours daily, leading to common ailments like sunburn (risk score 0.74) and heat exhaustion (risk score 0.70) shown Fig 6. The average risk for these physical hazards is 0.689, highlighting the urgent need for enhanced safety measures and support systems to protect these workers. Bhakta *et al.* (2021) ^[3] also reported similar injuries among monodon seed collectors in the Sundarbans, emphasizing the widespread nature of these risks.

Table 1: Risk from physical hazards faced by TPS collectors

Hazards	Severity	Probability	Exposure	Risk
Molluscan shells/ Glass piece	0.225	0.9	0.72	0.61
Sunburn due direct exposure to sung light	0.45	0.87	0.91	0.74
Heat Exhaustion due to high temperature	0.458	0.8	0.87	0.70
Average	0.37	0.85	0.83	0.68

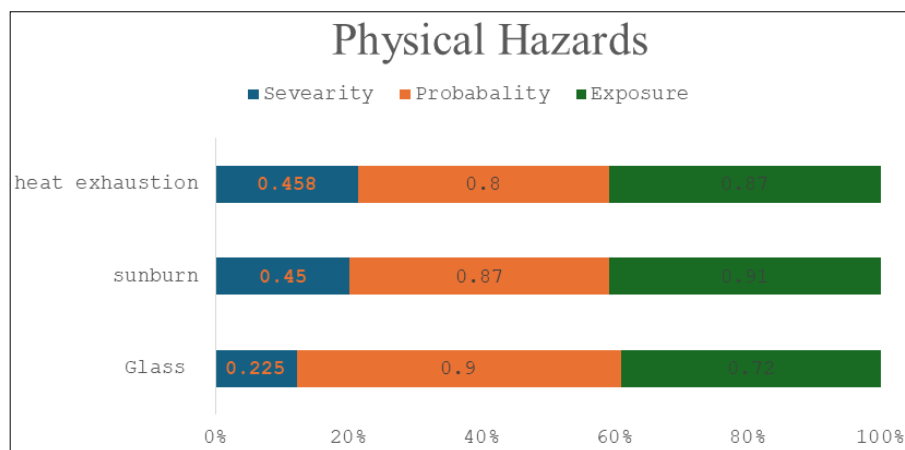


Fig 7: Risk from physial hazards faced by TPS collectors

Ergonomic hazards

Ergonomic hazards are operationalized in this study as risk factors arising from repetitive work or improper body posture during tasks, leading to physical discomfort. Monodon prawn seed collectors in the Sundarbans suffer from significant physiological load and extreme physiological stress due to prolonged working hours, predominantly in a standing posture, coupled with excessive work pressure, who are compelled to engage in physically demanding and repetitive tasks such as dragging nets

forwards and backwards, spreading nets, and collecting seeds. The continuous bending and net-dragging during long working hours often result in back pain with risk of 0.70 and neck pain with risk of 0.66. Additionally, repetitive strain injuries affect TPS collectors with risk of 0.62 of the collectors leading to substantial discomfort in various body parts. Alongside TPS collectors has to sort the very small tiger seeds with size of 1-3 mm, which leads to the strain in the eyes with risk factor of 0.62. Risk from ergonomic hazards given in the table-2.

Table 2: Risk from Ergonomic hazards faced by TPS collectors

	Severity	Probability	Exposure	Risk
Back pain due reparative movement/prolonged sitting and standing positions	0.51	0.76	0.84	0.70
Neck pain due to reparative movements/prolonged sitting and standing positions	0.43	0.77	0.78	0.66
Repetitive strain	0.42	0.75	0.71	0.62
Eye strain/blur vision due seed sorting	0.5	0.72	0.65	0.62
Total	0.46	0.75	0.745	0.65

