Present Ecological Status of Beki River, and the World Bank's interventions in the district of Barpeta, Assam

Manzur Hassan[1]*, Prof. Arup Kumar Hazarika[2]

[1]*Research Scholar, Department of Zoology, Cotton University, Guwahati, Assam-781001.
[2]Professor & Head, Department of Zoology, Dean Faculty of Life Sciences, Cotton University, Guwahati, Assam-781001

***Corresponding Author:** Manzur Hassan
*Research Scholar, Department of Zoology, Cotton University, Guwahati, Assam-781001.

Abstract
The Beki River, a crucial tributary of the Brahmaputra in Assam, plays a significant ecological and socio-economic role in supporting the local communities through agriculture, fishing, and other livelihood activities. However, the river has been facing various environmental threats, such as pollution from agricultural runoff, erosion, and overfishing, which have led to deteriorating water quality and declining biodiversity. This study aims to assess the water quality of the Beki River, evaluate its biodiversity, and analyze the socio-economic dependencies of local communities on the river. A comprehensive methodology was employed, including water sampling, biodiversity surveys, and socio-economic assessments. The study identifies key pollutants, such as heavy metals and fertilizers, affecting water quality and highlights the impact of river erosion on local livelihoods. Biodiversity assessments reveal a decline in native fish populations, exacerbated by anthropogenic pressures. The findings emphasize the need for sustainable management strategies, including pollution control, erosion prevention, and community-based conservation efforts to protect the river's ecosystem and support the local economy.

Keywords: Beki River, water quality, biodiversity, socio-economic impact, river erosion, pollution, conservation, Assam.

Introduction

Introduction to the Beki River

The Beki River, an important tributary of the Brahmaputra River, originates from the Black Mountains of Bhutan and flows southward through Assam, India. The river's significance stems from both its ecological importance and its role in sustaining the livelihoods of the local population. Stretching across the Barpeta district, the Beki River is critical for agricultural irrigation, fishing, and other activities that support the socio-economic fabric of the region. Historically, it has been a lifeline for communities along its banks, providing fresh water for drinking and agriculture, as well as being a source of fish, a staple food and economic resource for many households (Kalita & Sarma, 2015). The river is also a key part of the floodplain ecosystem, which supports diverse flora and fauna, contributing to the ecological richness of the region (Barman, 2020).

However, in recent years, the river has been under increasing pressure due to anthropogenic activities, including deforestation in the upper reaches, unregulated sand mining, and the use of chemical fertilizers in agricultural fields along its banks. These activities have not only degraded the water quality but also caused significant erosion along the river's course. The consequences of this erosion are severe, leading to the loss of agricultural land and homes, thereby threatening the livelihoods of the local population (Kalita & Sarma, 2015). Moreover, the biodiversity of the river has been adversely affected, with many aquatic species, particularly fish, facing a decline due to habitat degradation and pollution (Barman, 2020). Given the Beki River's integral role in both the environment and the economy of Assam, it is imperative to understand its current ecological status and devise strategies to mitigate the damage being done. The river's health is not only vital for maintaining ecological balance but also for sustaining the livelihoods of those who depend on it.

Anthropogenic Impacts

Human activities have significantly altered the ecological balance of the Beki River, contributing to its degradation over recent decades. One of the primary anthropogenic impacts is the extensive agricultural activity along the riverbanks, which involves the widespread use of chemical fertilizers and pesticides. These chemicals, when washed into the river during the monsoon season, have led to nutrient pollution, particularly increasing levels of nitrates and phosphates. This not only degrades the water quality but also triggers eutrophication, resulting in the excessive growth of invasive aquatic plants, which in turn suffocates native flora and fauna (Goswami & Singha, 2023). Moreover, unchecked deforestation in the upper catchment areas of the river has exacerbated soil erosion, leading to the silting of the riverbed. The sediment

load carried by the river during floods is often deposited on agricultural lands, diminishing their fertility and causing damage to local farming economies (Kalita et al., 2015).

