SUSTAINING SHIVANASAMUDRAM: A SOCIO-ECOLOGICAL BLUEPRINT FOR FISH SANCTUARY MANAGEMENT

Ten-year strategic roadmap for the collaborative management of the Shivanasamudram Fish Sanctuary, Karnataka

Version 1.

Supported by Aroon Raman

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From the roaring falls of Shivanasamudram,
Bengaluru draws its water daily. Yet, barely forty kilometers downstream, the city discharges its waste through the Arkavathy River, back into the Cauvery. To safeguard Shivanasamudram, then, is not just duty—it is the city's debt to the waters that sustain it.

Prepared by

WASI
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Designed by

AANAY

SUMMARY

The Shivanasamudram Fish Sanctuary Management Plan, developed under the Wildlife Association of South India (WASI), provides a detailed framework for the long-term conservation and sustainable management of the Shivanasamudram Fish Sanctuary, located in the state of Karnataka. This initiative aims to safeguard the sanctuary's rich biodiversity, which includes a variety of endemic and threatened species, while simultaneously promoting community participation in conservation efforts. The plan includes a compilation of work carried out over the past 18 years and emphasizes a holistic approach that integrates both scientific conservation strategies and social science considerations, recognizing the importance of local communities in the successful implementation of management measures.

Key components of the plan include the identification and protection of critical freshwater ecological zones, the establishment of sustainable fisheries management practices, and the strengthening of habitat corridors to facilitate species migration. It also addresses the socio-economic drivers of habitat degradation and the potential for eco-tourism and sustainable livelihoods for local communities. Through collaborations with government agencies, local stakeholders, and environmental organizations, the plan promotes active community involvement in monitoring, enforcement, and education, ensuring the sustainability of conservation efforts.

Furthermore, the management plan aligns with UNDP's Sustainable Development Goals (SDGs) goals and aims to enhance the resilience of the Shivanasamudram Fish Sanctuary in the face of climate change and other emerging environmental challenges. By focusing on both ecological and socio-economic outcomes, the plan aspires to create a model for community-driven conservation that can be replicated in other regions facing similar environmental and socio-economic pressures.

Cover page artwork by Priyanki Shah:
A reimagining of a lesser-known stone carving from the Badami Caves, this artwork features a pair of intertwined Makaras—mythological creatures often found in Indian temple architecture. These hybrid beings combine elements of aquatic life, human form, and occasionally elephantine features, symbolizing the union of land and water. Though their exact significance remains uncertain, some interpretations suggest a possible allusion to the tale of King Manu and Matsya, the first avatar of Lord Vishnu.

FOREWORD

The Shivanasamudram Fish Sanctuary management plan marks a significant milestone toward conserving one of Karnataka's ecologically significant aquatic ecosystems. Nestled within the tranquil expanse of the Cauvery River, the sanctuary is not only a haven for diverse freshwater species but also a vital lifeline for the communities that depend on it for their livelihoods.

This comprehensive document has been meticulously prepared by the Conservation Sub-committee at Wildlife Association of South India (WASI), in collaboration with local stakeholders and scientific experts. It represents a shared commitment to harmonizing conservation goals with the socio-economic needs of the communities residing in and around the sanctuary.

The plan outlines strategies for habitat restoration, sustainable fishing practices, and community-driven initiatives aimed at safeguarding the sanctuary's rich biodiversity. It also underscores the importance of fostering environmental stewardship among local populations while advocating for interdepartmental coordination and evidence-based policymaking to ensure the long-term sustainability of this critical ecosystem.
We are deeply grateful to the Department of Fisheries (Karnataka), conservation partners, and local institutions for their steadfast support and valuable contributions throughout the preparation of this plan. We believe this document will serve as a cornerstone for enhancing biodiversity conservation and fostering sustainable development in the Shivanasamudram region.

Together, let us continue working toward preserving the ecological integrity of our freshwater resources for generations to come.

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"The Department of Fisheries, Government of Karnataka, is pleased to present the *Shivanasamudram Fish Sanctuary Management Plan*—a timely and strategic initiative aimed at conserving one of the state's most ecologically and culturally significant freshwater ecosystems.

The Shivanasamudram Fish Sanctuary, is the pioneering initiative that integrates conservation with traditional knowledge and sustainable practices. Several organizations and government bodies are actively involved in conservation efforts, focusing on flagship species like the Humpback Mahseer (*Tor remadevii*), a species listed as Critically Endangered on the IUCN Red List. The Mahseer hatchery in Harangi near Kushalnagar, maintained by the Fisheries Department, is the first of its kind in South India and has been successful in breeding Mahseer and ranching have been done regularly. To have a holistic approach in conservation of fishes of river Cauvery and maintain ecological balance, *Management Plan* has been drafted.

This management plan, developed through a participatory process led by the Wildlife Association of South India (WASI), in collaboration with scientific experts, local communities, and conservation organizations, reflects a shared vision for balancing conservation priorities with socio-economic needs. The plan outlines robust strategies for habitat restoration, sustainable fishing, and community stewardship— all essential elements in building ecological resilience and adaptive management.

The Department of Fisheries recognizes the significance of such science-based and inclusive approaches, especially as we strengthen Karnataka's network of 22 fish sanctuaries. It is our sincere hope that the *Shivanasamudram Fish Sanctuary Management Plan* will serve not only as a roadmap for this site but also as a model for integrated aquatic conservation efforts across Karnataka."

(Dineshkumar Kaller)
Director of Fisheries,
Department of Fisheries,
Government of Karnataka

ACKNOWLEDGEMENTS

This management plan for the Shivanasamudram Fish Sanctuary is the result of the collective efforts of numerous individuals and institutions committed to the conservation of the Cauvery River. We are deeply grateful to the Governing Council of the Wildlife Association of South India (WASI) for their steadfast support and vision, which provided the foundation for a structured and sustainable approach to sanctuary management.

Our sincere thanks to Mr. Aroon Raman, whose generous support—both visionary and material—made this initiative possible.

We especially acknowledge Mr. Stan Renoldo for his outstanding work on the Matsyadhama Yatra Project, through which he documented the socio-ecological realities of 22 fish sanctuaries across Karnataka. His perseverance under challenging conditions has greatly informed this plan.

Heartfelt thanks to Mr. J. Suresh for his invaluable logistical, technical, and administrative support across WASI's Bengaluru and Shivanasamudram offices. His 30-year association with WASI reflects a deep institutional commitment that made smooth field operations possible.

We are also thankful to Dr. Parineeta Deshpande-Dandekar (Associate co-ordinator, South Asia Network on Dams, Rivers ad people SANDRP), Mr. Praveen Bhargav (Founder, Wildlife First), and Mrs. Priyanki Shah (Artist and public health strategist) for their thoughtful critiques and suggestions, which strengthened the plan's clarity and relevance.

The Matsyadhama Yatra Project was generously funded by Chalukya Technologies and supported by individual crowdfunders whose contributions reflect growing public commitment to freshwater conservation.

We gratefully acknowledge the WASI Watch and Ward team at Shivanasamudram—Messrs. Mohammed Hanif, Sadananda S, Mahadeva, Kumar, Jhan Josaf Alegsander, Mary, and all past members—for their enduring commitment to protecting this ecologically important site.

Special thanks to Ms. Roopa Santosh for her expertise in data digitization, which enhanced the accessibility of research outputs.

Finally, we extend our deepest gratitude to the people of Shivanasamudram Bluff. Their knowledge, engagement, and collaboration have shaped locally grounded, community-driven conservation strategies.

This plan stands as a testament to shared responsibility and the enduring link between nature and community. As Indian wisdom reminds us—"जले जीवनम्" (Life is in water)—may our collective efforts ensure the Cauvery's waters continue to nurture life for generations to come.

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LIST OF ABBREVIATIONS

1. BDA- Biological Diversity Act 2002
2. BES- Boundaries and Expansion Strategy
3. BMC- Biodiversity Management Committee
4. BWSSB- Bangalore Water Supply and Sewerage Board
5. CAMPA- Compensatory Afforestation Management and Planning Authority
6. CCTV- Closed-circuit television
7. CnR- Catch and release (in light of recreational angling)
8. CPUE- Catch per unit effort
9. CSR- Corporate Social Responsibility
10. DoF- Department of Fisheries
11. EPA- Environment Protection Act 1986
12. FCA- Forest Conservation Act 1980
13. FFSZ- Freshwater Fish Safe Zones
14. FGD- Focus group discussion
15. GIS- Geographic information system
16. Int.- Personal interviews
17. KEB- Karnataka Electric Board
18. KFD- Karnataka Forest Department
19. KPTCL- Karnataka Power Transmission Corporation Limited
20. KSPCB- Karnataka State Pollution Control Board
21. KSTDC- Karnataka State Tourism Development Corporation
22. IUCN- International Union for Conservation of Nature
23. LULC- Land Use/ Land Cover
24. MEB- Mysore Electric Board
25. MoEFCC- Ministry of Environment, Forest and Climate Change
26. MNREGA- Mahatma Gandhi National Rural Employment Guarantee Act
27. MoU- Memorandum(s) of Understanding
28. MPAs- Marine Protected Areas
29. MV- *Sir* Mokshagundam Visvesvaraya
30. NGOs- Non-governmental organizations
31. NW- Narrative walk
32. NWP- National Water Policy 1987
33. ONEs- Open Natural Ecosystems
34. PAs- Protected Areas
35. RMNH- Regional Museum of Natural History, Museum
36. SBR- Shiva Balancing Reservoir
37. SDGs- Sustainable Development Goals
38. SFS- Shivanasamudram fish sanctuary
39. TDS- Total dissolved solids
40. UNDP- United Nations Development Programme
41. UNESCO- United Nations Educational, Scientific and Cultural Organization
42. WASI- Wildlife Association of South India
43. WaW- Watch and Ward
44. WPA- Wildlife Protection Act 1972

Javangalli Betta, forms a backdrop for the inflow channel of the Shivanasamudram Fish Sanctuary

PC: J Suresh

1. OUTLINING THE PREMISE

1.1 Introduction

The Shivanasamudram Fish Sanctuary (hereafter, SFS) is a vital natural asset, renowned for its ecological, cultural, and socio-economic importance. Encompassing diverse ecosystems such as rivers, canals, wetlands, and surrounding forests, it provides a refuge for numerous species, including those that are endangered, vulnerable, and endemic to the region. The sanctuary offers essential ecosystem services such as water regulation, carbon storage, and soil protection while supporting sustainable livelihoods, recreation, and scientific research.

On May 4, 2004, the Department of Fisheries (DoF), Karnataka, and WASI formalized an agreement to collaborate on conserving mahseer fish (*Tor*) within the SFS. This initiative represented a significant milestone in the protection of one of Karnataka's emblematic freshwater species and its critical habitats. Building upon this foundation, a subsequent agreement (No. IN-KA02333758069193J) was signed on August 4, 2011, to further strengthen conservation efforts. This agreement specifically focused on mitigating illegal fishing activities, sustaining fish populations, and safeguarding the ecological integrity of the sanctuary.

SFS plays a crucial role in setting an example for protecting aquatic life and ecosystem health in the Cauvery River. It serves as a designated area for safeguarding fish species and their habitats, hosting a wide range of freshwater species threatened by overfishing, habitat destruction, and pollution. Beyond species conservation, the sanctuary contributes to broader ecosystem functions, including nutrient cycling, water purification, and habitat connectivity.

A comprehensive management plan for SFS is urgently needed to inform legislation governing fish sanctuaries and increasing human-driven pressures such as illegal fishing, habitat degradation, and unsustainable resource use—exacerbated by climate change. These challenges threaten the sanctuary's biodiversity and ecological balance, underscoring the need for a proactive and integrated approach to ensure its long-term protection.

This management plan— designed for implementation over the next decade (2025 to 2035)[1]— aims to restore and sustain healthy fish populations and their habitats while promoting sustainable human interactions and supporting local communities and wildlife. It adopts an inclusive ecological approach by considering the broader biodiversity of the region, including larger vertebrates and plant assemblages, to provide a holistic assessment of the ecosystem's current status and future prospects. The plan delineates strategies for regulating and monitoring fishing activities, establishing riparian niches, enhancing habitat protection, assessing water quality, and fostering community participation. Through collaboration with local fisherfolk and other stakeholders, the plan seeks to balance conservation objectives with sustainable livelihoods, ensuring that the sanctuary benefits both the natural environment and the communities that depend on it.

Grounded in adaptive management principles[2] and the UNDP's Sustainable Development Goals (SDG's)[3], the plan is dynamic, allowing for adjustments based on new scientific data and evolving socio-ecological contexts. These actions aim to ensure SFS remains a thriving, resilient ecosystem that supports both freshwater biodiversity and local communities.

[1]A 10-year implementation phase allows sufficient time for habitat restoration, fish population recovery, community engagement, policy integration, climate adaptation, and financial sustainability through phased execution

[2]Adaptive management is a flexible, science-based approach that involves implementing, monitoring, and adjusting conservation strategies based on changing ecological and socio-economic conditions to improve long-term outcomes.

[3]The Sustainable Development Goals (SDGs) are a set of 17 global objectives established by the United Nations to tackle key social, economic, and environmental issues by 2030. They aim to eradicate poverty, promote climate action, ensure quality education, provide access to clean water, and advance sustainable resource management.

1.2 Silent crisis: A critical ecosystem, overlooked and imperilled

Freshwater ecosystems, which include rivers, lakes, wetlands, and streams, are among the most vital ecosystems on the planet. These ecosystems support a remarkable diversity of endemic species provide essential ecosystem services such as water filtration, flood control, and nutrient cycling, and sustain the livelihoods of billions of people.

Freshwater ecosystems, although they cover less than 1 % of the Earth's surface (Calabon et al., 2023), support a large share of the world's biodiversity. According to the International Union for Conservation of Nature (IUCN), freshwater habitats harbour approximately 10 % of all known species and 40 % of all fish species (IUCN, 2025). Many of these species are endemic, near-threatened, and vulnerable and the loss of such is often irreversible. The first ever global multi-taxon assessment identifies that one-quarter of all freshwater species found globally face extinction risk and the Western Ghats of India has one of the greatest absolute richness of threatened species (Sayer et al. 2025).

In addition to supporting a wide range of species, freshwater ecosystems play a fundamental role in maintaining the health of the broader environment. They act as natural filters, removing pollutants and excess nutrients from the water, and help regulate the global water cycle. Wetlands, for example, store large amounts of carbon, helping to mitigate the effects of climate change.

Despite their significant contributions, these ecosystems are rarely prioritized in conservation plans and are significantly underrepresented in global efforts. They are severely threatened by human activities, climate change, and habitat degradation. The underrepresentation of freshwater ecosystems in conservation planning is a critical issue that needs urgent attention, as their degradation can have profound ecological, economic, and social consequences.

1.2.1 Reasons behind underrepresentation

There are several reasons why freshwater ecosystems are often overlooked in conservation planning (Fig. 1):

Bias towards terrestrial and marine ecosystems: Global conservation plans and initiatives tend to prioritize terrestrial and marine ecosystems due to their larger scale and visibility (Abell et al., 2007). Iconic terrestrial species, such as tigers and elephants, or marine ecosystems like coral reefs, often attract more attention and funding. Freshwater species, by contrast, are less charismatic and receive less public and political support (Convention on Biological Diversity, 2010[4]).

Fragmented governance: Freshwater ecosystems often cross political boundaries, making their management complex, and they are frequently regarded as global commons (Herrfahrdt-Pähle et al., 2019). Rivers, for instance, often flow through multiple countries or states, each with its own policies, priorities, and stakeholders (Giordano & Wolf, 2003). This fragmentation often leads to misaligned conservation efforts and weakens the overall protection of freshwater resources.

[4]*The Convention on Biological Diversity (CBD) set the Aichi Biodiversity Targets in 2010 as part of the Strategic Plan for Biodiversity 2011–2020, outlining global goals for conservation, sustainable use, and equitable benefit-sharing of biodiversity.*

Overexploitation and mismanagement: Anthropogenic activities such as dam construction, water diversion for agriculture, industrial pollution, and urban development have severely degraded freshwater ecosystems (Dudgeon et al., 2006; Carpenter et al., 2011). These activities are often prioritized for their immediate socio-economic benefits, ignoring long-term ecological consequences. This results in a lack of awareness about the urgent need to protect freshwater ecosystems. Impact assessment studies for dams underestimate the role and function of freshwater ecosystems, do not consider the impacts on fisherfolk communities. Environmental Management Plans (EMPs) of infrastructure project focus on remedying impact on commercially important fish species. Hatcheries and ranching are the solutions suggested. Absence of post facto assessments of infrastructure projects like dams and hydropower projects inflates their benefits without understanding their costs and impacts.

Lack of research and awareness: Another significant challenge is the limited data on freshwater species and ecosystems compared to terrestrial and marine environments (Revenga et al., 2005). Many freshwater species remain understudied, resulting in gaps in awareness and an unclear understanding of their conservation status. Without comprehensive data, it becomes difficult to advocate for the protection of these ecosystems (Darwall et al., 2018). This research gap exists because freshwater systems are less visible and harder to study than terrestrial or visually striking marine ecosystems like coral reefs, where issues like bleaching are more easily observed. Along with freshwater ecosystems, communities which depend on these ecosystems for their direct livelihoods are also understudied. For example, India does not have a realistic estimate of fisherfolk dependant on riverine capture fisheries or wetlands., These communities are often economically and socially disadvantaged and poorly represented. Many a times the communities hold important ecological knowledge and understanding about their ecosystems and can function as valuable partners in any conservation effort but are sidelined due to lack of appreciation and awareness.

1.2.2 Consequences of underrepresentation

The underrepresentation of freshwater ecosystems in conservation plans has far-reaching consequences (Fig. 1):

Loss of biodiversity: Freshwater species are disappearing at an alarming rate (Sayer et al., 2025). The Living Planet Index[5] reports that freshwater species populations have declined by an average of 84 % since 1970, a rate higher than that of any other ecosystem (WWF, 2022). The extinction of freshwater species not only impacts biodiversity but also disrupts ecosystem services. Studies have also reported a rapid decline in fish diversity in the Cauvery River, driven by factors such as habitat degradation, overfishing, and river fragmentation (Saravanan et al., 2003; Pownkumar et al., 2022).

Disruption of ecosystem services: Freshwater ecosystems provide essential services, including clean water, flood control, and habitat for fisheries. Their degradation can lead to the collapse of these services, resulting in water scarcity, environmental disasters and reduced food security for communities that depend on fisheries (Dodds et al., 2013). The destruction of wetlands, for example, removes natural buffers that protect against storms and floods, making human settlements more vulnerable to natural disasters (Government of Australia, 2016).

Human livelihoods: Nearly 200 million of the global population rely on freshwater ecosystems for drinking water, food, and economic activities such as fishing and agriculture (WWF, 2022). The Government of India estimates that approximately 23 million people across the country depend on inland and marine fisheries, though this figure is possibly underestimated (Kelkar & Arthur, 2022). More than half of these depend on freshwater fisheries. The loss or degradation of these ecosystems have been linked to poverty, displacement, and intra- and inter-community conflicts over resources (Green et al., 2015). Indigenous and local communities that have relied on these ecosystems for generations are particularly at risk.

[5] *The Living Planet Index tracks global wildlife population trends to assess the health of ecosystems, highlighting the impact of human activity on biodiversity.*

Water quality and human health: The decline of freshwater ecosystems also affects water quality (Kumaraswamy et al., 2019). Pollutants and excess nutrients from agriculture and industry accumulate in freshwater systems, leading to issues like algal blooms, dead zones, and contamination of drinking water supplies. Poor water quality can have serious health impacts on humans, including outbreaks of waterborne diseases.

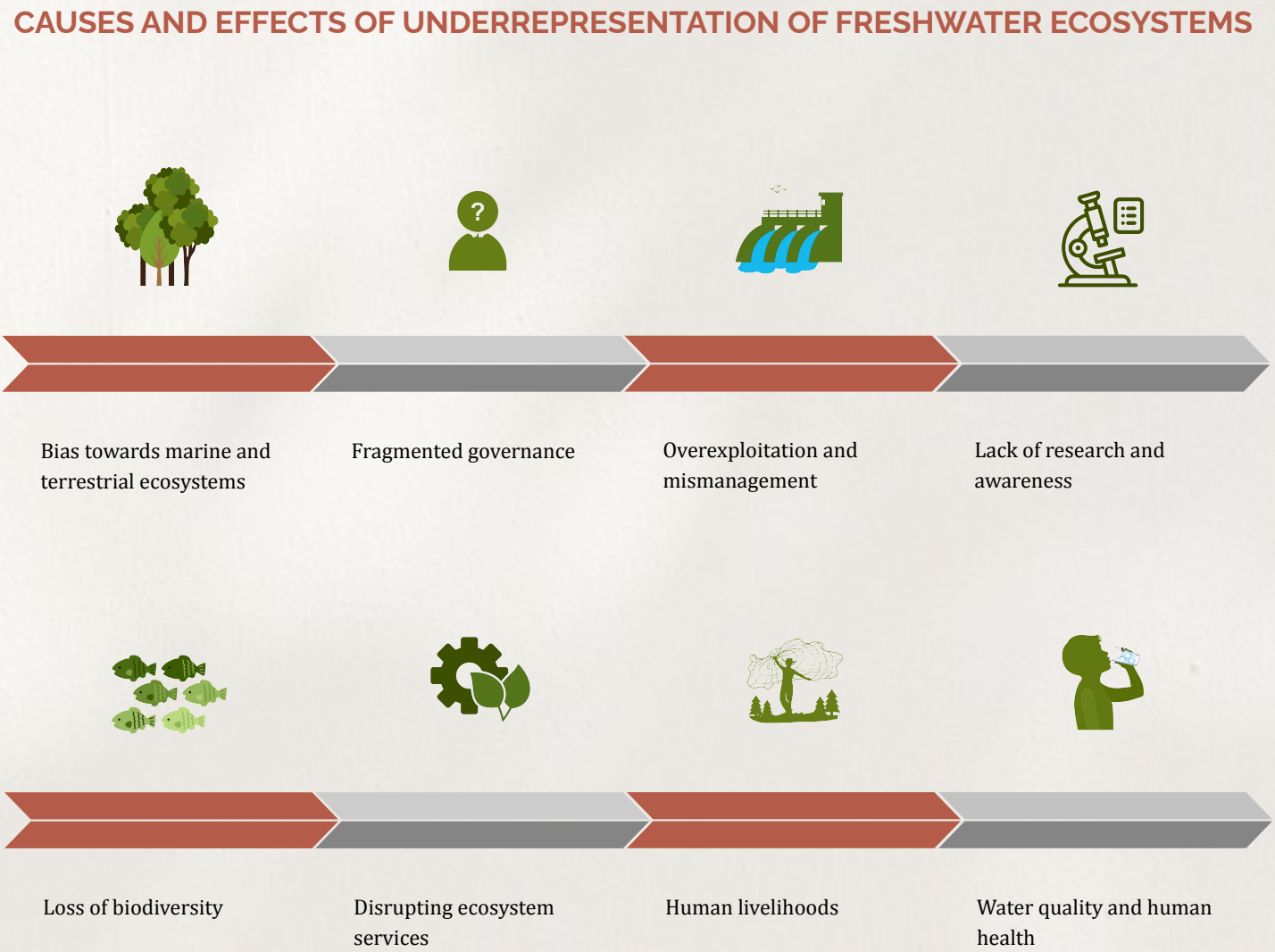


Figure 1: Underrepresentation of freshwater ecosystems in India

Nakurgaya Fish Sanctuary is located on the Kumaradhara River, Dakshina Kannada District. Local legend tells of an ancient temple, unseen by anyone alive today, that lies submerged in the river

PC: Stan Renoldo

2. THE NOTION OF FISH SANCTUARIES

Fish possess substantial commercial and cultural significance for human societies, facilitating the communication of the urgency surrounding freshwater habitat conservation. The establishment and management of the existing fish sanctuaries serves as a critical strategy in addressing the ongoing crisis in freshwater ecosystems, as these designated areas are designed to protect aquatic biodiversity,ensure the long-term sustainability of these essential environments and serve as excellent environment education sites.

The Humpback Mahseer (Tor remadevii) is Critically Endangered. Fish Sanctuaries offer critical refuge for native and endangered fish species.

2.1 Benefits of fish sanctuaries

Fish sanctuaries across India are designated areas in freshwater ecosystems where fishing and other disruptive activities are regulated or banned. These sanctuaries are either managed by the state or are entirely community owned and managed. They serve as protected areas for fish species, allowing them to breed, grow, and thrive without the pressures of human exploitation. Key reasons why fish sanctuaries are important include:

2.1.1: *Biodiversity conservation*: Fish sanctuaries protect threatened and endemic fish species by providing a safe environment where their populations can recover. These sanctuaries often play a vital role in conserving species that are vulnerable to extinction due to habitat degradation and overfishing.

2.1.2: *Source-sink dynamics*: Overfishing has led to the depletion of many native fish stocks and is impacting communities that rely on fishing for their livelihoods. Fish sanctuaries create safe spaces where fish can repopulate and grow (source). The spill-over effect from these sanctuaries helps replenish fish stocks in adjacent fishing concessions (sink), enabling both conservation and fishing based livelihoods.

2.1.3: *Ecosystem resilience*: Numerous species interact in complex food webs within a freshwater ecosystem. When a species assemblage is disrupted, it can cause cascading effects throughout the ecosystem. Fish sanctuaries, therefore, contribute to regulating this balance, ensuring the health and resilience of the entire aquatic system.

2.1.4: *Climate change*: Fish sanctuaries can act as climate refugia, offering stable freshwater environments where fish species can adapt to changing conditions. This can be particularly important for keystone and specialist species, that are often highly sensitive to environmental changes.

2.1.5: *Awareness and stewardship:* Freshwater bodies are picturesque and often make for popular recreational spots. Fish sanctuaries can offer a unique educational experience, raising awareness about their threatened status, thereby, fostering a sense of stewardship, pride, and ownership among local communities.

2.1.6 *Riverine Conservation:* India does not have a dedicated law to protect rivers like the Wild and Scenic Rivers Act (1968) in the US or the Heritage Rivers Act (1992) in Victoria, Australia. Any incidental protection that rivers get is when they flow through terrestrial Protected Areas. Even here, rivers are dammed, diverted and dried as in the case of National Chambal Ghariyal Wildlife Sanctuary or Ken Ghariyal Sanctuary. In this scenario, Fish Sanctuaries offer small but extremely valuable conservation spaces where, along with the fish, riparian areas and the river channel too is protected.

2.2 Benefits beyond 'just' fish conservation

While the primary objective of fish sanctuaries is to conserve fish species and their habitats, their benefits extend well beyond safeguarding aquatic biodiversity. Their most significant contribution, arguably, lies in shifting the narrative around freshwater resource management. Traditionally, freshwater management has been driven by utilitarian considerations alone. Fish sanctuaries, however, offer a foundation for reframing this approach, incorporating a social-ecological perspective that acknowledges the intricate relationships between human communities and freshwater ecosystems.

2.3 Fish sanctuaries in India: Where do we stand at present?

At the global scale, the Convention of Biological Diversity's Aichi Strategic Plan for Biodiversity 2011-2020 (refer to footnote 4) has set a precedent for conserving rivers and their biodiversity. The plan recommends that at least 17 % of terrestrial and inland waters are conserved by the year 2020. In India, the protection offered to fish, and aquatic ecosystems fall into two broad categories; more widely recognized Marine Protected Areas (MPAs) and a several types of management regimes that include inland freshwater bodies. For all purposes of this section, we are only concerned with the inland freshwater sector.

In India, the Protected Area (PA) network encompasses approximately 4.74% of the country's total land area, comprising 605 PAs, including 509 wildlife sanctuaries, 96 national parks, and 3 conservation reserves. Additionally, 85 wetlands designated as Ramsar[6] sites are not included within this network. While these protected areas are primarily established for the conservation of terrestrial wildlife, they also contribute to the protection of freshwater ecosystems. However, freshwater biodiversity remains underrepresented within the PA network (Sarkar et al., 2013).

Only a few PAs in India are specifically designated for the conservation of freshwater species, such as the National Chambal Gharial Wildlife Sanctuary (Rajasthan) for *Gavialis gangeticus* (Gharial), the Vikramshila Gangetic Dolphin Sanctuary (Bihar) for *Platanista gangetica* (South Asian river dolphin), the Katarniaghat Wildlife Sanctuary (Uttar Pradesh) and Tungabhadra Otter Conservation Reserve (Karnataka) for *Lutrogale perspicillata* (Smooth-coated otter).

[6]*Ramsar sites are wetlands recognized for their global importance under the Ramsar Convention, signed in 1971 in Ramsar, Iran. The convention aims to conserve and protect wetlands and their biodiversity. These sites include marshes, lakes, mangroves, and coral reefs, which play crucial roles in water purification, flood control, carbon storage, and supporting diverse plant and animal species.*

When it comes to areas designated for fish protection specifically, India has several examples that originate from various motivations. Among these, informally designated fish sanctuaries, particularly prevalent in the North-eastern states, play a significant role in protecting fish populations. These sanctuaries are typically situated along rivers and are community-owned and managed, often incorporating sustainable harvesting practices regulated by local communities. For instance, the Jadisil Fish Sanctuary in Meghalaya was established in response to the decline of local fish populations due to overexploitation. Managed by local communities, the sanctuary has also evolved into an eco-tourism destination, with stringent regulations in place to safeguard fish populations. Similarly, the Huma Mahseer Sanctuary in Odisha, located along the Mahanadi River, is actively maintained by local communities. This sanctuary also holds cultural significance, as reflected in a statue depicting a woman cutting a mahseer fish, symbolizing the deep connection between people and fish conservation. Community fish sanctuaries in the Western Ghats of Maharashtra like Walen Kondh and Tilase are places of worship and conservation.

