Uttar Pradesh Journal of Zoology

Volume 45, Issue 16, Page 154-163, 2024; Article no.UPJOZ.3640
ISSN: 0256-971X (P)

Wetlands of Assam: Livelihood Potential and Management Issues

Swarupa Bhattacharjee [a*], Sanchita Boruah [b] and S. P. Biswas [c]

[a] Department of Zoology, Bahona College, Jorhat, Assam, India.
[b] Department of Zoology, DHSK College, Dibrugarh, Assam, India.
[c] Department of Life Sciences, Dibrugarh University, Assam, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i164296

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/3640

Minireview Article

Received: 19/05/2024
Accepted: 23/07/2024
Published: 27/07/2024

ABSTRACT

The present study explores the wetlands of Assam, emphasizing their substantial livelihood potential and the various management issues they face. Assam's wetlands, characterized by a diverse array of aquatic ecosystems, provide crucial services which includes the purification of water, flood regulation, and also provides for the habitat for a variety of flora and fauna. These wetlands also underpin the livelihoods of local communities, offering resources for fishing, agriculture, and tourism. Through a combination of field surveys, remote sensing data, socio-economic assessments and also various available literature this research identifies key livelihood activities supported by these wetlands and quantifies their economic benefits. The study reveals that wetlands contribute significantly to the local economy, particularly through fisheries and agriculture, which sustain thousands of households. Additionally, emerging sectors such as eco-tourism have shown potential for future economic opportunities. However, the sustainability of these

**Corresponding author: Email: bhattacharjeeswarupa@gmail.com;*

Cite as: *Bhattacharjee, Swarupa, Sanchita Boruah, and S. P. Biswas. 2024. "Wetlands of Assam: Livelihood Potential and Management Issues". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (16):154-63. https://doi.org/10.56557/upjoz/2024/v45i164296.*

benefits is threatened by several management challenges. Encroachment, pollution, and unsustainable extraction of resources are prevalent issues exacerbated by inadequate policy frameworks and enforcement mechanisms. The study also highlights the impact of climate change, which is altering hydrological patterns and affecting wetland health. The research underscores the need for integrated wetland management strategies that balance ecological preservation with socio-economic development. Recommendations include the implementation of community-based management approaches, strengthening policy and regulatory frameworks, and promoting awareness and education programs. This study provides a comprehensive understanding of the wetlands of Assam, advocating for sustainable practices to ensure their continued contribution to local livelihoods and ecological balance.

Keywords: Assam; wetlands; livelihood potential; management issues; ecosystem services; sustainable development; community-based management.

1. INTRODUCTION

Wetlands are among the most productive ecosystems on Earth, providing a plethora of ecological services and supporting a diverse range of flora and fauna. In the context of Assam, a northeastern state of India, wetlands hold significant ecological, economic, and cultural importance. Assam, characterized by its high rainfall and extensive river systems, is home to a variety of wetlands, including floodplain lakes (locally known as *beels*), marshes, swamps, and riverine ecosystems. These wetlands are the major players in maintaining regional biodiversity, regulating hydrological cycles, and are backbone to local livelihoods through activities such as fishing, agriculture, and tourism. The wetlands of Assam serve as vital habitats for numerous species of fish, birds, and other wildlife. They act as breeding grounds for fish and support a rich diversity of aquatic plants. Notably, the region's wetlands are crucial for migratory birds, making them significant from a conservation perspective. Wetlands also contribute to groundwater recharge, flood mitigation, and water purification, thus maintaining the overall health of the ecosystem. For the local communities in Assam, wetlands are a cornerstone of economic sustenance. Fishing is a primary occupation, with many communities relying on the rich fish diversity for their daily livelihood. In addition to fishing, wetlands support agriculture, particularly the cultivation of paddy, which is adapted to wetland conditions. The harvesting of aquatic plants and the rearing of livestock in and around wetlands further contribute to the livelihood of the local population. Ecotourism, centered around the unique biodiversity of these wetlands, has also emerged as a growing sector, offering potential economic benefits while promoting conservation awareness. Despite their importance, Assam's wetlands face several management challenges. Anthropogenic pressures such as encroachment, unregulated fishing, and agricultural expansion are leading to habitat degradation. Pollution from agricultural runoff, industrial discharges, and urban waste is deteriorating water quality. Additionally, climate change poses a significant threat, altering hydrological patterns and impacting the delicate balance of these ecosystems. The lack of comprehensive wetland management policies and insufficient implementation of existing regulations further exacerbate these issues. Effective management of Assam's wetlands necessitates a holistic approach that integrates sustainable livelihood practices with conservation efforts.