Fishing practices, which have traditionally been sustainable, have also shifted towards more destructive methods due to increasing demand. The use of fine-mesh nets and overfishing in key breeding areas has severely impacted fish populations, particularly endemic species. As the fish populations decline, local fishermen are forced to either exploit the river further or abandon their traditional livelihood, leading to socio-economic distress (Khan, 2012). Additionally, sand and gravel mining, driven by the construction boom, has stripped away the riverbanks and destabilized the surrounding land, accelerating the process of riverbank erosion. The loss of natural vegetation along the riverbank further amplifies this problem, as there are fewer root systems to anchor the soil, making the land more vulnerable to erosion. These human-induced changes have not only altered the river's hydrology but have also threatened the ecological integrity of the Beki River, impacting both biodiversity and the communities dependent on the river for their livelihoods.

Research Objectives

The first objective is to **assess the water quality** of the river. With increasing concerns over pollution, particularly from agricultural runoff and domestic waste, it is crucial to analyze key water quality parameters such as pH, dissolved oxygen (DO), nitrate levels, and the presence of heavy metals. This assessment will help in identifying pollution sources and understanding how water quality changes are affecting both aquatic life and the people who rely on the river for drinking, agriculture, and fishing (Goswami & Singha, 2022).

The second objective is to **evaluate the biodiversity** of the Beki River, which has long supported a rich array of aquatic and terrestrial species. This evaluation will focus on the diversity of fish, invertebrates, and riparian vegetation, examining the impact of habitat loss, pollution, and overfishing. Biodiversity serves as a critical indicator of the river's health, and understanding the current status of species populations will provide insight into the long-term sustainability of the river's ecosystem (Kalita & Sarma, 2015).

Finally, the third objective is to **investigate the socio-economic impacts of river degradation**. The communities surrounding the Beki River have traditionally depended on it for their livelihoods, particularly through agriculture and fishing. However, as the river continues to degrade, these activities have become increasingly unsustainable, leading to economic and social challenges. By exploring the extent of these impacts, the research aims to highlight the interdependence between the river's health and the well-being of local communities, and to propose strategies that can balance ecological preservation with socio-economic needs (Khan, 2012; Kalita et al., 2015).

Literature Review

Ichthyofaunal Diversity

The ichthyofaunal diversity of the Beki River is a vital aspect of its ecological health and plays a significant role in maintaining the balance of the river's ecosystem. The river is home to a variety of freshwater fish species, many of which are crucial for both ecological and economic reasons. Fish species such as *Labeo rohita*, *Catla catla*, and *Cirrhinus mrigala* are commonly found in the Beki River and are not only integral to the river's food web but also form the backbone of the local fisheries (Kalita & Sarma, 2015). These species help regulate aquatic plant growth and contribute to nutrient cycling, thereby supporting the broader biodiversity of the river. The river's ichthyofauna also includes several endemic species that are adapted to its unique hydrological conditions, making the Beki River a vital reservoir of genetic diversity.

However, the ecological significance of the ichthyofaunal diversity in the Beki River extends beyond just local fisheries. These species contribute to the overall health of the aquatic ecosystem by serving as prey for larger predators, both aquatic and terrestrial, and by helping maintain the clarity and quality of the water. For instance, the foraging habits of many fish species in the river help to control algal growth and prevent the overabundance of invasive aquatic plants, which could otherwise deplete oxygen levels and degrade water quality (Goswami & Singha, 2023).

Unfortunately, this rich ichthyofaunal diversity is increasingly under threat due to several anthropogenic factors. Overfishing, habitat destruction, and pollution from agricultural runoff are key drivers of the decline in fish populations. The use of fine-mesh nets, especially in breeding seasons, has resulted in the depletion of juvenile fish stocks, thereby reducing the reproductive potential of the fish species. Additionally, the increasing use of chemical fertilizers in nearby agricultural fields has led to the contamination of the river with harmful substances like nitrates and phosphates, which, in turn, affect the survival rates of many fish species (Kalita & Sarma, 2015).

