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# Conservation of *Barilius barila* Through Innovative Cultivation: Ecological, Socio-Economic, Ethical Impacts in Bengal and Relevant Legal Issues

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## ABSTRACT

The conservation of *Barilius barila* (locally known as Boroli) is significant for maintaining ecological balance and supporting the socio-economic fabric of North Bengal, India. This study explores innovative cultivation techniques aimed at preserving this species, which is indigenous to the clear streams and shallow rivers of India, Nepal, Bangladesh, and Myanmar. Despite its classification as "Least Concern" by the IUCN, *Barilius barila* faces threats from environmental degradation, particularly in North Bengal. This research examines the ecological, socio-economic, ethical, and legal dimensions of *Barilius barila* conservation, with a focus on the artificial cultivation efforts

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initiated by the West Bengal government in South Bengal. The study employed a mixed-methods approach i.e. water quality assessments, and socio-economic analyses to assess the effectiveness of these conservation strategies. The findings highlight the challenges posed by anthropogenic activities, including pollution, deforestation, and climate change, which have led to the degradation of natural habitats and a decline in the quality of naturally sourced *Barilius barila*. The research also addresses ethical concerns regarding the potential impact of artificial cultivation on the species' taste and market value which necessitates legal frameworks to support sustainable practices. This study advances the understanding of *Barilius barila* conservation by providing an analysis of the species' ecological role, the socio-economic implications of its decline, and the effectiveness of innovative cultivation methods. The finding justifies the importance of balancing technological interventions with the preservation of natural habitats, ensuring the long-term sustainability of *Barilius barila* and its ecological niche in North Bengal.

**Keywords:** *Barilius barila*; river pollution; conservation; captive breeding; sustainable cultivation; socio-economic impact.

## 1. INTRODUCTION

*Barilius barila* is commonly referred to as Boroli in Bengal. It is a tropical freshwater fish indigenous to the foothills of India, Nepal, Bangladesh, and Myanmar. It belongs to the family Danionidae and the order Cypriniformes. This species occupies an ecological niche in the clear streams [1] and shallow rivers of these regions. Despite being classified as "Least Concern" by the IUCN, [2], the conservation of *Barilius barila* has garnered attention due to the increasing threats to its natural habitat, particularly in North Bengal. The historical and socio-economic importance of this species in parts of Bengal, coupled with its ecological role, manifests the necessity of its conservation.

The natural habitats of *Barilius barila* are under threat from various anthropogenic activities, mostly due to deforestation, pollution, and the effects of climate change. These activities have led to a decline in the population and quality of

naturally sourced Boroli, and have raised concerns among conservationists and local communities alike. The West Bengal government has responded by initiating innovative cultivation methods aimed at preserving the species in South Bengal, an area with different ecological conditions from its native northern habitats. These efforts seek to recreate the natural conditions of the northern rivers to maintain the species unique taste and quality [3].

However, the shift from natural to artificial cultivation has introduced a host of ethical and legal issues. The differences in taste and quality between naturally grown and artificially cultivated *Barilius barila* raise questions about consumer preferences and market dynamics. Moreover, the economic implications for local fishing communities, who rely on the natural populations of Boroli, cannot be overlooked. This research examines these issues with a focus on the conservation of *Barilius barila* within the broader context of environmental ethics and legal frameworks in India.



**Fig. 1. Matured *B. barila* (female)**



**Fig. 2. Matured *B. barila* (male)**

Picture of Boroli (*Barilius barila*) fish: Source [4]

This study aims to address the gaps in current conservation efforts by providing a comprehensive analysis of the ecological, socio-economic, and legal dimensions of *Barilius barila* conservation. It studies the effectiveness of innovative cultivation techniques and their impact on both the species and the local communities that depend on it. By integrating historical context with contemporary challenges, this research contributes to the ongoing discourse on fish conservation in Bengal and offers insights that could inform broader conservation strategies in similar ecological settings. The decline of *Barilius barila* (baril fish) is analysed in Table 1 provided here. The analysis highlights that *Barilius barila* is one of the species that significantly declined between the 1980s and 1990s. Specifically, this species, belonging to the Danionidae family and classified as Least Concern (LC) by the IUCN, is noted to have declined during the 1990s, particularly in the Lowlands and Hills. The decline is associated with its mid-water column position and its maximum size of about 10 cm [5].