Sacred Groves, are typically protected by the community and lie outside the Protected Area network. While these reserves are not exclusively associated with aquatic habitats, they are often situated along rivers, lakes, or freshwater springs, where individuals or local communities seek formal conservation recognition for their traditionally managed lands. Within these reserves, fish populations also benefit from community-led protection efforts, supported by government authorities, particularly the State Forest Departments.

For many years, scientists and conservationists have been proposing formally declared fish sanctuaries on rivers that flow outside PAs to protect native fish species (Dandekar, 2011). In their commentary, Gupta et al., (2014) propose a set of nine guidelines for consideration while declaring what they term as Freshwater Fish Safe Zones (FFSZ). Outside PAs, reservoirs are primarily managed as inland aquaculture and capture fisheries[7] through a system of commercial fishing tenders and licences. However, most riverine stretches remain unmanaged, unregulated and unlicenced. Inland fisheries are largely a 'state matter' with each state formulating its own rules. The declaration of fish sanctuaries in this context is complicated as there is no central policy for their management and state authorities would rather abstain from restricting fishing rights in fear of political backlash. In Karnataka (starting in 2006), the DoF have identified 22 community protected areas for declaration as fish sanctuaries (published in their handbook in 2020), 11 of which are supported by government orders via the Karnataka Inland Fisheries (conservation, development and regulation) Act (1996). However, rules and regulations for the declaration and management of Karnataka's fish sanctuaries are yet to be formulated.

The legislative and historical development of fish sanctuaries in India remains inadequately documented, and the following section provides a more detailed exploration of their evolution.

[7]*Aquaculture-based fisheries cultivate fish in controlled environments, whereas capture fisheries harvest wild fish from natural water bodies.*

2.4 Legislative history of fish sanctuaries in India

The legislative framework for establishing and managing fish sanctuaries in India has evolved in response to increasing concerns over the depletion of aquatic biodiversity and the need for sustainable fisheries management. The earliest legal efforts to conserve aquatic life in India date back to the British colonial era. Notably, the Indian Fisheries Act of 1897— often regarded as the foundational legislation for fisheries in India— was established to regulate riverine and inshore fisheries. This act sought to safeguard fish populations by addressing the increasing pressures of overfishing and habitat degradation. While the focus at the time was more on regulating fishing practices, these early guidelines laid the groundwork for the development of protected areas for fish and aquatic ecosystems. At the same time, there are mentions of existing fish sanctuaries in and their cultural importance in District Gazetteers like Dehu Fish Sanctuary on River Indrayani in Pune District or Audumbar Fish Sanctuary on the River Krishna. In fact, according to Gazetteer of Bombay Presidency 1885, during the last quarter of 19th century, Pune District alone had 27 pools where fish were never killed.

Following India's independence, the legislative landscape surrounding aquatic conservation began to shift significantly, reflecting the country's commitment to preserving its natural heritage. A key milestone came with the enactment of the Wildlife Protection Act (WPA) of 1972, which provided a comprehensive framework for the conservation of both terrestrial and aquatic species. The WPA 1972 granted state governments the authority to declare specific areas as protected zones for wildlife, including fish species, providing a critical tool for biodiversity management amid growing concerns over pollution, habitat degradation, and poaching. Although the WPA 1972 set a strong foundation for terrestrial sanctuaries, its protections for aquatic ecosystems were limited. It primarily focused on preventing harvest and trade of fish species from within PAs.

A more direct legislative push outside of PAs that benefits the notion of fish sanctuaries came with the introduction of the Biological Diversity Act (BDA) of 2002, which empowered the government to create legally protected areas specifically for the conservation of biodiversity and natural geology, including aquatic life. The BDA 2002 provided the legal backing for establishing 'Biodiversity Heritage Sites' which are managed by Biodiversity management committees (BMC's) or any local society. The National Water Policy (NWP) of 1987 marked a pivotal shift in India's approach to water resource management by framing water as a critical national resource under the jurisdiction of the Ministry of Water Resources, Government of India. Although it did not explicitly address fisheries management, the NWP underscored sustainable water management practices and acknowledged the value of protecting aquatic ecosystems. Alongside this policy, other legislations, such as the Environment Protection Act (EPA) of 1986 and the Forest Conservation Act (FCA) of 1980, addressed broader environmental issues, indirectly supporting fish sanctuary initiatives through pollution control and regulated land use in sensitive areas.

Furthermore, the Karnataka Inland Fisheries (Conservation, Development, and Regulation) Act (1996), later amended in 2003, provides the only instrument to legally establish fish sanctuaries outside of PAs in Karnataka. The act largely aims at streamlining the administration of the DoF and regulating commercial fisheries through tenders and licences. Section 7 of the Act is concerned with 'Declaration of Sanctuary' with the following provisions.

1. "The state government may, by notification, declare any of area of water to be a fish sanctuary, for the purpose of protecting, propagating or development of fisheries."
2. "Notwithstanding anything contained in the Act, no person shall fish or capture fish whether alive or dead or destroy or attempt to destroy fish or capture or destroy any fish in a sanctuary declared under sub-section (1)."

While sub-section (1) allows the state government to formally declare an area as a fish sanctuary, Sub-section (2) is obscure and simply prohibits fishing without considering a sustainable management regime. Of particular relevance to fish sanctuaries are sub-clauses in the Act that empower the State to:

- "prohibit or regulate... the fishing and using of fishing appliances" [Section 23(2)(a)(iv)];
- specify "the species of fish which shall not be caught or captured" [Section 23(2)(d)];
- lay down "the purposes for which a fish sanctuary may be declared under section 7" [Section 23(2)(f)];
- and "prohibit or regulate the extraction of fish in any water" [Section 23(2)(g)].

In addition, Section 23 of the Act grants the State Government the authority to make rules, by notification, for carrying out the purposes of the Act. This section serves as a vital legislative tool to operationalize sanctuary governance. These provisions provide a strong legislative foundation for the development of comprehensive rules to govern fish sanctuaries— ranging from the regulation of fishing practices and species protection to clearly articulating the purposes of sanctuary declaration and management. Recognizing the potential of this framework, the DoF, published a notification (No. AHF E-53 FSFM 2020; dated 15-03-2023) proposing "draft rules" that will support the effective implementation and sustainable management of fish sanctuaries across Karnataka. The DoF, assisted by WASI, are currently in the process of formulating rules for the management of fish sanctuaries and a road map for formalizing new sanctuaries. This initiative seeks to translate the intent of the Act into actionable conservation strategies by defining clear guidelines, permissible activities, and participatory governance mechanisms tailored to the unique ecological and social contexts of each sanctuary.

2.5 Categories of fish sanctuaries in Karnataka.

In 2024, in consultation with the DoF, WASI conducted a translational project and expedition titled Matsyadhamma Yatra (Appendix 1) to visit, map, and assess the status of 22 fish sanctuaries in the state of Karnataka. The key findings from this expedition are summarized in Table 1. Of the 22 fish sanctuaries, 16 were associated in some capacity with temple societies, while the remaining six were either located within protected areas (2) or affiliated with the DoF and/or non-governmental organizations (NGOs) (4).

The initial assessment, conducted between November and December 2024, indicated that water quality was consistently high across all sites, and the ecological integrity of most sanctuaries was well maintained. Several significant wildlife species were documented during the survey. Notable observations included Ratufa macroura (Grizzled giant squirrel), Macaca silenus (Lion-tailed macaque), Manis crassicaudata (Indian pangolin), and Elephas maximus (Asian elephant), which were recorded both within and in the vicinity of the sanctuaries. However, key management aspects, including boundary demarcation, awareness initiatives, and signage, were found to be inadequate.

Given that these sanctuaries are distributed across multiple river basins, districts, and management structures, conservation challenges vary significantly and are highly site-specific. Therefore, we recommend that management plans be developed following a classification framework that incorporates local communities and societies into future conservation and governance efforts.

The proposed classification of fish sanctuaries (Fig. 2) is based on public accessibility and the specific characteristics of each site and is adapted from Jumani et al. (2022). Fish sanctuaries (as published in the Karnataka Handbook of Fisheries Statistics, 2020) are grouped into two main categories: Open access and Restricted access.

1. *Open access:* These are further divided based on the presence of religious or cultural sites, which influence public access levels.

I) Temple-based sanctuaries are associated with temples or religious sites, such as Abhirama, Dharmasthala, and Sringeri. Their religious significance often attracts visitors, contributing to public engagement.

II) Non-temple-based sanctuaries are classified according to government designations:

Formal sanctuaries, like Harangi and Nisargadhama, are officially recognized and regulated by government authorities and NGO's.

Informal sanctuaries, such as Seethanadi, are identified and declared by individuals or local communities. These may include river stretches bordering private properties where commercial fishing is not practiced.

2. *Restricted access:* Located within state-protected areas, the Muttathi Fish Sanctuary (within the Cauvery Wildlife Sanctuary) and the Ranganathittu Bird Sanctuary have restricted access and are managed by the Karnataka Forest Department. Conservation priorities often limit public interaction in these areas, while management is further complicated by overlapping interests between the Forest and Fisheries Departments.

Table 1: Key findings from Matsyadhamma Yatra

Name of Fish Sanctuary	***Status***	***District***	***Type***	***Management***	***River***	***River basin***	***Location***	***Extent (m)***
Abhirama Fish Sanctuary	Declared	Chikkamagalur	Temple based	Adi Shankaracharya Sharada Peta	Tunga	Krishna	Hariharapura	500
Jammatagi Fish Sanctuary	Declared	Chikkamagalur	Temple based	Nellakanteshwara Temple	Tunga	Krishna	Hariharapura	No Data
Sringeri Fish Sanctuary	Declared	Chikkamagalur	Temple based	Vindyashankara Temple	Tunga	Krishna	Sringeri	1000

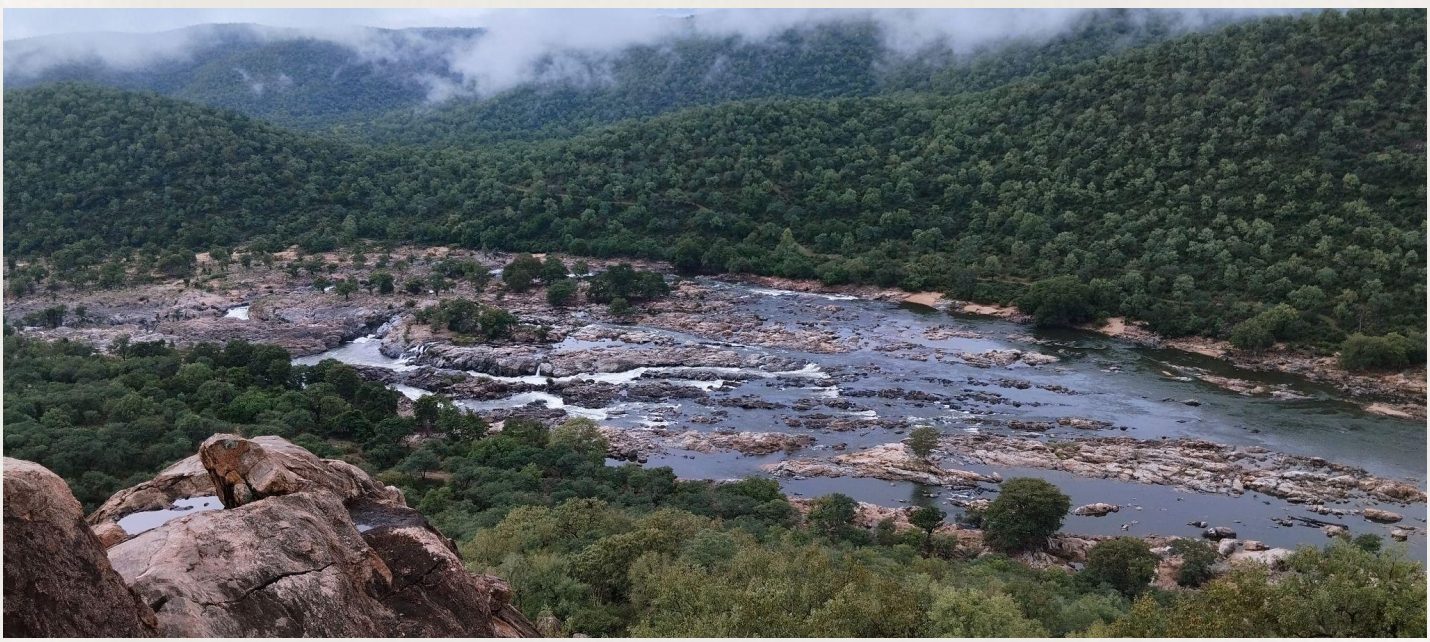
Bachanayakanagudi Fish Sanctuary	Declared	Dakshina Kannada	Temple based	Ullakula Bacchanya Temple	Kalleja	Netravathi	Yennekal	2000
Dharmasthala Fish Sanctuary	Proposed	Dakshina Kannada	Temple based	Rama Kshetra Temple	Netravathi	Netravathi	Belthangadi	1000
Kelkaru Fish Sanctuary	Proposed	Dakshina Kannada	Temple based	Majalingeshwari Temple	Palguni	Gurupura	Belthangadi	No Data
Marakatha Fish Sanctuary	Proposed	Dakshina Kannada	Temple based	Durga Parameshwari Temple	Kalleja	Netravathi	Sulya	No Data
Nakurgaya Fish Sanctuary	Proposed	Dakshina Kannada	Temple based	Gopalakrishna Temple	Kumaradhara	Netravathi	Puttur	No Data
Shishila Fish Sanctuary	Proposed	Dakshina Kannada	Temple based	Shishileshwara Temple	Kapila	Netravathi	Belthangadi	500
Thodikana Fish Sanctuary	Declared	Dakshina Kannada	Temple based	Mallikarjuna Swamy Temple	Payaswini (Tributary)	Payaswini	Sulya	500
Uppukala Fish Sanctuary	Proposed	Dakshina Kannada	Temple based	Aiyappa Swamy Temple	Uppukalla	Netravathi	Sulya	No Data
Ramanathapur Fish Sanctuary	Declared	Hassan	Temple based	Rameshwara Temple	Cauvery	Cauvery	Arakalgud	1000

Harangi Fish Sanctuary	Declared	Kodagu	Formal, non-temple based	Harangi Fish Hatchery	Harangi	Cauvery	Kudege	5000
Nisargadhama Fish Sanctuary	Proposed	Kodagu	Formal, non-temple based	Local community	Cauvery	Cauvery	Kushalnagar	No Data
Muttathi Fish Sanctuary	Proposed	Mandya	Within Protected areas	Karnataka Forest Department	Cauvery	Cauvery	Muthathi	No Data
Ranganathittu Fish Sanctuary	Proposed	Mandya	Within Protected areas	Karnataka Forest Department	Cauvery	Cauvery	S.R. Patna	5000
Shivanasamudram Fish Sanctuary	Declared	Mandya	Formal, non-temple based	Wildlife Association of South India	Cauvery	Cauvery	Bluff	1400
Chippalagudda Fish Sanctuary	Declared	Shimoga	Temple based	Siddhi Vinayaka Temple	Tunga	Krishna	Thirthahalli	500
Mattur-Hosahalli Fish Sanctuary	Declared	Shimoga	Temple based	Someshwara Temple	Tunga	Krishna	Shimoga	1500
Seethanadi Fish Sanctuary	Proposed	Udupi	Informal, non-temple based	Jungle Lodges and Resorts	Seethinadi	Seethanadi	Karkala	No Data
Thingale Fish Sanctuary	Declared	Udupi	Temple based	Mahakala Sivaraya Temple	Seethinadi	Seethanadi	Garadigundi	500
Bhagavathi Chaya Kolla Fish Sanctuary	Proposed	Yadgir	Temple based	Chaya Bhagavathi Temple	Krishna	Krishna	Surpura	No Data

Figure 2: Classification of fish sanctuaries in Karnataka, placing relevant examples within each category. The Sanctuaries mentioned below are done so based on the list published in the Karnataka Handbook of Fisheries Statistics (2020) by the DoF

Some fish sanctuaries have basic structures that allow water flow to be controlled.

The Shivanasamudram Fish Sanctuary serves as a field site for regular education and awareness programs



The Cauvery river cascades off the Deccan Plateau at Muthathi creating one of the most biodiverse riverine habitats found anywhere else in the basin.

2.6 Key considerations while establishing fish sanctuaries

Setting up fish sanctuaries is a multi-faceted process that requires careful planning, community involvement, and effective enforcement. The following factors are essential when establishing and managing fish sanctuaries:

2.6.1: *Site selection*: Choosing the right location for a fish sanctuary is critical. The area should have significant ecological value and connectivity and host a variety of species, including threatened or endemic ones. Hydrological conditions, water quality, habitat diversity and potential conflicts are important factors to consider while demarcating boundaries. In case of Temple Fish Sanctuaries, the sanctuary already exists and has received community protection over a considerable period.

2.6.2: *Community involvement*: The success of fish sanctuaries depends largely on the support and involvement of people, especially those who depend on the water bodies for their livelihoods. Engaging local communities in the planning and management of sanctuaries ensures that conservation goals align with their interests and can reduce the potential for conflicts in the future.

2.6.3: *Legal framework and enforcement*: Distinct statutory guidelines and strong enforcement mechanisms are essential to protect fish sanctuaries. Governments and local authorities must define sanctuaries' boundaries, establish regulations, educate the public and impose penalties for violations. Entering into agreements with local communities can bolster this effort.

2.6.4: *Ecological assessment*: Long-term ecological monitoring of fish populations, water quality, and habitat conditions is crucial to assess the effectiveness of these sanctuaries. Research can help identify species that are particularly vulnerable and develop targeted conservation strategies. Regular assessments can also provide insights into how sanctuaries contribute to broader ecosystem health and biodiversity goals.

2.6.5: *Monitoring and evaluation*: Ecological restoration and conservation are inherently long-term processes. The effectiveness of fish sanctuaries can only be assessed over extended periods following sustained adaptive management and conservation efforts. This necessitates a comprehensive monitoring and evaluation framework at both policy and implementation levels. A robust grassroots monitoring system can be complemented by a state-level decision-making commitee to ensure the development of a long-term conservation strategy. This may involve establishing state-level management committees for monitoring and evaluation or formulating a strategic roadmap to secure additional conservation status for fish sanctuaries.

A TIMELINE

1896
Bengaluru receives it's first water from Shivanasamurdram

1897
Indian Fisheries Act

1902
Shivanasamudram power station is established

1931
KRS Dam completed

1935
Ramanathapur FS is declared

1938
Fobes Sagar, Shiva Balancing Reservior(SBR) is created

1974
Kabini Dam is built

1975
Bengaluru's Cauvery Water Supply Scheme(CWSS) phase 1 begins; delivering MLD to Bengaluru

1987
National Water Policy

1996
Karnataka Inland Fisheries (Conservation, Development and Regulation Act. (KIFA 1996)+

1999
KPTCL takes over management of "the SFS area" from KEB

2002
Biological Diversity Act

2003
Amendment to the KIFA (1996) to include 'Declaration of Sanctuary'

2004
WASI and DoF begin talks to declare the SFS

2006
Abhirama, Jammatagi, Shringeri, Chippalagudda FS are Declared

2007
Thodikana, Thingale and Mattur-Hoshalli FS are declared

2009
Bachanayakanagudi and Shivanasamudram FS are declared

2011
WASI and DoF formalize an MoU to jointly manage the SFS

2012
Bengaluru water supply phase 4(2); delivering 1,500 MLD

2014
Harangi FFS is declared

2025
Management plan for the SFS published by WASI

3. RIPPLES THROUGH TIME: THE PRESENT AND PAST OF SHIVANASAMUDRAM FISH SANCTUARY

3.1 Historical background of Shivanasamudram village

The village of Shivanasamudram holds a rich and layered history that extends beyond its modern infrastructure. Located on the banks of the Cauvery River, it has a history dating back approximately 170 years, with much of its present form shaped during the British *Raj*. A significant figure associated with its development is Sir Mokshagundam Visvesvaraya (MV; 1861–1962), one of India's most distinguished civil engineers. MV, who served for the government of British India and later as the Prime Minister of the Kingdom of Mysore, played a pivotal role in the construction of the village's hydroelectric infrastructure, one of the first in Asia. The project was envisioned to supply electricity to the Kolar Gold Fields, marking a milestone in India's industrial history.

During the colonial period, Shivanasamudram was primarily a dense, forested area, uninhabited and relatively isolated. The British colonial administration, recognizing the potential of the Cauvery River, sought to harness its energy. According to local folklore, early colonial officials doubted the feasibility of this project after visiting the site and assessing the challenges posed by the river's strong current, rugged terrain and the thick surrounding forest that were teeming with wildlife.

It was at this critical juncture that MV entered the scene. Confident in his engineering expertise, MV assured the British authorities that constructing the dam and power station was possible. His proposal was initially met with scepticism, as colonial officials considered his plan overly ambitious, even labelling it as impractical or "stupid." This led to the addition of the term "Bluff" to the village's name, implying that MV's vision was unattainable. Despite these doubts, MV remained steadfast, securing funding from Krishnaraja Wodeyar IV, the then King of Mysore, to proceed with the project (1902).

MV employed a large workforce, largely composed of migrant labourers from neighbouring regions such as Kerala, Tamil Nadu, and northern Karnataka, as the area itself had no indigenous population at the time. The migration of workers into Shivanasamudram contributed to the village's multicultural population, with many of the current residents tracing their ancestry to these early labourers. Through meticulous planning and engineering, MV successfully completed the construction of both the dam and the power plant, defying the initial scepticism. His work not only transformed Shivanasamudram into a key hub for hydroelectric power but also set a benchmark in the field of civil engineering in India. Despite the project's success, the term "Bluff" became ingrained in the local nomenclature, and the village was known as Shivanasamudram (Bluff) even today.

In 1938, the Forbes Sagar balancing reservoir was created by demolishing a canal that ran water from the Shiva Anicut to the Shivanasamudram power station (later named the Sri Sheshadri Iyer Hydroelectric plant). This reservoir was inaugurated by the then Dewan of Mysore (22-12-1938) and a memorial stone still stands at the northern limits of the reservoir. Post-independence, the power station, originally built under British oversight, was taken over by the Indian authorities and renamed the Mysore Electric Board (MEB). Over time, it became part of the Karnataka Electric Board (KEB), and today it operates under the Karnataka Power Transmission Corporation Limited (KPTCL), continuing to serve as a crucial energy source for the region. MV's legacy in Shivanasamudram lives on not only through the physical infrastructure he helped create but also in the village's enduring historical narrative, symbolizing both engineering excellence and the triumph of visionary thinking over doubt.

3.2 Beneath the currents: An aquatic diversity in need of protection

In parallel with the development of Shivanasamudram's hydroelectric infrastructure, the Shivanasamudram waterfalls and surrounding areas became a focal point for tourism. The river here flows off the Deccan plateau, giving rise to fast flowing rapids, riffles, pools, waterfalls and cascades that make for a fantastic landscape view. The high degree of riverine habitat diversity permitted the evolution of a diverse fish assemblage, one of the highest along the entire Cauvery River. Shivanasamudram is home to over 100 species of indigenous fish, including the IUCN Red List Endangered *Hemibagrus punctatus* (Nilgiri mystus), *Hypselobarbus micropogon* (Kohri barb), and *Hypselobarbus dubius* (Nilgiri barb). The IUCN Red List.

Critically Endangered *Tor remadevii* (Humpback mahseer) was once abundant here but is believed to have gone locally extinct in the mid-1980s (Fig. 3). The influx of tourists brought a high demand for fish, today the Handpost area at Shivanasamudram is the largest point of sale of wild caught fish along the entire Cauvery River. The ever increasing demand for fish escalated the number of fishermen operating in the area and shifted traditional practices to more effective and often destructive practice. Dynamite fishing, trapping, poisoning and large-scale netting to catch fish for commercial gain has had a lasting impact on the rich fish assemblage of Shivanasamudram. WASI and DoF, in the year 2007, recognized the need to take action, pushing for a legitimate sanctuary to prevent destructive fishing practices (Fig. 3). Thus, the Forbes Sagar balancing reservoir was declared as the Shivanasamudram Fish Sanctuary (SFS) was officially declared on the 22nd of September 2009 (via G.O. AHF/46/MEE 2009).

Figure 3: A large specimen of the Humpback mahseer being held by a member of the Trans World Fishing Team alongside Mr. Sundar Raj at the SFS area (Photo source: WASI).

The fish sanctuary's inception was inspired by both the cultural and ecological significance of the river. For centuries, local communities, especially the fishing and agricultural communities around Shivanasamudram, have held the Cauvery River in reverence. Especially, the mahseer fish species (*Tor*), an iconic freshwater fish revered by locals and recreational anglers alike, became emblematic of these conservation efforts.

Over the years, the sanctuary's role expanded beyond the protection of fish species to encompass a broader ecological and educational purpose. The sanctuary not only protects the mahseer and other native fish species but also promotes sustainable fishing practices. Local communities actively participate in conservation initiatives, with many traditional fishing practices modified to contribute towards fish monitoring and habitat protection. Additionally, the SFS provides a space for science and conservation-based organizations to contribute towards generating ecological knowledge and developing strategies for preserving the river's ecology.

Today, SFS represents the only fish sanctuary in Karnataka that is actively managed within a policy framework rooted in site specific conservation principles. The sanctuary has become a symbol for the importance of riverine conservation and fish monitoring. However, it still faces challenges, including habitat loss, low flow during summer months, and occasional pressures from illegal and destructive fishing practices. Conservation advocates are calling for stronger collaborations, regulations, increased funding, and ecotourism initiatives to protect the sanctuary's resilience over the long term. This sanctuary remains essential for the river's aquatic life and is a living symbol of the enduring bond between the people of Shivanasamudram and the Cauvery River. The management plan aims to maintain this socio-ecological balance, ensuring the sanctuary's integrity beyond 'sole' legal designation.

3.3 Stakeholder mapping in the context of SFS

We used a strategic process to identify, analyse, and visualize the stakeholders involved in the SFS (Fig. 4). Our goal was to understand each stakeholder's interest, influence, and importance to manage their expectations and engage them effectively. We defined interest by asking, "How concerned or affected is the stakeholder by the project?" and power by asking, "How much power does the stakeholder have to impact the project?"

Stakeholders with high power and low interest:

1. *Karnataka Power Transmission Corporation Limited (KPTCL)*: Incorporated on 28 July 1999 under the Companies Act, 1956, KPTCL is a wholly government-owned entity established following the dissolution of the Karnataka Electricity Board (KEB). As the agency responsible for electricity transmission across the state, KPTCL holds significant influence due to the area's role as a source of hydroelectric power generation. Notably, KPTCL is one of the key stakeholders in the sanctuary, maintaining an on-site office and collaboratively managing waterways with WASI and the Bangalore Water Supply and Sewerage Board (BWSSB). However, its interest in the sanctuary's conservation and management is likely limited, as its primary focus remains on maintaining and expanding the state's power grid infrastructure.

2. *Bangalore Water Supply and Sewerage Board (BWSSB)*: The BWSSB holds significant authority due to its role in managing water supply and sewage systems for Bengaluru. While the SFS serves as a critical water source for the city and BWSSB plays a key role in its management, the board's primary mandate focuses on maintaining clean waterways, including activities such as removing water hyacinth and clearing vegetation along canals. However, BWSSB's interest in conservation initiatives within the sanctuary is likely limited, as its primary focus remains on urban water management and sanitation.

3. *Karnataka Forest Department (KFD)*: The Karnataka Forest Department is tasked with protecting forests and wildlife, biodiversity conservation, and the maintenance of ecological balance within the state. Headed by the Principal Chief Conservator of Forests, the department wields significant authority, particularly due to its strong bureaucratic influence and proximity to the Cauvery wildlife sanctuary. Although the department holds considerable power in managing species listed under the WPA 1972, including those occurring outside PAs, its interest in the SFS is expected to be limited. However, the department can be engaged for plantation activities and for addressing wildlife-related concerns in the region.

4. *Karnataka State Police*: The State Police (*Belekavadi* police station for SFS area) hold significant power due to their authority in maintaining law and order, but they likely have low interest in the Shivanasamudram Fish Sanctuary, as their primary focus is on broader public safety concerns rather than environmental or conservation issues. They can be included to address the illegal use of dynamite (mouth bombs) for hunting wild animals for meat.

5. *Karnataka State Pollution Control Board (KSPCB)*: The KSPCB holds significant authority due to its regulatory mandate over pollution control and environmental protection. This influence is particularly relevant given the area's role in water management for hydroelectric power generation and as a source of drinking water for Bengaluru. Additionally, the KSPCB oversees 36 water quality monitoring stations, some of which are located in and around the region. However, its direct interest in the SFS is likely minimal, as its primary focus lies on broader environmental regulations and industrial compliance rather than specific conservation initiatives.