The decline in fish diversity has broader implications for the river's ecosystem. As fish populations dwindle, the ecological balance of the river is disturbed, which can lead to cascading effects throughout the food web. This includes an increase in invasive species and a reduction in water quality, both of which further degrade the river's health. Protecting the ichthyofaunal diversity of the Beki River is, therefore, not only critical for maintaining ecological balance but also for sustaining the livelihoods of local communities that depend on fishing as a primary source of income. Effective conservation measures, such as regulated fishing practices and habitat restoration efforts, are needed to ensure the long-term survival of the river's fish species and the overall health of the Beki River ecosystem (Goswami & Singha, 2023).

Water Quality Assessment

The water quality of the Beki River has been a growing concern over the years, with multiple studies highlighting the increasing levels of pollution and its adverse effects on both the ecosystem and human health. Previous research has consistently shown that the river is highly vulnerable to contamination, primarily due to agricultural runoff, unregulated fishing activities, and industrial waste. One of the significant pollutants identified in the Beki River is the excessive presence of nitrates and phosphates, which are byproducts of the chemical fertilizers used in the nearby agricultural fields. These substances, when washed into the river during the monsoon season, significantly alter the water's chemical composition, leading to a phenomenon known as eutrophication. This process promotes the excessive growth of algae and other aquatic plants, depleting dissolved oxygen levels and making the water unsuitable for many aquatic organisms (Goswami & Singha, 2022).

The impact of human activities is most pronounced in the areas where the river is used extensively for fishing and agriculture. In particular, the excessive use of pesticides and fertilizers in the river's catchment area has been identified as a major source of water contamination. Goswami and Singha (2022) noted that the pH levels in certain parts of the river have dropped significantly, indicating increased acidity, which can be harmful to both fish species and the broader ecosystem. The decline in water quality is compounded by sedimentation caused by deforestation and soil erosion, further affecting the river's ability to support its natural biodiversity.

Another critical aspect of the water quality assessment relates to the river's role in supporting local livelihoods. Communities residing along the Beki River rely heavily on its waters for drinking, irrigation, and fishing. However, as pollution levels rise, the safety and availability of this water are severely compromised. Singh et al. (2020) emphasized that the contamination not only threatens aquatic species but also jeopardizes the health of people who depend on the river for their daily needs. This situation calls for urgent intervention, including stricter pollution controls and regular monitoring of water quality to ensure the river's health and the well-being of the communities that depend on it.

Socio-Economic Impact

The socio-economic impact of river erosion and pollution along the Beki River is profound, especially for the local communities who depend on the river for their livelihoods. The fishermen, in particular, are among the most affected groups as the river’s health directly correlates with their ability to sustain their traditional livelihoods. Over the years, unchecked riverbank erosion has not only reduced the amount of arable land but has also made many areas unsuitable for habitation and economic activities. Entire villages have had to be relocated due to the loss of land, and those who remain often face the double burden of reduced agricultural productivity and declining fish stocks (Khan, 2012).

The degradation of the Beki River has resulted in a significant reduction in fish populations, which is a primary source of income and food for local fishermen. Overfishing, combined with pollution from agricultural runoff and industrial waste, has severely depleted fish stocks, making it increasingly difficult for fishermen to sustain their livelihoods. Kalita et al. (2015) observed that many of the traditional fishing grounds have become barren due to the contamination of water with fertilizers, pesticides, and heavy metals. This has disrupted the breeding cycles of several fish species, leading to a sharp decline in catches. The lower availability of fish has not only affected income but also increased the competition among fishermen, pushing them into further socio-economic marginalization.

Pollution, particularly from chemical fertilizers and pesticides used in farming along the riverbanks, has compounded the problem. The runoff from agricultural fields enters the river, leading to water contamination that affects both fish and the quality of the water used by local communities for drinking and irrigation. Fishermen often find themselves caught in a vicious cycle where they are forced to fish in increasingly polluted waters, which reduces the quality and quantity of their catches. In turn, this leads to lower market prices for their fish, further exacerbating their economic hardships (Kalita et al., 2015). Additionally, fish from polluted areas may carry health risks, making them less desirable to consumers, which further depresses the local fish economy.