## 2. BACKGROUND

### 2.1 Historical Context and the Importance of *Barilius barila* in Bengal

*Barilius barila* has long held a place in the ecological and cultural landscape of Bengal. This tropical freshwater fish is indigenous to the rivers and streams of North Bengal, growing in the clear, fast-flowing waters at the base of the hills. Historically, Boroli has been highly valued not only for its tender meat and distinct mild, sweet flavor but also as a symbol of the rich biodiversity of the region [6,7]. The annual Boroli festival in Cooch Behar district manifests the cultural importance of this species, where it is celebrated through signature dishes that draw visitors from across the region. This festival, coupled with the fish's popularity in local cuisine, highlights the socio-economic role *Barilius barila* has played in Bengal over the years [8].

### 2.2 Current Challenges in *Barilius barila* Conservation

In recent decades, the natural habitats of *Barilius barila* have faced increasing pressure from anthropogenic activities. The rivers of North

Bengal, originating from the hilly regions, are subject to severe environmental degradation due to deforestation, land encroachment, and pollution. These activities have reduced the carrying capacity of these rivers that in consequence lead to habitat loss and a decline in *Barilius barila* populations. Climate change further exacerbates these challenges by altering precipitation patterns, increasing river temperatures, and accelerating glacier melt, all of which contribute to the degradation of the species' natural habitat [8]. Infrastructure developments, such as bridges and hydropower projects, have also disrupted the natural flow of rivers and are the causes of siltation and erosion, which in turn impact the aquatic ecosystems that *Barilius barila* relies on.

Pollution, particularly from urban sewage and agricultural runoff, has emerged as a major threat to the water quality in the rivers of North Bengal. The Teesta River, for instance, has been identified by the 'Central Pollution Control Board' as one of the most polluted rivers in the region [9]. This pollution has led to a decline in the quality of natural Boroli fish, as the polluted waters impact their growth and overall health. Additionally, the introduction of non-native species and unregulated fishing practices have further threatened the sustainability of *Barilius barila* populations [10].

### 2.3 Socio-Economic Impacts on Local Fishing Communities and Ethical Considerations in Conservation Efforts

The decline of *Barilius barila* populations has had socio-economic implications for the local fishing communities of North Bengal. These communities, many of whom rely on Boroli fishing as their primary source of income, have been severely affected by the reduced availability of this species. The need to travel long distances to find adequate fishing grounds, coupled with the diminishing returns, has placed economic strain on these communities. The variability in river water levels, often due to inadequate rainfall or mismanagement of water resources, has further exacerbated these challenges and fishing has increasingly become uncertain livelihood [12].

**Table 1. Species declining significantly between the 1980s and 1990s, and/or the 1990s [11]**

Species	Order	Family	Conservation status	Decade of decline detection	Elevational range	Water column position	Max size (cm)
Barilius barila	Cypriniformes	Danionidae	*LC	1990s	*L, H	Mid	10

\* LC-Least Concern, L-Lowland, H-Hills

**Table 2. Water Quality Information System, Polluted River Stretches' of North Bengal in West Bengal [16]**

SL No.	River	Priority	Polluted Stretch	BOD (mg/L) when identified as polluted	Target water quality (Class) See Table-1	BOD (mg/L) at present	pH at present	Dissolved Oxygen (mg/L) at present	Total Coliform (MPN/100ml) at present	Fitness comment(s)
1	Mahananda	II	Siliguri to Binaguri	6.5 - 25	Class "B" Outdoor Bathing (Organised)	18.0	7.05	3.3	220000.0	Not Fit for Bathing
2	Kaljani	V	Bitala to Alipurdwar	6.0	Class "B" Outdoor Bathing (Organised)	1.1	7.05	6.6	9000.0	Not Fit for Bathing
3	Karola	V	Jalpaiguri to Thakurer Kamat	3.9	Class "B" Outdoor Bathing (Organised)	2.2	7.31	5.9	22000.0	Not Fit for Bathing
4	Teesta	V	Siliguri to Paharpur	3.3	Class "B" Outdoor Bathing (Organised)	2.5	6.8	8.3	5000.0	Not Fit for Bathing

**Table 3. Comparison of Polluted River Stretches of North Bengal in West Bengal during 2018 & 2022 [17]**

Sl.	River	2018		2022	
		BOD range (mg/l)	Priority	Max. BOD (mg/l)	Priority
1.	Mahananda	6.5 - 25	II	31.0	I
2.	Teesta	3.3	V	3.8	V
3.	Kaljani	6.0	V	Excluded	
4.	Karola	3.9	V		

Ethical considerations also play a role in the conservation of *Barilius barila*. The artificial cultivation of Boroli in South Bengal [13], initiated by the West Bengal government, aims to counter the decline in natural populations. However, this approach raises concerns about the potential differences in taste and quality between naturally sourced and artificially cultivated fish. These differences could impact consumer preferences and market dynamics. Moreover, the long-term ecological impacts of relying on artificial cultivation rather than habitat restoration remain uncertain and this raises a need for careful ethical scrutiny of these conservation strategies [14].

