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Pollution and river drying: Socioeconomic ramifications for fishers along the Jalangi River, a tributary of the Ganga

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Abstract

The Jalangi River, a vital lifeline for numerous fishing communities in West Bengal, India, has been grappling with severe pollution issues in recent years. This study examines the relationship between pollution and river drying and its impact on the socio-economic conditions of fishers along the river. Studies have found that Jalangi is highly polluted with microplastics, heavy metals, and Bisphenol A (eBPA), posing severe risks to the aquatic ecosystem and local communities. The primary sources of pollution include agricultural runoff, household waste, jute retting, and sand mining, which collectively lead to water degradation and a decline in fish populations. This study incorporated Landsat imagery and identified 90.69 km of the river's length as dry-up. Socioeconomic studies have revealed that the predominantly male fishing community from the Scheduled Caste depends heavily on the river. Daily fish catches range between 0.8-1.2 kg throughout the year, increasing to 2-4.5 kilograms per day during the monsoon season. The average monthly family income is ₹5,488, with 43% of fishers earning less than ₹5,000 per month. Women have limited involvement in fishing but contribute through post-harvest activities. However, younger generations are less interested in fishing due to declining fish availability and environmental challenges. The socioeconomic conditions of fishers along the Jalangi River are deeply influenced by ecological degradation and the absence of alternative livelihood options. To address these issues, it is essential to implement effective government policies and conduct awareness programs, as well as training sessions or workshops. These initiatives can help improve the river's ecology and uplift the socioeconomic conditions of fishers.

Keywords: Jalangi river, pollution, river drying, socioeconomic, fishing communities

1. Introduction

"Jalangi" is a Bengali term that signifies 'water body'. The River Jalangi originates from the right bank of the River Padma near Jalangi village in Murshidabad District (Annual Food Report, WB, 2016). The river runs for 233 km from its original off-take to the confluence. However, an upper stretch from the Char Madhubona off-take near Jalangi to the Bhairab confluence is inactive due to irregular water flow and excessive siltation caused by the closure of its water intake from the Ganges (Das and Bhattacharya, 2020) [15]. A 182 km stretch from the Bhairab confluence to the Bhagirathi confluence has transformed into a paleochannel, maintained by the flow from the Bhairab River (Das and Bandyopadhyay, 2007; Das, 2020) [5, 17]. As a result, this lower segment is now recognised as the present Jalangi River. Its journey culminates at the confluence of the Bhagirathi and Hoogly rivers near Mayapur in the Nadia district, West Bengal. The confluence point of the Jalangi with the Bhagirathi is located near the town of Nabadwip (23°24´42´´ N and 88°22´50´´ E) in Nadia district (Rudra, 2018; Ray and Pal, 2021) [35, 31]. The Jalangi River functions as both a distributary, branching off from the Ganges, and a tributary, flowing into the Bhagirathi River (Rob, 2012; Das, 2022) [32,].

This river plays a vital role in the livelihoods of more than 1,200 fishers and their families along its banks, serving as an essential source of income for the fishing community (Sampling report, ICAR-CIFRI, 2024) [21]. The lower reach, where water flows through the river, is utilized for various activities, including fishing, ferry services, irrigation, navigation, and jute retting (Azad *et al.*, 2020) [3]. The River Jalangi is active during the monsoon as it receives water from the River Padma. As a result, the Nadia district is susceptible to flooding from the Jalangi and Bhagirathi-Hoogly rivers during monsoon season. The Jalangi River is currently experiencing a water supply shortage, which hinders its flow during the drier months of the year.

The depletion of river ecosystems is caused by pollution, habitat destruction, and unsustainable fishing practices. Overfishing depletes key species, disrupts food chains, and diminishes the overall biodiversity of river systems. Agricultural runoff releases harmful chemicals and excess nutrients, leading to eutrophication and habitat degradation (Jesintha and Madhavi, 2020) [23]. In addition, dam construction and river channelization intensify the loss of critical spawning and feeding grounds (Azad *et al.*, 2020) [3]. All these factors led to a severe decline in fish populations. The river waters of Jalangi became polluted at its downstream stretch in Krishnanagar due to the discharge of municipal waste and the mixing of industrial effluent from the *Kishan Cooperative Milk Producer Union Ltd* (Das, 2023) [14]. Additionally, the dumping of garbage contributes

to the degradation of the river's condition. The excessive presence of water hyacinth in the lower part of the river indicates eutrophication.

These changes directly impact the livelihoods of fishers. Consequently, the economic stability and cultural traditions of artisanal fishers are threatened, leading to increased poverty and social disruption (Anderson *et al.*, 2019) [1]. Although it is evident that environmental and anthropogenic activities impact fishing communities, there is a lack of comprehensive studies that explore their socio-economic dynamics, challenges, and needs. Moreover, GIS and remote sensing are recognised as practical tools for watershed delineation and analysing morphological changes in river systems (Basnayaka *et al.*, 2022). Numerous studies have explored the socio-economic impacts of riverbank erosion and flooding on livelihoods in various districts of West Bengal (Majumdar, 2018; Das *et al*., 2012; Iqbal, 2010). However, there is a lack of research on the impact of river drying and pollution on the fishing communities living along the river.