The socio-economic impact of river erosion and pollution extends beyond the fishermen to other sectors of the local economy. Farmers, too, suffer as fertile land is lost to erosion, and the contamination of water used for irrigation negatively impacts crop yields. As the river continues to degrade, both farmers and fishermen find themselves increasingly vulnerable to poverty and food insecurity. Khan (2012) pointed out that this situation has led to an increase in rural-to-urban migration, as people seek better opportunities in cities after losing their livelihoods due to the river's deterioration.

Morphometric Studies

Morphometric studies of rivers involve the quantitative analysis of various characteristics such as the river’s shape, size, and drainage patterns. These studies are essential for understanding the dynamics of a river system and are particularly important for effective river management. In the case of the Beki River, morphometric analysis helps in identifying how the river’s physical characteristics influence its hydrology, erosion patterns, and overall ecosystem. By assessing parameters such as basin area, drainage density, and stream length, researchers can gain insights into the susceptibility of the river to erosion, sedimentation, and flooding (Barman, 2020).

One of the critical aspects of morphometric studies is the evaluation of the river's **drainage basin** and its shape. The Beki River’s basin has been identified as elongated, which affects how water flows through the system, particularly during the monsoon season. An elongated basin typically has a slower runoff, which can increase the likelihood of flooding as water takes longer to drain from the area. This is particularly important for river management strategies, as it

helps predict flood risks and informs decisions on where embankments or flood control structures should be placed (Barman, 2020). Understanding the basin shape also aids in determining the potential areas where erosion might be most severe, allowing for targeted intervention to prevent land degradation and protect nearby communities.

Stream order and stream length are other critical morphometric parameters that play a significant role in river management. The Beki River's drainage network has been categorized into different stream orders, with higher-order streams being more prone to sediment transport and erosion. The length of these streams and their gradient influence the river's ability to carry sediment downstream. Areas with steep gradients often experience faster water flow, which can lead to increased erosion of the riverbanks. Conversely, in flatter regions, sediment tends to accumulate, which can cause blockages and alter the river's course over time (Patgiri& Amin, 2017). By analyzing these characteristics, river managers can develop strategies to minimize erosion in vulnerable areas and ensure that sediment transport remains balanced to prevent downstream blockages.

Methodology

Study Area Description

The Beki River Basin, located in the Barpeta district of Assam, plays a crucial role in the region's ecological and socio-economic landscape. The river originates from the Black Mountains in Bhutan and flows southward into Assam, eventually joining the Brahmaputra River. The basin is characterized by a subtropical monsoon climate, with high levels of rainfall, particularly during the monsoon season from June to September. Annual rainfall ranges between 2,000 to 4,200 millimeters, contributing to significant seasonal fluctuations in river flow. The region experiences hot summers with temperatures reaching up to 35°C, while winters are cooler, with temperatures dropping to around 10°C (Saikia et al., 2010). The landscape surrounding the Beki River includes a mix of agricultural land, forested areas, and floodplains, making it a vital resource for both ecological biodiversity and local livelihoods (Kalita & Sarma, 2015). This geographic and climatic diversity influences the hydrological behavior of the river and the socio-economic activities of the communities along its banks.

Data Collection

Water Quality Sampling

Water quality sampling was conducted at multiple sites along the Beki River, with particular focus on areas heavily affected by human activities such as agriculture and fishing. Sampling sites were strategically chosen to represent different sections of the river, including upstream, midstream, and downstream areas. At each site, water samples were collected during different seasons (pre-monsoon, monsoon, and post-monsoon) to capture seasonal variations in water quality. Key parameters measured included temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), and concentrations of nitrates, phosphates, and heavy metals such as arsenic and lead. The temperature and pH levels were measured using a digital thermometer and a calibrated pH meter, respectively, while DO levels were determined using Winkler's modified method. The presence of heavy metals was assessed using spectrophotometric analysis (Goswami & Singha, 2022). These parameters were chosen to evaluate the overall health of the river and to identify pollutants that could be affecting aquatic life and human usage.