The Brahmaputra and the Barak basins have over 5,000 large-sized wetlands and about 6,000 medium and small wetlands (locally called *beel* / *haor*) cover an area of 7,64,372 ha, which accounts for about 10% of the total geographical area of Assam [1]. The requirements of riverine species in the name of food and shelter and also the breeding ground is mainly fulfilled by the the adjacent floodplain lakes (*beels*), and are considered "fish granaries" of Assam [2-5]. Not only this but the *beels* further, hold excess flood water. They are the the natural sink for waste materials and most importantly for flood mitigation.

Wetlands of Assam are broadly categorized as (a) oxbow lakes (open *beel*); (b) tectonic lakes (close *beel*); (c) Seasonal water-logged areas; (d) Man-made tanks (such as historical tanks of upper Assam). *Beels* are shallow and characterized by high organic load and weed infestation, primarily by water hyacinth. The depth and volume of water in the beels are highly variable. In the peak summer, some *beels* are even dried up.

In many studies conducted in the wetlands of Assam various threats they are facing have been mentioned time and again. Various writers have also registered their concern regarding the degrading conditions of the wetlands of Assam. This study provides a collective and inclusive idea about the wetlands of Assam, their importance, threats over them and the possible solutions which will also form the base for the future studies.

2. SPECIES COMPOSITION AND DIVERSITY

Species diversity a very vital element of an ecosystem, speaks a lot about the overall ecosystem health. In Assam, wetlands are blessed with various residential and migratory forms of ichthyofauna [6]. Fish production is highly variable. The minor carp, small catfishes and barbs together on an average contribute about 60% of the landings. During the dry months the air-breathing group shares about 30% of the catch. Giant catfishes and IMCs contribute about 10% of the catch between November and April. Not only the perennial wetlands, the roadside canals, paddy fields and also the ditches etc which may be considered the seasonal water bodies also act as natural habitats for many wild ornamental fishes which breed in the water bodies [7]. But surprisingly, mostly all of these waterbodies are either ignored or underutilized. The availability of seasonal water bodies many in numbers in Upper Assam provides a variety of scopes for further aquaculture development [8].

Table 1. Common fish species found in the Beels of Assam

SL. No.	Scientific Name	Family	Vernacular Name	IUCN status
1	*Notopterus notopterus* (Pallas)	Notopteridae	Kandhuli	LC
2	*Chitala chitala* (Hamilton)		Chital	NT
3	*Amblypharyngodon mola* (Hamilton)	Cyprinidae	Moah	LC
4	*Cirrhinus reba* (Hamilton)		Lashim	LC
5	*Danio rerio* (Hamilton)		--	LC
6	*Devario devario* (Hamilton)		Laupata	LC
7	*Esomus danrica* (Hamilton)		Doricana	LC
8	*Labeo bata* (Hamilton)		Bhagan	LC
9	*L. gonius* (Hamilton)		Kuri	LC
10	*L. rohita* (Hamilton)		Rohu	LC
11	*L. catla* (Hamilton)		Bahu	LC
12	*Rasbora daniconius* (Hamilton)		Darikana	LC
13	*Puntius sarana sarana* (Hamilton)		Puthi	LC
14	*Puntius sophore* (Hamilton)		Puthi	LC
15	*Pethia ticto* (Hamilton)		Puthi	LC
16	*P. jelius* (Hamilton)		Puthi	LC
17	*Botia dario* (Hamilton)	Cobitidae	Gethu	LC
18	*Lepidocephalichthys guntea* (Hamilton)		Botia	LC
19	*Mystus cavasius* (Hamilton)	Bagridae	Singora	LC
20	*M. tengara* (Hamilton)		Singora	LC
21	*Ompok pabda* (Hamilton)	Siluridae	Pabo	NT
22	*Wallago attu* (Bloch-Schneider)		Borali	VU
23	*Ailia coila* (Hamilton)	Schilbeidae	Bahpati	NT
24	*Clarias magur* (Hamilton)	Clariidae	Magur	EN
25	*Heteropneustes fossilis* (Bloch)	Heteropneustidae	Singir	LC
26	*Macrognathus pancalus* (Hamilton)	Mastacembelidae	Tura	LC
27	*Macrognathus aral (Bloch & Schneider*			
28	*Chanda nama* (Hamilton)	Chandidae	Nama	LC
29	*Badis badis* (Hamilton)	Badidae	Randhoni	LC
30	*Nandus nandus* (Hamilton)	Nandidae	Gedgedi	LC
31	*Glossogobius giuris* (Hamilton)	Gobiidae	Patimutura	LC
32	*Anabas testudineus* (Bloch)	Anabantidae	Kawoi	LC
33	*Trichogaster fasciata* (Schneider)	Belontidae	Kholiana	LC
34	*T. sota* (Hamilton)		Kholiana	LC
35	*Channa marulius* (Hamilton)	Channidae	Hal	LC
36	*C. punctata* (Bloch)		Goroi	LC
37	*C. striata* (Bloch)		Xol	LC
38	*Leiodon cutcutia* (Hamilton)	Tetraodontidae	Gangatup	LC

