# Assessing the contribution of aquatic ecosystem services to human wellbeing and sustainability

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## Abstract

Aquatic ecosystems support human wellbeing and provide services critical to furthering and maintaining wellbeing and health, through, e.g., provisioning, regulating, cultural, and supporting ecosystem services, and sustainable development. Servicing these ecosystems and their links to human wellbeing and health, while vital to policy and management, is often overlooked. This study assesses aquatic ecosystem services for human wellbeing, health, and sustainability through provisioning, risk mitigation, cultural benefits, and recreation. Analyzing these datasets through field surveys, ecosystem service valuation, and sustainability indicators, this paper assesses how aquatic ecosystems fortify community resilience and stimulate economic and social cohesion. Most importantly, the data revealed that managed aquatic ecosystems improve human health and wellbeing while sustaining the service economy, social wellbeing, and supporting long-term ecosystem sustainability. This study also documented the impacts that climate change, pollution, and habitat loss have on these ecosystems. This aligns with the growing concern that attacks on aquatic ecosystems pose to sustainable climate management and ecosystem-driven economies, making this study essential to many. Ultimately, this research seeks to provide and support environmentally sustainable climate policies and ecosystem management to preserve and intergenerationally sustain the services supporting ecosystems and the services and climate managed by ecosystems beyond simply their climate stabilization.

**Keywords**: Aquatic ecosystem services, Human wellbeing, Sustainability, Environmental management, Climate change, Ecosystem valuation

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## Introduction

The various ecosystems formed by rivers, lakes, wetlands, estuaries, and coastal zones are critical to human livelihoods and wellbeing, as they provide numerous and varied ecosystem services vital to the survival of human societies. These include provisioning services such as the supply of freshwater, fish and other aquatic foods, and plants and biomass; regulating services such as the services of climate regulation, water purification, and nutrient cycling, flood control, and control of other ecosystem services; cultural services of recreation and other aesthetic and spiritual values; and supporting services of habitat provision and biodiversity maintenance (Ferreira *et al.*, 2023). For instance, ecosystem services studies of a particular kind highlight how ecosystems transform the resources of land, water, vegetation, and the atmosphere into various goods and services for people. These services are particularly critical, underpinning food and water security, livelihoods, and health (through the recreation and clean water), as well as resilience to environmental changes (flood mitigation, water filtration, and habitat buffering). Yet, the aquatic ecosystems themselves are increasingly and directly impacted by pollution, land use, climate change, invasive species, and hydrological alterations (Ureta *et al.*, 2024). This diminishes the capacity of support to sustain service flows, thereby undermining human wellbeing and ultimate sustainability.

The past decades have seen a growth in studies surrounding ecosystem services (Lynch *et al.*, 2023). The Millennium Ecosystem Assessment's pioneering studies connected ecosystem services to human well-being and global change, capturing the essence of flow services and their deterioration. Reviews of studies on particular services within an ecosystem have continued to develop; for instance, an overview of the ecosystem services of water notes the diversity in service types, variability in their supply, and various delivery threats to service delivery. Studies have also explicitly connected ecosystem services to human well-being and employed frameworks that map service supply, flow, and use to well-being outcomes (e.g., access to clean water, the provision of fish, health and nutrition (income), and social relations). Methodological progress is also evident in the measurement and valuation of ecosystem services, including aquatic valuation, simplification of spatial trade-offs, and linking services to sustainability outcomes (e.g., resilience, adaptive capacity) (Calapez *et al.*, 2023).

Nonetheless, significant disparities persist in critical areas of the tech literature, particularly in the field of ecosystem services provision and the services provision or wellbeing pathway model (De Carvalho *et al.*, 2025). First, the bulk of the literature review focuses on land ecosystem services, and far less is devoted to the effective integration of aquatic systems (fresh and coastal) (Oberdorff, 2022). Second, although service provision has been more accurately conceptualized in the literature, fewer studies robustly quantify the direct contribution of aquatic ecosystem services to the explicit human wellbeing drivers (health, livelihood, social indicators) and social determinants

of health (resilience, adaptive capacity, equity, intergenerational equity) (Huang *et al.*, 2024). Third, the literature is unevenly global, with a focus on specific regions of the world; case studies on ecosystem services provision and the integration of developing countries within (especially the particular ecosystems) remain scarce (Mannonov *et al.*, 2025). Finally, the integration of ecosystem service analysis with human wellbeing and sustainability frameworks (e.g., how ecosystem service flows enable sustainable development within ecosystem service provision systems at the community or regional scale) is, to some extent, still in its initial stages (Reke *et al.*, 2025).