Stakeholders with high power and high interest:

1. *Karnataka State Fisheries Department (DoF)*: The Fisheries Department has high power and high interest in the SFS. It manages and regulates fisheries, ensures sustainable practices, and supports local fishermen. Its strong focus on the sanctuary's aquatic resources makes it a key stakeholder in its conservation and management. The department is also responsible for proposing and declaring fish sanctuaries across the state via the Karnataka Inland Fisheries Act, 1996.

2. *Wildlife Association of South India (WASI)*: This organization have been active in the area for over 50 years and holds both significant authority and a strong interest in the SFS, playing a central role in wildlife conservation with a clear focus on protecting natural habitats and biodiversity. Its long-term influence and commitment position it as a key stakeholder in the sanctuary's management and preservation. WASI's close collaboration with the DoF strengthens the regulation and management of the area, ensuring sustained outcomes. Under the agreement (IN-KA02333758069193J; signed on August 4, 2011), only the DoF and WASI are authorized to issue permits for recreational and monitoring activities along waterways. Additionally, in consultation with DoF, WASI will oversee fish stock replenishment in the river, with all fish catch details systematically recorded in a register.

Stakeholders with low power and low interest:

1. *Local Governance Institutions*: Local governance institutions such as the *Gram Sabha* and *Gram Panchayat* currently hold low power and low interest in the management of the Shivanasamudram Fish Sanctuary. With limited authority over environmental matters and no role in decision-making or benefit-sharing, they remain peripheral to the sanctuary's conservation efforts. Similarly, the Cauvery Neeravari Nigam Limited (CNNL), despite its significant control over water releases and irrigation infrastructure in the region, has limited engagement with the sanctuary's ecological concerns. However, both local governance bodies and agencies like CNNL could be meaningfully engaged to enhance their interest, build accountability, and contribute to a more integrated and participatory management approach.

2. *Fishing cooperatives* like *Sanga*: Fishing cooperatives have low power and low interest in the SFS management. They have limited influence over sanctuary management and are primarily focused on fisheries as a livelihood stream which gets scrubbed with the Sanctuary regulations. Therefore, they are not highly involved in or concerned with its conservation efforts. The *Gangaparameshwari* fishing society who once operated in the area have now shifted their operations to a neighbouring fishing concession in Belakavadi.

Stakeholders with low power and high interest:

1. *Local communities*: Local communities (including local leaders) exhibit high interest but limited influence in the management of the SFS. Their concern for the sanctuary's conservation stems from its cultural significance and its impact on their livelihoods and well-being. Despite their limited decision-making power, these communities maintain a strong socio-cultural and psychological connection to the sanctuary, positioning them as essential partners in community-driven conservation efforts.

2. *Karnataka State Tourism Development Corporation (KSTDC)*: KSTDC has low power but high interest in the SFS management. While it may have limited influence over sanctuary management due to the dominance of other state departments, it is very interested in promoting and developing tourism in the area, recognizing its potential for attracting visitors and boosting local tourism.

Stakeholders' influence and interest may change over time, so it is important to regularly revisit the stakeholder map and adjust strategies as needed.

Figure 4: Stakeholder mapping of potential players involved in the management of the SFS area

3.4 LULC mapping of SFS in a decadal span

The Land Use/ Land Cover (LULC) data for the SFS region from 2009 to 2023 detailed the changes in land cover types over this period. This included shifts in forest cover, agricultural land, built-up areas, water bodies, and other land uses within and outside the sanctuary area. The analysis was conducted over an area of 105 km^2 to capture long-term temporal changes from surrounding regions, including Shivanasamudram Island, Cauvery Wildlife Sanctuary, Belakavadi, and the Shimsha area.

Key LULC categories that were considered for SFS:

1. *Forest cover/Vegetation*: Changes in the extent of forested areas, including any deforestation or reforestation activities.
2. *Water bodies*: Variations in the size and shape of rivers, lakes, and other aquatic habitats- this holds primary importance since the sanctuary is centric around water bodies.
3. *Agricultural land*: The expansion or reduction of agricultural fields within or near the sanctuary is a signature of human activities and land conversion.
4. *Shrubs and Scrubs*: Changes in shrublands and scrublands, collectively referred to as Open Natural Ecosystems (ONEs), were analyzed as a distinct category separate from grasslands, as data for grasslands was unavailable for 2019.
5. *Built-up areas*: Development of infrastructure such as roads, buildings, or other constructions.
6. *Barren land*: Areas that have remained undeveloped or have become degraded over time are a signature of land health in the area.

Key observations from the LULC analysis:

1. 2009: Predominantly forest cover with significant water bodies from the river system, limited agricultural activity, and minimal built-up areas (Table 2; Fig. 5).
2. 2016: Significant increase in agricultural land and an increase in forest cover as well (due to the Cauvery Wildlife Sanctuary in the ambit of the LULC map), with minor expansion of built-up areas. The increase in the area under agricultural land is mostly at the expense of the shrub- and scrub lands (since the latter showed a decrease) (Table 2; Fig. 5).
3. 2020: Noticeable urbanization (significant increase in built-up areas as compared to 2009) and infrastructure development, leading to further areal intensification of agricultural land as well. The forest area also shows an increase given the PA regulation of the Cauvery Wildlife Sanctuary. The percent cover of water remained almost the same as in 2016 but decreased as compared to 2009 (Table 2; Fig. 5).
4. 2023: Continued trends of urban expansion and agricultural intensification, with significant impacts on natural habitats, particularly near the riverine ecosystems. The shrub and scrub land displayed a significant decrease at the expense of an increase in area under croplands. The forest percent cover further improved considering plantation efforts and state protection in the Cauvery wildlife sanctuary (Table 2; Fig. 5).

The growth of built-up areas and agricultural fields at the expense of scrub- and shrublands threatens the biodiversity and ecological health of the fish sanctuary.

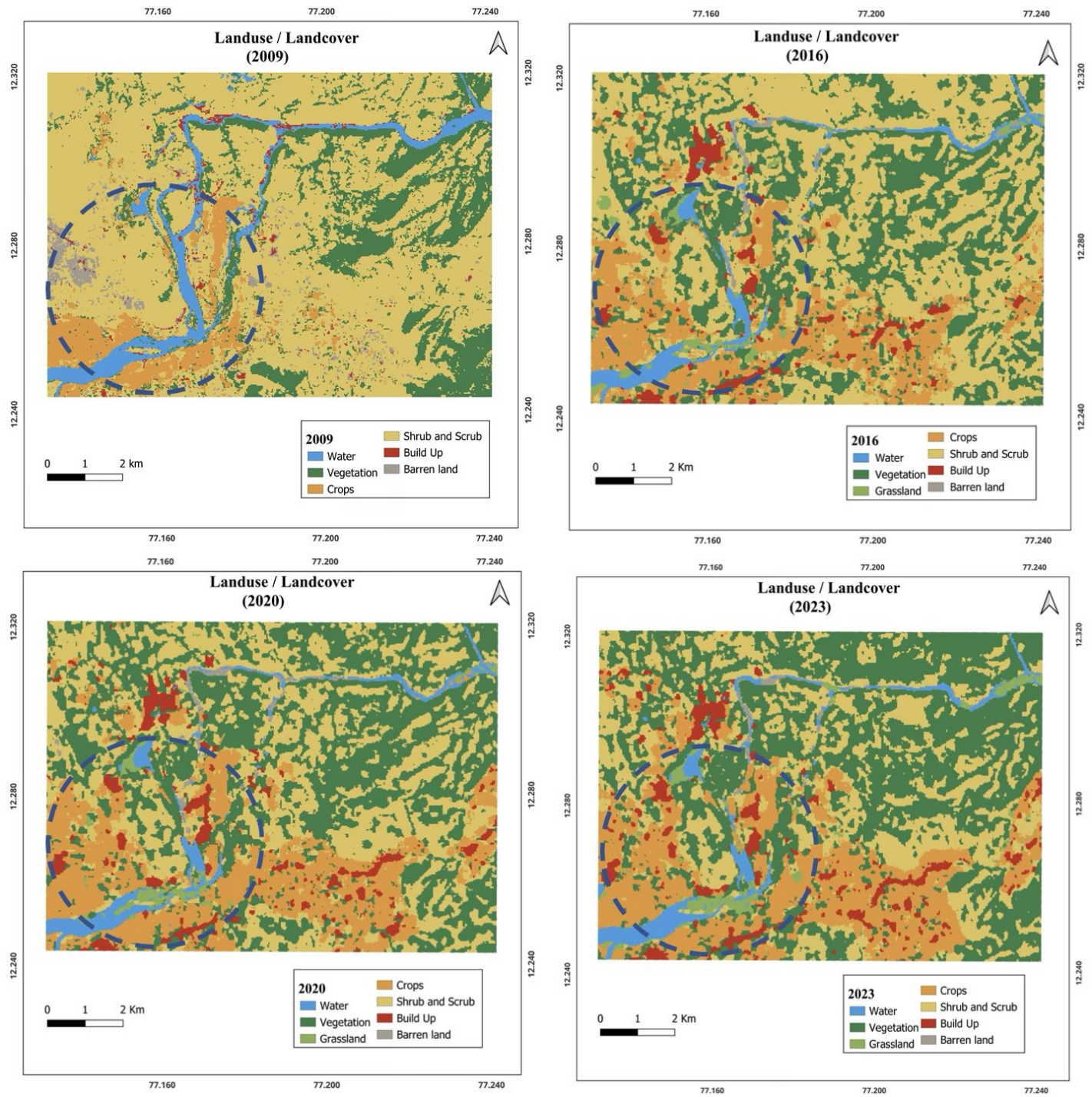


Figure 5: Visual representation of LULC analysis of the SFS area, encircled in blue. The right corner of each panel illustrates the Cauvery wildlife sanctuary region

Using LULC data, this management plan aims to guide conservation efforts, including habitat restoration, buffer zones, and sustainable land use, to protect the SFS. The detailed methodology of the LULC analysis is provided in Appendix 2.

Table 2: LULC classes, their extents and changes for 15 years in SFS

Class	2009 (in %)	2016 (in %)	2020 (in %)	2023 (in %)	Percent change
Water	5.39	3.08	2.95	3.23	-2.16
Vegetation	19.4	29.9	37.1	41.34	+21.94
Crops	7.77	16.03	19.45	20.93	+13.16
Shrubs and scrubs	63.75	45.52	34.3	27.07	-36.68
Built-up	1.06	3.37	4.21	4.95	+3.89
Barren land	2.62	0.64	0.79	0.45	-2.17

3.5 Spatial land use patterns of Shivanasamudram balancing reservoir (Forbes Sagar)

The Shivanasamudram balancing reservoir (SBR), also known as Forbes Sagar, is the primary wetland associated with the SFS. Historically, this area comprised a seasonal stream interspersed with cultivable land. The southern and western flanks were bordered by a canal supplying water to the Shivanasamudram power station. Subsequently, the canal was dismantled to create the balancing reservoir, which facilitated the emergence of a wetland ecosystem.

As part of this management plan, an assessment was carried out in the areas surrounding the SBR to identify major land use patterns, ecological restoration sites, and long-term conservation priorities. The mapped area covers approximately 287 acres (1,160,871 m^2) and is bordered by key transportation routes (Fig. 6). To the west, a road connects Rottikatte Circle to Gagganachukki Waterfalls, while to the east, another road links Gagganachukki Waterfalls to the Kollegal main road. The southern boundary is marked by the Kollegal main road, which runs from Rottikatte Circle to Sathegala Bridge.

This area encompasses a diverse array of land use/cover types, including forest patches, open water bodies, privately owned and cultivated lands, scrubland, wetlands, and road networks. Each category offers unique ecological opportunities and presents specific management challenges, which have been incorporated into the broader conservation framework detailed in Chapter 8. Table 3 provides a summary of the key characteristics, restoration potential, and associated challenges for each land use type (Spatial details for each land use type are provided in Appendix 3).

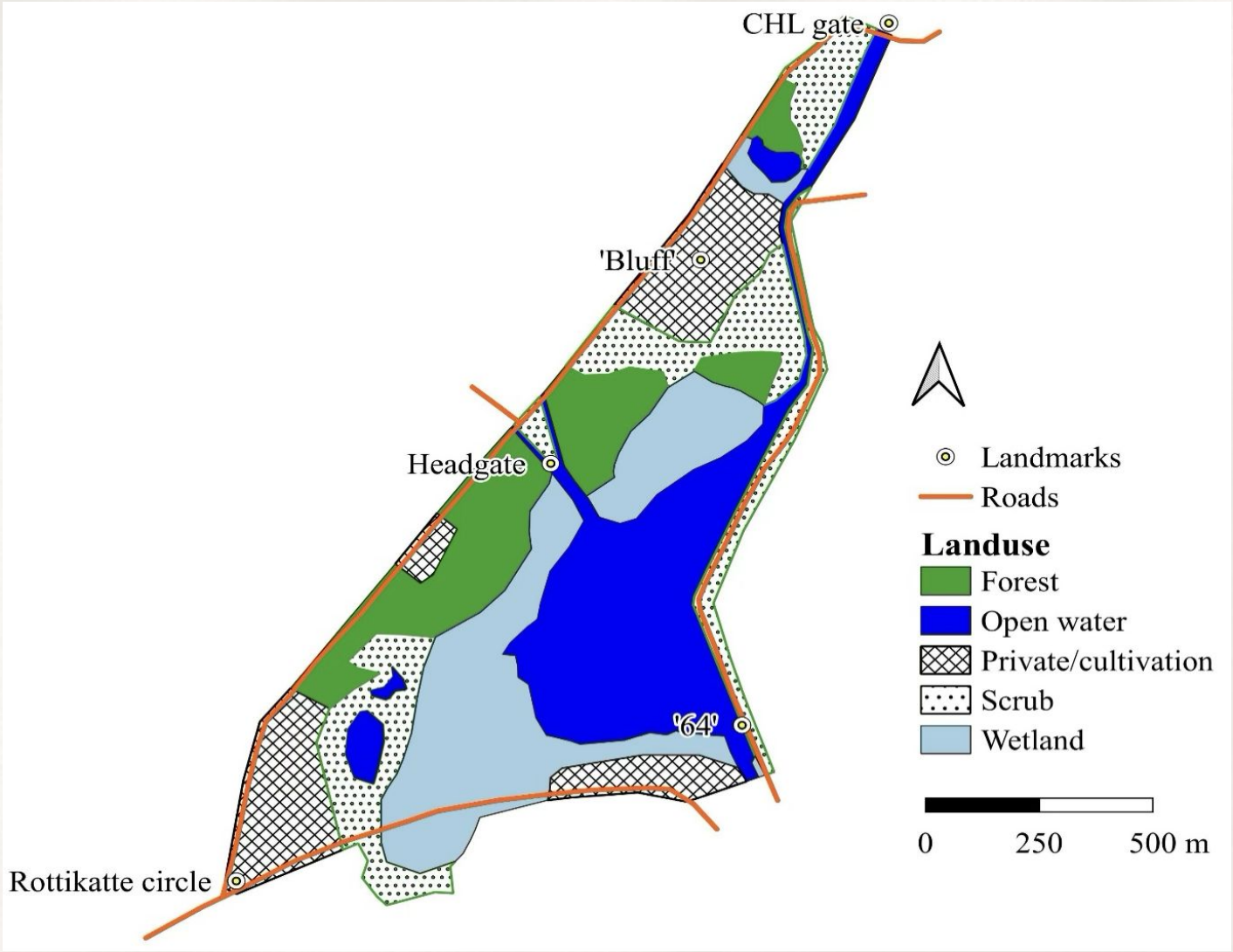


Figure 6: Spatial features of the SBR and surrounding landscape

Table 3: Summary of land use and management considerations

Land use	Area (m²/ Acres)	Key features	Opportunities	Challenges
Forest	183,080/ 45	- Comprises four distinct forest patches in the western region. - Supports diverse fauna. - Contains bamboo, dry deciduous species, and introduced tree species. - Includes a Forest Department nursery in the southern block.	- The nursery can aid in riparian and forest species propagation. - Forest patches serve as seed sources for restoration. - Potential reference sites for monitoring restoration success.	- Requires coordination with the Forest Department and local communities for afforestation and ecological restoration.

Open water	282,648/ 70	- Contains a submerged island in the western section (see Chapter 3). - Floating aquatic weeds present along the periphery require periodic removal.	- Provides space for recreational activities. - Serves as a critical habitat for aquatic species.	- Long-term sediment accumulation has reduced the water-holding capacity.
Private/ Cultivated land	200,528/ 50	- Includes settlements like 'Mallikyathanahalli' hamlet of Shivanasamudram Bluff and Rottikatte village. - Encompasses private farmlands in the south-eastern region.	- Local communities can actively participate in conservation efforts. - Potential for agroforestry initiatives.	- Land tenure conflicts and challenges in integrating tree planting with existing agricultural practices.
Scrubland	227,549/ 56	- Includes village common lands and designated forested areas. - Dominated by thorny scrub vegetation. - Used for livestock grazing and firewood collection.	- Suitable for agroforestry and ecological restoration. - Potential habitat for terrestrial mammals.	- Overgrazing and uncontrolled livestock movement. - Unsustainable tree lopping for firewood.
Wetland	267,066/ 66	- Part of the SBR submergence zone. - Characterized by grasslands and reed beds interspersed with water bodies.	- Critical habitat for aquatic biodiversity. - Suitable sites for riparian tree and shrub reintroduction.	- Overgrowth of reed beds affects water flow. - Declining water levels threaten soil moisture retention. - High grazing pressure in wetland zones.
Roads	Total length: 5.5 km	- Asphalt roads accommodating two- and four-wheel vehicles. - Facilitates connectivity across the SBR landscape.	- Can support nature-based tourism, public awareness programs, and conservation messaging.	- Increased vehicular traffic may cause ecological disturbances. - Litter accumulation along roadsides requires active management.

In summary, the diverse land use classifications around the SBR reflect a complex ecological landscape with various conservation and management challenges. A strategic, multi-stakeholder approach— integrating forest restoration, wetland conservation, sustainable land use, and community participation— will be essential to ensuring the long-term ecological integrity of this region.

3.6 Bathymetric analysis of SFS

The provided bathymetric map (Fig. 7) illustrates the underwater topography of two interconnected waterbodies: the Malligemaradahalla lake or cottage lake and Forbes Sagar or the Shiva Balancing Reservoir (SBR)— both of which form the SFS area (under WASI's directives). The bathymetry model used depth contours and a gradient of colours to illustrate variations in depth, along with labels marking key infrastructural elements such as the siphon, headgate, and bluff.

Cottage lake, located on the left side of the map, displays a relatively wide and open morphology. The deepest zones, represented in yellow, exceed 23 feet and are predominantly concentrated in the central and southern parts of the lake. Shallower areas, shown in purple and reddish hues (1–10 feet), are more prominent along the edges and extend towards the northern region, near the siphon. In contrast, Forbes Sagar on the right exhibits a narrower and more elongated shape. Its deepest zones are found in the central and south-eastern portions (influenced by the inflow from the southeast), while the shallower areas dominate the lake's peripheries and extend towards its northern and eastern borders near the outflow. The old canal (demolished to create the reservoir) can be seen as a deeper section skirting the southern and western flanks. Just south of the outlet to headgate, a shallower area is visible which represents an old island (submerged in 2010) that once had trees. This island maybe restored with riparian trees to support nesting bird species. The narrow channel connecting these two waterbodies is predominantly shallow, primarily serving as a conduit for water flow and ecological connectivity.

The map also highlights key infrastructural features. The siphon at the northern edge of cottage lake is designed to facilitate water management, for transferring water out of the lake towards the Netkal lake which in turn supplies water to Bengaluru City and the Shimsha power station. The headgates, located near the connecting channel and at the Western end of Forbes Sagar, regulate water flow between the two water bodies (North channel) and to a pipeline that supplies water to Bengaluru City (East channel). The bluff gate or the CHL gate, situated at the North end of Forbes Sagar, supplies water to the Shivanasamudram Power Station which eventually delivers the water back to the Cauvery River via the Gagganachukki stream.

From an ecological perspective, the variation in depth across these waterbodies has significant implications. The deepest areas, marked in yellow, may provide critical habitats for aquatic species that thrive in cooler and deeper waters. These zones could also serve as refuges during periods of environmental stress, such as drought or heatwaves. Meanwhile, the shallower regions along the peripheries might support aquatic plants and act as spawning grounds for fish. These shallow areas could also play an essential role in maintaining biodiversity by providing habitats for a variety of species.

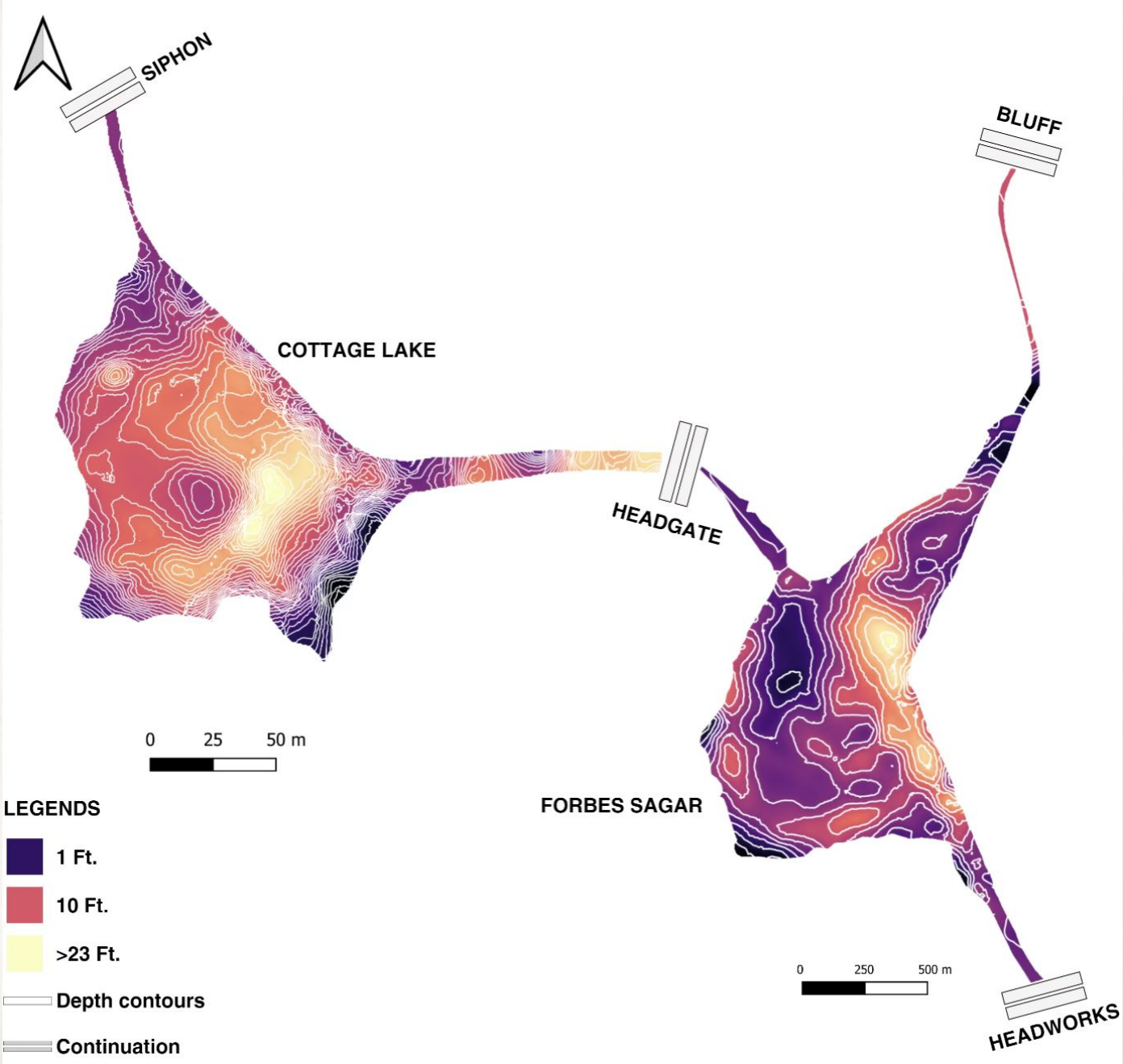


Figure 7: Bathymetric map of cottage lake and Forbes Sagar: Depths are shown in a gradient, with shallow zones in purple (1–10 ft), moderate depths in red (10–23 ft), and deeper areas in yellow (>23 ft)

Furthermore, depth variations can also indicate the extent of siltation in the waterbodies. Shallower zones may signify sediment deposition over time. This siltation process, driven by factors such as upstream erosion, agricultural runoff, or reduced water flow, can gradually alter the depth profile and reduce the water holding capacity of these waterbodies, impacting aquatic ecosystems and potentially altering their ecological balance. Identifying and addressing siltation through regular monitoring is critical for the long-term conservation of these aquatic environments.

The channel connecting Cottage Lake and Forbes Sagar is particularly important for maintaining ecological connectivity. It facilitates the movement of aquatic organisms such as fish, otters, and crocodiles, as well as the exchange of nutrients between the two lakes. Therefore, effective management of this channel is crucial for maintaining an optimal water balance between the lakes and preventing issues such as flooding in one or desiccation in the other.

In conclusion, the bathymetric map (in Fig. 7) offers a comprehensive overview of the underwater topography and infrastructure of cottage lake and Forbes Sagar. Integrating this information into management strategies can support sustainable practices and enhance the overall resilience of these aquatic ecosystems. The detailed methodology of the bathymetric analysis is provided in Appendix 4.

3.7 Recreational catch and release (CnR) angling: Fish conservation and research

Recreational angling (hereafter referred to as angling) is widely recognized as an activity that contributes to fish conservation and the protection of aquatic habitats. It involves capturing fish using various fishing tackle, including hooks, lures, reels, and rods. The SFS area has been a popular angling destination, historically producing several trophy-sized mahseer for the Maharajas of Mysore. Anglers play a vital role in conservation efforts through financial contributions via license fees and taxes on fishing equipment, which support habitat restoration, fisheries management, and water quality improvements. Catch-and-release (CnR) angling, in particular, helps maintain fish populations while ensuring the sustainability of sports. Additionally, angling generates economic benefits by supporting local businesses and conservation initiatives.

Beyond its conservation and economic contributions, angling fosters a deep connection between individuals and nature. Whether undertaken alone or with family and friends, it provides opportunities for relaxation, adventure, and an enhanced sense of environmental stewardship. Engaging in outdoor activities, observing wilderness, and practicing ethical fishing techniques contribute to a greater appreciation for aquatic ecosystems. Through responsible participation, anglers play a crucial role in sustaining fish stocks while enjoying a rewarding nature-based activity that strengthens social bonds and promotes well-being. The SFS management framework incorporates these principles at its core.

3.7.1 Angler-generated data and its scientific utility

Crowdsourced[8] data from recreational anglers is increasingly recognized as a cost-effective tool for studying fish populations, particularly in developing countries (Erisman et al., 2011; Ward et al., 2013). For instance, angler catch logs from the Cauvery River have proven valuable in assessing *Tor* spp. (Mahseer) populations (Pinder et al., 2015a; Pinder et al., 2015b). Notably, the reclassification of *Tor remadevii* (Humpback mahseer) as "Critically Endangered" on the IUCN Red List was informed in large part by data obtained from angling catch records. Although such data sources provide substantial insights (Mosindy & Duffy, 2006), they are subject to limitations, including self-reporting biases, inaccurate measurements, selective reporting of charismatic and predatory species, and recall biases when anglers document catches retrospectively (Essig & Holliday, 1991; Tarrant et al., 1993; Cooke et al., 2000).

[8]*Crowdsourced refers to obtaining input, data, or services by soliciting contributions from a large group of people rather than relying on a few experts or a centralized team.*

Despite these challenges, catch-and-release angling has been widely adopted as a conservation strategy in Global North countries such as Canada and the United States of America (Brownscombe et al., 2017). In India, however, systematic angling data collection remains limited to a few angling associations (Gupta et al., 2015). Nevertheless, the increasing popularity of recreational angling presents significant opportunities for research and conservation. Anglers, given their extensive time spent observing water bodies and fish behaviour, often develop a strong conservation ethic. With appropriate guidance, angling can serve as an effective platform for public engagement in conservation initiatives. The integration of citizen science into angling practices could further align this activity with conservation goals, mitigating potential negative impacts on fish populations and gaining support from the scientific community.

3.7.2 Long-term angling data for fisheries management in SFS

The SFS management has compiled 18 years of angling data (2007–2024), structured according to the financial year cycle, spanning from April of the preceding year to March of the succeeding year. This dataset, sourced from a single monitoring station managed by WASI, excludes a one-and-a-half-year gap (January 2020–July 2021) due to the COVID-19 pandemic. As a citizen science initiative, it represents 29,176 hours of recorded fishing effort, encompassing 20,501 angling observations (measured by the number of fishes caught) contributed by over 300 anglers. Over this period, the data has captured population trends and species presence across 10 broad fish categories— some of which group multiple species due to low representation (Table 4). Additionally, a total of 41 unique species have been documented (refer to section 5.4.1)

Two primary datasets were used for the analysis. The first dataset, obtained from an office-based booking system, recorded angling permit issuances along with the corresponding dates and names of anglers. This system, audited annually, served as the basis for estimating angling effort in terms of hours spent. The second dataset consisted of angler entries that documented key information such as angler identity, date, species caught, catch numbers and weight (measured using a digital balance), as well as details on fish released or retained and the angling methods used. These entries were maintained in a WASI-supervised register at the angling site, where anglers were required to manually record their daily catches, often with assistance from their guides.