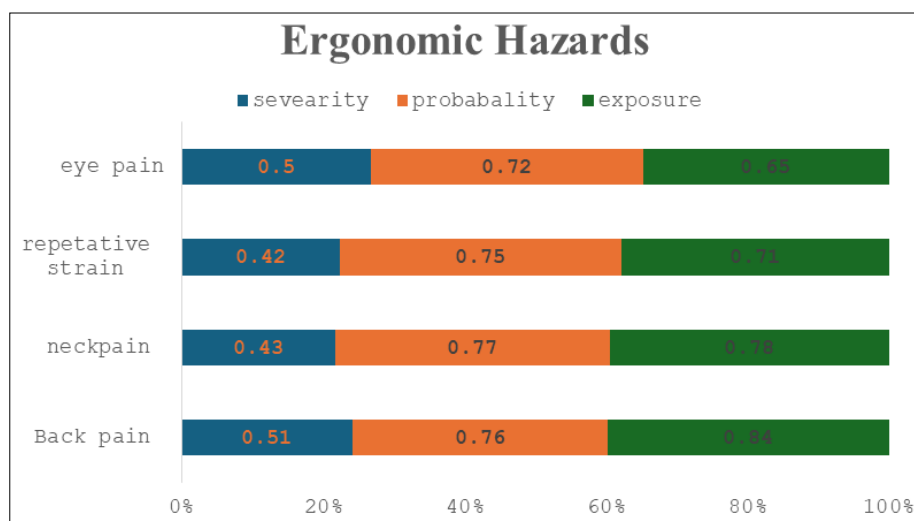


Fig 8: Risk from Ergonomic hazards faced by TPS collectors

These findings underscore the substantial ergonomic hazards faced by prawn seed collectors, indicating an average risk score of 0.6533 for ergonomic hazards. These results highlight the urgent need for targeted interventions to mitigate ergonomic hazards and improve the working conditions of prawn seed collectors in the Sundarbans.

Similar Ergonomic hazards such as back pain, knees, shoulders, ankles, and feet, as noted by (Das *et al.*, 2012)^[12].

Biological Hazards

In this present study, biological hazards are operationalized

as risks posed by living organisms that can infect or harm tiger prawn seed collectors, adversely affecting their health and well-being. Shrimp seed collectors in the Sundarbans are also exposed to various biological hazards depicted in table 3, that significantly impact their health and safety. Skin infections, particularly fungal infections, affect the collectors due to prolonged exposure to water and mud with the risk of hazard 0.54 which shows the moderate level of risk and action required to mitigate them. Women are more prone to skin infections compared to men, and there is a significant difference between the occurrence of skin infections in men and women ($p < 0.05$). The results align with previous studies like (Bhaumik *et al.*, 2002) reported several types of diseases of seed collectors especially women in the tidal areas of Indian Sundarbans such as skin diseases, leucorrhoea, eye problem, stomach disorder, loss

of body hair, weakness, problem of urination

The presence of dangerous wildlife in the mangrove areas poses additional risks. Tiger prawn seed collectors operate at a risk score of 0.37 for snake bites, 0.21 for crocodile bites, and 0.29 for tiger attacks. Although the overall risk scores are moderate to low, the risk score for those who encounter tigers and crocodiles is very high, indicating the potential damage they can cause. These hazards are exacerbated by the collectors' activities, which involve wading through waist-deep water, navigating dense vegetation, and handling nets in challenging and often unsafe environments. Additionally, (Chowdhury *et al.*, 2008), reported attacks by crocodiles and sharks, which mainly happened to the seed collectors in the Gosaba area of Sundarbans.

Table 3: Risk from Biological hazards faced by TPS collectors

	Severity	Probability	Exposure	Risk
Skin infections due prolonged water contact	0.39	0.35	0.89	0.54
Crocodile bites	0.062	0.02	0.55	0.21
Snake bites	0.19	0.4	0.61	0.4
Tiger attacks	0.05	0.12	0.71	0.29
Total	0.17	0.15	0.75	0.35