### 3. CAUSES OF DECLINING THE QUALITY OF NATURAL BOROLI FISH

The decline in the quality and population of natural *Barilius barila* (Boroli) in North Bengal can be attributed to a combination of human population growth, economic development and environment change, overfishing, anthropogenic, and ecological factors. This section examines these causes with an emphasis on the intricate interplay between human activities and natural processes that have led to the deterioration of Boroli habitats [15].

#### 3.1 Environmental Degradation and Habitat Loss

One of the primary causes of the decline in natural Boroli fish is the extensive environmental degradation in North Bengal, particularly in the river systems originating from the hilly regions. The rivers, which carry rain and snowmelt, are increasingly burdened by deforestation and land conversion activities. The removal of vegetation along riverbanks and floodplains has led to significant soil erosion, which in turn has reduced the carrying capacity of these rivers. This loss of natural buffers not only exacerbates flooding but also disrupts the delicate balance of the river ecosystems, essential for the survival of Boroli.

Climate change further compounds these issues by altering the hydrological cycles in the region. Increased rainfall intensity and the accelerated melting of glaciers contribute to erratic river flows, which can lead to both severe flooding and prolonged dry periods [18]. These fluctuations in water levels create hostile conditions for Boroli, which grows in stable, clear water environments.

#### 3.2 Pollution and Water Quality Degradation

Pollution has emerged as a critical threat to the health of *Barilius barila* populations. The rivers of North Bengal, particularly the Teesta, are subject to significant contamination from urban and industrial waste, as well as agricultural runoff. The 'Central Pollution Control Board' has identified the Teesta River as highly polluted, particularly in stretches near Paharpur and Siliguri [19]. The introduction of harmful substances into these rivers, such as chemicals and untreated sewage, has degraded water quality, adversely affecting the growth and reproductive health of Boroli fish.

**The data of the 'West Bengal Pollution Control Board, Water Quality Information System', Polluted River Stretches of North Bengal in West Bengal are:** The decline in water quality is also evident in the Biological Oxygen Demand (BOD) levels recorded in various rivers. For example, the Mahananda River has seen its BOD levels rise significantly, indicating increased organic pollution. These polluted conditions are detrimental to Boroli, which requires high-quality, oxygen-rich water to thrive.

#### 3.3 Impact of Hydropower Projects and Infrastructure Development

Hydropower projects and infrastructure developments pose additional challenges to the conservation of *Barilius barila*. The construction of dams and reservoirs has altered the natural

flow of rivers, leading to sediment buildup and changes in water temperature. These modifications disrupt the natural habitats of Boroli, which are adapted to fast-flowing, cool waters. Furthermore, the increased siltation caused by these projects smothers spawning grounds and reduces the availability of clean water, critical for the survival of Boroli larvae and juveniles.

While hydropower projects contribute to energy generation and economic development, their environmental costs are often overlooked. The lack of adequate environmental impact assessments and the failure to implement sustainable management practices have exacerbated the decline of Boroli populations [20].

### 3.4 Consequences of Captive Breeding and Artificial Cultivation

The decline in natural Boroli populations has led to increased reliance on captive breeding and artificial cultivation as conservation strategies. However, these methods come with their own set of challenges and ethical concerns. Captive breeding, often facilitated by synthetic hormones, can lead to genetic and phenotypic changes in the fish, compromising their ability to thrive in natural environments. Moreover, artificially cultivated Boroli may exhibit differences in taste and quality compared to their wild counterparts. This raises questions about their market viability and consumer acceptance.

The use of artificial cultivation also shifts the focus away from habitat restoration, which is important for the long-term sustainability of Boroli populations. While captive breeding can serve as a stopgap measure, it should not replace efforts to protect and restore the natural habitats of *Barilius barila*.

## 4. INITIATIVE TAKEN TO CONSERVE THE NATURAL BOROLI FISH

The conservation of *Barilius barila* (Boroli) in Bengal has become a concern of the West Bengal government's efforts to preserve the region's biodiversity and sustain the livelihoods of local communities. This section examines the various initiatives undertaken to conserve this species with a focus on the innovative strategies employed and the challenges faced in implementing these conservation efforts.