Table 4: Monthly trends in CPUE (n fish hr^{-1}) for the ten major fish species categories, incorporating all angling calculations[9]. This dataset represents consolidated monthly data from 2007 to 2024, with a 1.5-year gap between 2020 and 2021.

Months	Carnatic carp	Catla	Mahseer	Mrigal	Native carp	Native catfish	Rohu	Tilapia	Snake head	Others
1	0.33	0.27	5.96	0.16	0.41	0.41	0.41	1.63	0.60	2.19
2	0.11	0.14	5.46	0.19	0.58	0.67	0.38	2.94	0.47	3.34
3	0.25	0.30	4.65	0.18	0.44	0.51	0.48	1.14	0.96	2.02
4	0.17	0.40	7.53	0.11	0.27	0.29	0.51	1.60	0.89	2.43
5	0.30	0.16	8.48	0.18	0.25	0.34	0.58	2.06	2.08	4.07
6	0.40	0.33	5.07	0.20	0.27	0.43	0.45	2.12	0.41	2.45
7	0.26	0.38	5.46	0.40	0.80	1.06	0.47	2.23	0.81	2.94
8	0.15	0.32	7.96	0.67	0.90	1.11	0.79	2.94	0.73	3.59
9	0.44	0.85	4.84	0.77	0.97	1.22	0.81	1.85	0.68	2.37
10	0.33	0.12	6.07	0.52	0.62	0.80	0.73	1.62	0.90	2.40
11	0.51	0.28	6.40	0.41	0.67	0.73	0.66	2.14	1.77	3.74
12	0.22	0.24	6.41	0.31	0.40	0.44	0.66	1.76	0.89	2.55
Total	3.48	3.79	74.30	4.09	6.57	8.01	6.93	24.03	11.19	34.07

To standardize the dataset for analysis, angling effort was estimated using an average threshold of four angling hours per session. This threshold was determined based on informal interviews, which indicated that most anglers typically fish for four hours. Therefore, the standardized effort value was obtained by multiplying the number of permits issued each month within a given year by 4, providing a consistent calculation of fishing effort over time. Analysis of the standardized dataset reveals an increasing trend in effort, particularly from 2012 onward, suggesting a rise in angling activity (Fig. 8). The median effort varies across years, with some periods (e.g., 2015 and 2022) exhibiting notably high interquartile ranges, indicating greater variability in effort. The presence of outliers (marked in orange) suggests occasional instances of exceptionally high fishing effort in certain years. Additionally, a notable gap in data is observed in 2020-21 due to the COVID-19 pandemic. Overall, this upward trend in angling effort reflects growing participation in angling and improved data collection efforts over time.

[9] The "Others" category includes species such as African Catfish, while the "Native Carp" category comprises species like Kalabanse.

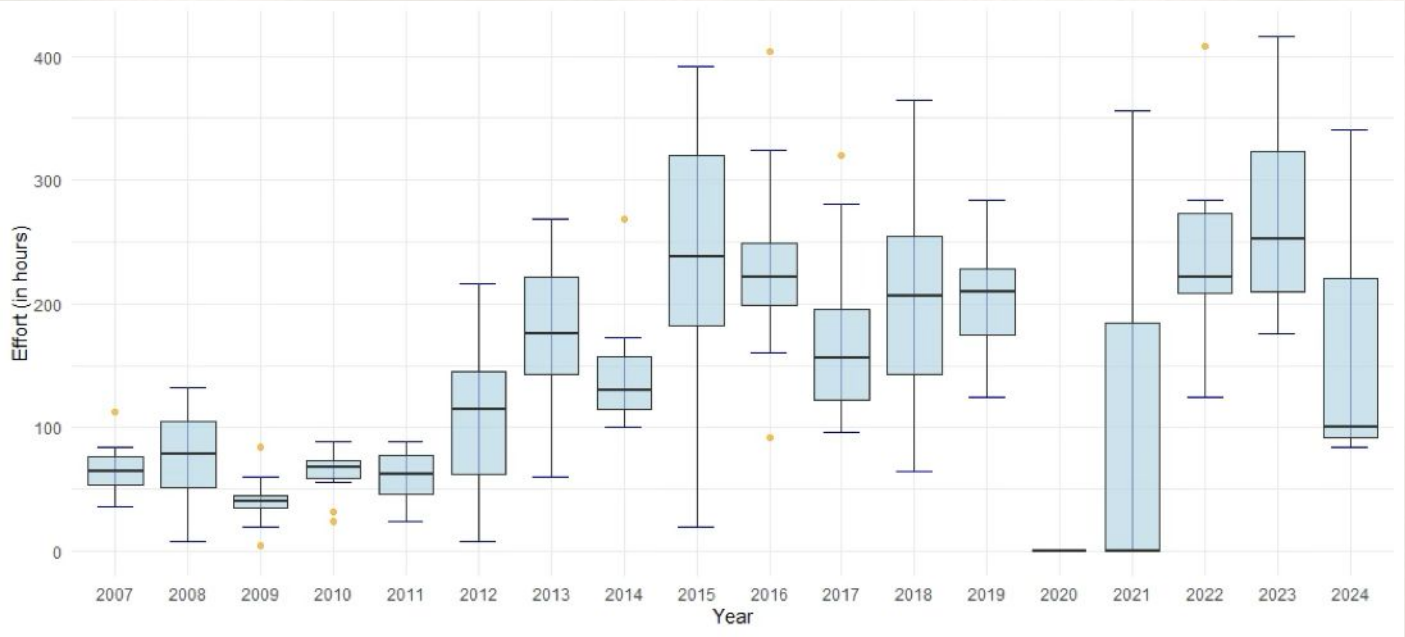


Figure 8: Angling effort in the WASI-managed SFS area from 2007 to 2024. Orange dots represent outliers. The absence of data in 2020 and the skewed box plot for 2021 reflect the 1.5-year gap in data collection due to the COVID-19 pandemic. Data for 2024 is limited to three months (January–March) due to alignment with the financial calendar

Catch per unit effort (CPUE) was calculated by dividing the total number of fishes caught in a given month by the corresponding monthly effort, as derived from the above calculation (Appendix 5). Fig. 9 presents the temporal variation in CPUE in the WASI-managed SFS area from 2007 to 2024, highlighting interannual fluctuations in fish capture rates. The distribution of CPUE values exhibits substantial variability across years, with periods such as 2010 and 2017 displaying higher median values and wider interquartile ranges, indicating greater catch efficiency and variability in fishing success. The presence of multiple outliers in years such as 2009, 2012, and 2016 suggests episodic peaks in CPUE, potentially driven by ecological factors, fishing pressure, or environmental conditions. The absence of data in 2020 is attributed to the COVID-19 pandemic, which resulted in a disruption of monitoring efforts. This data gap is also reflected in the skewed distribution for 2021, where the CPUE variability is influenced by the 1.5-year discontinuity. In recent years (2022–2024), the CPUE appears to decline with reduced variability, potentially indicating shifts in fish population dynamics, fishing effort, or ecological conditions. These trends underscore the complex interplay of management interventions, environmental variability, and anthropogenic factors in shaping fishery productivity over time. These findings underscore the importance of long-term angling data in monitoring fish population dynamics and assessing the sustainability of fisheries management practices.

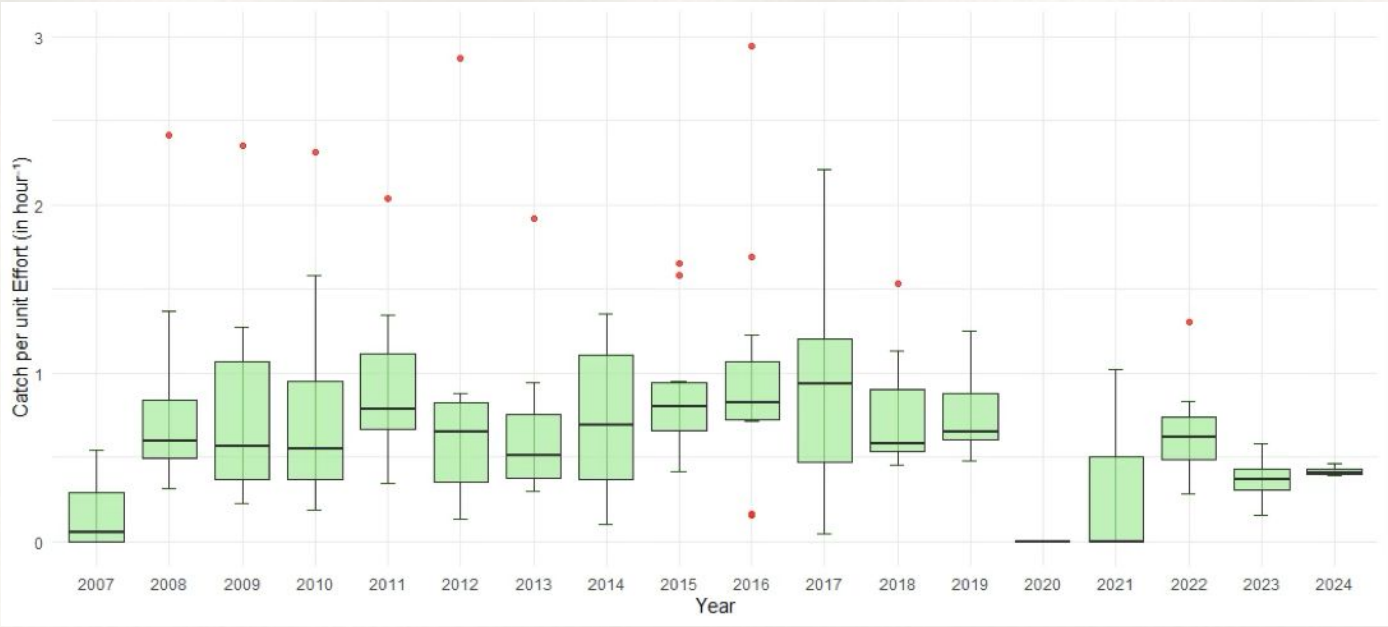


Figure 9: Catch per unit effort in the WASI-managed SFS area over a 14-year period. Red dots indicate outliers. The absence of data in 2020 and the skewed box plot for 2021 reflect the 1.5-year gap in data collection due to the COVID-19 pandemic. Data for 2024 is limited to three months (January–March) due to alignment with the financial calendar

The figure 10 illustrates the monthly variation in mean CPUE from 2007 to 2024, with error bars representing the standard error of the mean. A distinct seasonal trend is observed, with CPUE generally increasing from April to August, peaking in May and August, before stabilizing towards the end of the year. These trends are likely influenced by monsoonal effects, as the southwest monsoon (June–September) significantly impacts river hydrology, nutrient availability, and fish movement.

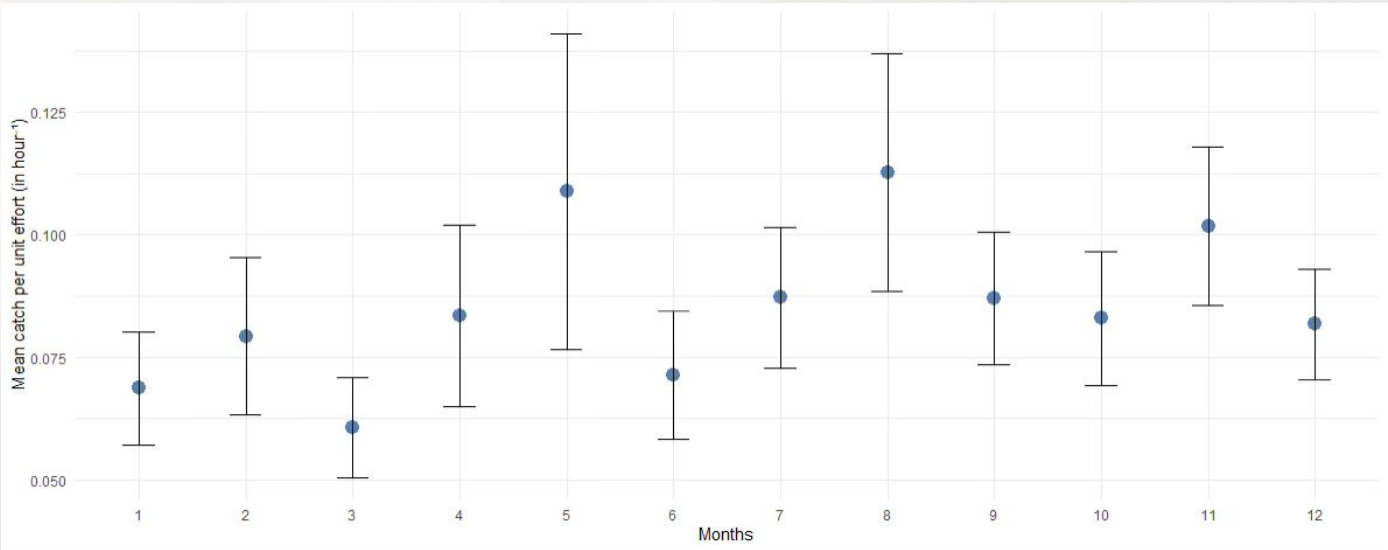


Figure 10: Monthly variation in mean CPUE from 2007 to 2024. Error bars represent the standard error

Increased water levels and turbidity during the monsoon may enhance fish dispersal and availability to anglers, contributing to higher CPUE in monsoon and immediate post-monsoon months. Conversely, the pre-monsoon period (January–March) exhibits relatively lower CPUE, possibly due to reduced fish activity, lower water levels, and increased fishing pressure in constrained habitats. The greater variability in CPUE during peak monsoon months may be attributed to interannual differences in rainfall intensity, flood dynamics, and fish recruitment success. These seasonal patterns underscore the critical influence of monsoonal hydrology on fish abundance and catch rates, providing valuable insights for fisheries management and conservation planning.

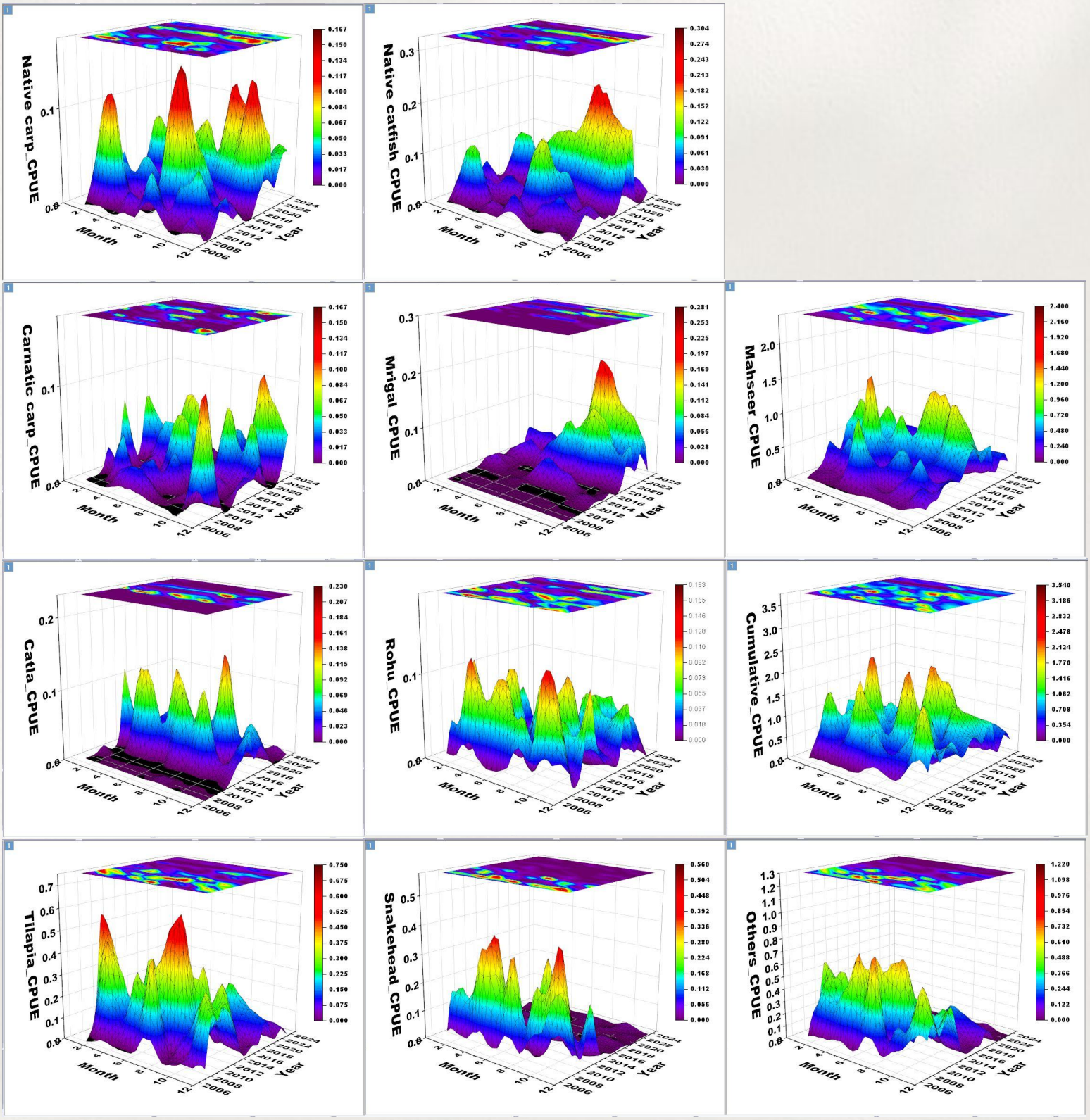


Figure 11: Annual trends in mean CPUE for different fish species between 2006 and 2024. Each panel represents a specific fish species, with CPUE (fish/hour) plotted (y-axis) against months (x-axis). The z-axis represents years, illustrating temporal variations in species abundance and seasonal trends

This figure 11 presents the monthly trends in mean CPUE for different fish species across four distinct year brackets (2007–2010, 2011–2013, 2014–2018, and 2019–2024). Each panel represents a specific fish species, highlighting temporal variations in CPUE over time. The data reveal clear seasonal trends, with species like Mahseer, Native catfish, and Tilapia exhibiting pronounced CPUE peaks during the monsoon and post-monsoon months (June–September), likely due to increased fish movement, breeding activity, and favourable environmental conditions. Mrigal, in particular, shows a significant rise in CPUE in the 2019–2024 period, especially from August to October, which may indicate a recovery in population or a shift in fishing effort. Temporal variability is evident across year brackets, with Catla and Rohu displaying higher CPUE values in 2011–2018, followed by a decline in recent years. Conversely, Mrigal and Native carp show an upward trend in the latest bracket (2019-2024), suggesting potential shifts in population dynamics or fishing pressure.

The monsoonal influence is prominent, as CPUE peaks during this period for multiple species, while values remain relatively low in the dry months (January–March), possibly due to restricted fishing activities or reduced fish movement. Some species, such as Snakehead and Native catfish, display declining trends in the most recent years (2019-2024), which could indicate overexploitation, habitat degradation, or fisheries management shifts. The declining CPUE for the "Others" category in recent years may also suggest a decrease in non-target species abundance or alterations in fishing effort. These trends have significant ecological and management implications, emphasizing the need for adaptive strategies to sustain fish populations. The increasing CPUE of Mrigal and Native carp could reflect improved conservation outcomes or a targeted shift in fishing efforts, while declining CPUE in species like Snakehead calls for further assessment to determine if the trend is driven by ecological factors or unsustainable fishing practices. The strong monsoonal influence on CPUE patterns highlights the importance of seasonal fishing regulations to ensure sustainable harvesting, particularly during breeding periods. Overall, these findings highlight the complex interplay between environmental conditions, fisheries management policies, and long-term ecological changes in influencing fish populations, providing crucial insights for sustainable conservation and fisheries management strategies.

Recreational angling is recognized world wide as a tool for conservation and monitoring of fish. In the Cauvery basin recreational anglers have contribute significantly to such monitoring programs since the early 1970's. In pic: a WASI research team on a field survey of the Ranganthittu area.

3.8 Current management regime in SFS

At present, SFS is managed through a collaborative effort between DoF and WASI, with each organization serving different aspects of conservation and management to ensure the health and sustainability of the sanctuary's ecosystem (Fig. 12).

1. *Prohibition of commercial fishing*: The DoF and WASI jointly play a critical role in safeguarding fish populations by enforcing a prohibition on commercial fishing within the sanctuary limits. This regulation is designed to prevent overfishing and protect the native fish species, allowing them to multiply and grow. In this regard, the DoF do not issue commercial fishing tenders or fishing licences to any society or individual.
2. *Watch and Ward (WaW)*: WASI is responsible for monitoring and securing the sanctuary through watch and ward activities. This involves regular patrols and remote surveillance to deter illegal activities, such as unauthorized fishing, dynamite fishing, or poaching. Currently, the WaW team consist of five uniformed patrol staff who take turns in routinely patrolling and reporting on illegal activities over a 24-hour cycle. The WaW team are hired from the local community and tasked with maintaining good relations with government authorities, stakeholders and tourists visiting the area. They serve as a crucial link between stakeholders and the SFS management. WaW personnel are encouraged to document offenses rather than to engage with offenders. Incidents and field encounters are documented along with photographs and a report in the WASI wildlife crime database. By maintaining a strong presence, WASI helps to enforce sanctuary regulations, spread awareness about project activities and protect the area's ecological integrity. The field teams are supported by remote surveillance using CCTV camera and camera traps positioned at known offence hotspots and key access points such as roads and foot paths. The CCTV footage is routinely monitored by WASI office bearers and volunteers.
3. *Research and conservation*: WASI also take the lead in conducting ecological research and conservation efforts within the sanctuary. These initiatives focus on studying the behaviour, health, and population dynamics of the fish species, as well as their interactions with the surrounding ecosystem. WASI's research activities contribute valuable knowledge that informs evidence-based conservation strategies to maintain biodiversity. Important research includes studies on the impact of recreational angling on the physiology of mahseer (Bower et al. 2016), mark recapture studies on large-bodied carps (ongoing), long term fish monitoring (Citizen Science), taxonomic studies on mahseer and biodiversity monitoring (ongoing) and radio-telemetry studied on Mahseer (ongoing).
4. *Fish monitoring*: Both DoF and WASI work together in monitoring fish populations. This joint effort includes conducting surveys and assessments to track changes in fish abundance, health, and diversity over time. Through continuous monitoring, employing catch and release angling, they can identify trends and address any emerging threats to fish populations in a timely manner. The program has been self-sustaining for over 18 years and remains one of the few long-term fish monitoring programs in the country (See section 3.6).
5. *Fish stocking*: As part of its management policy, WASI releases around 1,00,000 carp fingerlings each year into the Malligemaradahalla and Forbes Sagar reservoirs. These fish grow healthy and spread into nearby fishing areas where they are caught and consumed by fishing societies. Within the SFS, they are protected and have access to plenty of natural food, allowing them to develop into healthy individuals. This benefits local communities by supporting livelihoods and businesses through their high nutritional value
6. *Community engagement, capacity building, and nature education*: WASI actively collaborates with local communities to promote the conservation objectives of the sanctuary. By raising awareness about the ecological significance of the sanctuary and involving community members in conservation initiatives, WASI aims to foster a sense of shared responsibility and long-term partnerships. Community engagement efforts include educational programs, workshops, internships and volunteer opportunities that enable stakeholders to actively participate in conservation activities.

Over the years, WASI has trained more than 300 individuals in best practices for recreational angling, which have been refined and socially enforced for over five decades. Additionally, 25 individuals from neighbouring villages have been trained as professional angling guides and Watch and Ward patrols, contributing to both conservation and local livelihoods.

Malligemaradahalla lake serves as a key site for exposure visits by government authorities and conservation organizations seeking to learn about wild fisheries management and fish sanctuary conservation. Notable institutions that have participated in these visits include the Karnataka Forest Department, Indian Institute for Human Settlements (IIHS) Bengaluru, Foundation for Ecological Research Advocacy and Learning (FERAL) Bengaluru, National Bureau for Fish Genetic Resources (NBFGR) Lucknow, and Sanctuary Nature Foundation, Maharashtra.
Public engagement initiatives have also played a significant role in increasing awareness about the SFS management and field staff efforts. These include a video (https://www.youtube.com/watch?v=cBP_4WTdM_w) featuring the challenges posed by dynamite fishing in the Cauvery, a podcast episode by *Tigress on Tuk Tuk* (yet to be published), a short film titled *Cauvery WASI*, and an upcoming documentary produced by *Gaia People* and *The Habitats Trust*.

7. *Habitat restoration and clean up:* WASI has undertaken several tree-planting initiatives along selected riparian sites, including a 3-acre restoration project at Malligemaradahalla Lake. This site features a unique swamp wetland that provides habitat for various aquatic species. The SFS, located downstream of multiple human settlements, faces significant challenges due to trash and plastic waste accumulating during the monsoon season. To address this, the Watch and Ward team regularly removes debris from waterways using boats. Additionally, past clean-up drives have targeted popular tourist locations such as the Gaganachukki and Barachukki viewpoints to mitigate pollution and maintain ecosystem health.

The SFS management carefully assesses the ecological implications of fish stocking on native species. While fish stocking has long been a standard fisheries management practice across India, outright prohibition is neither feasible nor straightforward. Currently, the only fingerlings available from government hatcheries belong to the Indian Major Carps (IMC), none of which are native to the Cauvery River basin. To minimize ecological impact, stocking is limited to non-territorial, non-predatory bottom feeders with a broad dietary range, such as *Labeo rohita* (Rohu), *Catla catla* (Catla), and *Cirrhinus mrigala* (Mrigal). This selection ensures a balanced distribution of resource consumption across different ecological niches. Furthermore, there have been no documented instances of these species breeding naturally in the Cauvery basin, supporting existing observations that their populations in such environments are primarily maintained through human intervention. This reduces the likelihood of competition with native fish populations.

On November 4, 2024, the SFS (in collaboration with WASI) hosted a national event to commemorate a milestone conservation initiative led by the NBFGR, Lucknow. As part of this initiative, 1,000 artificially reared fingerlings of the endemic and critically endangered *Hemibagrus punctatus* (Nilgiri mystus), bred from wild-caught brooders, were released into the wild under the sanctuary's protection. The event was graced by Padma Shri *Dr. Subbanna Ayyappan* as the Chief Guest and marked the first-ever successful conservation breeding of a Cauvery-endemic catfish. With over 100 local community members in attendance, the event served as an inspiration for future conservation programs focused on safeguarding the threatened fish species of the Cauvery basin. This collaborative management approach leverages the strengths of both WASI and the DoF, ensuring that the SFS is effectively protected and managed. Each organization brings its expertise to the table, contributing to a holistic strategy that balances ecological preservation with community involvement.

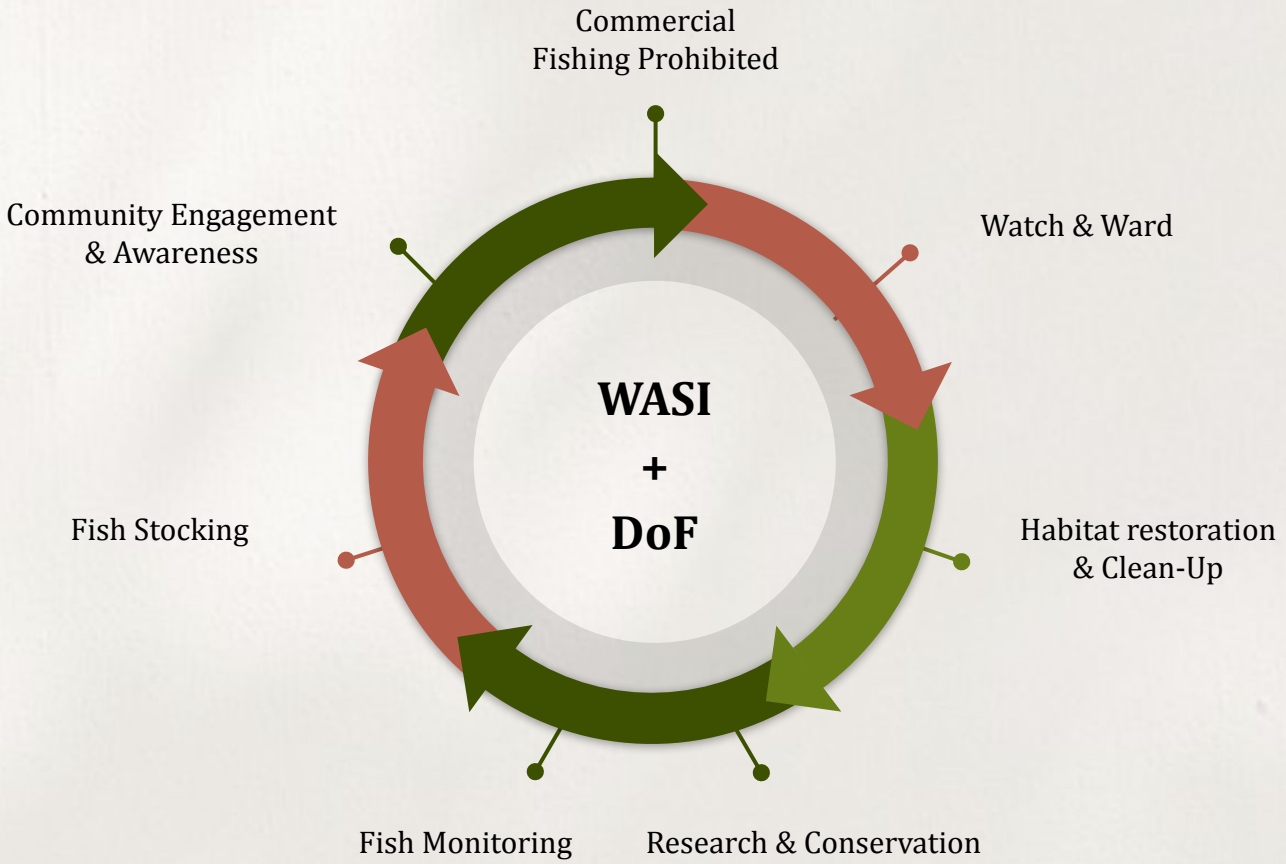


Figure 12: Schematic representation of current management practices in SFS by WASI and DoF

3.8.1 Investments and expenditure

The SFS operations span 18 financial years, with all payment details meticulously documented and maintained in digital spreadsheets. For the purpose of this management plan, expenses have been categorized into five main accounting heads: Administration, Angling Development, Eco-Development and Restoration, Research and Outreach, and Watch and Ward.