To bridge this research gap, the present study was undertaken to understand the impact of pollution on the socioeconomic conditions of fishers who rely on fishing as their primary source of livelihood, with additional utilisation of temporal Landsat images to observe changes in the river's drying patterns over time in the study region. This comprehensive approach aims to understand the combined impact of river drying and pollution on fishers who depend on fishing as their primary source of livelihood. The study's findings will be crucial for policymakers in identifying the unique challenges faced by fishing communities and in formulating targeted policies to optimize societal benefits from natural resources.

2. Materials and Methods

Study area: The study was conducted along the stretch of 123 km of the Jalangi River in West Bengal, India. Five places were selected as sampling sites: Hassanpur, Islampur, Maloupara in Murshidabad district, Tehatta, and Nabadwip in Nadia district, West Bengal.

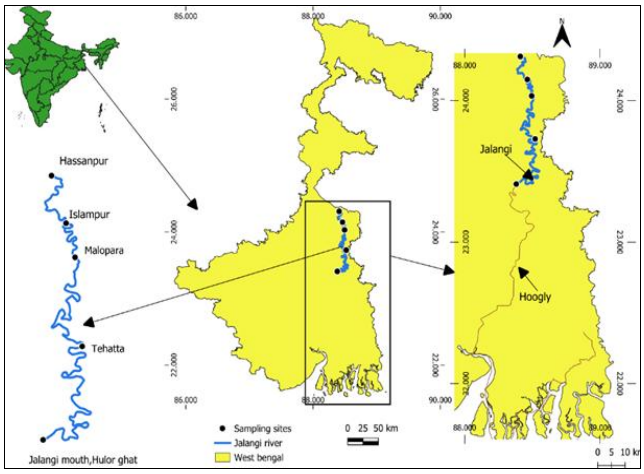

Fig 1: Map of Jalangi River stretch from the origin to the river mouth

Methodology

To identify river course drying, Landsat satellite images from 1994 **(**Landsat 5 TM Collection 2) and 2024 (Landsat 9 OLI-2/TIRS-2) were used for spatiotemporal analysis. The dynamics of the Jalangi River were estimated using remotely sensed satellite data, with a focus on river drying patterns between these two years. Cloud-free surface reflectance images from the pre-monsoon dry period were acquired and analysed using Google Earth Engine and QGIS 3.40 software.

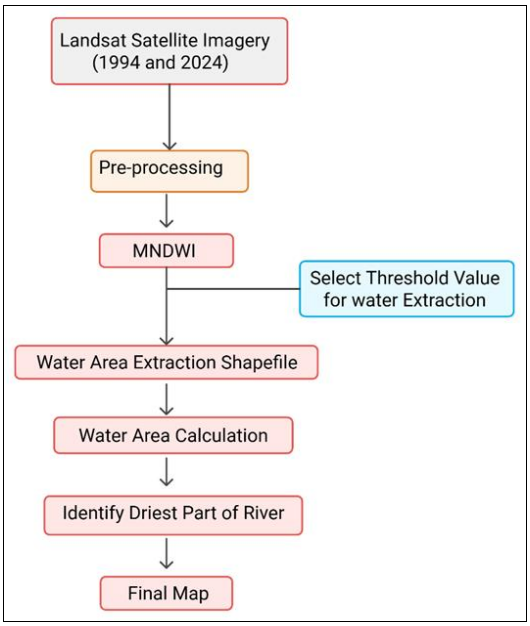

Fig 2: Flow diagram depicting spatio-temporal changes using Landsat imagery

Sample size, Data Collection, and Statistical analysis

To understand the socio-economic status of fishers along the Jalangi River, 120 fishers were selected randomly from five sampling sites along 123 km of river stretch. Purposive sampling is employed to choose sampling points, aiming to capture a diverse range of socio-economic conditions across different locations along the river. By adopting this approach, the study seeks to provide a balanced and comprehensive understanding of the socio-economic impacts of fishing on various segments of the fishing population.

The socioeconomic survey is based on primary data. Field visits were conducted to collect primary data. A semi-structured interview schedule was developed and used to collect data related to socio-economic variables such as Age, Sex, Caste and Religion, Educational Status, Family Size and Type, Housing Condition, Land Ownership, Occupation, Loan and Credits, Fishing expense, Catch Estimation, Monthly Income, Marketing Channel, Expenditure, And Fishing Crafts and Gear Ownership. Analysing these variables will help in comprehensive socio-economic understanding. Focus Group Discussions (FGDs, N = 5) were conducted to collect general information, and the researcher's observations were combined with transect walks along the adjacent areas. The data were collected from January to May 2024, spanning a period of five months, in the study area.

Secondary data on fish populations and habitats, as well as fishing gear and crafts used by fishers, have been sourced from a 2024 sampling report. This report is part of ICAR-CIFRI's study on Riverine Dynamics and Faunal Variations

in the Jalangi River. The data were accessed from the Krishi Portal, a centralized data repository system managed by ICAR. Additionally, soil and water quality indicators, including pollution markers such as nutrient pollution, microplastic contamination, heavy metal accumulation, and faecal coliform contamination, have been included. All important data were collected and analysed using descriptive statistical tools. Frequency, percentage, and graphs were prepared to explain various variables of interest.