Biodiversity Surveys

To assess the biodiversity of the Beki River, extensive surveys of aquatic fauna and riparian vegetation were conducted. Sampling of aquatic species, particularly fish and macroinvertebrates, was carried out using nets, traps, and electrofishing techniques in various habitats along the river. Special attention was paid to the identification of endemic species and their abundance, as well as invasive species that may be impacting the river's ecosystem. Riparian vegetation was surveyed using quadrat sampling, where the diversity, density, and health of plant species along the riverbanks were recorded. The biodiversity surveys aimed to understand the ecological health of the river and how it has been affected by factors such as pollution, habitat destruction, and riverbank erosion (Kalita & Sarma, 2015). Data from these surveys will provide a clearer picture of the changes in species composition and the overall health of the river ecosystem.

Socio-Economic Surveys

The socio-economic impact of river degradation was assessed through detailed interviews and focus group discussions with local communities, particularly those involved in agriculture and fishing. The interviews focused on understanding how pollution, erosion, and reduced fish populations have affected their livelihoods. Fishermen, for instance, were asked about changes in fish catch over time, while farmers were questioned about the impact of riverbank erosion and water quality on crop yields. These surveys also explored the coping mechanisms adopted by local communities in response to the ecological challenges they face (Kalita et al., 2015; Khan, 2012). The socio-economic data gathered from these interviews will help highlight the direct link between the health of the Beki River and the economic stability of the surrounding communities.

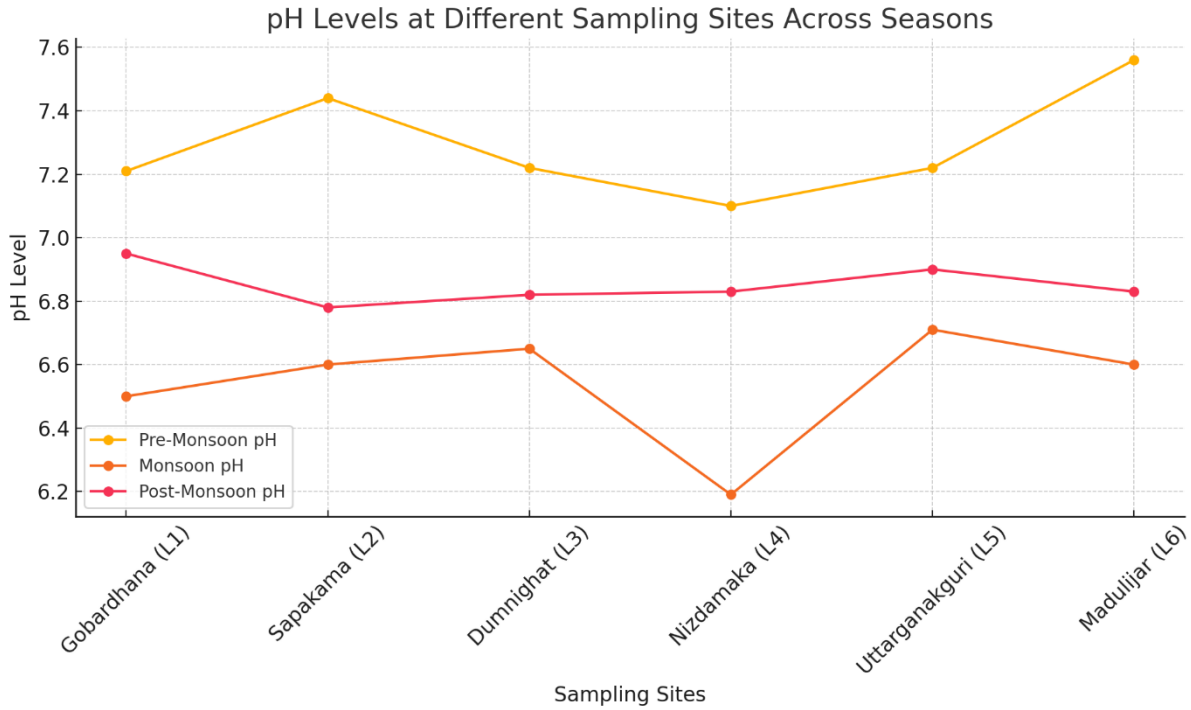
Secondary Data

Secondary data on the Beki River's management, specifically related to the **World Bank**-funded erosion protection project, was obtained from the Water Resource Department in Barpeta. This data includes technical details on the

embankment construction, erosion control measures, and the geographical locations where these projects have been implemented. The project, funded by the World Bank, focuses on using advanced techniques such as geo-bags and porcupine structures to stabilize riverbanks and reduce the impact of seasonal flooding. This data provides a crucial context for evaluating the effectiveness of current efforts to manage riverbank erosion and protect local communities (Baruah & Choudhury, 1999). Integrating this information into the study allows for a comprehensive analysis of both traditional and modern river management techniques and their socio-economic implications.