Over the 18-year period, total expenditure amounts to ₹1.55 crore, as detailed in Table 5. A rising trend in investments is observed across the management years, despite the COVID-19 lockdown (Fig. 13). There has been a notable increase in expenditure from 2022–23 onwards. During this period, substantial investments have been made in Research and Outreach, as well as in strengthening the Watch and Ward framework through enhanced equipment and patrols.

Administration

Administration expenses have remained consistent and relatively low over the years, averaging less than ₹60,000 annually. These expenditures include local travel and conveyance, as well as travel from Bengaluru to Shivanasamudram via public transport. This category also covers expenditure towards official fees, documentation, panchayat taxes, and singing agreements. Additionally, administration costs include expenses incurred at the Bengaluru office and the purchase and maintenance of office equipment.

Angling development

Significant investments in angling development began in FY 2018–19, primarily due to the hiring of dedicated recreational angling guides. These guides assist anglers, ensure compliance with Angling Best Practices, and oversee the accurate reporting of research data. Other key expenditures under this category include costs related to renewing four government fishing leases for conservation, the annual stocking of 1,00,000 fingerlings of Rohu, Catla, and Mrigal (from the DoF), and investments in safety equipment, boats, and angling platform construction.

Eco-development and restoration

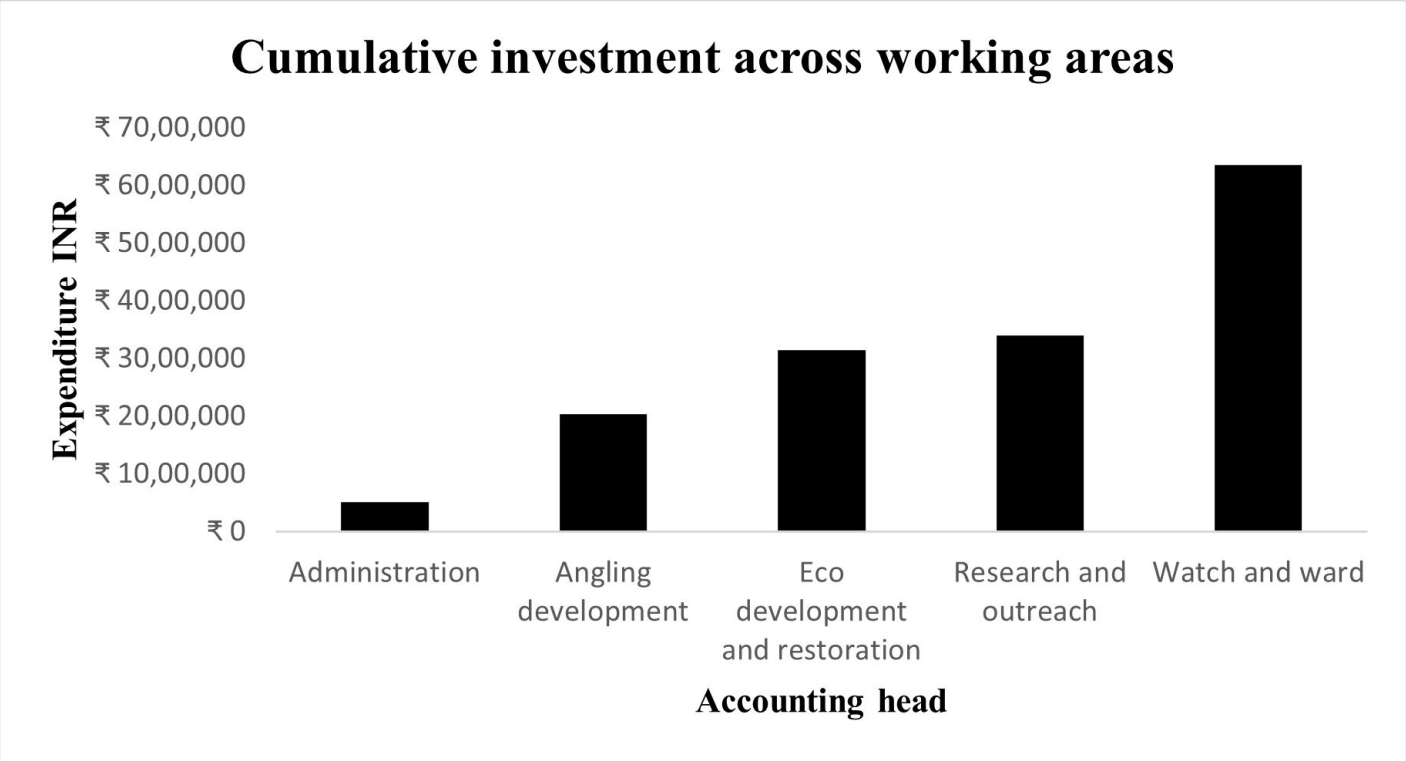
Since its inception, SFS management has prioritized eco-development and nature education. Under this category, significant investments have been made in restoring bank integrity by promoting the natural growth of grasses and reeds and planting over 1,000 trees in and around water bodies. Restoration initiatives also include regular waterway clean-ups and the establishment of a wetland ecosystem as a habitat refuge for aquatic flora and fauna.

To facilitate nature immersion and experiential learning, SFS management has invested substantially in infrastructure at the Malligemaradahalla (Cottage Lake) campus. The campus is equipped with two kitchens, bathrooms, outdoor camping facilities, and audio-visual amenities. These facilities also serve as Watch and Ward (WaW) camps and accommodations for interns and volunteers. In FY 2023–24, SFS management plans to establish a second campus adjacent to the SFS, expanding its nature education awareness program to the large number of tourists visiting the Shivanasamudram waterfalls on weekends.

Research and outreach

WASI's research program, initiated in 2014, has grown into one of the largest in the state, focusing on the ecology of the mahseer and the Cauvery River Basin. Research and outreach expenses have steadily increased, initially relying on in-house funding. Since FY 2022–23, WASI has sought external funding from sources such as crowdfunding, wildlife grants, and CSR projects to expand research programs and enhance outreach efforts.

Key expenditures under this category include costs incurred during research expeditions, hiring and training professional field guides for riverine research, purchasing state-of-the-art equipment for ecological studies, and providing free internships and volunteer programs for school and university students interested in riverine research.



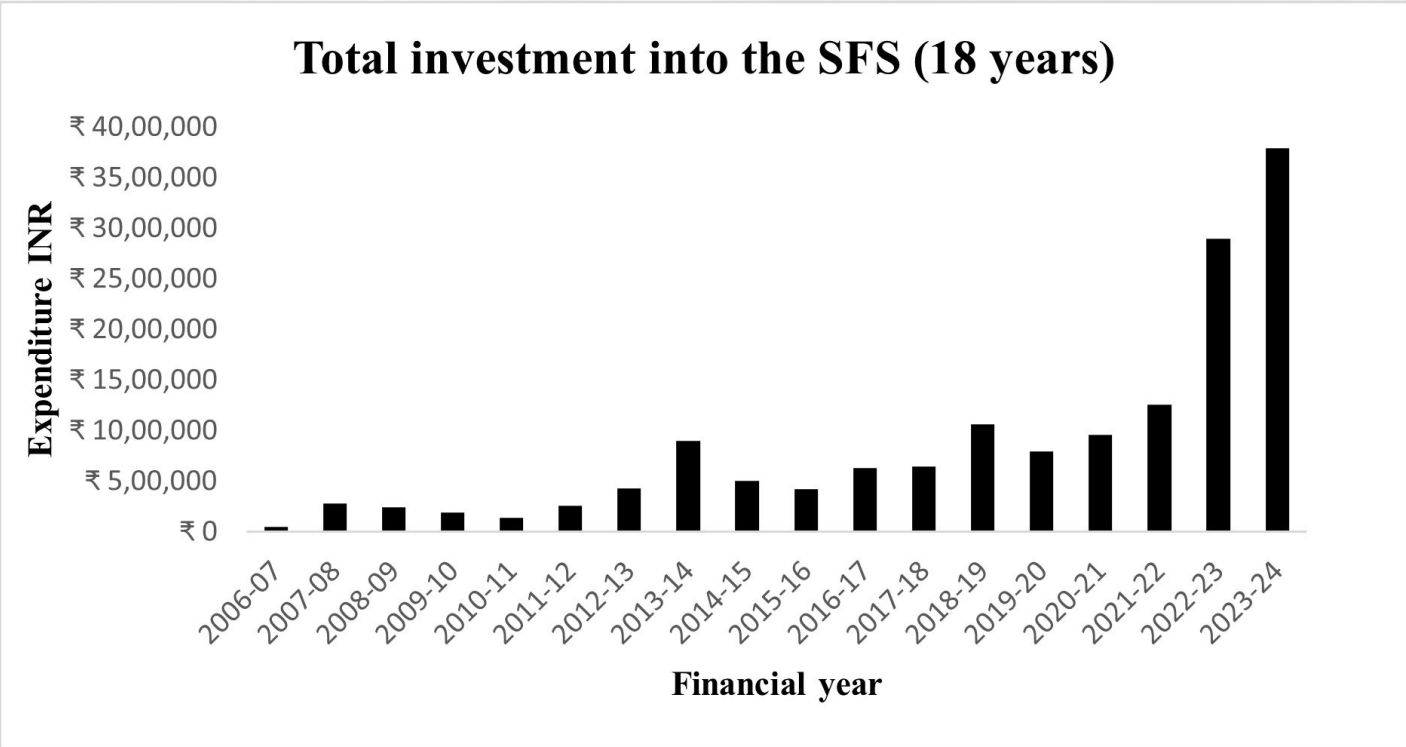


Figure 13: Overview of expenditures in SFS management across key categories (top) and time (below)

Table 5: Summary of expenditures per financial years allocated to various components of SFS management.

Financial year (FY)	Administration	Angling development	Eco development and restoration	Research and outreach	Watch and ward	Grand Total
2006-07	₹ 2,083	₹ 1,361	₹ 20,826	₹ 0	₹ 28,000	**₹ 52,270**
2007-08	₹ 23,071	₹ 4,024	₹ 24,159	₹ 0	₹ 2,26,897	**₹ 2,78,151**
2008-09	₹ 20,295	₹ 13,500	₹ 23,700	₹ 0	₹ 1,86,686	**₹ 2,44,181**
2009-10	₹ 13,534	₹ 23,100	₹ 7,610	₹ 0	₹ 1,49,000	**₹ 1,93,244**
2010-11	₹ 8,854	₹ 2,574	₹ 7,330	₹ 0	₹ 1,22,960	**₹ 1,41,718**
2011-12	₹ 12,117	₹ 34,337	₹ 14,995	₹ 0	₹ 1,98,337	**₹ 2,59,786**
2012-13	₹ 10,709	₹ 2,779	₹ 2,18,772	₹ 400	₹ 1,93,355	**₹ 4,26,015**
2013-14	₹ 27,764	₹ 1,32,570	₹ 3,31,146	₹ 17,920	₹ 3,88,180	**₹ 8,97,580**
2014-15	₹ 11,929	₹ 29,797	₹ 57,217	₹ 1,36,419	₹ 2,67,880	**₹ 5,03,242**
2015-16	₹ 31,594	₹ 11,402	₹ 64,470	₹ 18,568	₹ 2,97,210	**₹ 4,23,244**
2016-17	₹ 51,915	₹ 1,61,020	₹ 63,389	₹ 43,667	₹ 3,13,580	**₹ 6,33,571**
2017-18	₹ 46,775	₹ 2,846	₹ 2,60,505	₹ 27,405	₹ 3,04,195	**₹ 6,41,726**
2018-19	₹ 38,119	₹ 2,04,338	₹ 2,46,608	₹ 79,288	₹ 4,95,513	**₹ 10,63,866**
2019-20	₹ 39,597	₹ 2,13,379	₹ 59,650	₹ 1,32,381	₹ 3,51,030	**₹ 7,96,037**
2020-21	₹ 20,096	₹ 2,40,763	₹ 90,684	₹ 2,52,387	₹ 3,57,519	**₹ 9,61,448**
2021-22	₹ 38,393	₹ 2,84,107	₹ 82,057	₹ 4,37,330	₹ 4,13,506	**₹ 12,55,393**
2022-23	₹ 59,766	₹ 3,94,459	₹ 1,18,928	₹ 11,58,806	₹ 11,61,873	**₹ 28,93,832**
2023-24	₹ 57,504	₹ 2,80,320	₹ 14,56,907	₹ 10,92,859	₹ 8,99,969	**₹ 37,87,559**
Grand total	**₹ 5,14,115**	**₹ 20,36,676**	**₹ 31,48,953**	**₹ 33,97,430**	**₹ 63,55,689**	**₹ 1,54,52,863**

Watch and Ward (WaW)

The Watch and Ward program has received the largest share of investment under SFS management. Since its inception, the WaW patrol team has comprised between two and six members. Salaries, which initially averaged ₹2,500 per month, have increased to an average of ₹14,500 (a 480 % increase over 18 years) by the end of FY 2023–24.

SFS management recognizes the dedication and courage required by WaW personnel and has invested in their social welfare, medical care, children's school fees, and insurance schemes to safeguard their families. In the past two financial years, management has also upgraded remote surveillance by installing CCTV cameras in high-risk areas prone to dynamite fishing, animal poaching, and trapping. Additional expenditures include equipping patrol teams with safety gear, uniforms, boats, and flashlights.

A coracle or *theppa* is a versatile boat that is used frequently for angling and patrolling water bodies in the SFS

PC: Naren Sreenivasan

4. SOCIAL CONTEXT OF THE SFS

4.1 Social dimensions— Community experiences and engagement

Community experiences and collaborative engagement in the SFS management should be considered seriously to ensure the sustainability and effectiveness of management. This is specifically imperative in the context of SFS, wherein waterways were historically utilized by local people. Research in forest conservation shows that when communities participate in conservation efforts, they are more likely to follow the rules, resulting in healthier ecosystems (Niraula et al., 2013; Loveridge et al., 2021; Fischer et al., 2023). Engaged communities feel a sense of belonging when they are involved in decision-making, instead of unilateral power display where they are excluded from access to the place and resources (Roy & Sengupta, 2025- in press).

4.1.1 The importance of involving local communities

While the joint efforts of DoF and WASI are vital for protecting the fish species in SFS, the success of these efforts will depend on how well they integrate the needs, knowledge, and participation of the local community. Conservation cannot be seen as an isolated, top-down 'fortress conservation' process; rather, it must be inclusive, offering sustainable solutions for both the environment and the people who rely on it.

1. *Local knowledge and practices*: Local communities often possess traditional ecological knowledge that can enhance management strategies. Their involvement ensures that valuable insights and sustainable practices are integrated into the management plan.
2. *Stakeholder involvement*: Engaging community members as stakeholders fosters a sense of ownership and responsibility for the sanctuary, promoting better compliance with regulations and conservation initiatives.
3. *Conflict resolution*: Community engagement facilitates addressing potential conflicts between conservation goals and local livelihoods, such as fishing rights. Open dialogue helps develop compromises that benefit both the ecosystem and the community.
4. *Social cohesion*: Collaborative conservation efforts can strengthen community bonds and foster a shared sense of purpose and relational values aligned with sanctuary protection.
5. *Economic resilience*: Community involvement can support the development of alternative income streams that reduce pressure on fish populations, contributing to long-term sustainability. For example, WASI's experience in catch-and-release angling can offer fishermen and anglers new opportunities.
6. *Environmental education*: Involving local communities in nature-based education programs fosters knowledge exchange between participants, enhancing awareness and promoting sustainable practices.

4.2 Perspectives of local communities on the current state of SFS

Using a social science research framework, data were gathered from 7 key informants, including officials from the Shivanasamudram power station, members of the *Gram Sabha*, and erstwhile representatives of local fishing cooperatives, as well as 28 local residents of the Bluff area. The methods utilized included personal interviews (Int.; Weller, 1998), focus group discussions (FGD; Parker & Tritter, 2006), and narrative walks (NW; Moles, 2008). The tools applied were semi-structured questionnaires and observation checklists. Prior to analysis, all responses were compiled, and the specific data collection method used for each respondent was documented to facilitate accurate coding. Verbal and written consent were obtained from all respondents prior to data collection. The majority of the information collected was audio recorded, while the remaining data were documented in handwritten form. These responses were transcribed verbatim and analysed using value-coding techniques, as adapted from Yuliani et al. (2022), together with descriptive statistics. The initial stage of analysis involved inductive coding (Thomas, 2003) to identify emergent themes, followed by multiple revisiting of the data to interpret responses within the context of SFS management (Fig. 14).

Three major themes emerged from our conversations with respondents about the social dimensions related to the SFS: (1) Preserving cultural symbolism and rituals through SFS regulative framework; (2) Community exclusion in SFS governance, and (3) the adoption of integrative conservation approaches in SFS management. The following sections elaborate on these themes, incorporating direct insights from respondents. To maintain confidentiality, respondents are not identified by name but by coded identifiers based on the method of data collection. For example, "Int. 2" refers to the second interview respondent, "NW 3" denotes the third respondent in a narrative walk, and "FGD 6" corresponds to the sixth respondent in a focus group discussion.

Preserving cultural symbolism and rituals through SFS regulative framework

The Cauvery River holds notable cultural and spiritual significance for local communities, deeply embedded in their traditions and practices. For instance, residents visit the river to symbolically invite it to weddings, collect water for rituals, and consume its water, which is valued for its perceived sweetness. However, these cultural affiliations primarily centre around the river itself rather than the fishes within it. During weddings, river water is often transported for use in traditional rituals and customs. One respondent (Int. 7) explained, "*We treat the Cauvery River as a goddess. Before any major event, like a wedding, we invite the river's blessings by collecting its water. It is not just a custom; it is a deeply spiritual practice for us.*" Another added (Int. 12), "*The river water has a unique sweetness. It is unlike any other water and is essential for our rituals.*"

The cultural practices associated with the river are predominantly rooted in the beliefs of Hinduism. A prominent example is the Chikka-Muttati temple, dedicated to Lord Hanuman, situated along the riverbank bordering the SFS area. Festivals and rituals linked to the temple are scheduled according to the Hindu calendar and draw significant local participation. "*During the temple festivals, the entire village gathers*", one respondent (Int. 17) explained. "*It is not just about religion; it is a time for us to connect as a community.*"

Through the SFS framework, efforts to protect the river ecosystem not only ensure ecological balance but can also help preserve its cultural symbolism and traditions, which remain integral to the identity of local communities.

Although the mahseer fish is considered an iconic species due to its large size and strength, there are no significant rituals or beliefs specifically associated with it. One respondent (FGD 3) noted that illegal activities, such as dynamite fishing and habitat destruction through blasting, had led to a significant decline in the mahseer population before the sanctuary was established. Protective measures implemented through SFS management since then have allowed the fish population to recover, making them a more common sight. "*The Mahseer is the king of the river,*" a respondent said. "*Seeing it swim freely again after so many years gives us hope that we can restore the river's health.*"

Community exclusion in SFS governance: Challenges and implications

Respondents highlighted a lack of involvement of local communities in decision-making processes related to the sanctuary's management. When asked about the potential for sustainable local engagement, one respondent (NW 2) remarked: "*Of course! Local people are the best protectors of the river because we have an intrinsic connection to it that spans generations. We have lost complete access to the area, a place that once belonged to us and held deep cultural and livelihood significance. It feels unjust that decisions are being made without our involvement. They should actively engage more with the local community and include us in the decision-making process, rather than unilaterally imposing regulations. Our insights and traditional knowledge could significantly contribute to the sustainable management of the sanctuary.*"

Figure 14: Representative images from social data collection methods—1. Personal interview, 2. Narrative walk, 3. Focus group discussion

Another respondent (Int. 24) expressed frustration over the exclusionary nature of current management practices: "*They have drawn boundaries and implemented rules without consulting us or seeking our input. This river, which has always been an integral part of our lives and community, belongs to all of us. Yet, the way things are managed now makes us feel like outsiders, disconnected from a resource that once defined our identity and livelihoods.*"

Several respondents (78 %; N= 35) believed that involving locals could help curb illegal practices such as dynamite fishing and foster a sense of stewardship. Many traditional fishermen, forced to abandon their livelihoods due to sanctuary regulations, expressed dissatisfaction with the lack of consultation and sudden imposition of rules. One respondent (Int. 28) shared their frustration stating that this exclusion has diminished the community's sense of belonging and pride in their traditional practices: "*The way decisions are made now makes us feel disconnected from the river. It's as if our role and traditions no longer matter.*"

Some of the respondents (22 %, N= 35) also emphasized the detrimental impact of management decisions on traditional livelihoods, lamenting: "*The river is natural, and so are the fishes. The authorities have turned it into something mechanical, a small reservoir with so much protection that it feels artificial. We have lost our traditional livelihood streams, and people now feel ashamed to admit they were fishermen. Is this the world we aspire to?*"

Integrative conservation approaches in SFS management

The respondents acknowledged the positive impact of the SFS conservation efforts. These initiatives have been credited with the revival of species like the mahseer. "*We would not see these fish today if not for WASI's efforts*," a respondent (FGD 9) noted. "*But conservation should also include us, the locals, who know this river better than anyone else.*"

One respondent (Int. 15) proposed employing retired staff from the nearby power station, who have both local knowledge and strong community ties, as part of the sanctuary's management framework. "*These individuals have seen the river change over decades,*" he explained. "*They can bridge the gap between conservation efforts and community needs.*" Another respondent, FGD 5, suggested regular interaction programs between WASI, local residents, and key stakeholders to improve transparency and mutual understanding. "*If we are included in the discussions, we will understand the purpose behind the rules,*" he said. "*Right now, it feels like we are being excluded from our own heritage.*"

Additional concerns included the safety of field staff, who often encounter wild animals during patrols, and the need to address invasive species such as water hyacinth, which threaten the sanctuary's ecological balance. Some of the respondents (23 %, N= 35) emphasized the importance of holistic conservation strategies that integrate both ecological protection and community welfare, ensuring that all stakeholders feel valued and empowered: "*We need more patrol staff,*" one respondent shared (FGD 7). "*Some areas are too dangerous because of wild animals. Proper support would make these jobs safer.*"

Another respondent (NW 1) underlined the importance of holistic conservation efforts, stating, "*If we let the water hyacinth grow unchecked, they will choke the river and disrupt the entire ecosystem. Conservation is not just about saving fish; it is about preserving the whole ecosystem. The river sustains not only aquatic life but also the livelihoods and traditions of the communities that depend on it. Ignoring issues like invasive plant species means risking the delicate balance that supports everything from fish populations to water quality.*" This perspective highlights the interconnected nature of conservation, where addressing one aspect, like invasive species, has broader implications for maintaining ecological health and community well-being. Proactive management of invasive plants, like *Pontederia crassipes* (Water hyacinth), is seen as essential for ensuring the long-term sustainability of both the river's biodiversity and its role as a cultural and economic lifeline.

4.2.1 Identifying key players for involvement

- *Local communities*: Residents who depend on the sanctuary for their livelihoods or recreation should be involved in decision-making processes, as they have valuable knowledge and a vested interest in maintaining the ecosystem.
- *Fishermen and fishing cooperatives*: Engaging local fishermen can provide insights into fish populations and sustainable practices, helping to create regulations that are effective and acceptable.
- *Village institutions*: These institutions (like *Gram Sabha* and *Gram Panchayats*) can help build trust between the community and external stakeholders, facilitating collaboration and participation. They can also assist in mobilizing resources and support for conservation efforts, whether through funding, volunteer efforts, or educational programs.
- *Local tourism operators*: Those involved in hotel chains and resorts in that area and are interested in eco-tourism can help promote sustainable practices and raise awareness about the importance of the sanctuary.
- *Grassroots-level environmental leaders*: An environmental steward and leader, even if they are not from the local community but have experience working on fish sanctuaries at the grassroots level, can join the community team. Their involvement can inspire local people by demonstrating that dedicated individuals are working for a change, encouraging them to believe they can make a difference as well.

4.2.2 Types of involvement

Broadly, there are five different, yet interconnected ways local communities in the SFS area can be involved in the management regimes of the sanctuary:

1. Informative involvement

   a. Providing the community with information about fish sanctuary management, conservation efforts, and ecological practices. It is a passive way of involvement but directly caters to the sense of empowerment of local communities.
   b. This can be achieved through distributing newsletters, social media, and community meetings to disseminate knowledge.

2. Consultative involvement:

   a. Seeking feedback from community members on proposed plans or initiatives, while being open to constructive criticism. It is mostly built on the principles of inclusion within diversity supporting popular opinions and outliers alike.
   b. This can be accomplished by conducting surveys, focus groups, or public forums to collect opinions and suggestions. Additionally, local residents can participate in fish stocking and may serve as local partners in research-driven projects.

3. Collaborative involvement:

a. Collaborating with community members to implement the sanctuary guidelines, which involves them directly in the plan.
b. This approach can be strengthened by prioritizing the hiring of individuals from local communities or collaborating with local organizations to enhance engagement and distribute responsibilities more effectively. Employing local community members directly not only fosters economic opportunities but also ensures a deeper understanding of local ecological and socio-cultural contexts.

4. Empowered involvement:

a. Encouraging community members to take leadership roles in decision-making processes. This is largely based on the idea that having local representatives in decision-making committees better reflects local issues.
b. This can be done by supporting local initiatives that promote stewardship and sustainable practices or having a local leader on board who is collectively voted by the communities.

5. Voluntary involvement:

a. Inviting community members to participate in volunteer opportunities such as clean-up drives, fish counting, angling events, educational programs, or monitoring activities.
b. This can be achieved through recognizing and appreciating the contributions of volunteers to build a sense of ownership.

Over the past 50 years, WASI has developed a community around freshwater conservation. From the organizations member base to training professional angling guides, community has been at the core of WASI's work.

A cormorant attempts to capture a mahseer signifying an ecological continuum between land and water.

PC: Barbara Van der Ven

5. ECOLOGICAL CONTEXT OF THE SFS

5.1 Present land use and practices

The land use in the Shivanasamudram area, including the SFS, represents a delicate balance between conservation initiatives and significant human habitation. The sanctuary's primary purpose is to restore and safeguard critical aquatic habitats essential for the survival and reproduction of various native fish species, thereby conserving the ecosystem. Within the waterways and areas surrounding them, conservation measures are emphasized to preserve ecological integrity, with restrictions on activities that could disrupt the natural riverine ecosystem and/or cause harm to wildlife.

In the areas surrounding the sanctuary, land use includes extensive human habitation, encompassing residential zones and agricultural lands. The nearby villages and settlements depend heavily on the waterways for domestic use and irrigation. Agricultural activities, such as paddy cultivation, coconut and banana plantations, and vegetable farming, are closely linked to waterbodies. However, the abstraction of water for these purposes poses a challenge, highlighting the need to balance agricultural demands with the ecological requirements of the sanctuary.

Riparian vegetation plays a critical role in maintaining water quality and preventing erosion, and efforts are being undertaken to conserve natural vegetation in these areas. However, vegetation along canals and tank bunds is routinely cleared for maintenance, despite these areas serving as important habitats for numerous freshwater species. To enhance the ecological resilience of riparian zones, reforestation efforts and the management of invasive species are being actively implemented. Beyond agriculture, the region also supports a growing tourism sector. Eco-tourism initiatives, particularly those highlighting the river's biodiversity and scenic value, are being promoted as part of broader sustainable development strategies. Designated tourism zones, such as Malligemaradahalla Lake and the Gaganachukki-Barachukki Falls viewpoint, along with eco-friendly accommodations, are designed to minimize ecological impacts while generating economic benefits for local communities.