## Aim and Objectives

This paper evaluates the contribution of wetland ecosystem services to the well-being of the populace and the sustainability of the Chalan Beel Wetland Complex in Northern Bangladesh. There is a need to assess the contribution of ecosystem services to the well-being of the population (health, income, recreation, social relations) and to sustainability (resilient systems, services, and the system's capacity to cope). The following are the aims of the study;

- To determine the principal aquatic ecosystem services and the advantages to the human population.
- To examine the connection between these services and the potential for human well-being.
- To evaluate the effect of the current level of service provisions on sustainability.
- To propose policies with integrated management for the improvement of ecosystem services and sustainable development.

## Materials and Methods

This study is a primary assessment of the Chalan Beel Wetland Complex in northern Bangladesh. It is one of the country's major, most productive, and most biodiverse ecosystems. Chalan Beel is an extensive system of lakes, rivers, and seasonal wetlands (Bishop *et al.*, 2025). It is a significant component of a floodplain system, helping regulate water quality and flood flows, and supporting the freshwater and fisheries needs of over 1 million people. The local economy is built on the area's biodiversity and diverse, productive ecosystems, including wetlands, agriculture, fisheries, and water supply. The wetlands have recently been experiencing significant climate change, pollution, and resource extraction. These factors, when combined, significantly affect the ecosystem balance and the essential services provided by the area (Arthington, 2025). The study combined primary and secondary data collected via remote sensing and conventional datasets. The primary provisioning services were the fish catch and freshwater supply. The regulating services were flood control, water purification, nutrient cycling, and flood control and water purification, as well as flood control; the cultural services were recreational, spiritual, and cultural traditions associated with the wetland ecosystem (Newton *et al.*, 2023). Socio-economic studies, health record collection, and community interviews were used to assess individuals' well-being, particularly to demonstrate the benefits to the community from the

services of the water ecosystem; the focus was on the positive effects on health and social well-being. Sustainability indicators were determined by ecological health assessments, biodiversity surveys, and geopolitical analyses of wetland conservation and management practices.