In the upper reaches of the Brahmaputra basin especially the riparian ecotone, there is a huge variety when it comes to the species composition as well as the diversity. When compared to the adjacent/connecting river, the floodplain lakes (FPL) in riparian zones were mostly seen richer in species composition. It is to be noted that the FPLs are the prominent storehouses of inland fisheries in the entire N.E. India. The closed types of FPL have lower fish species diversity than the open type, but the closed type registers more fish production per unit area in its name. The energy produced in the closed FPL's gets largely converted to the production of macrophytes. The shallowness, intense vegetation along with the low DO concentration of closed FPLs favour the production of air breathing and carnivorous fish's more. However, flood pulses are the strong determinants of population size and are found to be the most prominent factor for species diversity in the riparian zones. Trophic structure is typically present in the FPL from surface dwelling to typical substrate dwelling species like *Glossogobius giuris* to mud-dwellers like *Monopterus cuchia* or burrower like *Channa barca*.

Wetland fish species may be grouped as: (a) food fish; (b) larvicidal (c) ornamental; and (d) medicinal. *Amblypharyngodon, Botia, Esomus, Channa, Crossocheilus, Danio, Glossogobius, Labeo, Macrognathus, Pethia, Puntius, Rasbora, Salmophasia* and *Trichogaster* are some of the small sized fishes found in wetlands (Table 1) and seasonal water bodies of the region and are suitable candidates for culture and propagation without much effort.

A proper and reliable assessment of the population density of the different groups of biota is extremely useful for establishing the relationship among the biota, especially food webs, which is the a centre of interest for both the discipline of general ecology and. Also with time, they are being widely recognised and appreciated as critical tools very useful for application of freshwater biodiversity conservation and management. It is the hightime to effectively execute the Environment Impact Assessment as per the notification of 1994.

3. MAJOR ISSUES RELATED TO WETLAND FISHERIES

The fish resources of the wetlands are significantly impacted by the anthropogenic and physical disturbances which includes illegal fishing, excessive use of pesticides and also from runoffs from adjoining agricultural lands. Physical disturbances like regulation of rivers and reduction of shoreline structures are of higher significance in controlling community structure of fish and other fauna, notably river dolphins and turtles. Siltation of rivers and *beels*, decline in fish production eventually affected the livelihood of thousands of fishermen in the Brahmaputra basin.

Since the 1970's in the whole Brahmaputra Basin a trend of gradual decline in fisheries has been reported [9]. Many reasons have been enlisted to be the cause of a low fish yield in the Brahmaputra basin. Among natural factors two major factors namely siltation and geomorphological changes have impacted fish production in the region over the decades. The are other problems related to riverine and beel fishery in the region - a) Shrinkage and alteration of fish habitats: Construction of embankments and Developmental (river dam) projects; b) Urbanization c) Waste disposal especially the solid wastes in the wetlands; d) Various mining activities like unscientific exploitation of sand and stones/ boulders from the river bed resulted in habitat loss of many small fishes; e) Increased fishing pressure/ unscrupulous fishing using prohibited fishing gear; f) Agricultural pollution [8].