The waterways in and around the SFS area are experiencing intense fishing pressure due to the high demand for fish meat. Fish harvested from these waters are supplied to individuals, local festivals, and markets such as the Shivanasamudram-Handpost market, with some catches even transported to neighbouring towns and cities. This escalating demand has led to unsustainable fishing practices, particularly during the summer months (February–July), when fish populations are most vulnerable. Methods such as dynamite fishing, trapping (using cages), and gill netting are commonly employed, posing significant ecological threats by depleting fish stocks and disrupting aquatic habitats.

Beyond fishing, the use of dynamite for hunting wild boar and deer is emerging as a major conservation and human-wildlife conflict issue. These indiscriminate methods not only impact wildlife populations but also pose severe risks to people and livestock. In a recent incident reported by WASI's WaW team on November 21, 2024, two cows suffered catastrophic injuries when they accidentally chewed on dynamite-laced bait (mouth bombs), disguised with corn. The detonation destroyed their lower jaws, necessitating their euthanasia. Despite being formally reported, no action was taken by the authorities. In a similar incident a few weeks later around BRT (within 25 Km of SFS), four cows and one young boy were injured by a mouth bomb, the boy unfortunately lost his hand. Mouth bombs are regularly deployed between 9 PM and 6 AM, making them an imminent danger to wildlife, domestic animals, and even children. Such incidents are increasingly being reported from the area.

Other forms of poaching and human-wildlife conflict continue to threaten biodiversity in the region. On December 7, 2024, an elephant was electrocuted on the PGL Road after stepping on a fallen high-tension wire; the incident was subsequently addressed by the Karnataka Forest Department, Kollegal Division. Additionally, on September 30, 2024, the WASI Watch and Ward team discovered the bloated remains of an adult pangolin, suspected to have been poisoned in a neighbouring agricultural field. Unfortunately, a post-mortem examination was not possible.

Such incidents are not isolated but rather indicative of a larger, ongoing crisis. Cases of illegal fishing, poaching, and human-wildlife conflict are systematically documented in a wildlife crime database maintained by WASI. The increasing frequency and severity of these activities underscore the urgent need for enhanced enforcement measures, community engagement, and stricter regulations to mitigate the threats facing the region's aquatic and terrestrial ecosystems.

5.2 Geology and geography

The Cauvery River flows eastward for approximately 880 km from its origin at Talakaveri in the Brahmagiri Hills (Western Ghats) to its confluence with the Bay of Bengal. The river's elevation profile (Fig. 15) can be divided into three distinct reaches based on variations in slope gradient. The upper course extends from Talakaveri to the Shivanasamudram Falls, which marks the ridge of the Deccan Plateau. The middle course, characterized by the steepest gradient, extends from Shivanasamudram Falls to the Mettur Dam. This segment, which traverses the Cauvery Wildlife Sanctuary for approximately 117 km, represents the most biodiverse stretch of the river, supporting 76 confirmed fish species (expected be range between 95-120 species), over 60 species of mammals and reptiles, and one of the richest avian diversities in South India. The lower course extends from the Mettur Dam to the Bay of Bengal.

Several significant tributaries join the Cauvery upstream of the SFS, with ten being classified as major tributaries, all of which have dams, except for the Lakshmanathirtha River. The Harangi, Hemavathi, Lakshmanathirtha, and Kabini Rivers drain into the Krishna Raja Sagara reservoir, while the Suvarnavathy River (now seasonal) converges with the Cauvery near Talakadu, just upstream of the SFS. Two major dams upstream of the SFS regulate water flow into the sanctuary: the Krishna Raja Sagara Dam (completed in 1931) and the Kabini Dam (completed in 1974). At the origin of the SFS, the Shiva Anicut, a U-shaped weir constructed across the Cauvery River, diverts water toward the Shivanasamudram area for hydroelectric power generation and to pumping stations that supply water (~1,500 Million Litres per Day) to Bengaluru, the capital city of Karnataka.

Metamorphic gneiss rocks line the bed of the Cauvery River. Formed by ancient volcanic eruptions during the rise of the Deccan Plateau, molten rock folded under immense pressure—leaving behind the striking mineral veins visible in these formations today.

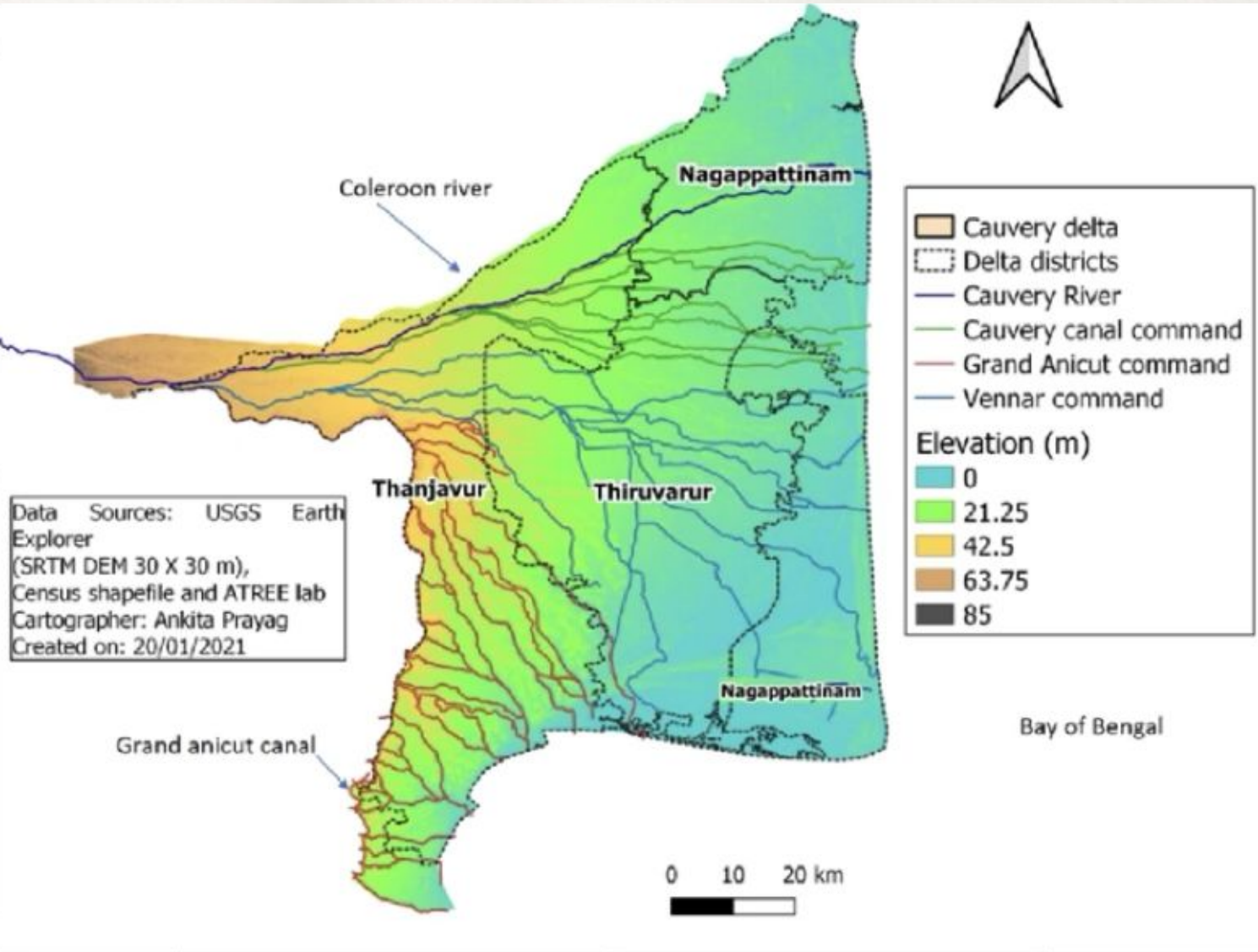


Figure 15: The digital elevation map of the Cauvery Delta with canal network and districts; Source: Prayag et al., 2023

The geological composition of the region is predominantly metamorphic, with formations originating from the Deccan Traps. Common rock types include gneiss, quartzite, hornblende, and schist, while igneous formations such as black granite and Tiger Black granite appear as outcrops at higher elevations. The soil composition varies significantly across the landscape. Red sandy loam is prevalent, while clay deposits are found along the riverbanks. Sand deposits are distributed throughout the riverbed. Soil characteristics, including structure, composition, and depth, vary depending on the local topography and geomorphological features.

5.3 Floral distribution

Plant surveys were conducted across various seasons between May and December 2024, following an opportunistic sampling approach along various walking trails. All observed species were documented in the field (Appendix 6), while unidentified specimens were photographed and later identified using online resources. Aquatic plant surveys were conducted by boat, with specimens collected from water bodies and identified to the species level.

The SFS area exhibits a diverse assemblage of plant species, encompassing a total of 147 unique species distributed across 52 botanical families. The family Fabaceae emerges as the most dominant, with 34 species recorded, followed by Apocynaceae (9 species), Convolvulaceae (8 species), Lamiaceae (5 species), and Malvaceae (5 species) (Fig. 16). The dominance of Fabaceae suggests its ecological adaptability and possible importance in nitrogen fixation, which could influence soil fertility and ecosystem dynamics. The representation of multiple families highlights the floristic richness of the region and underscores the need for detailed ecological evaluations.

Regarding nativity, 87 species (59 %) are native, 58 species (39 %) are non-native, and 2 species (2 %)— *Cocos nucifera* (Coconut) and *Tamarindus indica* (Tamarind)— are considered possibly native due to their widespread cultivation (Fig. 16). The predominance of native species suggests that the region still retains a significant proportion of its indigenous vegetation, playing a vital role in maintaining local biodiversity. However, the presence of non-native species, including known invasive taxa such as *Argemone mexicana* (Mexican prickly poppy), *Chromolaena odorata* (Devil weed), *Lantana camara* (Lantana), and certain species of *Senna* (Golden wonder) raises concerns regarding potential ecological competition, habitat degradation, and resource depletion. A comprehensive investigation into the functional traits and ecological roles of these non-native species is essential to understand their impact on ecosystem stability and long-term habitat resilience.

From a conservation standpoint, the IUCN Red List assessment reveals that 58 species fall under the Least Concern (LC) category, while a smaller subset is classified under threatened categories: 8 species as Vulnerable (VU), 2 as Endangered (EN), 4 as Near Threatened (NT), and 5 as Data Deficient (DD) (Fig. 16). The remaining 70 species are not listed in the IUCN database, highlighting significant knowledge gaps in their conservation status. The presence of VU and EN species underscores the urgent need for conservation interventions, such as habitat protection and population monitoring, to prevent further decline. Additionally, the absence of assessment for a considerable number of species emphasizes the necessity for further taxonomic and ecological research to better understand population trends and potential threats.

The habit-based classification of species reveals that trees dominate the SFS landscape with 67 species, followed by herbs (30 species), shrubs (24 species), climbers (14 species), and aquatic herbs (12 species). The prevalence of tree species suggests a relatively stable canopy structure, which can provide essential ecosystem services such as carbon sequestration, microclimate regulation, and habitat provisioning for various faunal groups. The presence of a considerable number of herbaceous and shrub species indicates a well-developed understory layer, potentially supporting a diverse range of pollinators and seed dispersers. The occurrence of climbers and aquatic herbs, though in lower numbers, suggests the presence of varied microhabitats within the study area, contributing to the overall ecological heterogeneity.

The plant species within the SFS area play vital ecological roles and provide a broad spectrum of ecosystem services, contributing to biodiversity, habitat stability, and sustainable land management. Tree species such as *Prunus dulcis* (Almond) enhance both ecological balance and agricultural productivity by serving as a food source and habitat for various organisms. Large canopy-forming trees like *Artocarpus heterophyllus* (Jackfruit) and *Ficus benghalensis* (Banyan) further support biodiversity by creating microhabitats, stabilizing soil, and regulating the hydrological cycle, which is particularly crucial in this riverine ecosystem.

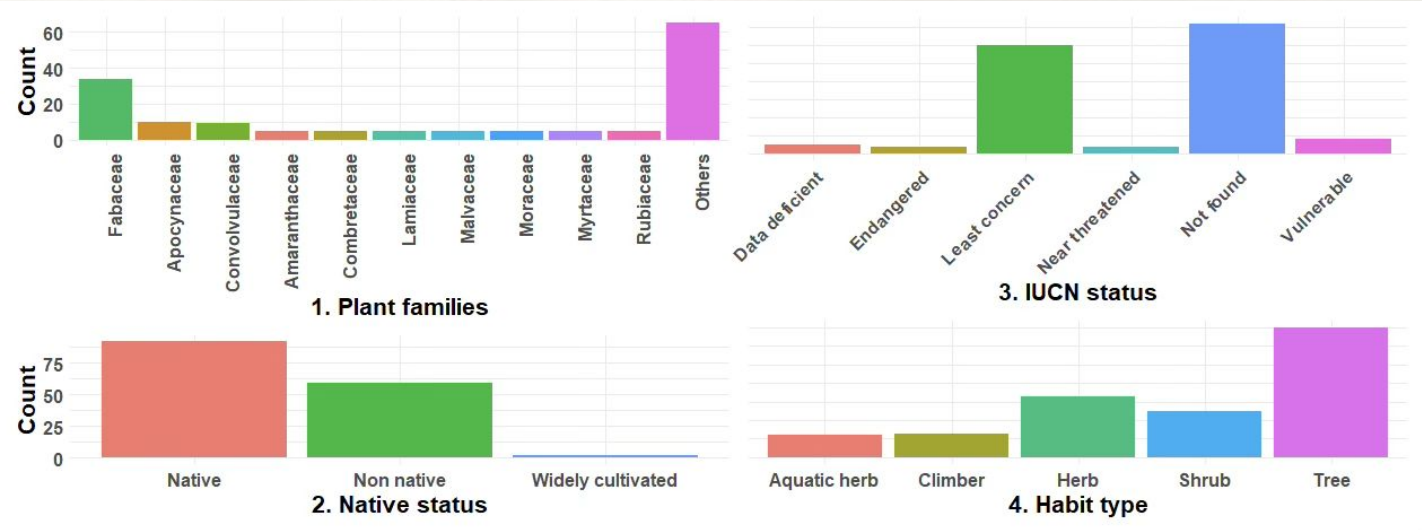


Figure 16: Summary of floral distribution, including: (1) the number of species per family, with families containing fewer than five species grouped under "Others"; (2) native status, with two species that are possibly native but widely cultivated; (3) conservation status based on the IUCN Red List of Threatened Species; and (4) the five habit types

Fast-growing pioneer species such as *Albizia saman* (Monkeypod tree) play a significant role in carbon sequestration while also providing shade for understory vegetation, thereby promoting habitat heterogeneity. Moreover, certain species such as *Azadirachta indica* (Neem) is well known for its pest-repellent properties. *Calotropis procera* (Giant milkweed), a xerophytic species adapted to arid conditions, contributes to erosion control and has various ethnobotanical uses. Meanwhile, *Erythrina variegata* (Indian coral tree) serves as a crucial nectar source, supporting pollinators and playing an essential role in agroforestry.

Riparian vegetation plays a crucial role in maintaining the stability and functionality of riverine ecosystems by facilitating water filtration, sediment retention, and nutrient cycling. Among these, *Spirodela polyrhiza* (Common duckweed) contributes significantly to water quality regulation. Beyond their ecological functions, several riparian plant species also possess bioactive compounds with important medicinal applications. *Bacopa monnieri* (Water hyssop), a cornerstone of Ayurvedic medicine, is rich in neuroprotective compounds and has long been used to manage cognitive disorders, insomnia, epilepsy, and anxiety. Likewise, *Toddalia asiatica* (Orange climber) contains phytochemicals with antimalarial, antipyretic, and analgesic properties, making it a valuable resource for treating malaria, fever, respiratory infections, and musculoskeletal pain.

Beyond the riparian zone, the herbaceous layer further contributes to ecosystem stability. Species such as *Leucas aspera* (Common Leucas) and *Polygonum glabrum* (Common marsh buck-weed) provide essential ground cover, reducing soil erosion and promoting soil moisture retention. Leguminous plants like *Crotalaria verrucosa* (Blue rattlepod) play a key role in nitrogen fixation, thereby enhancing soil fertility and supporting plant community dynamics. Additionally, climbers such as *Tinospora cordifolia* (Ambevel) enhance vertical stratification in the forest canopy, fostering habitat complexity and optimizing light availability for diverse flora and fauna. The coexistence of these ecologically and pharmacologically significant species stresses the intricate balance between biodiversity conservation and ethnobotanical potential, emphasizing the need for continued research and conservation efforts. The dataset (Appendix 6) also categorized species based on their locations, suggesting potential site-specific floristic patterns. For example, the presence of species like *Albizia saman* (Monkeypod tree) and *Senna tora* (Sickle Senna) in Bhoruka might indicate preferences for certain microclimatic or soil conditions prevalent in this area. Understanding these spatial patterns is decisive for formulating localized conservation strategies.

The diverse vegetation of the SFS area highlights its ecological, economic, and conservation significance, underscoring the need for comprehensive conservation strategies. Protecting both dominant and less prevalent species is crucial for maintaining ecosystem stability and biodiversity. The IUCN Red List classifications further underscore the urgency of conservation efforts, particularly for threatened species such as *Saraca asoca* (Ashoka), categorized as Vulnerable, and *Terminalia arjuna* (Arjuna), listed as Endangered. Targeted conservation interventions are essential to mitigate their population decline and safeguard their ecological functions. Additionally, the proliferation of invasive species like *Argemone mexicana* and *Lantana camara* poses a significant threat to the native biodiversity in the region, necessitating continuous monitoring and management. Future research should focus on assessing functional traits, population dynamics, and species interactions to inform sustainable conservation and management strategies.

5.4 Faunal distribution

Visual encounter surveys, time constrained line transects and point counts were used to create a checklist of fauna occurring in and around the SFS. The surveys were carried out between May and December 2024. Additionally, reports of animals from interviewees and from the WASI archives and studies were included in the checklist.

5.4.1 Piscean diversity

The fish diversity within the SFS area has been systematically documented using multiple data sources, including angling records, photographic evidence, interviews, visual observations, and market surveys. A total of 41 fish species across 17 families were identified within the sanctuary boundaries. However, species richness is estimated to be higher (60–90 species) in the surrounding riverine sections, likely due to increased habitat heterogeneity. Notably, the sanctuary harbours endemic and threatened species, alongside translocated and invasive taxa, necessitating an integrated conservation and management approach.

The documented fish assemblage in SFS is dominated by Cyprinidae, which exhibits the highest species richness and abundance. Other prominent families include Bagridae and Siluridae, represented primarily by native catfish species (Fig. 17). The presence of a freshwater jellyfish, *Limnocnida indica*, further highlights the ecological complexity of the system. The distribution of species across diverse habitat types suggests a structurally complex fish community.

Among the 41 documented species, 28 are categorized as Least Concern, indicating their relative abundance and stability. However, the sanctuary also supports three Critically Endangered species, two Endangered species, and two Vulnerable species, emphasizing its conservation significance. Additionally, two species are classified as Near Threatened, while three are Data Deficient, highlighting gaps in knowledge that necessitate further research (Fig. 17). One species lacks an assigned conservation status. This distribution underscores the importance of targeted conservation measures to protect at-risk species within the SFS.

Of the 41 species recorded, eight were identified as translocated or exotic. Five species— *Clarias gariepinus* (African catfish), *Ctenopharyngodon idella* (Grass carp), *Cyprinus carpio* (Common carp), *Oreochromis niloticus* (Nile tilapia), and *Pterygoplichthys* sp. (Armoured sucker-mouth catfish)— are recognized as alien-invasive taxa with significant ecological ramifications. Their proliferation within the Cauvery River system raises concerns regarding competition with native species, habitat modification, and disruptions in trophic interactions. In addition, three stocked species— *Labeo rohita* (Rohu), *Cirrhinus mrigala* (Mrigal), and *Labeo catla* (Catla)— are introduced to enhance fishery yields. While stocking follows established protocols usually, it may have ecological consequences by influencing native species interactions and ecosystem stability.

The species checklist (Appendix 7) includes eight species endemic to the Western Ghats, with five restricted to the Cauvery River basin. Among these, *Hemibagrus punctatus* (Nilgiri mystus) and *Tor remadevii* (Humpback mahseer) are classified as "Critically Endangered", while *Hypselobarbus dubius* (Nilgiri barb) and *Hypselobarbus micropogon* (Kohri barb) are listed as "Endangered".

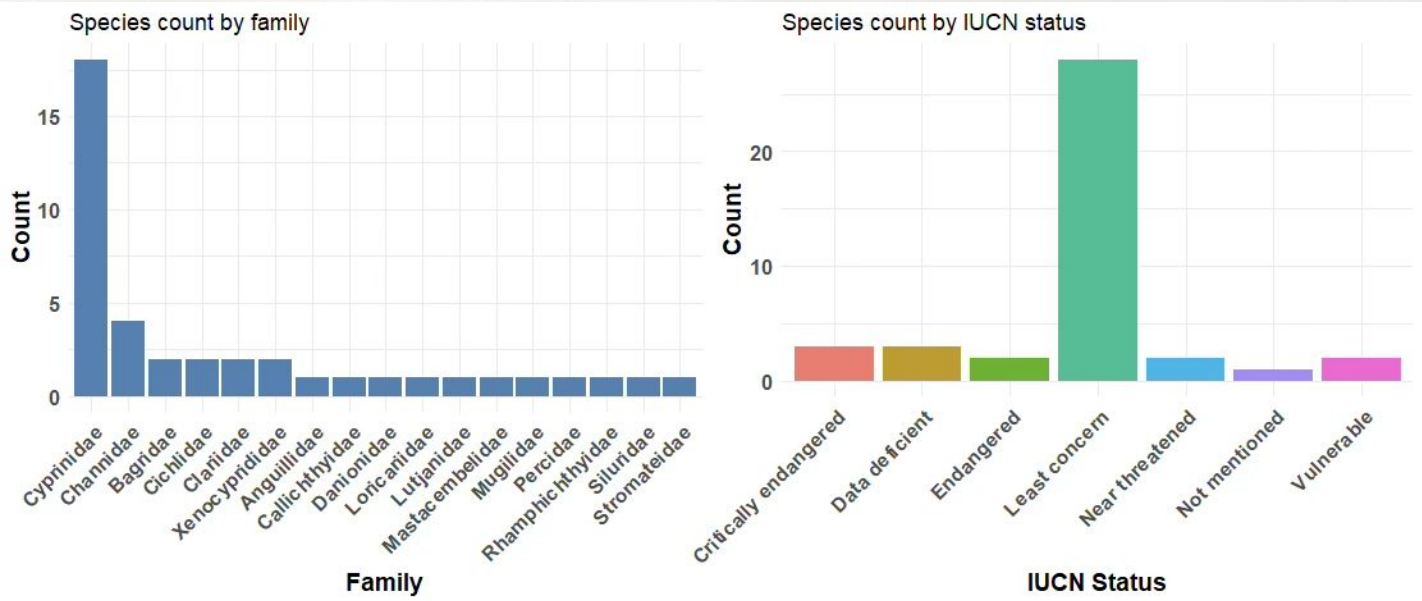


Figure 17: Distribution of fish species categorized by family and conservation status as per the IUCN Red List

The coexistence of native, endemic, and invasive species within the SFS necessitates targeted management interventions. Strategies should prioritize invasive species mitigation while ensuring the protection of threatened taxa. Additionally, stocking practices must be aligned with ecosystem integrity to minimize potential disruptions. This comprehensive assessment provides a foundation for evidence-based conservation and fisheries management within the Cauvery River system and other similar riverine ecosystems.

5.4.2 Avian diversity

The avian diversity recorded in the study area underscores the ecological richness and the integral roles birds play in sustaining ecosystem functions. Birds contribute to pollination, seed dispersal, pest control, and nutrient cycling, making them essential components of ecological networks. An opportunistic sighting survey was conducted to compile a dataset of avian species. The resulting dataset (Appendix 8) records 86 bird species distributed across 41 families, reflecting the region's diverse habitat composition and ecological importance. According to the IUCN Red List of Threatened Species, 82 of the recorded species are classified as Least Concern, indicating stable populations. However, two species are designated as 'Near Threatened,' and one species is categorized as Vulnerable, highlighting the need for targeted conservation efforts. Additionally, one species lacks sufficient data, underscoring the necessity for further ecological research and long-term monitoring.

Among the notable species recorded, *Prinia socialis* (Ashy Prinia), *Merops orientalis* (Asian green bee-eater), and *Anastomus oscitans* (Asian openbill) stand out due to their ecological roles. The Ashy Prinia, a small insectivore, aids in pest control by preying on insects that affect agricultural productivity. The Asian green bee-eater, another insectivore, helps regulate insect populations, including potential agricultural pests. The Asian openbill, a specialized feeder, primarily consumes freshwater molluscs, particularly *Pomacea* spp., preventing the unchecked proliferation of these snails, which could otherwise disrupt wetland ecosystems.

The dataset also records significant wetland-associated species such as *Ciconia episcopus* (Woolly-necked stork) and *Threskiornis melanocephalus* (Black-headed ibis). These water-birds contribute to nutrient cycling and serve as indicators of wetland health. The woolly-necked stork, often found in riparian and floodplain habitats, signals habitat quality, while the black-headed ibis, a scavenger, plays a crucial role in decomposing organic matter and maintaining ecosystem stability.

Additionally, species like *Pavo cristatus* (Indian peafowl), *Dicrurus macrocercus* (Black drongo), and *Spilopelia chinensis* (Spotted dove) highlight the significance of terrestrial ecosystems in supporting avian diversity. The Indian Peafowl, a culturally significant species, also serves as an ecological indicator due to its sensitivity to habitat disturbances. The black drongo, an aggressive insectivore, provides natural pest control by feeding on agricultural pests, reinforcing the role of birds in maintaining ecosystem balance.

The recorded avian diversity presents vital opportunities for eco-tourism, public engagement, and conservation education, therefor promoting greater appreciation and deeper understanding of biodiversity's importance. To enhance conservation outcomes, future research should prioritize examining seasonal variations in avian diversity, breeding behaviours, and habitat preferences. Assessing the impacts of anthropogenic pressures— such as habitat fragmentation, pollution, and the proliferation of invasive species— are equally essential. The protection of critical habitats, particularly riparian zones and wetlands, is imperative for safeguarding the survival of these avian species and the ecosystem services they provide.

5.4.3 Herpetofauna diversity

The checklist (Appendix 9) highlights the diversity and distribution of herpetofauna across various sites in the SFS area. This diversity encompasses species with critical ecological functions, some of which are recognized as threatened under the IUCN Red List of Threatened Species, underscoring the necessity of conservation-oriented management actions. The opportunistic sighting survey recorded 11 herpetofaunal species spanning 9 families and 29 mammalian species across 17 families. All documented herpetofaunal species are classified as Least Concern under the IUCN Red List of Threatened Species. Among the mammalian species, 14 are categorized as Least Concern, while 5 are listed as Endangered, 6 as Vulnerable, and 4 as Near Threatened.

The recorded herpetofaunal diversity comprises a range of amphibian and reptile species that contribute significantly to ecosystem stability and biodiversity conservation. Reptiles such as *Crocodylus palustris* (Mugger crocodile), *Ptyas mucosa* (Indian rat snake), and *Varanus salvator* (Monitor lizard) play essential roles in trophic interactions, with the crocodile functioning as a keystone predator that regulates aquatic prey populations. Amphibians, like *Euphlyctis cyanophlyctis* (Skittering frog), *Microhyla ornata* (Ornate narrow mouthed frog), and *Ramanella variegata* (Variegated Ramanella), are bioindicators due to their sensitivity to environmental fluctuations, making them crucial for monitoring ecosystem health. The conservation status of these species, though predominantly classified as Least Concern under the IUCN Red List, emphasizes the necessity of habitat protection measures to counteract the adverse effects of habitat degradation and climate change. Continued ecological assessments and conservation efforts are essential to ensure the persistence of these species within their natural habitats.

5.4.4 Mammalian diversity

The recorded mammalian diversity encompasses (Appendix 9) species from various trophic levels and ecological niches, several of which are classified as threatened under the IUCN Red List. Large herbivores such as *Elephas maximus* (Asian elephant), categorized as Endangered, play a crucial role in seed dispersal and forest dynamics. Similarly, *Tetracerus quadricornis* (Four-horned antelope), listed as Vulnerable, requires targeted conservation efforts due to habitat fragmentation and poaching. Other herbivores, including *Axis axis* (Spotted deer), *Muntiacus muntjak* (Barking deer), and *Rusa unicolor* (Sambar), influence vegetation structure through browsing and grazing, shaping forest regeneration processes.

The carnivore assemblage includes apex predators such as *Panthera tigris* (Bengal tiger), *Panthera pardus* (Indian leopard), and *Melursus ursinus* (Sloth bear), with the latter two categorized as Vulnerable. These species exert top-down control in the food web, regulating herbivore and mesopredator populations, thereby preventing overgrazing and promoting vegetation stability. Mesopredators such as *Mellivora capensis* (Honey badger) and *Lutrogale perspicillata* (Smooth-coated otter) contribute to ecosystem balance and display varying degrees of vulnerability to habitat degradation. Smaller carnivores like *Herpestes edwardsii* (Indian grey mongoose) and *Paradoxurus hermaphroditus* (Asian palm civet) play a role in rodent control and seed dispersal, further enhancing ecological stability.