Results

Water Quality Findings



Biodiversity

The biodiversity of the Beki River, particularly its ichthyofaunal diversity, is a crucial component of its ecosystem health and reflects the broader environmental changes occurring in the region. The river is home to a wide variety of fish species, including commercially important species like *Labeo rohita* (Rohu), *Catla catla* (Catla), and *Cirrhinus mrigala* (Mrigal), as well as smaller indigenous species that support the local food chain (Kalita & Sarma, 2015). Historically, these fish populations have thrived, supporting both the river's ecological balance and the livelihoods of local fishermen. However, in recent years, fish diversity has shown signs of decline due to habitat degradation, pollution, and overfishing.

Studies conducted by Goswami & Singha (2023) have documented a reduction in the population health of several key species. Overfishing, particularly the use of fine-mesh nets during breeding seasons, has severely impacted reproductive cycles, leading to a decline in the overall population of fish species. Furthermore, the degradation of water quality due to pollutants such as nitrates, phosphates, and heavy metals has directly affected the survival rates of juvenile fish, further exacerbating the decline in fish stocks. This loss of biodiversity has significant implications not only for the river's ecosystem but also for the communities that rely on fishing as a primary source of income and food.

The impact of habitat changes on local fauna is further evidenced by the increasing prevalence of invasive species, which outcompete native fish for food and resources. These invasive species often thrive in polluted waters, where native species struggle to survive. The disruption of the river's natural balance has led to a cascading effect on the food chain, impacting not only fish populations but also the animals and birds that rely on the river for sustenance. Protecting the biodiversity of the Beki River requires immediate and coordinated efforts, including habitat restoration, pollution control, and sustainable fishing practices to ensure the long-term health of both the river and its inhabitants (Kalita & Sarma, 2015; Goswami & Singha, 2023).

Socio-Economic Impact

The socio-economic impact of the Beki River's degradation is most profoundly felt by local fishermen, who have traditionally relied on the river's rich fish populations for their livelihoods. As the fish populations have dwindled due to pollution, habitat loss, and overfishing, these communities have faced significant economic challenges. Many fishermen report smaller catches and the need to travel further downstream in search of fish, which increases fuel and labor costs, while the income generated from the smaller, lower-quality catches does not compensate for these additional expenses (Kalita et al., 2015). The decline in fish stocks, exacerbated by the use of fine-mesh nets that capture juvenile fish before they can reproduce, has created a cycle of diminishing returns, where each year's harvest is smaller than the last. This

has left many fishermen struggling to support their families, and some have had to abandon fishing altogether, seeking out alternative livelihoods that are often less stable and remunerative (Khan, 2012).

Agricultural issues further compound these economic struggles. Farmers along the Beki River also face challenges due to declining water quality and the effects of erosion on agricultural land. Fertile soil along the riverbanks is continually washed away during seasonal floods, reducing the amount of arable land available for cultivation. As the soil erodes, it not only diminishes crop yields but also exposes agricultural lands to further degradation, making farming increasingly unsustainable (Khan, 2012). Additionally, polluted water from the river, containing high levels of nitrates, phosphates, and heavy metals, affects the quality of irrigation water, leading to poor crop health and reduced productivity. This, in turn, places additional financial burdens on farmers, who are forced to invest in costly fertilizers and pesticides in an attempt to maintain yields.