Irrational and excessive exploitation of resources, encroachment mainly ichthyofauna from these wetlands, together with the conversion of low-lying land for agriculture, have already threatened the wetland habitats extensively. Indiscriminate killing of fish by using pesticides and other illegal and prohibited fishing devices is another major setback to the already depleted fishery resources of the floodplain lakes [10].

3.1 'Flood pulse' and its Impact on Aquatic Biota

Beels have been seen to receive back-flow water from the connecting river or from the huge catchment area after monsoon rains. A long rainy season (April to October) experienced especially in Arunachal Pradesh leads to regular floods in Assam which contributes, among other things, the auto stocking of *beels*. The Auto stocking of the open *beel* is facilitated by the influx the flood water when many riverine species including the Indian Major Carps (IMC) entered the *beel* for

spawning purposes. The annual flood is necessary as it not only replenishes the *beels* by filling them with fresh water and ample of nutrients but also significantly delay the process of eutrophication by flushing out all the floating weeds which would have clogged the *beels* otherwise.

3.2 Increasing Aquatic Pollution

Siltation and various organic matters carried by the run off water from connecting rivers and catchment areas are the primary reasons of turbidity in case of open *beel*. Various types of pesticides, agricultural fertilizers and other harmful chemicals used in tea gardens and also paddy fields over years ultimately find their way into the nearby wetland [9]. The destruction of planktonic fauna and fishes and water pollution in the water bodies near the tea gardens were reported [11] and the situation has not yet improved. Unregulated use of pesticides in agriculture and tea garden has also very badly impacted the other aquatic biota. These types of chemicals which are inadvertently mixed with seasonal water bodies as run-off are also destructive to the entire food chain including humans.

3.3 Construction of Dams and Embankments Over the River

The decline in the natural stock of Indian major carp(IMC) in the Brahmaputra system is also attributed to various 'ecologically detrimental' river embankments construction. Damming of the tributaries will undoubtedly have an impact on 'environmental flow' which subsequently will have a grave impact on the wetland's fish assemblages along with other aquatic biota. Embankments should be there, but the channels of connectivity of natural wetlands should be taken care of by providing sluice gates.

3.4 Increasing Fishing Pressure

Except high flood and festivals fishing is a regular activity throughout the year. The maximum fishing, however, is done when the flood water recedes. The use of fine-meshed *kapda jal* (mosquito net) is highly destructive as fish eggs and spawn are also caught in it. Another highly destructive gill net, known as *current jal* is responsible for the mass killing of fish [12]. Explosives and pesticides are common ways of fishing in remote areas. *Jeng* fishing too is an unsustainable fishing method.

3.5 Fisherfolk and their Socio-economic Condition

Approximately 0.2 million people are directly or indirectly related to fishing activities in the Brahmaputra basin. The socio-economic status of the *beel* community is very poor. The majority are under the BPL category with annual income ranging from INR 20,000 - INR 50,000 per family. Most of the fishers also have other supporting activities as a second means of income generation beside fishing being their primary income source. This signifies that fishing alome is not capable enough to fulfil their economic needs presently.

3.6 Management Issues

The *beels* of this region are also subjected to the adverse effects arises from the pesticides and other agricultural runoff. The tea gardens of the state use a huge number of different types of pesticides, insecticides, herbicides and acaricides like paraquat, endosulfan, dicofol, etc. annually. Moreover, disposal of outdated stock, containers and packets of insecticides and fertilizers, wastewater from industries are serving as major sources of pesticide pollution in such aquatic systems. This is responsible for mass mortality of fishes as well as other aquatic biota in the *beels*.

The primary objective of fisheries management in the *beels* of Assam includes the stabilization the ecological system as part of the integrated approach to preserve the wetland as a major water resource along with boosting the fishery yield and income of the locals by sustaining a viable fishery and other aquatic species. A second objective is to promote ecotourism and thereby generating income of the locals. However, during the conflict of interest of the two goals, the first goal will be prioritised; water quality cannot be compromised for the needs of fishery. Fishery management in *beel* consists of multiple components, including: (1) regulating fishing practices by implementing existing laws and regulations, and (2) exploring the possibility of culture-based fisheries in the marginal areas of the wetland [13].