Arboreal species, including *Ratufa macroura* (Grizzled giant squirrel) and *Ratufa indica* (Malabar giant squirrel), former classified as Near Threatened, underscore the importance of forest canopies as critical habitats. Primates such as *Semnopithecus entellus* (Hanuman langur) and *Macaca radiata* (Bonnet macaque) also contribute to canopy dynamics and seed dispersal. Notably, *Manis crassicaudata* (Indian pangolin), classified as Critically Endangered, faces severe population declines due to illegal hunting and trade, highlighting the urgent need for conservation interventions.

Effective conservation strategies should prioritize mitigating key threats, including habitat fragmentation, poaching, and human-wildlife conflict. Strengthening habitat connectivity through the establishment of ecological corridors, enforcing stringent anti-poaching regulations, and fostering community participation in conservation initiatives are essential for safeguarding species. Additionally, continuous monitoring of population trends and addressing the socio-economic drivers of habitat degradation will enhance conservation efficacy.

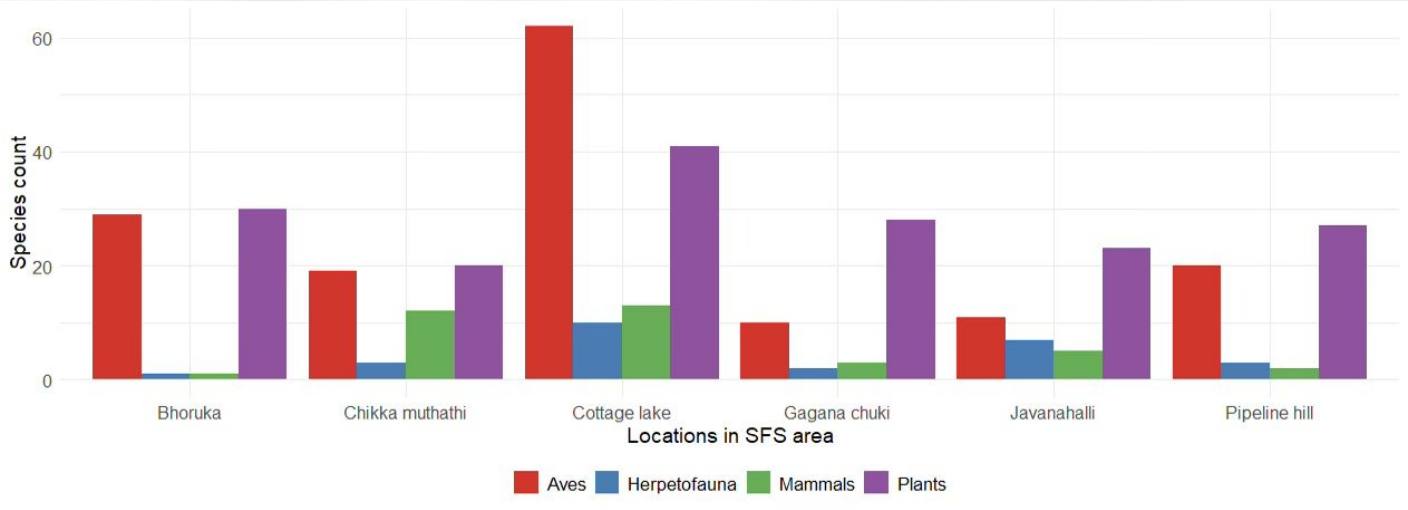


Figure 18: Biodiversity assessment of multiple taxonomic groups in the SFS area

In conclusion, Citizen Science initiatives, such as contributing bird sightings to online platforms like *eBird*, can significantly expand knowledge on avian distribution and contribute to a publicly accessible avifaunal profile for the Shivanasamudram region. The presence of diverse plant, herpetofaunal, and mammalian species, including those classified under the IUCN Red List and the Schedules of the WPA (1972), underscores the ecological significance of these sites. Ensuring the protection of these habitats is imperative for preserving biodiversity, maintaining critical ecosystem services, and enhancing resilience against ongoing environmental challenges. The spatial distribution of biodiversity across the six locations within the SFS area is depicted in Fig. 18, without fish species, which were studied only in WASI managed cottage lake.

5.5 Ecosystem services

A conceptual framework is developed to illustrate the connections between ecosystem services provided by SFS and human well-being. This framework is specifically tailored to align with the management recommendations discussed in the following section (Fig. 19). This framework categorizes ecosystem services into four primary groups: provisioning, regulating, supporting, and cultural services, each contributing uniquely to the constituents of human well-being.

Provisioning services encompass essential resources such as habitats for species, breeding grounds, tourism revenue, and fishing benefits. These services directly enhance basic materials for living by supporting livelihoods, ensuring access to goods, and generating economic value. Additionally, they contribute to security by ensuring resource availability, which bolsters community resilience against disasters.

Regulating services include ecosystem processes that mitigate natural hazards and maintain environmental quality, such as erosion control, vegetation stabilization, carbon sequestration, and population regulation. These processes improve human health by providing cleaner resources and environmental stability.

Supporting services, like nutrient cycling, soil formation, primary production, and local economic activities, form the foundation for all other ecosystem services. These services sustain the fundamental processes necessary for life, thereby enhancing health and basic living conditions by maintaining ecosystems that provide food and resources.

Cultural services contribute to the intangible dimensions of human well-being, including educational and research opportunities, recreational activities, and religious and aesthetic values. These services foster social cohesion, mutual respect, and ecotourism, thereby promoting good social relations and improving societal well-being.

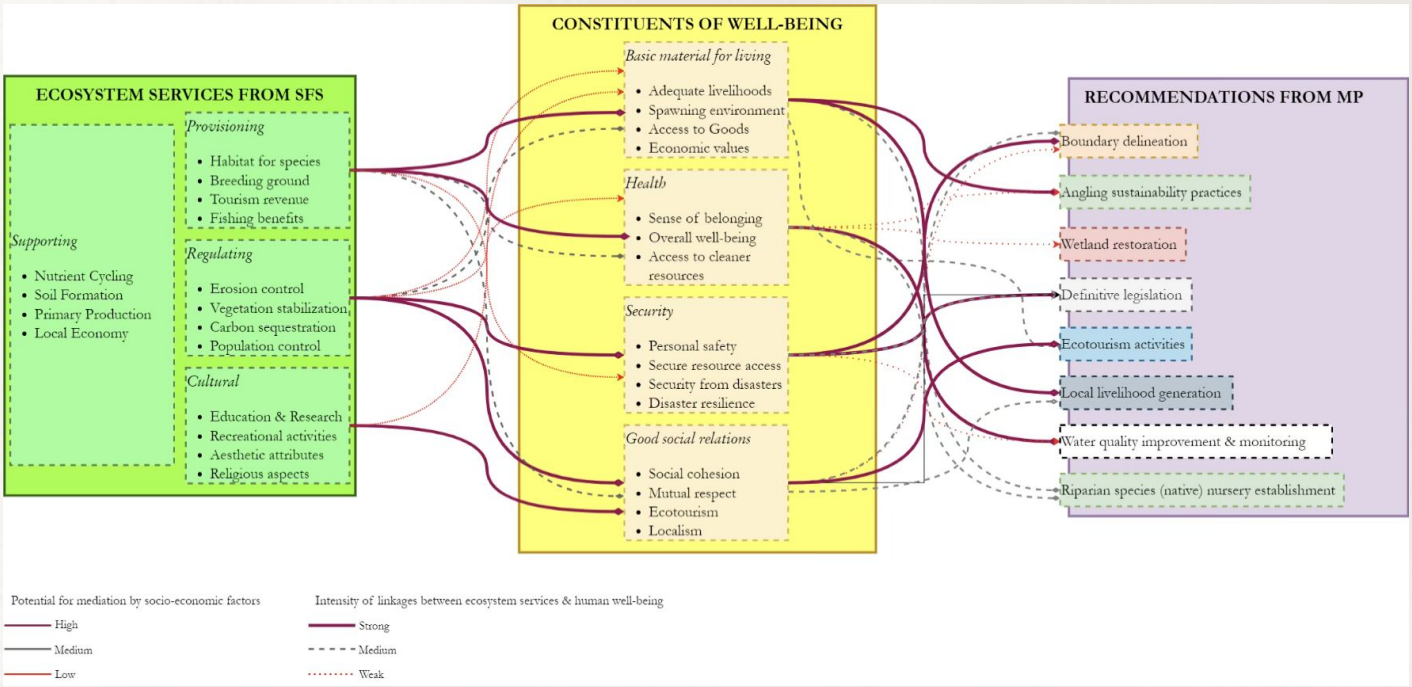
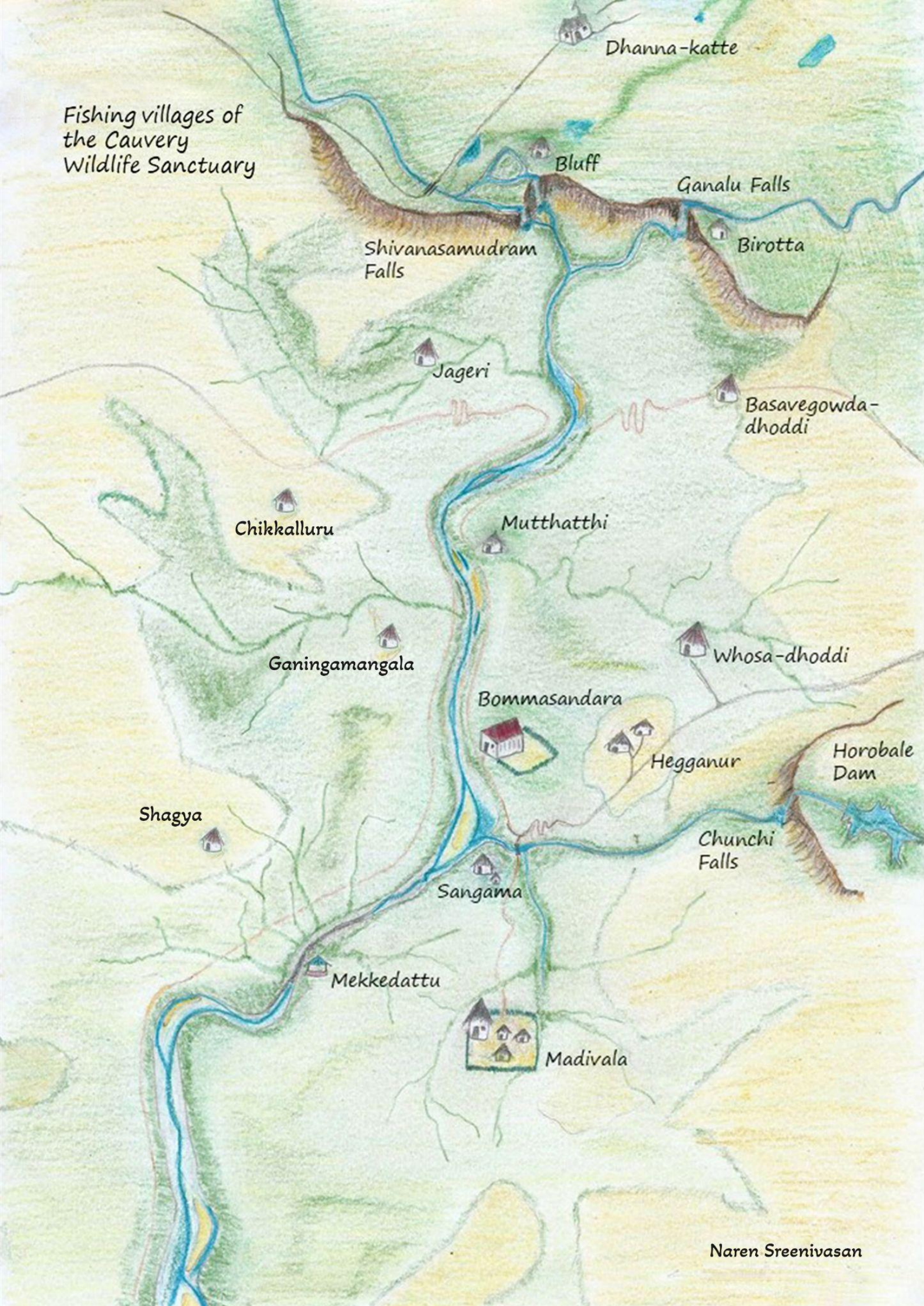


Figure 19: The framework illustrates the linkages between ecosystem services provided by SFS and human well-being, alongside the broader recommendations outlined in the management plan. Strong relationships are depicted by solid lines, while medium to weak connections are represented by dashed lines. Socio-economic factors are identified as mediators of these linkages and are categorized as high (dark red), medium (black), or low (grey). These mediating factors have the potential to either enhance or limit the positive impacts of ecosystem services on human well-being

The framework emphasizes the complex, multi-directional linkages between these ecosystem services and human well-being. Management recommendations derived from this framework include actions such as boundary delineation, sustainable angling practices, wetland restoration, ecotourism promotion, local livelihood development, and water quality monitoring. These measures aim to preserve or enhance ecosystem services to ensure their continued support for human well-being amidst socio-economic and environmental changes. Figure 8 underscores the holistic nature of ecosystem services, advocating for integrated management practices that balance ecological, social, and economic considerations to achieve sustainable outcomes for human and environmental health.


Fishing villages of the Cauvery Wildlife Sanctuary
Dhanna-katte
Bluff
Ganalu Falls
Birotta
Shivanasamudram Falls
Jageri
Basavegowda-dhoddi
Chikkalluru
Mutthatthi
Ganingamangala
Whosa-dhoddi
Bommasandara
Hegganur
Horobale Dam
Shagya
Chunchi Falls
Sangama
Mekkedattu
Madivala
Naren Sreenivasan

6. THE SFS MANAGEMENT PLAN: RATIONALE TO RECOMMENDATIONS

6.1 Rationale behind the Management Plan

A management plan in the context of the SFS is essential for several reasons. First and foremost, it provides a clear and well-founded justification for implementing a structured and strategic approach to the conservation of this unique ecosystem. This underscores the importance of addressing specific ecological challenges, such as the threats posed to endemic and threatened fish species, habitat degradation, and the pressures of unsustainable fishing practices. By thoroughly outlining these issues, the management plan is not based on mere assumptions or generalized conservation efforts, but rather on a deep understanding of the site-specific conditions at Shivanasamudram. This ensures that the plan is scientifically credible, reinforcing its authority and making it more likely to gain the support of decision-makers and conservationists alike.

Further, a comprehensive discussion about the necessity of the management plan helps to contextualize the ecological, cultural, and socio-economic factors that distinguish SFS from other protected areas. This is particularly important because the sanctuary faces unique challenges that require tailored solutions, not generic conservation measures. By emphasizing the local context, this management plan draws attention to the specific conservation needs of the fish species and the communities that depend on the sanctuary for their livelihoods, ensuring that both ecological and human dimensions are considered. Furthermore, the inclusion of this detailed analysis serves as a tool for engaging key stakeholders, such as government officials, conservation organizations, funding agencies and local communities, by demonstrating the long-term benefits of implementing a well-crafted management plan. It fosters a deeper understanding of the necessity for collaboration and cooperation in protecting the sanctuary's biodiversity.

Finally, this management plan lays the groundwork for presenting a long-term vision for the sanctuary. This management plan will act in the capacity of a roadmap for sustainable conservation efforts that will evolve over time. By articulating the need for a robust and flexible framework, this reinforces the importance of long-term planning in safeguarding the sanctuary’s fish populations, preserving the ecosystem, and ensuring the livelihoods of local communities. It ties together the ecological and human dimensions into a coherent argument that underscores the critical role of thoughtful and informed management in achieving lasting conservation success.

6.2 Integrating the SFS Management Plan with the UNDP’s Sustainable Development Goals

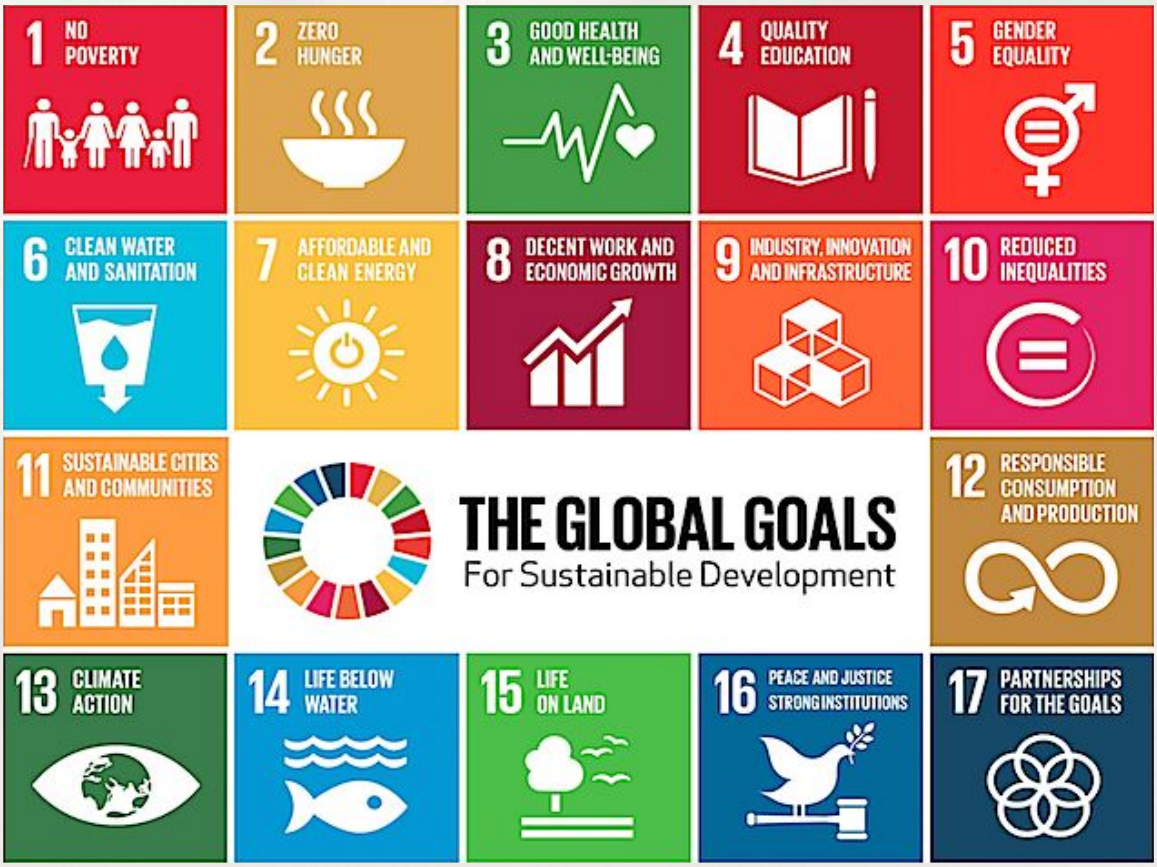
The Sustainable Development Goals (SDGs) are a set of 17 global objectives adopted by the United Nations in 2015, aiming to address the most pressing challenges faced by the world, including poverty, inequality, environmental degradation, and peace. These goals are interconnected, focusing on promoting economic growth, social inclusion, and environmental protection, with the target year for achieving them set at 2030. Key SDGs related to environmental sustainability include *Goal 13 (Climate Action), Goal 14 (Life Below Water)* and *Goal 15 (Life on Land)*, all of which are essential in promoting the health of ecosystems and biodiversity.

The management recommendations for SFS aligns with these SDGs, particularly by focusing on the conservation of aquatic and terrestrial biodiversity, sustainable management practices, and fostering community involvement. The sanctuary's core objective is to protect the river's unique aquatic life and flora and fauna that depend on it, notably endangered species like the humpback mahseer, which directly supports *SDG 14 (Life Below Water)*. By establishing and maintaining the sanctuary, the management plan helps safeguard aquatic biodiversity, addressing the challenges of habitat destruction, illegal fishing, and pollution.

Additionally, the plan emphasizes the involvement of local communities, promoting sustainable livelihoods and traditional knowledge systems. This aligns with *SDG 1 (No Poverty)* and *SDG 10 (Reduced Inequalities)*, as the sanctuary's management approach creates opportunities for local employment and inclusive participation in conservation efforts. Furthermore, by encouraging sustainable fishing practices and protecting the river ecosystem, the plan contributes to *SDG 8* (*Decent Work and Economic Growth),* supporting sustainable development in the region.

The focus on restoring and maintaining the river's ecological balance also resonates with *SDG 15 (Life on Land)*, as it highlights the importance of integrated management of terrestrial and aquatic ecosystems for the long-term health of both. The sanctuary's ongoing efforts to mitigate pollution and illegal activities also contribute to climate resilience, linking the plan to *SDG 13 (Climate Action)*.

Overall, the SFS management plan serves as an important example of how local conservation efforts can contribute to global sustainability goals, fostering a harmonious relationship between people and nature while advancing the broader agenda of sustainable development.



Source: Google search engine, sustainable development goals

6.3 Steps in developing the SFS Management Plan

The management planning process for a wetland ecosystem consists of three key phases: Pre-Planning, Planning, and Post-Planning (Fig. 20).

In the Pre-Planning phase, groundwork is laid through data collection, evaluation, and identifying key constraints and opportunities. Background research establishes ecological, hydrological, and socio-economic context, while data analysis helps identify trends and potential challenges. Recognizing constraints such as seasonal water fluctuations, pollution sources, and biodiversity loss ensures planning efforts focus on critical areas. Stakeholder engagement, including local communities, conservation groups, and regulatory bodies, is vital at this stage.

The Planning phase involves structuring the management plan by setting a clear vision, objectives, and strategic framework. Best practices from similar wetland conservation efforts are reviewed to refine goals and mitigate risks such as invasive species, habitat fragmentation, and climate change impacts. The plan must be adaptive, balancing conservation with sustainable resource use. Considerations like hydrological connectivity, buffer zone management, and ecosystem services (e.g., flood control, water purification) should be incorporated. Adequate resource allocation, policy alignment, and community participation are crucial for long-term success.

The Post-Planning phase focuses on evaluation, capacity building, and documentation. Monitoring water quality, species populations, and human impact ensures ongoing adaptability. Documentation fosters transparency and institutional learning, supporting future conservation efforts.

This structured, dynamic approach ensures the effective management and sustainability of wetland ecosystems. The detailed steps are provided in Appendix 10.

The physical limits of the Shivanasamudram Fish Sanctuary are marked by signboards that display the status and conservation significance of the area.

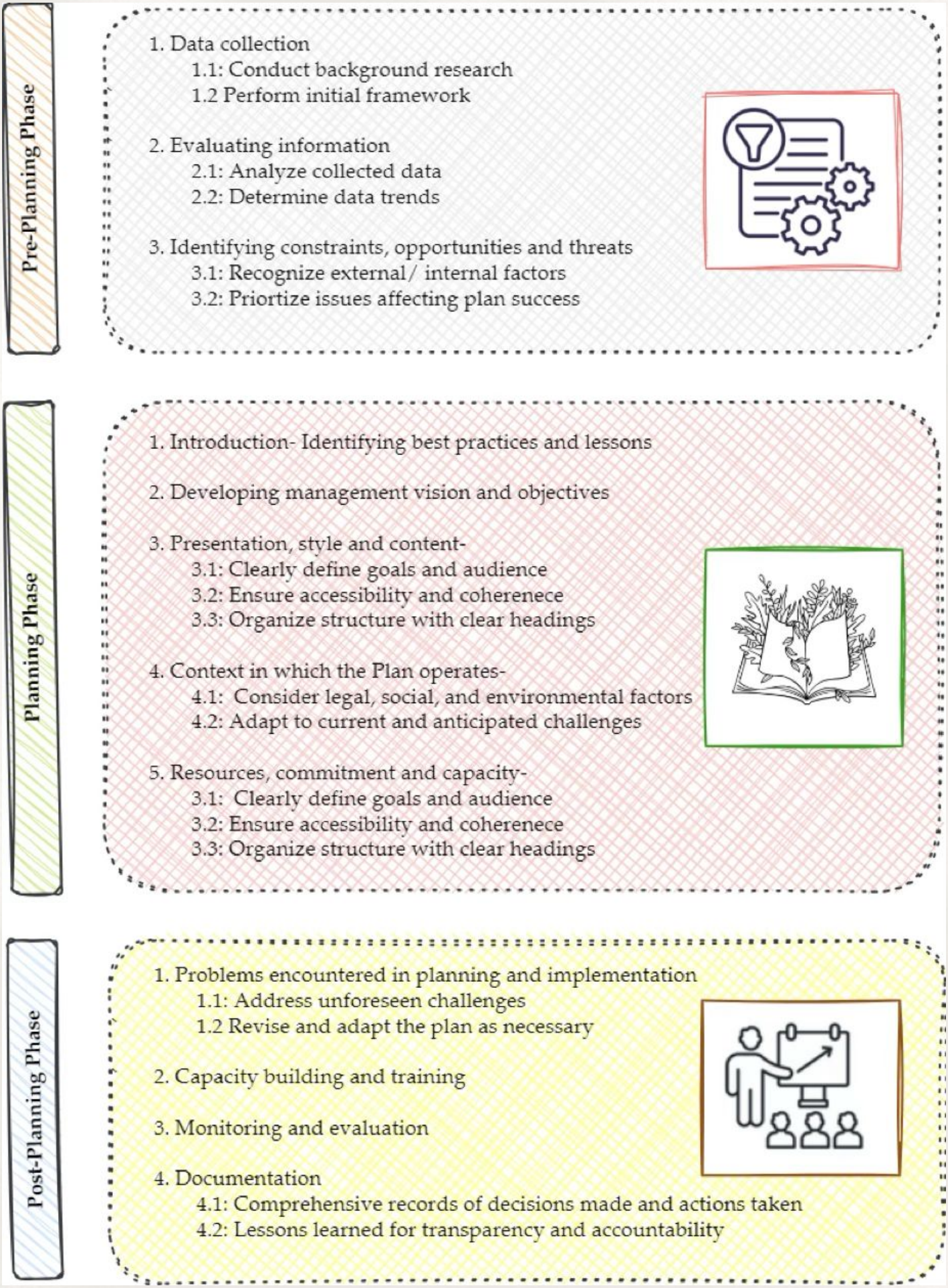


Figure 20: A schematic representation of the process involved in developing the SFS management plan

6.4 Management guidelines

The first management goal is generic and applies broadly to all fish sanctuaries in Karnataka, while the others are tailored to address specific conservation challenges at the SFS.

The 12 management goals outlined in this section are structured to align with the overarching objectives of the SFS. Each management goal comprises two key components:

- *Management considerations*, which are derived from critical themes discussed throughout this document and are directly linked to the identified conservation challenges.
- *Management actions*, which are prioritized for implementation to effectively address these considerations.

Each management action may be executed as an independent initiative, contingent upon the availability of funding and resources. The overarching aim is to implement all management actions within the next decade.

This section has been designed with flexibility to accommodate unforeseen developments. Accordingly, management goals, considerations, and actions may be revised and published in multiple iterations as necessary.

Management goal 1:

Strengthen legislative clarity and coherence to enhance the conservation and management of inland fish sanctuaries across Karnataka.

SDG relation: SDG 16

Management considerations:

i. *Inadequate legislative framework*: Management of inland fisheries in Karnataka is entirely governed by state. The Karnataka Inland Fisheries Act, 1996 (amended in 2003), lacks comprehensive guidelines on conservation practices and rules, creating challenges for management across the state.
ii. *Need for state-wide regulations*: The absence of standardized regulations hinders the implementation of participatory conservation and development practices tailored to safeguard the ecological and socio-economic contexts within Karnataka's inland water resources.

Proposed management actions:

- Advocate for the amendment and gazettement of the Karnataka Inland Fisheries (Conservation, Development, and Regulation) Act Rules 2023 (AHF E-53 FSFM 2020; dt.15-03-2023). Specifically incorporating provisions for securing the status and boundaries of fish sanctuaries, promoting local participation and sustainable tourism, regulated fishing, habitat restoration, fish stocking policies, and systematic monitoring frameworks. Certain amendments to the existing rules are under consideration; however, this management action aims to enhance clarity and adopt a more community-inclusive approach.

- Establish a committee (Karnataka State Fisheries Board) comprising fisheries experts, legal advisors, and key stakeholders including local community that meets regularly to develop comprehensive recommendations for legislative and management updates. Integrate a robust state-level review mechanism within the committee to periodically assess the effectiveness of the legislation and ensure it is adapted to evolving conservation priorities and ecological challenges.
- Create and implement management plans for the three different Fish Sanctuary categories namely, 'temple based', 'non-temple based' and 'within Protected Areas'. Include detailed management handbook for State fisheries authorities and stakeholders, summarizing rules. Regulations and key conservation measures, roles, and responsibilities under the revised legislation.
- Facilitate the establishment of formal agreements between state authorities (DoF) and locally registered entities, such as temple management bodies, *Panchayat*, Biodiversity Management Committee (BMC, BDA[10] 2002) etc., to promote effective implementation and compliance at the grassroots level.

- Conduct state-wide awareness programs for local communities, fishers, and enforcement agencies to ensure uniform understanding and adherence to updated regulations.