Discussion

Water Quality Concerns

The current water quality of the Beki River presents significant concerns when compared to past studies and established environmental standards. Recent research indicates a marked decline in key water quality parameters such as pH, dissolved oxygen (DO), and the presence of harmful pollutants like nitrates, phosphates, and heavy metals. For instance, Goswami & Singha (2022) found that pH levels in certain stretches of the river have dropped to levels that indicate increasing acidity, which poses a threat to aquatic life. This stands in contrast to earlier assessments, where pH levels were within the safe range for most aquatic organisms. Similarly, the dissolved oxygen levels in some areas of the river, particularly during the monsoon season, have been recorded at critically low levels, far below the thresholds required to support a healthy fish population (Singh et al., 2020). The comparison with past studies underscores a significant degradation in water quality, making it increasingly difficult for both aquatic species and human populations that rely on the river for drinking water and agriculture.

The declining water quality can be directly linked to the intensification of agricultural activities along the riverbanks. The heavy use of chemical fertilizers and pesticides in nearby agricultural fields has led to a substantial increase in nutrient runoff, particularly during the monsoon season. This runoff introduces high concentrations of nitrates and phosphates into the river, contributing to eutrophication, which leads to excessive algal growth and the depletion of dissolved oxygen (Kalita et al., 2015). As a result, aquatic species, particularly fish, face heightened stress, and many have experienced significant population declines due to the reduced oxygen levels and habitat changes. Moreover, agricultural runoff often contains other harmful chemicals that accumulate in the river, affecting not only water quality but also the health of the river's biodiversity.

Sand mining has further exacerbated the pollution levels in the Beki River. The unregulated extraction of sand from the riverbed disrupts the natural flow of the river, leading to increased sedimentation and the release of previously buried pollutants. The sediment clouds the water, reducing sunlight penetration, which is essential for aquatic plants and phytoplankton, and destabilizes the riverbanks, making them more prone to erosion. As the riverbanks erode, more pollutants from the land, such as agricultural waste, are washed into the water, further degrading its quality (Kalita et al., 2015). In many cases, sand mining has also altered the physical structure of the river, changing its flow patterns and leading to stagnant areas where pollutants can accumulate. These stagnant zones often become breeding grounds for bacteria and other harmful microorganisms, further compounding the river's water quality issues.

Impact of River Erosion

River erosion has long been a pressing issue along the Beki River, with devastating effects on both the local environment and communities. The **World Bank**-funded erosion protection project implemented in recent years aims to mitigate these impacts through various measures, including the construction of embankments and the use of innovative techniques like geo-bags and porcupine structures to stabilize the riverbanks. The project's primary goal is to prevent the loss of land and protect the livelihoods of people living near the river, particularly farmers whose fields are often the first to be claimed by the eroding banks. Early assessments of the project suggest that these protection measures have been effective in reducing the rate of erosion in key areas, particularly during the monsoon season when the river is most volatile (Baruah & Saikia, 2015). The geo-bags, which consist of synthetic materials filled with sand, act as barriers that absorb the river's force, while porcupine structures help dissipate the energy of flowing water, reducing its capacity to erode the banks.

The consequences of river erosion extend beyond the immediate loss of land and property; they also have significant implications for agricultural sustainability. Farmers along the Beki River depend on the fertile floodplain soil for their crops, but as erosion continues to strip away this land, their ability to cultivate crops is severely diminished. In some cases, entire fields have been lost to the river, leaving farmers with little to no land to work on. Even when land remains intact, the constant threat of erosion discourages investment in long-term agricultural practices, as farmers are unsure if their fields will survive the next rainy season (Gogoi et al., 2015). This instability contributes to a cycle of poverty, where the lack of reliable land reduces crop yields, leading to lower incomes and, ultimately, less capacity to invest in sustainable farming methods.

Conservation and Biodiversity

Conservation efforts aimed at protecting the biodiversity of the Beki River and its surrounding ecosystems have gained increasing importance, particularly as the threats posed by habitat loss, pollution, and overexploitation have intensified. Among the species most in need of protection is the Indian Gharial, a critically endangered crocodilian that relies on the river for both its habitat and prey. The Gharial has suffered greatly due to the degradation of the river's water quality and the destruction of its nesting sites caused by riverbank erosion and human encroachment. Conservation efforts in the region, such as habitat restoration projects and protected breeding zones, are essential for ensuring the survival of this species. Saikia et al. (2010) noted that despite these efforts, much more needs to be done to address the systemic issues of pollution and habitat loss that continue to threaten the Gharial and other species. These conservation initiatives require collaboration between government agencies, non-governmental organizations, and local communities to restore the ecological balance of the river while protecting its most vulnerable species (Goswami & Singha, 2023).