3.7 Policy Issues

The Upper Brahmaputra basin encompasses part of the eastern Himalayan region covering

Assam, Arunachal Pradesh, and Nagaland – the trijunction of India, China and Myanmar. The wetlands present in this entire region are of special importance and are recognised globally for their biological wealth. Therefore, they are very significance ecological, economic along with the social benefits of the region [14]. However, presently wetlands are in a very pathetic state because of increasing pressure from various anthropogenic activities: - habitat shrinkage, alteration of land use and flow regimes, increasing aquatic pollution, exotic species invasions, and over exploitation of fish stocks [15]. The wetland management research in India primarily focuses on limnological elements and ecological/environmental economics. But the physical and socio-economic processes that result in limnological changes is a part which is relatively untouched side of research. Wetland management and related institutional features have recently gained the attention of researchers. The main issues are institution related, infrastructure and production related, supply and delivery related and also societal which are outlined as follows: -

3.8 Establishment of Wetland Regulatory Board

Wetlands have been hugely exploited in the name of urban development and economic growth, either as a dumping site of wastes from entire locality or their conversion into residential areas to pacify the growing need of land. Immediate establishment of the Wetland Regulatory Board in line with the State Biodiversity Board is the need of the hour. Also, community and *jeng/ katal* fishing in *beels* are to be restricted.

3.9 Judicial Utilisation of Wetlands Biotic Resources

It is roughly estimated that almost 60% of the ichthyofauna found in this region are residing in the wetlands of the basin. People in the vicinity of wetlands also depend either directly or indirectly on available wetland resources. Unscrupulous exploitation of resources should be avoided to derive the long-term benefits.'

3.10 Contingency Plan for Mitigation of Extreme Weather Impact

A trend of increasing frequency of extreme weather events over the years like high-intensity rainfall, substantially high rate of siltation and often rising temperature resulting in a drought-like situation has already had a significant impact on the wetland biota. In one of the highly precipitated zone like N.E. India, the creation of ponds/ artificial lakes in specified areas will not only be of help to mitigate urban flooding but also an area with the potential for further development of recreation and aquaculture [16]. A restoration plan for mitigating the impact of climate change has been advocated for biodiversity conservation and carbon storage.

3.11 Religiously Following the Environmental & Fisheries Acts

Strictly following the present environmental & Fisheries Acts will be of great use to mitigate the problems such as unregulated fishing and over-fishing, use of destructive and prohibited methods of fishing, habitat destruction, etc. that are putting a huge pressure on the aqua resources to meet the ever-increasing market demand [10]. EIA for any developmental project should be made mandatory.

3.12 Promotion of Culture-based Fishery in the Periphery of *Beels*

Ecological condition of wetlands provides great potentiality for the growth and development of small edible and ornamental fish species. Farming of small fishes in their natural habitats can be useful in generating revenues with minimal inputs for; thus opening the door for the poorer sections to venture into aqua-farming in the periphery regions of the *beels*. The availability of huge seasonal water bodies and self-help group augurs well for the development of wetland aquaculture [17-19].

3.13 Perspectives

Wetlands in Assam are central to the local fisheries industry, supporting both capture fisheries and aquaculture. They provide a source of income and nutrition for many rural communities. Traditional fishing practices, combined with modern aquaculture techniques, can enhance productivity and sustainability. The diversity of fish species, including economically valuable ones like Rohu, Catla, and Hilsa, highlights the potential for developing a robust fishery sector. The wetlands' nutrient-rich soils support agriculture, particularly the cultivation of paddy and other crops that require waterlogged

conditions. The practice of integrated farming, where fish culture is combined with paddy cultivation (pisciculture in rice fields), is a common livelihood strategy that maximizes resource use and income. Eco-tourism centered around wetlands has significant potential in Assam. The scenic beauty, bird watching opportunities, and unique cultural experiences associated with traditional wetland-based lifestyles attract tourists. Properly managed, eco-tourism can provide sustainable economic benefits while promoting conservation. Wetlands support the growth of various plants used in traditional handicrafts and Handicrafts and Non-Timber Forest Products The harvesting and processing of reeds, grasses, and other plant materials into mats, baskets, and other crafts provide supplementary income for local communities. Additionally, medicinal plants found in wetlands are integral to traditional health practices and have commercial potential [20-26].