### 4.1 Government-Led Conservation Initiatives

The 'West Bengal Fisheries Department' has been at the forefront of the efforts to conserve *Barilius barila*. Recognising the ecological and socio-economic importance of this species, the department has implemented a series of initiatives aimed at sustaining Boroli populations in both their natural and artificial habitats. One of the strategies has been the artificial cultivation of Boroli in South Bengal [21], a region with different ecological conditions from the fish's native habitat in the north. This initiative is driven by the need to mitigate the impact of environmental degradation due to which the species faces significant threats from pollution, deforestation, and climate change [22]. 'The State Fish Development Corporation' (SFDC) has played an important role in these efforts by setting up specialised fish ponds in Burdwan, designed to replicate the natural conditions of northern rivers. These ponds are equipped with advanced technologies, such as electrical paddle wheel aerators and air jets, to maintain optimal water temperatures and oxygen levels. By mimicking the cool, oxygen-rich waters of the northern streams, these artificial environments aim to preserve the distinct taste and quality of Boroli fish [23].

### 4.2 Scientific Research and Technological Innovation

Scientific research has helped many of the conservation initiatives, with a focus on developing sustainable aquaculture practices that can be scaled up across the region. The use of synthetic hormones in captive breeding programs has been one such innovation, enabling the mass production of Boroli seeds for distribution across South Bengal. This approach has been instrumental in increasing the availability of Boroli, particularly in areas where natural populations have dwindled due to habitat loss and water pollution. However, while these technological advancements have shown promise, they also present certain challenges. The long-term ecological impacts of synthetic hormone use, for instance, remain uncertain, and there are concerns about potential genetic changes in the artificially cultivated Boroli populations. Furthermore, the shift towards artificial cultivation raises questions about the sustainability of these practices and whether they can truly replicate the ecological dynamics of natural habitats [24].

### 4.3 Community Involvement and Socio-Economic Considerations

The success of Boroli conservation efforts hinges not only on technological innovation but also on the active involvement of local communities. The West Bengal government has recognised the importance of community participation in conservation, particularly in areas where fishing is a primary source of livelihood. Initiatives such as awareness programs, training sessions, and financial incentives have been introduced to encourage sustainable fishing practices and reduce the pressure on natural Boroli populations. Moreover, the government's efforts to cultivate Boroli in South Bengal have provided new economic opportunities for fishers, who can now access a more reliable source of income through the sale of artificially cultivated Boroli. This shift has the potential to alleviate some of the socio-economic challenges faced by these communities, particularly in light of the declining availability of natural Boroli. However, these initiatives are not without their ethical and economic challenges. The differences in taste and quality between natural and cultivated Boroli have led to market uncertainties, with consumers often expressing a preference for the naturally sourced fish. This has implications for the pricing and marketability of cultivated Boroli, which could affect the economic viability of the conservation initiatives.

## 5. ETHICAL ISSUES REGARDING ARTIFICIAL CULTIVATION

The artificial cultivation of *Barilius barila* (Boroli) in South Bengal, while innovative and necessary to counter the decline in natural populations, raises significant ethical concerns. These issues span various dimensions, including the potential impact on the species' genetic integrity, market dynamics, consumer trust, and the broader implications for conservation ethics.

### 5.1 Genetic Integrity and Ecological Impact

One of the primary ethical concerns associated with the artificial cultivation of Boroli is the potential for genetic and phenotypic alterations. The use of synthetic hormones in captive breeding programs, while effective in boosting reproduction rates, may lead to unintended consequences such as reduced genetic diversity and altered behaviors. These changes could compromise the resilience of Boroli populations,

particularly if artificially bred fish are released into the wild or if their genetic material intermingles with that of natural populations. The long-term ecological impact of these practices remains uncertain, raising questions about the sustainability of relying on artificial cultivation as a conservation strategy.

Moreover, the artificial environments created to replicate the natural conditions of Boroli's native habitat, while technologically advanced, cannot fully mimic the complex ecological interactions present in the wild. This discrepancy could lead to differences in the fish's adaptation, survival rates, and overall health, further complicating conservation efforts.

### 5.2 Market Dynamics and Consumer Trust

The introduction of artificially cultivated Boroli into the market introduces ethical dilemmas related to consumer trust and market dynamics. Traditionally, Boroli from the natural rivers of North Bengal has been highly prized for its distinct taste and quality, which are products of the specific environmental conditions in which it thrives. The artificial cultivation of Boroli, despite efforts to replicate these conditions, may result in fish that differ in taste, texture, and nutritional value. This has the potential to erode consumer confidence, especially if the differences are not clearly communicated to buyers.