The Beki River is also home to a variety of other fish and aquatic species, many of which are vital to both the river's ecosystem and the local economy. Ensuring the sustainability of these populations requires not only protecting their habitats but also implementing sustainable fishing practices. Overfishing has been a significant problem, particularly with the use of unsustainable methods such as fine-mesh nets, which indiscriminately catch fish of all sizes, including juveniles that have not yet had a chance to breed. This practice leads to long-term declines in fish populations, which affects the overall health of the river's ecosystem (Kalita et al., 2015). Conservation strategies must therefore focus on regulating fishing practices and encouraging methods that allow fish populations to recover. Implementing seasonal fishing bans during breeding periods and enforcing limits on the size of fish that can be caught are among the strategies that can help to restore balance to the river's ecosystems.

Local communities play a crucial role in the success of conservation efforts, as they are often the ones most directly impacted by the river's health. Many community members depend on the river for their livelihoods, particularly through fishing and agriculture. Kalita et al. (2015) highlighted the importance of involving these communities in conservation initiatives, not only to ensure their cooperation but also to empower them to take an active role in protecting the environment that sustains them. Sustainable fishing practices can be taught and enforced through community-based programs that emphasize the long-term benefits of conserving fish populations, both for the ecosystem and for future generations of fishermen. Additionally, local knowledge and traditional practices can provide valuable insights into the river's natural cycles and how best to manage its resources sustainably.

Conclusion

Summary of Key Findings

The findings from the study of the Beki River highlight a complex interplay between environmental degradation and socio-economic challenges, primarily driven by human activities. One of the key discoveries is the severe **degradation of water quality**, which has been significantly impacted by agricultural runoff, industrial pollution, and unsustainable land use practices. Goswami & Singha (2022) documented alarming levels of pollutants such as nitrates, phosphates, and heavy metals, particularly in areas where agricultural activities are intense. The use of chemical fertilizers and pesticides has led to nutrient overloads in the river, resulting in eutrophication, a process that depletes oxygen levels and disrupts aquatic ecosystems. Additionally, the presence of harmful substances like arsenic and lead in the river water not only threatens aquatic life but also poses serious health risks to the local population that relies on the river for drinking water and irrigation.

Alongside water quality issues, there is a noticeable **decline in biodiversity** across the Beki River, with habitat destruction emerging as a critical factor. Kalita & Sarma (2015) observed that the degradation of the riverbanks due to erosion and the destruction of riparian vegetation have contributed to the loss of habitat for both aquatic and terrestrial species. Fish populations, in particular, have suffered from the combined effects of overfishing and the degradation of their breeding grounds. The use of fine-mesh nets, often employed during spawning seasons, has reduced fish stocks to unsustainable levels. Furthermore, the decline of species such as the Indian Gharial is indicative of the broader ecological crisis, as their natural habitats along the riverbanks are continuously eroded or disrupted by human activity. The diminishing biodiversity not only affects the ecological balance of the river but also threatens the livelihoods of the local communities dependent on fishing and agriculture.

The **socio-economic challenges** faced by these local communities are another major finding of the study. Khan (2012) pointed out that the degradation of the river has left many fishermen and farmers struggling to maintain their traditional livelihoods. As fish populations dwindle and agricultural land is lost to erosion, many families are finding it increasingly difficult to sustain themselves. The constant threat of erosion, which displaces entire communities and destroys farmland, forces people into economic hardship and insecurity. Many fishermen report significantly lower catches, which not only affects their income but also their ability to provide food for their families. Similarly, farmers are experiencing reduced crop yields due to both soil degradation and the contamination of irrigation water with pollutants from the river. This has resulted in a cycle of poverty and rural displacement, with many community members seeking alternative employment in urban areas, where opportunities are often scarce and unstable.

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