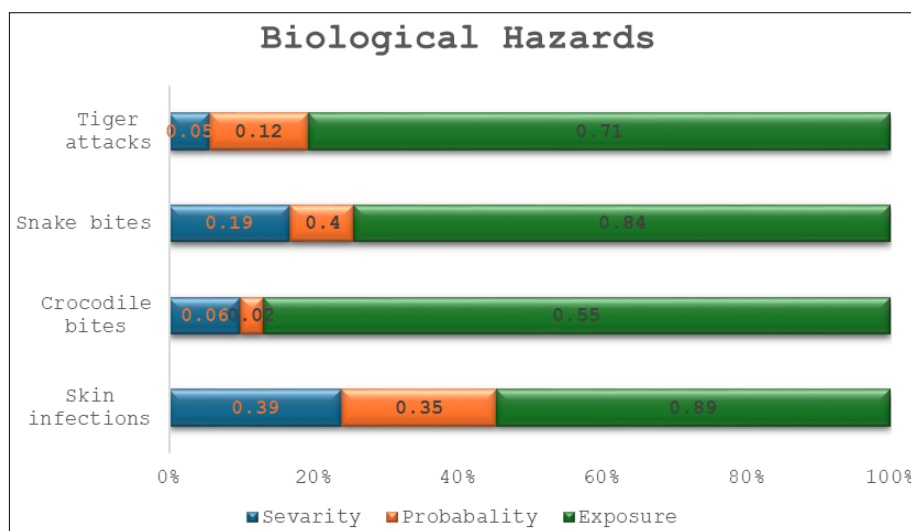


Fig 9: Risk from Biological hazards faced by TPS collectors

Psychological Hazards

Psychological hazards are operationalized as risks stemming from various psychosocial factors perceived as unsatisfactory, frustrating, or demoralizing, arising from work conditions, which can negatively impact mental health. In the study of psychosocial hazards among *Penaeus monodon* seed collectors in the Sundarbans region, it was observed that work-related stress affected the tiger prawn seed collectors with risk score of 0.26. This significant

prevalence indicates (please write). Additionally, respondents reported anxiety due to economic instability with the risk score of 0.5, reflecting the financial uncertainties and insecurities associated with their livelihood. Fatigue due to long hours was the most prevalent issue, affecting tiger prawn seed collectors with the risk score 0.62, highlighting the physically demanding nature of their work depicted in table - 4

Table 4: Risk from Psychological hazards faced by TPS collectors

	Severity	Probability	Exposure	Risk
Work related stress	0.18	0.37	0.25	0.26
Fatigue due to economic instability	0.46	0.62	0.41	0.5
Fatigue due long working hours	0.34	0.69	0.83	0.62
Total	0.32	0.56	0.49	0.46

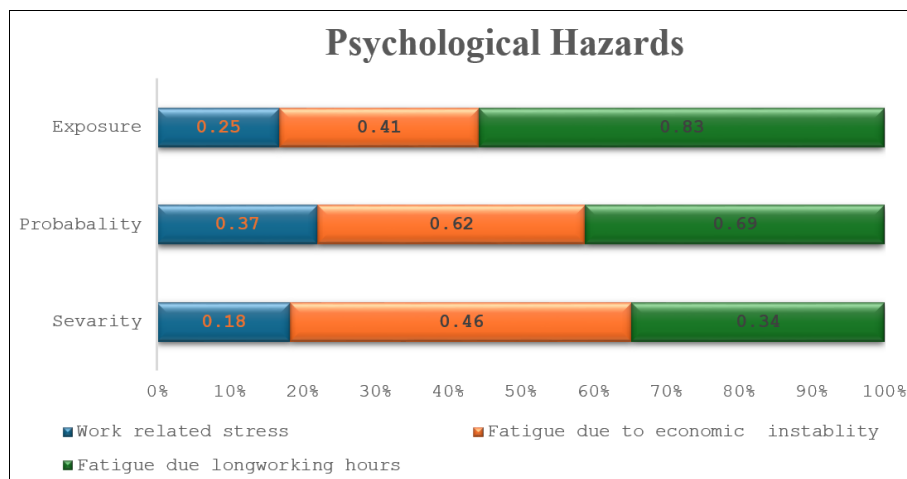


Fig 10: Risk from Psychological hazards faced by TPS collectors

Overall occupational hazards faced by the TPS collectors in Sundarbans region

The quantitative assessment of occupational hazards faced by tiger prawn seed collectors in the Sundarbans reveals (depicted in Fig 10) significant risks across various categories. Physical hazards exhibit a high probability (0.87) and substantial exposure (0.72), despite a moderate severity (0.37). This indicates frequent occurrence of physical injuries, likely from handling equipment and adverse environmental conditions. Ergonomic hazards are particularly concerning due to their moderate severity rating (0.46), coupled with high probability (0.75) and exposure (0.74). This suggests that repetitive tasks and poor working