3. Results and Discussion

The Drying of the Jalangi River and rising pollution

A thorough review of the literature and community concerns near the river has revealed that Jalangi River is under great threat due to human activities such as the establishment of bridges, use of chemicals, pesticides, excessive irrigation, jute retting, effluents, etc., as well as natural causes such as climate change, drought, temperature, rainfall patterns, etc. As a result, the drying up of the river is evident.

To visually depict the evolving landscape of the Jalangi River and its vulnerability to pollution, we employed Landsat imagery through ArcGIS, capturing the upper and middle stretches of the river from January 1994 and March 2024. Figure (2) demonstrates the significant reduction in river coverage, especially in these two stretches, which have experienced severe shrinkage over time. revealing a stark correlation between river drying and increased susceptibility to pollution.

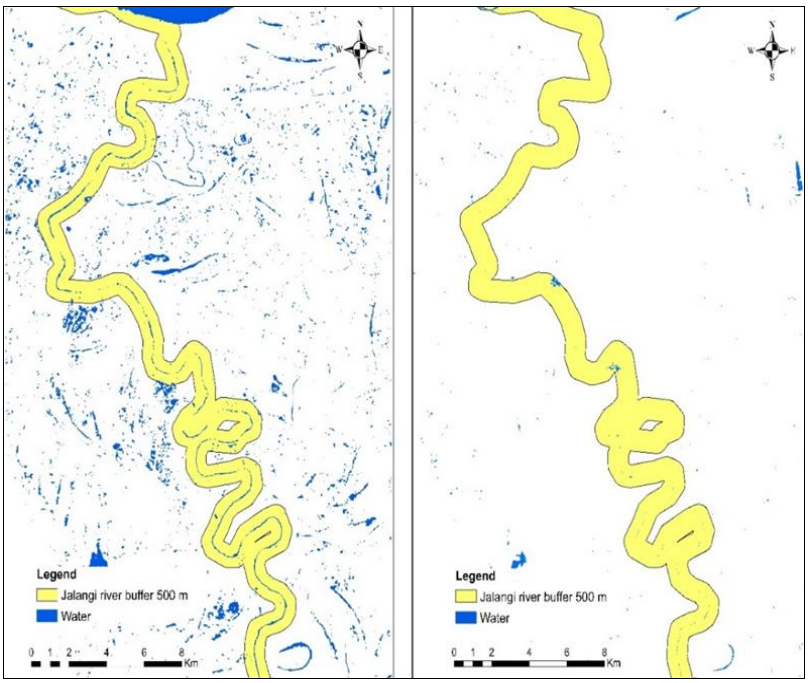

Fig 2a: Comparative Landsat Imagery of Jalangi River (1994 & 2024): Upper stretch showing river drying and pollution vulnerability

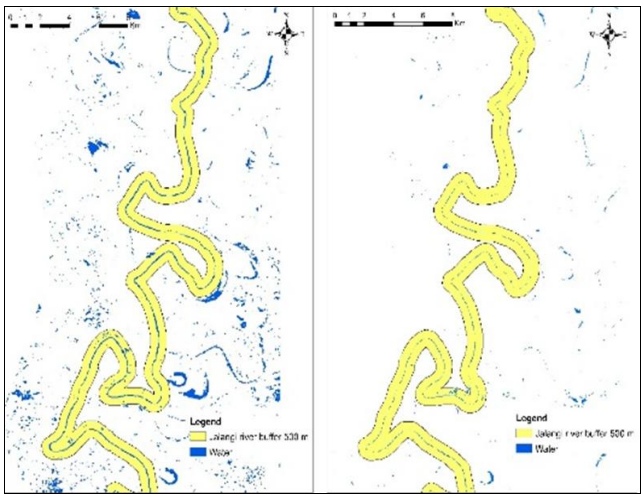

Fig 2b: Comparative Landsat Imagery of Jalangi River (1994 & 2024): Middle stretch showing river drying and pollution vulnerability

Satellite imagery identified 90.69 km of the river's length that has dried up to Nawra and Karimpur Block. This section, located predominantly in the upper and middle stretches, has ceased to support the socioeconomic activities of the adjacent communities. The drying of the Jalangi River is a multifaceted issue influenced by human-induced and natural factors. The rapid siltation occurring at the off-take of the Jalangi River prevents the discharge from entering the Jalangi course except during the monsoons. The current recorded water velocity range of 0.1-0.3 m/s and depth variation from 0.8 to 5.2 m confirm that the Jalangi River is gradually degrading, with reduced flow and inconsistent depths indicating sedimentation and stagnation, which are signs of declining river health (Sampling Report, ICAR-CIFRI, 2024). Additionally, Unsustainable water use practices, such as excessive irrigation for agriculture and quarrying activities, have significantly depleted the river's flow. The construction of hydropower projects and barrages has further disrupted natural water patterns. Simultaneously, long-term changes in rainfall patterns have added to the pressure. The cumulative impact of these factors has resulted in a significant decline in the river's water levels. This has worsened pollution and caused severe problems for the communities that depend on the river for income

sources. As the upper reach is severely deteriorated and consists of a series of linear pools, its riverbed is now being utilised as cultivable land for crop production. Soil cutting on river banks and beds creates pond-like structures called "khadaans" to trap silt. Over time, this leads to bank erosion and gradual shifting of the river. According to DL & LRO, WB, 2009, there were 71 brickfields along the banks of Jalangi. However, this is outdated data, and the number of brickfields is likely to have increased since then. And these brick fields have invaded the river terribly (Bandyopadhyay *et al.*, 2014) [6].