The economic implications are also significant. If consumers begin to perceive cultivated Boroli as inferior, this could lead to a price disparity between natural and artificially cultivated fish, affecting the livelihoods of fishers and market stability. Furthermore, the potential for mislabelling or confusion about the origins of the fish poses additional ethical concerns, particularly in terms of transparency and fair trade practices.

### 5.3 Conservation Ethics and the Shift from Habitat Protection

The reliance on artificial cultivation as a primary conservation tool raises broader ethical questions about the priorities and goals of conservation efforts. Traditionally, conservation has emphasised the protection and restoration of natural habitats as a means of preserving biodiversity. However, the shift towards artificial cultivation may divert attention and resources away from these critical habitat restoration

efforts, potentially undermining the long-term sustainability of Boroli populations.

This shift also challenges the ethical principles of conservation biology, which advocate for the preservation of species in their natural environments. The use of artificial methods, while potentially beneficial in the short term, may compromise the ecological integrity of Boroli's natural habitats and fail to address the root causes of its decline, such as pollution, habitat loss, and climate change.

#### **5.4 Intellectual Property and Ethical Ownership**

The issue of intellectual property (IP) and ownership in the context of artificial cultivation introduces another layer of ethical complexity. Naturally occurring species like Boroli are not considered intellectual property, as they are not human inventions. However, when a species is artificially cultivated through human intervention, questions arise about who holds the rights to the resulting organisms. This is particularly relevant in cases where significant technological innovation has been applied, such as the use of synthetic hormones or specialised breeding environments.

The potential for patenting or claiming ownership over artificially cultivated Boroli raises ethical concerns about the commodification of biodiversity. It also poses challenges for traditional fishers and local communities who rely on Boroli as a natural resource. Ensuring that the benefits of these conservation efforts are equitably shared and do not disproportionately favor commercial interests over ecological sustainability is a critical ethical consideration.

### **6. LEGAL FRAMEWORK AND RELEVANT ISSUES**

The conservation of *Barilius barila* (Boroli) in India is situated within a broader legal and regulatory context that governs environmental protection and biodiversity conservation. While no specific laws directly address the conservation of Boroli, several key pieces of legislation provide the necessary legal framework to support efforts in this area. This section critically examines the existing legal provisions, their applicability to *Barilius barila* conservation, and the gaps that need to be addressed to ensure the long-term sustainability of this species.

#### **6.1 'The Water (Prevention and Control of Pollution) Act, 1974'**

One of the most relevant pieces of legislation for the conservation of *Barilius barila* is the 'Water (Prevention and Control of Pollution) Act, 1974'. This Act established the 'Central' and 'State Pollution Control Boards', which are responsible for promoting the cleanliness of water bodies and preventing pollution. Section 24 of the Act specifically prohibits the discharge of harmful substances into water bodies, with violations punishable by imprisonment. This provision is particularly relevant to the conservation of Boroli, as pollution from urban, industrial, and agricultural sources is a major threat to the rivers and streams where this species thrives.

Despite its importance, the Act has certain limitations, particularly in terms of groundwater management, which is important for maintaining the overall health of aquatic ecosystems. Additionally, enforcement of the Act has been inconsistent, with many polluted water bodies, such as the Teesta River, continuing to suffer from inadequate regulatory oversight. Strengthening the implementation and enforcement mechanisms of this Act is essential for the effective protection of *Barilius barila* habitats.

#### **6.2 'The Wildlife (Protection) Act, 1972'**

'The Wildlife (Protection) Act of 1972' is another piece of legislation that, while primarily focused on terrestrial wildlife, also provides a framework for the protection of certain aquatic species. Under Section 49M, new regulations have been introduced for the ownership and breeding of exotic wild animals in captivity, which could apply to artificially cultivated species like *Barilius barila*. However, freshwater fish like Boroli have traditionally received less attention under this Act. This highlights a gap in legal protection.

To address this, there is a need for amendments to the Wildlife (Protection) Act that would specifically include provisions for the conservation of freshwater fish genetic resources. Such amendments could introduce stricter controls on fishing practices, habitat destruction, and the introduction of non-native species.