postures substantially contribute to musculoskeletal problems among workers. In contrast, biological hazards present a lower severity (0.17) and probability (0.15) but high exposure (0.75), indicating that workers are often in contact with biological agents, although the impact and likelihood of adverse effects are relatively low. Psychological hazards, with low severity (0.32), moderate probability (0.56) and exposure (0.49), highlight the mental stress and fatigue experienced by workers. These findings underscore the multifaceted nature of the occupational risks in this sector, necessitating comprehensive safety measures and ergonomic interventions to mitigate the identified hazards effectively.

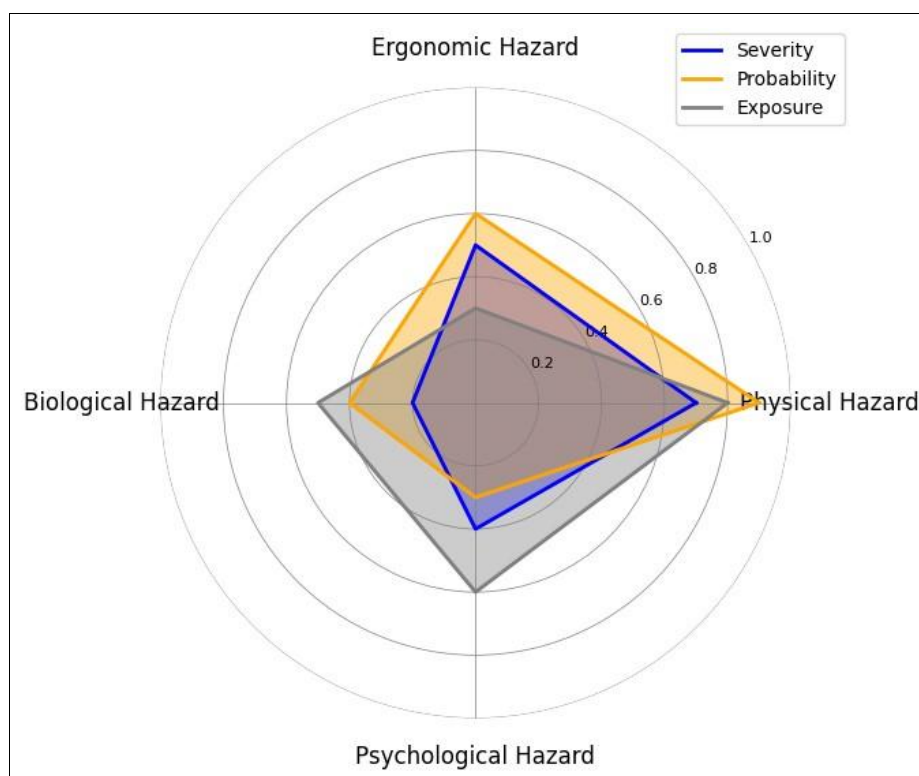


Fig 11: SPE of Occupational hazards faced by TPS collectors

Risk from occupational Hazard

The calculated risk values for the occupational hazards faced by tiger prawn seed collectors (Depicted in Fig 11) in

the Sundarbans provide a comprehensive insight into the potential dangers these workers encounter. Physical hazards present the highest risk at 0.68, reflecting the significant

combined impact of high probability (0.87) and exposure (0.72) with a moderate severity (0.37). This suggests that physical injuries from handling equipment and adverse environmental conditions are frequent and impactful. Ergonomic hazards follow closely with a risk value of 0.65 (moderate risk), indicating that the severity (0.46), probability (0.75), and exposure (0.74) of musculoskeletal issues due to repetitive tasks and poor working postures are substantial. Biological hazards have a lower risk value of

0.35, which aligns with their low severity (0.17) and probability (0.15) but high exposure (0.75), suggesting less frequent but potentially significant health impacts from biological agents. Psychological hazards exhibit a moderate risk value of 0.46, reflecting the cumulative effect of moderate severity (0.32), probability (0.56), and exposure (0.49) associated with mental stress and fatigue. These risk values underscore the need for targeted interventions to mitigate the identified hazards effectively.