The flow of the Jalangi River has slowed and diminished over time. This stagnation intensifies pollution levels and accelerates the degradation of water quality. The drying of the riverbed has further led to the invasion of human activities, such as the expansion of brickfields, which contribute additional pollutants. Similarly, Das (2023) [14] revealed that quarrying (extraction of materials, such as sand, gravel, or stone) from the riverbank changes into the dry riverbed, and effluent contamination is released into the river. The once-flourishing ecosystem is now unable to support aquatic life, and the communities that rely on the river for livelihoods face severe health and economic challenges due to this compounded environmental degradation.

Impact of Pollution on Fish Populations and Habitat

Fertilisers and pesticide runoff from adjacent agricultural fields, household runoff, plastic containers, and various waste products, such as vegetable, animal, and human waste, were also dumped into the Jalangi water. Jute retting is another significant activity contributing to water quality degradation.

Fig 3: Photomicrograph of polluted area of the Jalangi river

The river is gradually becoming narrower and has less depth due to reduced water flow and heavy siltation brought down by the riverbanks. Layers of scum were seen to be accumulated on the water's surface, giving a foul smell of detritus. The river dolphin (Ganges river dolphin) is a sensitive indicator species. Dolphins were sighted at the major tributaries of the River Ganga, including Jalangi, in 2014 (Chowdhury *et al.*, 2016) [10]. According to fishers along the Jalangi, Dolphin sightings have decreased abruptly for over a decade, indicating severe ecological degradation. Their habitat is severely stressed due to dams and barrages, habitat degradation and fragmentation, and river water pollution (Aggarwal *et al.*, 2020) [2]. Similarly, the drying and pollution of the Jalangi River have disrupted fish migration patterns and limited access to spawning grounds, resulting in a significant decline in fish populations, particularly the Hilsa (*Tenuolosa ilisha*).

The sampling report (2024) reveals the dominance of fish species like *Puntius conchonius*, *Labeo calbasu*, *Xenentodon cancila*, *Parambassis baculis*, and *Macrognathus pancalus* in the Jalangi River indicates pollution and oxygen depletion. Their dominance suggests that more sensitive species may have been driven out. The river's health is likely compromised. Also, the presence of *Xenentodon cancila* and *Macrognathus pancalus* in the Jalangi River indicates localized oxygen stress, likely due to nutrient overload and eutrophication. While these species are thriving, they serve as indicators that the overall health of the river system may be compromised. The presence of Gobiiformes like *Brachygobius* sp., which thrive in variable water conditions, including muddy and sediment-rich environments. However, the occurrence of *Parambassis lala*, a species categorised as Near Threatened (NT), raises significant concerns.

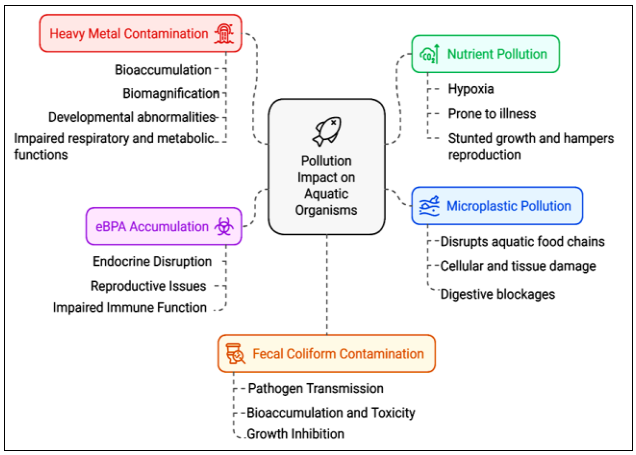

Fig 4: Graphical representation of the Impact of Pollution on Aquatic Ecosystems

The Impact of Pollution on the Water Quality of Jalangi River

The 2024 Sampling Report includes a Microplastic analysis that reveals a predominance of polystyrene foam and synthetic textile fibres, which disrupt benthic habitats and impede light penetration. Heavy metal contamination, including aluminium, chromium, nickel, and arsenic, is concentrated at the Jalangi Mouth, posing toxicity risks to fish. Furthermore, the presence of eBPA indicates a potential for endocrine disruption within the river's fauna. Elevated faecal coliform levels indicate contamination from human and animal waste, further compromising the river's state. These multifaceted stressors collectively threaten the Jalangi River's ecological integrity, with cascading effects on fish populations and overall biodiversity (Fig. 4).

Socioeconomic Consequences of Pollution and Drying in the Jalangi River Fishers

The fishing community along the Jalangi River faces numerous socioeconomic challenges, including factors such as age distribution, gender roles, educational levels, family size, and reliance on fishing as a primary source of livelihood. This section examines how these factors impact the livelihoods of fishers and their families, particularly as the river dries up and pollution levels rise.