#### **6.3 'The River Boards Act, 1956'**

The 'River Boards Act of 1956', which aims to regulate and manage inter-state rivers and river



valleys, offers another avenue for protecting *Barilius barila* habitats. This Act empowers the central government to establish River Boards for the purpose of developing and conserving water resources. While this legislation provides a framework for managing water resources, its application has been limited, and the establishment of River Boards has been inconsistent.

For *Barilius barila* conservation, the River Boards Act could be taken into consideration to promote better coordination among states that share river systems critical to the species' survival. Enhanced inter-state collaboration and the creation of dedicated River Boards focused on the conservation of biodiversity could improve the management of Boroli habitats.

## 7. CONCLUSION

The conservation of *Barilius barila* (Boroli) in Bengal represents a intersection of ecological preservation, socio-economic development, and ethical considerations. This study has highlighted the complex challenges including habitat degradation, pollution, and the impacts of climate change. Despite being classified as "Least Concern" by the IUCN, *Barilius barila* is increasingly vulnerable due to the ongoing environmental pressures in North Bengal.

The innovative cultivation initiatives undertaken by the West Bengal government have demonstrated that artificial breeding can play a role in sustaining Boroli populations. By recreating the natural conditions of northern rivers in controlled environments, these efforts would help mitigate some of the immediate threats to the species. However, these initiatives also raise important ethical and ecological questions, particularly concerning the long-term sustainability of relying on artificial environments and the potential genetic and phenotypic changes in the species.

The socio-economic implications of *Barilius barila* conservation are equally significant. The reliance on Boroli as a source of income for local fishing communities suggests the need for conservation strategies that balance ecological goals with economic realities. The differences in taste and quality between naturally sourced and artificially cultivated Boroli also highlight the importance of maintaining consumer trust and market stability.

This research has suggested the necessity of a comprehensive legal and policy framework to support *Barilius barila* conservation. While existing laws like the 'Water (Prevention and Control of Pollution) Act' and the 'Wildlife (Protection) Act' provide a foundation, there is a clear need for more targeted legislation that addresses the specific challenges facing freshwater fish species. Strengthening enforcement mechanisms and promoting inter-state collaboration are essential steps toward ensuring the long-term viability of *Barilius barila* populations.

Moving forward, it is imperative that conservation efforts for *Barilius barila* continue to evolve. This requires integrating both traditional habitat restoration methods and innovative cultivation techniques. Collaboration between government agencies, researchers, local communities, and international conservation organisations will be key to overcoming the challenges identified in this study. With these efforts the conservation of *Barilius barila* can serve as a model for similar efforts across the region and beyond. It should be kept in mind that the conservation of *Barilius barila* is not just about preserving a species; it is about sustaining the ecological integrity of Bengal's river systems and supporting the livelihoods of the people who depend on them. The lessons learned from this study can inform broader conservation strategies and contribute to the global effort to protect our planet's biodiversity.

## 8. RECOMMENDATIONS

To effectively conserve the *Barilius barila* species, a set of recommendations is proposed. Firstly, it is imperative to strengthen the legal and policy frameworks by amending the 'Wildlife (Protection) Act, 1972', to include specific provisions for freshwater fish species like *Barilius barila*. Additionally, enhancing the enforcement of the 'Water (Prevention and Control of Pollution) Act, 1974', is necessary for protecting rivers and streams in North Bengal, with stricter penalties for violations and regular monitoring of water quality. Promoting inter-state collaboration under the 'River Boards Act, 1956', is also recommended to ensure the cooperative management of river systems essential to this species. Furthermore, implementing comprehensive groundwater management policies is important for maintaining the health of aquatic environments where *Barilius barila* thrives.

In terms of conservation practices, it is recommended to integrate habitat restoration efforts with artificial cultivation to create a strategy that enhances the *Barilius barila* populations. Expanding community-based conservation initiatives is also essential, so initiative should be taken to provide training and financial incentives to local fishing communities for sustainable practices. Monitoring and mitigating the ecological impact of artificial cultivation, particularly regarding synthetic hormone use, should be prioritised to protect the genetic integrity and health of the species. To address the socio-economic and ethical dimensions, clear labelling and marketing standards should be developed to distinguish between naturally sourced and artificially cultivated *Barilius barila* as it would ensure consumer trust and market transparency. Lastly, advancing research and global conservation efforts is recommended by prioritising research on the ecological role, breeding patterns, and environmental impacts on *Barilius barila* populations.

Implementation of these recommendations will not only address the immediate threats to *Barilius barila* but also contribute to broader environmental sustainability and socio-economic development.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

#### COMPETING INTERESTS

Author has declared that no competing interests exist.

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