An integrated approach to wetland management involves the participation of multiple stakeholders, including government agencies, local communities, and non-governmental organizations. This approach ensures that management plans are holistic and address the ecological, economic, and social dimensions of wetland conservation. Strengthening and enforcing policies and legislation related to wetland conservation is crucial. This includes the implementation of the Wetlands (Conservation and Management) Rules, 2017, and the Ramsar Convention guidelines. Effective policy frameworks can regulate land use, prevent pollution, and promote sustainable practices. Empowering local communities through education and capacity-building initiatives fosters stewardship and sustainable management of wetlands. Community-based management practices, such as participatory mapping and monitoring, can enhance conservation efforts and ensure that local needs and knowledge are incorporated. Wetland restoration projects aim to rehabilitate degraded wetlands through activities such as reforestation, removal of invasive species, and restoration of natural hydrology. These projects not only restore ecological functions but also enhance the livelihoods of local communities by improving ecosystem services. The wetlands of Assam hold immense livelihood potential while providing critical ecological functions. However, their sustainability is threatened by various management issues. A balanced approach that integrates conservation with livelihood development, supported by strong policy frameworks and community involvement, is essential for the sustainable management of Assam's wetlands. By addressing these challenges, Assam can harness the full potential of its wetlands, ensuring their preservation for future generations while enhancing the well-being of its people [27-32].

It is the high time we should realise the importance of wetlands and their contribution and ecological context in Assam and go for constructive ways to mitigate the problem. Involvement of institutions in the proper management of wetlands can be a crucial and good step as seen in the case of Deepor beel [26].

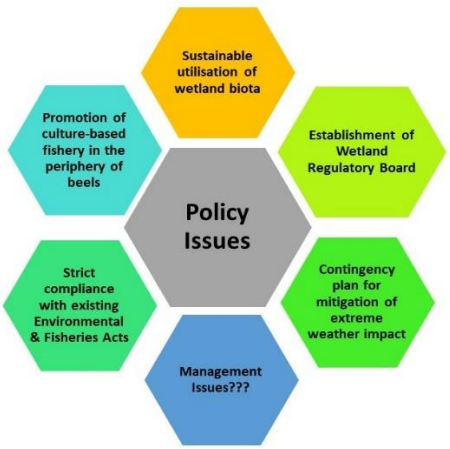

Fig. 1. Diagrammatic representation of various policy issues that can be used to improve the present system of wetland management in Assam

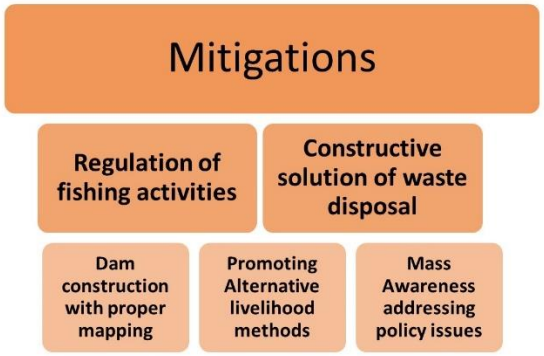

Fig. 2. Diagrammatic representation of possible solutions of managing and conserving the wetlands of assam

4. CONCLUSION

From a national perspective, Assam contributed about 2.78% of the country's total inland fish production and the per capita fish consumption in the state at present is 7.58kg/year. In beels, the current production is <200kg/ha/yr against the potential of 1500kg/ha/yr. Therefore, the present level of productivity in all categories of seasonal and perennial wetlands is much below the potential of the resources [33-35]. One of the ways widely suggested by the experts is to explore the possibilities of rearing commercially important carp in suitable low-cost cages in *beels* and to popularize culture-based fisheries among the fishermen [35]. However, the entire *beel* should not be converted into an aquaculture firm; instead, a maximum of 10-15% of the periphery of the *beel* area may be utilized for culture-based fishery leaving the rest of the *beel* area for the growth and propagation of wild fish species.

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 manuscripts.

COMPETING INTERESTS

The authors declare that they have no potential competing interests.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.mbimph.com/review-history/3640