Age distribution of fishers

Age is important in fisheries activity (Sharma *et al.*, 2018) [38]. In the present study, ages ranged from 21-77 years, with a mean age of 46 years. The age of fishers was grouped into

three categories: up to 35 years, 36-50 years, and over 50 years. The maximum number of fishers was in the age range of 36-50 years (40%), and this group was most prominent in the fishing activity at Jalangi River. This may be due to their lower educational background and greater experience in fisheries activities, which is a cultural identity. It is followed by fishers who have been fishing for more than 50 years (38%). While fishers aged 35 and older (22%) were the least involved in the fisheries activity. It shows that fishing is not attracting young people around Jalangi due to the limited catch throughout the year and less profitable job opportunities.

Sex

The observation revealed that 100% of the fishers were male, with minimal involvement of women in fishing along the Jalangi. Most women are engaged in social reproduction. However, a few women do participate in post-harvest fishing activities such as sorting, grading, gear cleaning, and mending.

Caste and Religion

The Scheduled Castes (SC), particularly the Halder and Biswas communities, were found to be predominant in fishing along the Jalangi River. And all the fishers were Hindu in religion.

Educational status

Education is a crucial socio-economic factor that facilitates the understanding and adoption of new technologies in the fishing sector (Gautam *et al.*, 2020) [18]. The educational status of fishers influences their participation in various fishing activities. This study revealed that 38% of fishers were illiterate and had no formal education, 34% had completed primary education, 21% had reached the middle school level, and 5% had secondary education. Only 2% of the fishers had attained a graduate level of education or higher. In the present study, most of the illiterate fishers were over 50 years old, likely due to their low economic status and limited educational opportunities available to them during their formative years.

Family Size and type

Family size is a significant socioeconomic indicator, as it impacts household income, food consumption, and overall socioeconomic well-being (Hossain *et al.*, 2022) [20]. In the present study, the family size of fishers is classified into three groups *viz*. 2-4 members (small family), 5-7 members (medium family), and more than seven members (large family). According to the present study, the majority of families (53%) in this village belong to the medium group, with more than 5-7 members. In contrast, 42% of families have 2-4 members, and the remaining 5% have more than 7 members. The family size of the fisher community usually consists of 70% nuclear families, with the remaining being joint families. Family arrangements are shifting from joint to nuclear.

Housing condition

Housing conditions are essential to study because most fishers are resource-poor. According to the results of the present study, 10% of people used kutcha houses, 85% used semi-pucca houses, and 5% used pucca houses. This is because most fishers are poor.

Land ownership

Approximately 85% of households own only homestead land, while 15% have agricultural land used for activities such as vegetable farming, banana farming, watermelon farming, and mustard farming. Fishers have expressed that they have limited options for alternative livelihoods due to a lack of capital and economic hardship.

Occupation

All the fishers interviewed for the study are primarily dependent on fishing and fish trading activities along the Jalangi River. However, to sustain their families, many have taken up secondary sources of income in addition to fishing, which has helped them immensely during the fishing ban period. Although they spend the majority of their time on fishing activities, the reduced catch has compelled them to seek alternative employment. Where 8% of fishers are involved in horticulture (fruit and vegetables), 5% in the jute industry, 13% as daily labourers, 9% in part-time masonry work, and 5% in livestock rearing for selling cow or buffalo milk. However, 60% of fishers remain strictly dependent on fishing and selling fish at the market, unable to engage in other activities due to a lack of land, old age, and limited skills.

Loan and credits

Fishers are poor and highly vulnerable, often exploited by influential stakeholders. They spend more than 60% of their monthly income on various activities, leaving no room for savings. This study has revealed that fishers rely on informal sources of credit, such as mahajans (middlemen), to sustain their families during crises. Fishers are often forced to take loans with high interest rates, ranging from 10% to 15% and sometimes higher. They are victimised because they lack negotiating power. The majority (70%) of fishers rely on loans provided by *Mahajans*, 12% on loans from friends and relatives, and 15% on loans from locally established cooperative groups, all at high interest rates. Only 3% of fishers obtain loans from banks, such as Grameen Bank. Since the majority cannot provide collateral for institutional credit, fishers must rely on private money lenders. Poor fishers reportedly cannot avail of bank loans due to a lack of mortgage assets.

Fishing Experience

Fishers of Jalangi River have varying levels of fishing experience, with an average of 24 years. Their experience is categorised into three groups: up to 10 years, 11-20 years, and 21-30 years. It has been observed that 52% of fishers have 21-30 years of experience in fishing. Many fishers over 50 years old possess extensive experience in fishing, often due to their disadvantaged educational and economic backgrounds, which has allowed them to continue their ancestral activity. This group is followed by 38% of fishers with 11-20 years of experience, and only 10% of fishers have up to 10 years of fishing experience.

Catch estimation

Fishers have reported a drastic reduction in their catch over

the past decade. Specifically, the catch of carp has declined due to pollution, and the Hilsa catch has dropped to zero outside of the monsoon season. During the monsoon, Hilsa migrates from the Padma to the Jalangi, with individuals typically ranging in weight from 0.2 to 0.25 kg to 0.5 to 1 kg. For most of the year, the river is populated with small indigenous fish, including weed fish, resulting in an average daily catch of only 0.8 to 1.2 kg per fisher. However, during the peak monsoon season, when water levels rise, the catch per fisher increases significantly to approximately 2-4.5 kilograms per day. The daily catch per fisher varies widely based on these seasonal changes.