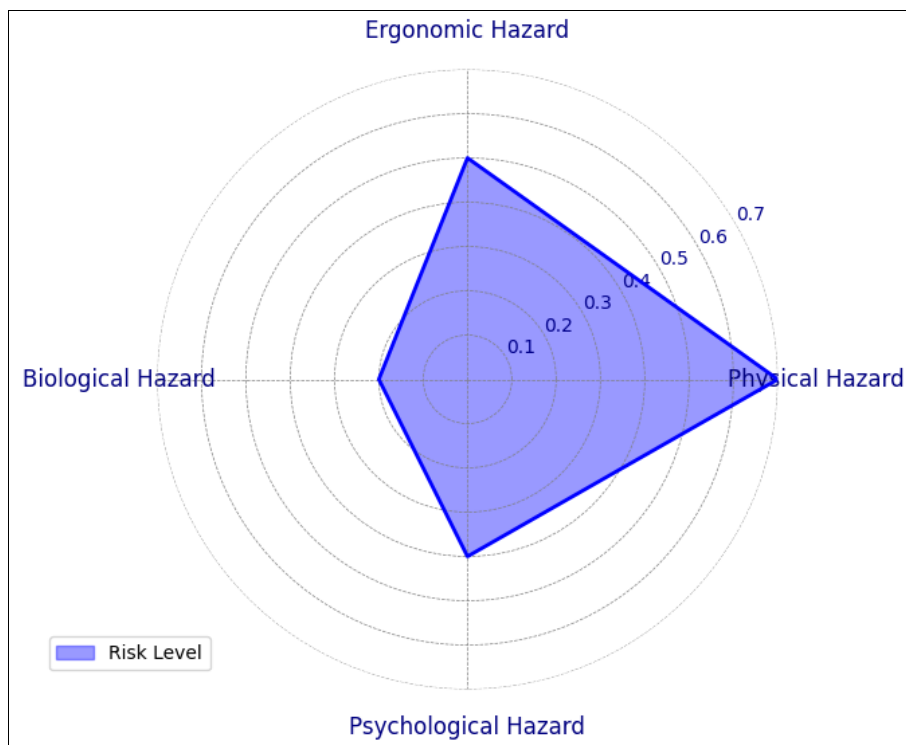


Fig 12: Risk from Psychological hazards faced by TPS

Evidence based strategies for migrating risks of Tiger prawn seed collector in Sundarbans



Conclusion

This comprehensive study sheds light on the socio-economic conditions, occupational hazards, associated risks, and environmental impacts of tiger prawn seed collection in the Sundarbans estuary. Income from tiger prawn seed collection exhibits significant seasonal variation, with maximum income recorded from April to July, approximately ₹11,400. While tiger prawn collection provides crucial economic benefits to local communities, it also leads to significant biodiversity loss and ecological damage. Despite government regulations, the lack of alternative livelihoods keeps these communities dependent on this occupation. Establishing alternative livelihood opportunities and government support is crucial to alleviate economic dependence on this hazardous occupation, gradually reducing the number of people solely dependent on it and mitigating its environmental implications. Tiger prawn seed collectors encounter various occupational hazards, such as physical, ergonomic, biological, and psychological. The analysis of risks reveals that high risk is associated with physical hazards (0.68), underscoring the frequent and impactful injuries due to harsh working conditions and environmental factors. Ergonomic hazards also pose a substantial risk (0.65), largely due to repetitive, physically demanding tasks that lead to musculoskeletal problems. Biological hazards, though presenting a lower risk (0.35), still require attention due to high exposure to waterborne pathogens and dangerous wildlife. Psychological hazards, with a moderate risk (0.46), highlight the mental stress due to economic instability faced by collectors. Addressing these occupational hazards through targeted strategies will enhance the safety and quality of life for the collectors and contribute to the sustainable management of the Sundarbans' rich biodiversity. This comprehensive approach is essential for ensuring the long-term sustainability and resilience of the Sundarbans and its inhabitants.

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