[10] *The Biological Diversity Act (BDA), 2002, mandates the formation of Biodiversity Management Committees (BMCs) at the local level to conserve biodiversity, document traditional knowledge, and promote sustainable use of resources.*

Management goal 2:
Implement a Boundaries and Expansion Strategy (BES) to enhance protection measures and expand the scope of the SFS.

SDG relation: SDG 16

Management considerations:

i. *Need for distinct boundaries*: Well-defined and visibly marked boundaries are critical for preventing encroachment, managing access, and safeguarding management interests.
ii. *Expansion opportunities*: Adjacent river stretches which are currently unregulated (no fishing licenses or tenders issued), present potential for including additional riverine habitat types within the SFS management. Including these areas could expand the SFS's scope and allow for flexible conservation strategies in designated zones, such as implementing no-fishing or regulated fishing policies.

Proposed management actions:

- Define the SFS boundaries along with DoF, specifying whether they encompass only aquatic zones or include and extent of adjacent land areas as well. Digitize the SFS boundaries using GIS technology to create precise maps for management, enforcement, and public dissemination.
- Demarcate the outer limits of the SFS using permanent physical markers such as survey stones or appropriate signage.
- Install updated signboards in high-traffic areas with maps showing key landmarks, rules, and regulations to improve visitor orientation and awareness.
- Identify adjoining river stretches, (as units or *Bhagas* defined by the DoF) which are suitable for inclusion in the SFS. Develop proposals for their formal annexation to the SFS framework.
- Amend the existing agreement between DoF and WASI to annex the 'Borukha stretch' and 'Head-gate to Siphon' stretch which is currently under review by the DoF (proposal letter Dt. 20-2-2023). Additional river stretches to include: Headworks dam to the confluence of the Gaganachukki and Barachukki streams of the Cauvery River (Mandya District).
- Collaborate with local authorities and stakeholders to resolve ownership uncertainties in the wetland area (including identifying any grey zones[11]) by leveraging participatory land-use planning (engaging communities, conservation groups, and authorities to reach a consensus on land use), formal agreements (establishing legally binding contracts defining rights and responsibilities), local governance mechanisms (utilizing *Panchayat* resolutions to reinforce agreements), and adaptive management committees (including key stakeholders to address disputes and adapt agreements as needed). This will ensure consensus, clarity, and the adoption of sustainable land-use practices.

[11]*In land management, grey zones refer to areas where regulations, policies, or land-use classifications are ambiguous, contested, or inadequately enforced. These zones may arise due to overlapping jurisdictional claims, unclear legal frameworks, informal land use, or gaps between policy and implementation.*

Management goal 3:

Develop an ecotourism plan for the local community that supports habitat protection and encourages active participation.

SDG relation: SDGs 1, 8, and 10

Management considerations:

Ecotourism development framework: A structured ecotourism approach, incorporating activities such as, trekking, boating, wildlife viewing, cultural tours etc., can help build stewardship and income opportunities among the local community while offering a nature immersion experience to visitors. Such an initiative, if owned by the local community and supervised by the SFS management, will build healthy collaboration and local buy-in for the future.

Proposed management actions:

- List out nature/wildlife-based activities, trails and cultural experiences around the SFS and identify the relevant authorities to approach for permissions.
- Empower local authorities or communities to develop an ecotourism plan that includes a transparent cost/benefit sharing mechanism and the management of permissions, enabling them to autonomously oversee and sustain the initiative in the future.
- Train local guides and wardens in ecotourism principles, wildlife tourism and conservation-based management to build the conservation context among ecotourism practitioners.
- Develop visitor facilities, including information kiosks or interpretation centres to assist in disseminating information.
- Engage with volunteers and organizations to facilitate a system for waste management in and around the SFS area. Specifically target high foot fall areas such as the two waterfalls, temples etc.
- Provide dustbins and waste management solutions at tourism hotspots.

Management goal 4:

Improve and expand the scope of the recreational angling program.

SDG relation: SDGs 3 and 12

Management considerations:

Angling as a conservation tool: WASI pioneered and sustained a 'Cauvery recreational angling model' for over 50 years. While other similar angling programs exist across the country, none of them incorporate a robust conservation and fish monitoring program. This angling model has functioned as a 'Citizen Science' initiative well before the concept gained widespread popularity.

Proposed management actions:

- Advocate for angling as a conservation activity by organizing workshops, talks, and other engagement opportunities targeted at the general public.
- Establish an on-site recreational angling training program. Identify and train individual angling tour operators in Angling Best Practices.
- Update and formalize the angling policy and best practices annually. Ensure the goals are aligned with government regulations and objectives.
- Enhance facilities at designated angling areas to ensure safety and provide an optimal angling experience. Additionally, create new angling areas by utilizing platforms at Forbes Sagar.
- Identify and designate specific 'no-angling zones' within the SFS to minimize environmental impacts and ensure safety of anglers and local residents.
- Promote the fish monitoring program as a 'Citizen Science' initiative using science conferences and social media platforms. Consider starting a separate social media profile for the 'angling for conservation' CitSci initiative.
- Streamline catch data management (currently recorded in handwritten registers) to ensure that data is being accurately and regularly reported and digitized. A mobile phone application can be considered in this regard to encourage reporting and improve data accuracy.
- Streamline the data entry regarding issue of angling licences and long-term fishing permits to ensure that we can standardize the 'effort' i.e. the number of hours each angler spends fishing.
- Conduct a catch per unit effort[12] (CPUE) analysis following established protocols once in 3 years.
- Ensure that the revenue generated from angling-based activities is directed entirely towards conservation efforts, with 100 % of the funds allocated to conservation-related activities.
- Promote scientific research projects to support and improve angling best practices. Research may follow the dissertation of Bower (2017) and ongoing projects initiated by WASI.

[12] *Catch per unit effort (CPUE) is calculated for each species as the sum of fishes caught in one month per unit time- refer to the section on 3.7.2: Long-term angling data for fisheries management in SFS*

Management goal 5:

Improve the diversity and abundance of regional riverine flora to strengthen fundamental ecological processes which can in turn support riparian fauna.

SDG relation: SDGs 14 and 15

Management considerations:

i. *Importance of riparian vegetation*: Riparian ecosystems are considered 'narrow range' ecosystems and provide habitat for a large array of habitat specialists[13] making them significant for biodiversity conservation. Healthy riparian vegetation is also crucial for maintaining water quality, preventing erosion, providing habitat for wildlife, and supporting biodiversity, contributing meaningfully to the ecological integrity of the SFS area.

ii. *Community engagement and government schemes*: Leveraging community involvement through (native) tree-planting initiatives not only promotes environmental stewardship but also provides socio-economic benefits via government programs like the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA)[14], which supports rural employment and ecological restoration. A newly formed trust between WASI and the local community can be used for this purpose.

Proposed management actions:

- Conduct a comprehensive survey of riparian flora, assessing species richness and distribution, along both adjacent and undisturbed stretches of the Cauvery River (relative to the SFS). The findings will inform restoration guidelines based on the natural distribution of species within wetland zones (refer to Fig. 6).
- Identify and prioritize key riparian areas (refer to Fig. 6) within wetlands for ecological restoration, integrating habitat requirements and local communities' inputs.
- Establish a native plant nursery in wetland areas (refer to Fig. 6) to propagate regionally occurring riparian species, ensuring that germplasm (seeds and pollen) is sourced from riverbanks near the SFS.
- Utilize programs like MNREGA to engage local communities in restoration activities, providing both employment opportunities and environmental benefits alike.
- Develop a targeted non-aquatic tree-planting strategy for scrubland areas in Fig. 6, incorporating local knowledge of native dry-deciduous species and utilizing plants from the nursery to enhance ecological resilience.

[13]*Habitat specialists are species that thrive only in specific types of environments or habitats, and cannot easily survive in others. They are highly adapted to particular conditions, like certain types of plants, water, or climate.*

[14]*MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act): MGNREGA provides financial support for rural communities by guaranteeing wage employment for unskilled manual laborers. It can be leveraged to fund conservation activities, such as afforestation and habitat restoration, by engaging local communities in meaningful ecological projects.*

Management goal 6:

Enhance social collaboration and strengthen stakeholder participation in the conservation and management of the SFS

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SDG relation: SDGs 10 and 17

Management considerations:

i. *Building local partnerships*: Establishing robust linkages between the SFS and local community groups, institutions, and key stakeholders will facilitate the development of a cohesive network to promote sustainable practices and enhance management effectiveness.
ii. *Ensuring regular engagement*: Annual stakeholder meetings (Sabhas) will serve as a platform for communication, addressing challenges, and promoting joint decision-making and action, ensuring sustained collaboration.
iii. *Active youth involvement*: To foster a sense of community ownership and engagement, it is essential to encourage active participation from youth and local groups in meetings and related activities. By establishing clear pathways for involvement and underscoring potential incentives— such as skill development, employment opportunities, and recognition within the community— this approach strengthens the management rationale and ensures long-term commitment to the initiative.

Proposed management actions:

- Connect the SFS with local organizations such as conservation institutions, fishing societies, *Panchayats*, *Gram Sabhas*, youth groups, and village forest committees to build a coordinated network for implementing management goals. Define the role of each connection through government schemes, agreements, or mutual support pledges.

  Potential tools for creating these connections are—
  a) *Policy and administrative instruments*: Partner with government schemes like MGNREGA or CAMPA[15] and use *Panchayat* or *Gram Sabha* resolutions to secure funding and ensure local participation in conservation efforts.
  b) *Collaborative committees and task forces*: Establish joint committees with WASI, DoF, and local authorities to oversee management and create task forces for specific roles such as biodiversity monitoring and community outreach.
  c) *Capacity-building workshops*: Organize training sessions using participatory tools to improve stakeholder knowledge in sustainable practices and conservation strategies.
  d) *Digital platforms and networks*: Utilize digital platforms like WhatsApp, apps, and online databases for communication, and use social media campaigns to engage the community while ensuring accessibility in local languages.

- Recruit a team of youth members from the village (Shivanasamudram Bluff) to participate in the SFS program as field guides or river stewards, integrating them into conservation activities.
- Develop a standardized agenda for the *Sabhas*, including updates on conservation initiatives, resource management, and addressing community concerns. A newsletter— managed by editors/representatives from both WASI and local communities— could be a good way to keep everyone informed.
- Strengthen the role of BMCs by leveraging the provisions of the BDA 2002, to foster community-driven conservation, sustainable resource management, and fair sharing of revenue benefits.

[15]CAMPA (Compensatory Afforestation Management and Planning Authority): CAMPA is a fund established to promote afforestation and compensate for the loss of forest cover due to development projects. It can be utilized for large-scale ecological restoration and conservation activities in areas like the Shivanasamudram Fish Sanctuary.

Management goal 7:
Assess and improve the ecological integrity of waterways within the SFS.

SDG relation: SDGs 14 and 15

Management considerations:
Ecological function: A scientifically sound understanding of the riverbed structure, water flow patterns, vegetation encroachment and sediment distribution are critical for improving habitat quality and managing water resources effectively. This is vital for reclaiming aquatic habitats and sustaining a healthy population of indigenous fish in the SFS.

Proposed management actions:

- Conduct bathymetric surveys (once in 5 years) to map the benthos, and identify areas of erosion, sediment build-up to inform dredging and desilting activities to maintain/improve the water holding capacity of the SFS and connecting canals.
- Identify hotspots where waterway improvements, such as dredging, channel stabilization, or sediment removal can be implemented to enhance habitat for fish and other aquatic species.
- Utilize satellite imagery, drone images and remote sensing data to assess changes in surface habitat features such as, water body limits (flood vs low flow), bank vegetation cover, encroachment of floating and non-floating vegetation and flood dynamics, to inform restoration goals.
- Collaborate with BWSSB and KPTCL during de-weeding operations by informing them on focus areas identified by the above activities.
- Restore vegetation on the Forbes Sagar Island (now submerged) to encourage riparian growth and nesting habitat for birds and otters.
- Collaborate with the DoF and local stakeholders to strategize on removal of invasive fish species in a regulated and supervised manner.

Management goal 8:

Improve local livelihood opportunities by exploring market-based incentives within the SFS and at the district level.

SDG relation: SDGs 1, 3, 8, and 10

Management considerations:

Economic empowerment and livelihoods: Monetizing harvestable resources, such as exotic fish species and plants, can offer local communities improved income opportunities both within and outside the SFS. This approach may reduce their reliance on unsustainable practices and foster overall economic well-being and support for the SFS management.

Proposed management actions:

- Explore options for sustainable fisheries such as cage culture and sustainable harvest based fishing.
- Conduct a feasibility study (locally and district wise) of harvesting exotic fish species, such as exotic catfish and tilapia, for sale in local markets or incorporation in agriculture/pet food/poultry/pig farming industry. This would address the problem of exotic species while generating more livelihood streams.
- Carry out a district-wise feasibility study to assess the potential for harvesting invasive aquatic plants, especially, aquatic weeds, for commercial use, including biogas production and the development of other value-added products.
- Co-lease fishing concessions (lakes and rivers) at the district level to enhance livelihood options through inland fisheries; using sustainable harvest methodologies, providing easy access to markets and complimenting their income via recreational fisheries.

Management goal 9:

Prioritize outreach and environmental education to raise awareness about fish sanctuaries (using SFS as a case study) in Karnataka, highlighting their objectives and the critical need for preserving freshwater ecosystems.

SDG relation: SDGs 13 and 17

Management considerations:

i. *Building stakeholder support and compliance*: Raising awareness about the formal declaration of fish sanctuaries and their conservation goals is critical to garnering local support and compliance with regulations. Increased knowledge also encourages active community participation in conservation efforts.
ii. *Education opportunities*: The SFS offers a valuable and accessible platform for engaging the public, particularly children, youth, and educational institutions, in learning about freshwater ecosystems, cultivating ecological awareness, and encouraging support for nature conservation efforts.

Proposed management actions:

- Initiate an annual newsletter (English and Kannada) to disseminate and update stakeholders on conservation activities, projects and events associated with the SFS.
- Develop educational materials in both English and Kannada focused on freshwater ecosystems, including fish, aquatic plants, and aquatic food webs, highlighting their crucial role for humans, terrestrial life, and aquatic life.
- Create multiple curricula for educational institutions and trainers/teachers using visual aids which are focused on freshwater ecology and conservation. Such material can be plugged into existing awareness initiatives or be used to design inhouse workshops and training programs.
- Train one or two youth leaders as nature educators (linked to WASI) who may use the above materials.
- Host workshops, awareness sessions, and field visits for local stakeholders, including fishermen, local authorities, and residents, to increase their understanding of fish sanctuary regulations and objectives.
- Establish partnerships with schools and colleges to offer annual internship programs for students to gain hands on experience with freshwater ecology and to contribute to WASI's in-house research projects.
- Create interactive signage and information boards at key visitor locations within the sanctuary to educate tourists and locals about the significance of the area and its biodiversity.
- Utilize digital platforms, including social media and websites, to disseminate information about the SFS and other fish sanctuaries, engaging a wider audience and promoting visitation.
- Rent/lease a house in a high footfall area (possibly, an abandoned house in Shivanasamudram, Bluff), in collaboration with KPTCL (Karnataka Power Transmission Corporation Limited) and establish an educational interpretation centre. Here the public can be exposed to content in the likeliness of WASI's museum gallery at the RMNH (Regional Museum of Natural History), Mysuru, live aquariums of native flora and fauna, documentary screenings and Shivanasamudram's rich history.
- Publish all research findings in peer reviewed journals and various wildlife and conservation magazines.
- Engage with local media through collaborating with local newspapers, radio stations, and TV channels to share stories, news, and educational content related to fish Sanctuaries and conservation efforts.

Management goal 10:

Secure sustainable funding for the conservation and management of the SFS through diversified financing mechanisms.

SDG relation: SDG 8

Management considerations:

i. *Long-term financial stability*: Ensuring sustainable funding sources is critical for the long-term conservation and effective management of the SFS. Diversified financing strategies, including government allocations, private-sector partnerships, and international grants, are essential to maintaining operational continuity.
ii. *Private sector and stakeholder engagement*: Engaging the private sector and local stakeholders in funding initiatives not only helps generate financial support but also fosters a sense of shared responsibility towards conservation. This could include corporate social responsibility (CSR) contributions, eco-tourism revenue, and investments in sustainable practices.
iii. *Government support*: Establishing Memorandums of Understanding (MoUs) and agreements with various government authorities can streamline the permission process, create access to otherwise unattainable opportunities, and potentially alleviate financial constraints.

Proposed management actions:

- Create and adopt a permanent fundraising job profile under WASI.
- Develop a comprehensive list of funding sources that WASI intends to pursue over the next five years. This should include government grants and subsidies, private sector investments, wildlife conservation grants, and opportunities for in-house revenue generation.
- Utilize 'management actions' in this management plan to create a project and fundraising portfolio to approach corporate and individuals to build private sector partnerships to finance projects and build public participation.
- Ensure income from any co-managed eco-tourism initiatives, such as guided tours, treks, angling, and educational programs, are compliant with adopted revenue sharing mechanisms.
- Apply for international funding from conservation organizations, environmental NGOs, and bilateral aid agencies to support specific projects within the sanctuary, such as habitat restoration, interpretation centres and species monitoring.
- Consider strengthening the conservation status of the Shivanasamudram area using widely recognized institutions such as RAMSAR sites (UNESCO) and Biodiversity Heritage Sites (BDA, 2002).
- Consider the option of partnering with other NGO's to implement individual projects or the entire management plan.
- Work towards creating an endowment fund dedicated to the SFS, ensuring a sustainable and reliable source of income for the sanctuary's long-term operations and conservation programs.
- Develop transparent financial management systems (perhaps a separate bank account) to track income and expenditures, ensuring accountability and fostering trust with stakeholders and funding bodies.
- Declare income and expenditures in a transparent manner via an annual report or newsletter.

Management goal 11:
Bolster Watch and Ward (WaW) systems to combat wildlife crime, illegal fishing and enhance enforcement within the SFS.

SDG relation: SDGs 14 and 15

Management considerations:
Strengthening safeguards: Refining and upgrading the existing watch and ward system at the SFS is essential to enhance its overall effectiveness. Improvements should focus on strengthening patrolling efforts, streamlining reporting mechanisms, fostering positive public perception, increasing field engagement, and ensuring timely and effective legal action.

Proposed management actions:

- Transition the use of the term 'Anti-poaching' to 'Watch and Ward' which is more socially acceptable among conservation circles.
- Regularly engage and inform the DoF, Karnataka Forest Department and local police stations (example, a WhatsApp group) regarding WaW activities. This can ensure swift action against wildlife crimes, and other illegal activities.
- Include job title on WaW uniforms using key words such as 'Fish Sanctuary Security', 'Watch and Ward' or 'WASI guard'.
- Equip WaW personnel with patrolling gear, radios, field motorcycles, batons, point and shoot cameras, and boats (coracle or motor boat).
- Create a monthly patrolling schedule to achieve patrolling targets. Make provisions for reporting on daily patrolling activities using 'live location' reporting on WhatsApp (example) or other mobile application.
- Include mandatory monthly scouting in the patrolling schedule for removal of gill nets, ghost nets, ghost lines, fish traps, mouth bombs (dynamite), plastics, debris and routine inspection of sanctuary signage etc.
- Identify one or two 'Sanctuary Wardens' from the local community who can engage at the village level and serve as local informants.
- Invest in modern surveillance technologies, such as camera traps, drones, and CCTV, to monitor sensitive areas more efficiently and detect/report illegal activities in real-time.
- Enhance the training and recruitment of youth, including both men and women, from the Shivanasamudram bluff and surrounding villages to promote a gender-inclusive approach to conservation efforts.

Management goal 12:

Implement a comprehensive monitoring program to assess the success and progress of conservation efforts in the SFS.

SDG relation: SDG 17

Management considerations:

i. *Importance of monitoring*: A robust monitoring program is essential to assess and showcase the effectiveness of the management regime, ecological health, changes in biodiversity, water quality, and social buy-in. Systematic monitoring will enable data-driven decisions, allowing for timely identification of threats, evaluation of conservation interventions, fundraising and improved management outcomes.

ii. *Ensure simplicity and flexibility*: While designing the monitoring program, ensure that metrics are measured in a simple manner and systems are kept flexible and adaptable. As the monitoring program is long-term and on-going, account for the fact that much of the documentation will be done by several individuals coming from varying backgrounds.

Proposed management actions:

- *Ecotourism*: Design a monitoring mechanism with defined metrics (number of visitors, activities on offer, locally trained personnel, households benefitted, indirect businesses, amount of revenue generated, etc. to evaluate the social impact of ecotourism activities—

a. Visitor surveys: Collect feedback digitally or on paper to evaluate ecotourism quality.

b. Compliance monitoring: Use surveys and environmental assessments to gauge the impact on local resources like water and waste management.

- *Riparian restoration*: Establish permanent vegetation sampling plots at restoration and non-restoration sites. Standardize data collection for long-term monitoring. Maintain a tree checklist of species in the riparian nursery.
- *Biodiversity census*: Conduct annual biodiversity census using indirect and direct evidences, focus on Mammals, reptiles, amphibians, birds and insects. Encourage entries into the SFS 'sightings book'.
- *Community engagement*: Incorporate systems to monitor the outcomes and actions decided upon during the *Sabhas*, ensuring accountability and measurable progress. Progress can be measured by the amount of monetary investment and the number of activities jointly executed.
- *Ecological integrity*: Establish a permanent water quality monitoring station at 'Milestone 64' to systematically measure parameters such as the nitrogen cycle, dissolved oxygen, pH, total dissolved solids (TDS), conductivity, turbidity, water flow rate, and water level. Additionally, consider integrating a terrestrial weather station to complement aquatic monitoring efforts.
- *Livelihood opportunities*: Maintain a data base of jointly managed programs conducted by WASI and local institutions. Ideally each program should have its own monitoring system.
- *Watch and Ward*: Conduct regular evaluations of the watch and ward system to assess its effectiveness and make necessary adjustments to improve coverage, enforcement, and response time. Metrics can be number of reports (illegal activity or wildlife crime/conflict), hours patrolled, and actions taken.

The Authors

Anirban Roy holds a bachelor's degree in biological sciences and pedagogy and a master's degree in plant sciences. He is pursuing a Ph.D. at the Academy of Conservation Sciences and Sustainability Studies (ATREE) in Bengaluru, where his research examines the socio-ecological impacts of community forest rights. Taking an interdisciplinary approach that combines forest ecology, management, and policy analysis, his work aims to support more just and sustainable conservation practices rooted in the relationships between people and forests.

As a Fulbright Visiting Scholar (2021-22) at the University of Minnesota Twin Cities (USA), Anirban examined how forest carbon-based mechanisms can be strengthened in both the USA and India.

He has developed environmental education initiatives and regularly engages in outreach efforts to raise public awareness on climate and forest-related issues. A strong advocate for public engagement, he also writes popular science articles to make environmental research more accessible and meaningful to diverse audiences.

As an ecological consultant at the WASI, Anirban led the formulation of the SFS Management Plan. He conducted multiple rounds of fieldwork— including ecological surveys, household and key-informant interviews, and focus group discussions— to gather insights on both biodiversity and local priorities. These findings informed a socio-ecological Management Plan that integrates ecological targets with community knowledge and aspirations.

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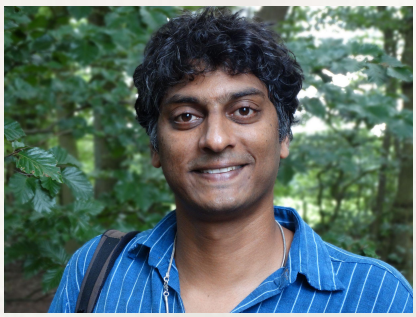

Naren Sreenivasan is a field biologist with a master's degree in Animal Ecology from Wageningen University and Research, The Netherlands. His graduate research focused on the dietary patterns of large herbivores in fenced game reserves within South Africa's Waterberg Biosphere Reserve. During this work, he became particularly interested in the role of freshwater availability in shaping herbivore distribution, foraging behaviour and predator-prey interactions.

As an ecological consultant to the Timbaktu Collective in Andhra Pradesh, he worked with the Kalpavalli Tree Growers' Cooperative Society to develop an Environmental Management Plan for the 10,000-acre Kalpavalli Community Conservation Area (KCCA), a semi-arid grassland ecosystem stewarded by multiple village committees and shaped by water scarcity.

Naren has since worked extensively on freshwater ecology, with a particular focus on the conservation and policy needs of the *mahseer*—a group of iconic large-bodied carps native to South Asian rivers. His work bridges ecological science and community engagement, and he regularly contributes to both scientific publications and popular media. He is a member of the Wildlife Association of South India (WASI), where he currently leads the organisation's conservation and ecological research programme. In this role, he collaborates with government bodies and local communities to generate ecological insights and advance the conservation of aquatic biodiversity in the Cauvery River Basin.

Naren first visited Shivanasamudram and the Cauvery Wildlife Sanctuary at the age of two, and its rivers and forests have remained central to his life and work. His long-standing association with the landscape inspired the vision and development of this Management Plan for the Shivanasamudram Fish Sanctuary, which he hopes will guide conservation efforts over the next decade and inform similar initiatives across Karnataka.

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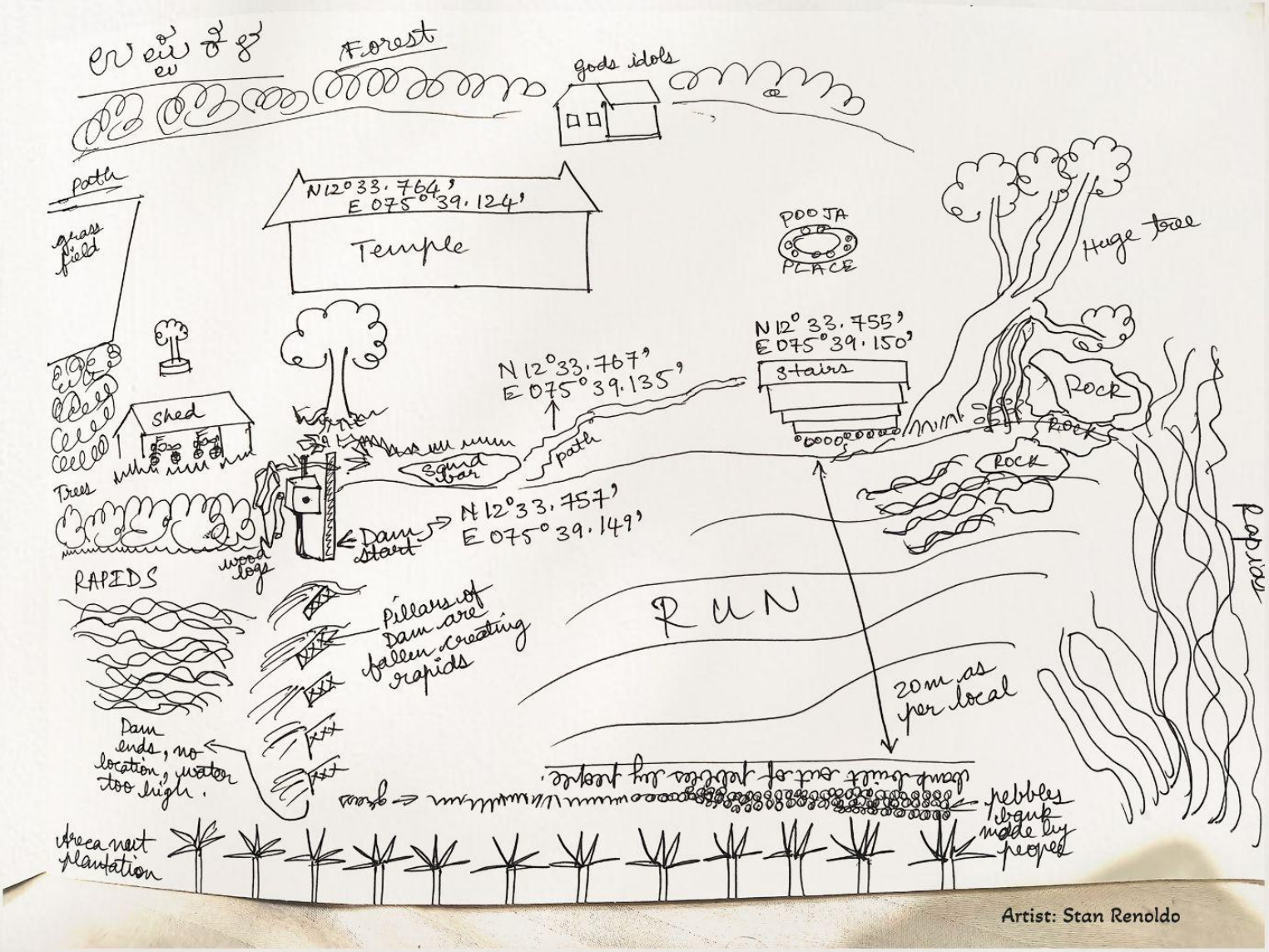

Village maps—like this hand-drawn rendering of the Uppukala Fish Sanctuary—do far more than chart geography. They breathe life into the landscape, capturing not only the contours of fields and the winding of footpaths, but also the scale of old trees, the rhythms of daily life, and the subtle shifts in how the land is used over time. Sketched from memory and experience, such maps often carry the emotional weight of a place—moments of wonder, quiet observations, and the deep connections formed through walking, watching, and listening. They invite us to see with both the eyes and the heart.