Monthly Income

It was found that the primary occupation of the respondents was fishing. Some fishers were also involved in secondary activities, such as working as daily wage labourers and similar roles. However, more than half of the respondents were entirely dependent on income from fishing. The average monthly income of the fishers was ₹5,488. Approximately 43% of fishers are abysmal, earning only up to ₹5,000 per month from all sources. And 38% of fishers earn between ₹5,000 and ₹10,000. Additionally, 16% of fishers earn between ₹10,000 and ₹15,000 per month. Only 3% of fishers earn between ₹15,000 and ₹20,000 per month.

Marketing channel

The primary fish marketing channels in Jalangi River are Direct sales, door-to-door delivery and middlemen. About 68% of fishers sell their fresh catch directly to consumers at the local markets. This helps them receive immediate payment and avoid the costs associated with intermediaries. 10% of fishers sell fish directly to households going door to door. Which provides higher returns for fishers. 22% of fishers sell their daily catch to middlemen or wholesalers. Some fishers are unable to sell their catch directly in the market due to old age or a lack of proper transportation.

Expenditure

Fishers spend a considerable amount of money on fishing operations, with the remainder allocated to family or household purposes. In the present study, it was found that fishers spent approximately 20% of their income on fishery operations and 80% on family expenses. Fishers use traditional fishing gear and crafts, which require less maintenance. For fishers, household expenditure was highest for food (50%), followed by healthcare (12%), children's education (10%), and miscellaneous expenses (8%). These findings align with Karthikeyan *et al.* (2013) [25], who reported that the majority of fisherfolk in the southern coastal districts of Tamil Nadu also spent the largest portion of their income on food.

Fishing crafts and gear ownership

The fishing craft used in the river were wooden boats and steel tin sheet boats (Fig. 5). Steel tin boats are locally made and are mainly used for fishing during low water levels. This boat is only operated in shallow rivers. The wooden boat is large and operated throughout the year. About 95.44% of the population fish with their own fishing crafts and gear, while the remaining 4.56% do not own such equipment and are thus engaged in traditional shore-based passive fishing methods.

About gears, fishes are caught using pole and line, cast net, Charpata Jaal, Suti Jaal, Bessal Jaal, Chinese dip net, Gill net, mosquito net of mesh size 10 mm - 25 mm along with spearfishing, light fishing and box traps. There are no target fisheries in the river; however, the catch primarily comprises Small Indigenous Fishes (SIFs) and weed fish species.

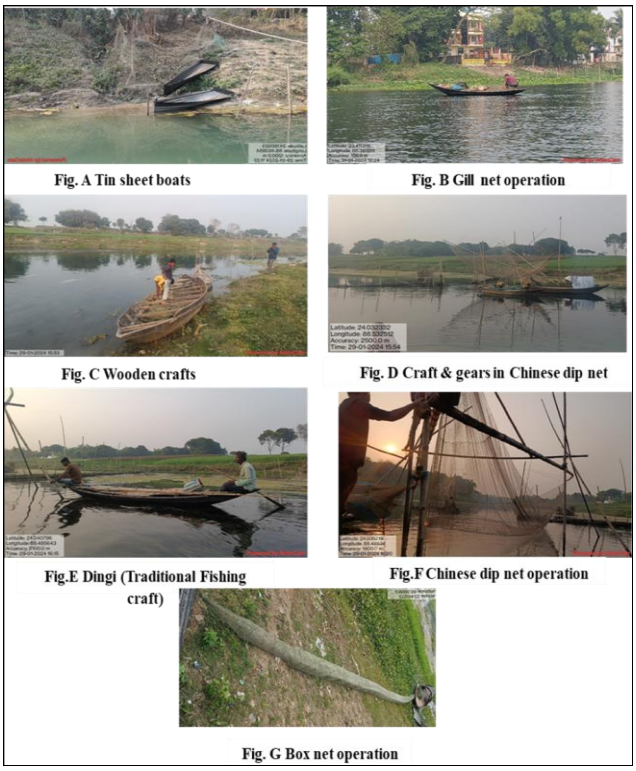

Fig 5: Figures A-G illustrate the Crafts and Gear operation at different sites along the Jalangi River

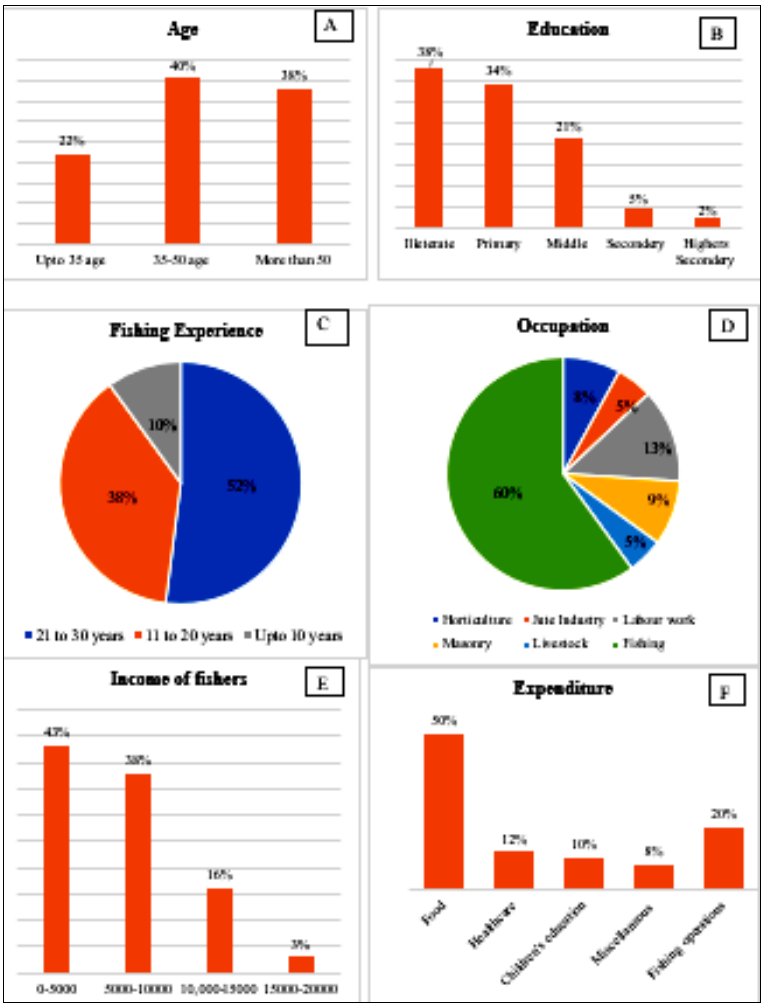

Fig 6: Figures A-F showing socioeconomic variables of fishers of Jalangi river

4. Fishers Adapting to Change

Fishers of the Jalangi River are frustrated due to various challenges. Social conflicts over resources, declining fish catches, extreme weather events, fluctuating market prices, erratic rainfall patterns, low water levels, and pollution have all contributed to the decline in fish stocks. Additionally, political conflicts and the lack of current budg*et al*locations from the state fisheries department are hindering the improvement of fishers' livelihoods. Synergistic and multiplier relations between climatic, non-climatic, and low working capital are key drivers of vulnerability. To cope with it, economic diversification is the primary adaptive strategy adopted by fisherfolks to reduce vulnerability, often involving low-income or high-risk activities, such as daily wage labour. As a result, many youths have lost interest in fishing due to its low profitability and have migrated to cities in search of better opportunities. Additionally, many of these fishers lack alternative sources of income, such as agricultural land or other economic endeavours. They are particularly vulnerable due to their advanced age and limited skills. Forced migration is a real possibility for many fishers, as limited livelihood diversification options may compel them to leave their cultural identity behind in search of alternative sources of income. The majority of fishers surveyed acknowledged the increasing difficulty of relying solely on the Jalangi River. It is unlikely that younger individuals will choose to pursue this profession. This loss of traditional knowledge and skills could have long-lasting consequences for the local communities and the overall health of the river ecosystem.

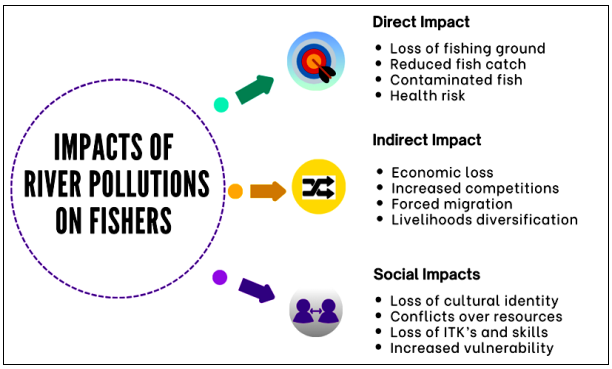

Fig 7: Graphical Representation of the Impact of Polluted Rivers on Fishers

5. Discussion

In the present study, GIS analysis for different periods, i.e., 1994 and 2024, has revealed the drying up of the Jalangi River stretch and stagnation of water flow, which has triggered water pollution and ecological risk. Biswas and Dhara (2019) [8] reported that the Jalangi River is undergoing morphological changes, with active meander cut-offs leading to its gradual decay, which is influenced by

factors such as shear stress and tortuosity, and is linked to significant land-use changes over the past 25 years.

River decay has been a significant concern in recent years, largely due to the impact of climate change and increased human intervention worldwide (Rana and Joshi, 2021; Vliet *et al*., 2023) [34, 41]. Most tropical rivers in India face the problems of discharge shortage, siltation, and poor water quality due to industrial effluents, sewage, dirt, and other toxic substances (Misra 2010; Bastia and Equeenuddin 2016; Sarkar and Islam 2019; Singh *et al.* 2021) [27, 4, 36, 39]. The problem is more severe in areas with higher population density. Naturally, major fluvial systems, such as the Ganga, are facing river decay, which tends to increase river water pollution to a higher magnitude (Trivedi, 2010; Pathak and Mishra, 2020) [40, 30].

The present study found that the drying up of the Jalangi River stretch and the stagnation of water flow triggered water pollution and ecological risks. Earlier studies by Biswas and Dhara (2019) [8] revealed that, up to 51 km from Moktapur village, the river is dry because it has no connection with the Padma River, from which Jalangi formerly received its water supply. Following the completion of the Farakka project, the water level of the Padma was further lowered, resulting in the deterioration of all its branches, including the Jalangi (Das *et al.*, 2020) [17].

The drying up of the Jalangi River has a devastating impact on the ecology, and along with pollution stress further deteriorates water quality for fish species (Sarkar and Islam, 2020) [37]. Roy *et al.* (2022) [33] found that Jalangi River is contaminated with heavy metals such as chromium (Cr), copper (Cu), arsenic (As), nickel (Ni), zinc (Zn), and lead (Pb), primarily from municipal sewage and agricultural runoff. Additionally, Ray (2021) [31] found that the Jalangi River has high levels of sodium, Potassium, and magnesium, supporting the growth of abundant blue-green algae, submerged plants, and phytoplankton. The presence of faecal coliform bacteria in Jalangi is supported by the findings of Das (2023) [14], who reported that the faecal coliform count in Jalangi River water ranged from 1,700 to 300,000 per 100 mL in 2013-14 and from 4,000 to 110,000 per 100 mL in 2014-15. This elevated bacterial presence is primarily due to the discharge of untreated municipal wastewater into the river through the city's drainage systems. Further studies have been conducted by Islam *et al.*, (2024) [22] to examine the water quality of the Jalangi River and found that the Organic Pollution Index (OPI) ranges from 7.17 to 588, and the Eutrophication Index (EI) exceeds the standard of 1, indicating the critical situation of the ecological status of Jalangi River. The Overall Index of Pollution (OIP) indicating a polluted state ranges between 2.67 and 3.91.

The elevated levels of pollution in the river have been linked to a significant decline in fish populations. The declining abundance of Indian major carp (IMC) in the Jalangi River is concerning, as it suggests potential disruptions to the river's ecological balance, which can have adverse effects on local fisheries and overall aquatic biodiversity. In rivers, fish community structure is a reliable indicator of environmental stress (Barrella and Petrere, 2003) [7], as the composition of particular groups within fish communities reflects the level of habitat degradation (Wichert and Rapport, 1998) [42]. Reduced aquatic diversity in River Jalangi due to industrial effluent influx, impacting both flora and fauna. These hydrobiological conditions were observed by Panigrahi *et al.* (2021) [29]. Fishers have reported that Hilsa was observed more than a decade ago in the Jalangi, a finding supported by Chakrabarty and Das (2006) [9]. The declining productivity of the Jalangi River has a significant impact on the Area. According to Mandal (2021), 80% of people are concerned about the degradation of the Jalangi's water quality. The declining productivity of the river has severely impacted its ecosystem and the livelihoods of the local fishing community, which heavily relies on it.

The findings of the present socio-economic study on fishers are unsatisfactory. Fishers' low monthly income (Average 5488 Rs per month) and high expenditure reveal that fishers are selling their catch at low prices to purchase the daily household requisite, and Many fishers rely on middlemen, which often results in lower profits due to bargaining. Due to a lack of bargaining power, middlemen demoralised the fish farmers (Kumar *et al.*, 2018) [26]. This is contributing to the poor socioeconomic condition (Kalita *et al.*, 2015) [24].

The study's findings show the severe consequences of the deteriorating Jalangi River ecosystem on the livelihoods of local fishers. Restoring the river's health could benefit the local community, including those who depend on the river for various livelihoods. This study aims to inspire collective action to protect the Jalangi River from further human-induced degradation and ensure its long-term sustainability.

6. Conclusion

The River Jalangi, at present, has become a defunct, narrow, and silted channel. Recent satellite imagery reveals that the upper stretch of the Jalangi River is inactive due to irregular water flow and siltation resulting from the closure of its water intake from the Ganges. The complete drying up of many parts of the river is a common scenario during the lean season, which is detrimental to fish populations and the overall ecological ecosystem. Moreover, the river has been losing its productivity due to indiscriminate pollution. The drying and pollution of the Jalangi River are driven by severe siltation, reduced water flow, unsustainable irrigation practices, quarrying, and hydropower construction, all of which are compounded by changing climate patterns. Human activities, such as agricultural expansion and brickfields, have exacerbated the river's degradation. The absence of the river dolphin and declining Hilsa populations signal an ecological collapse, while shifts in species dominance reflect oxygen depletion and habitat stress. It was found that fishing is one of the most common practices in the areas adjacent to the Jalangi River. As a result, the interconnectedness between pollution and socio-economic conditions of fishers along the Jalangi is evident. Pollutants have a devastating impact on the livelihoods and well-being of fishers along the river. The study revealed that fishing is the primary occupation for most fishers. Despite spending a significant portion of their time on fishing, the reduced catch has forced them to seek alternative sources of livelihood. Fishers have varying levels of experience, with most having over 20 years in the field. They use a variety of fishing crafts and gear but have reported a drastic decline in their catch over the past decade. Most fishers fall into the low-income category. The majority of fishers rely on

informal sources of credit, often with high interest rates, to sustain their families during crises. The socio-economic conditions of fishers along the Jalangi River are deeply affected by ecological degradation. Reversing this requires a multifaceted approach, including awareness programs, pollution prevention, institutional support, government participation, regulatory enforcement, collaborative research, and public awareness, similar to the National Mission for Clean Ganga (NMCG). Aligning strategies with the Sustainable Development Goals, such as SDG 1, SDG 13, and SDG 14, will promote sustainability, restore biodiversity, and ensure a healthy aquatic environment for future generations while supporting the socio-economic resilience of river-dependent communities.

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