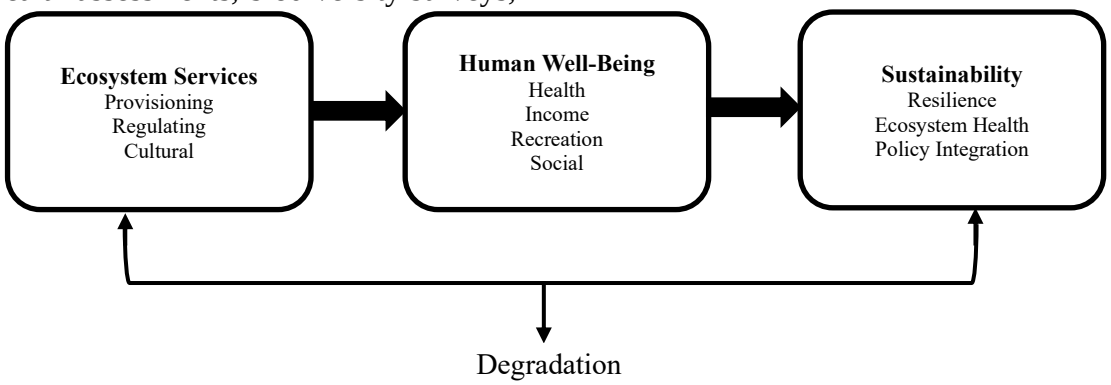


**Figure 1: Conceptual framework of aquatic ecosystem services and sustainability.**

The conceptual framework guiding this NHF-GI research project is predicated on the premise that the aquatic ecosystem services accruing in Chalan Beel are ecologically functional and interconnected with the region's socio-economic realities (Mahajan and Daw, 2016). As Figure 1 explains, the framework theorizes that the flow of ecosystem services, particularly in the provision of fish, flood moderation, and maintenance of water quality, reinforces positive outcomes for health, income, recreation, and other facets of human well-being in an ecologically balanced and resilient manner (Newton *et al.*, 2023). This relationship is symbiotic and, for that reason, critical, as human activities and climate change that impact aquatic ecosystems also negatively affect the well-being of people and the sustainability of the ecosystems. The study utilized a mixed-methods approach in data collection (Nabout *et al.*, 2023). The ecosystem services in Chalan Beel were monetarily valued, using economic valuation methods, particularly the contingent valuation method (CVM) and the replacement cost method. Various statistical approaches, particularly regression methods, were used to analyze indicators of human well-being, income, and health related to the water available to people, as well as the recreation, culture, and other social benefits of ecosystem services, especially in aquatic ecosystems (Lengyel *et al.*, 2023). GIS technologies were utilized to identify the geographical diffusion of ecosystem services to determine the effects of land use transformation and environmental degradation (Petropoulos and Lefèvre, 2025). Participatory approaches, such as community workshops and interviews with key informants, were conducted to gain local understanding of the perception, use, and valuation of the wetland ecosystem services by the dependent community (Lee *et al.*, 2023). Ecosystem services were measured by fish catch, water quality, flood control, and recreation, and the human wellbeing was captured on health-related (water-borne diseases, water access, and health), income (fishing and farming), and community activism in wetland

conservation (Naselli-Flores and Padisák, 2023). Sustainability was measured by biodiversity, ecosystem resilience to perturbations, and the extent to which adaptive management was practiced in the community (Nissar *et al.*, 2023).

## Results

Particularly in relation to the provision of fish and freshwater, the provisioning services of the Chalan Beel Wetland Complex became essential for the livelihood of the surrounding communities. The average annual fish harvest from this wetland was around 12,000 metric tons, which was a significant contribution to the local dietary and economic diversification. Furthermore, the wetlands annually supplied around 5,000,000 liters of freshwater for every individual, which was used for domestic, agricultural, and livestock purposes. The sale of fish harvested from the wetland annually earned the surrounding communities around $1,500,000, positively impacting more than 1,200 households. Hence, the wetlands were crucial in maintaining the provision of food and stabilizing the economy of the region. Table 1 presents the details of provisioning services which includes the fish yield and the water utilizations obtained during the respective seasons. This illustrates there seasonal differences in the availability of the services.

**Table 1: Provisioning services (fish yield and freshwater supply).**

| Month | Fish Yield (metric tons) | Freshwater Supply (liters) |
|---|---|---|
| Month 1 | 1066.13 | 372,896 |
| Month 2 | 951.07 | 460,602 |
| Month 3 | 1127.31 | 430,396 |
| Month 4 | 743.85 | 378,936 |
| Month 5 | 1129.46 | 436,571 |
| Month 6 | 1119.13 | 374,661 |
| Month 7 | 909.69 | 290,354 |
| Month 8 | 698.25 | 391,927 |
| Month 9 | 937.86 | 338,636 |
| Month 10 | 935.83 | 457,630 |
| Month 11 | 926.29 | 362,194 |
| Month 12 | 1053.70 | 376,604 |

Research shows that Chalan Beel contributes flood control and water purification services which greatly alleviates the community's risk exposure. The wetlands mitigation of flood risk is especially valuable during the flood months. Model simulations demonstrated that the wetland has the potential to lower peak flood levels by 2.5 meters and save 2 million dollars' worth of flood damages each year. In addition, the wetland has the capacity to purge 15,000,000 m3 of water each year, thereby improving water quality for consumption and agricultural use.

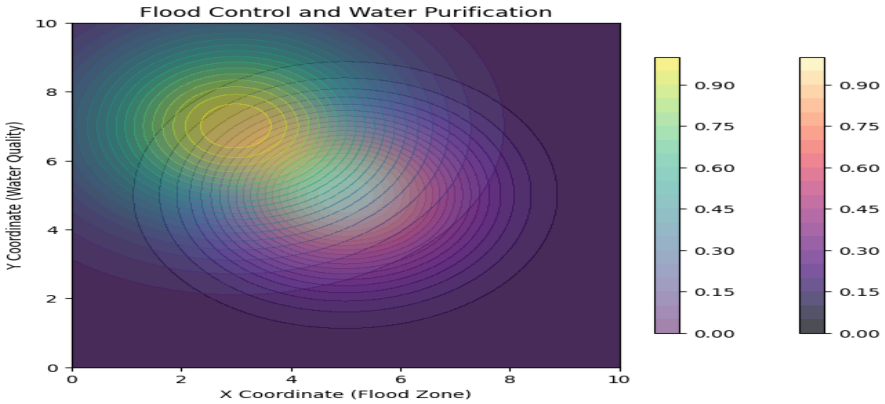


**Figure 2: Flood control and water purification: impact of wetland services.**

Figure 2 shows the difference in flood damages in years with and without the wetland's regulatory function and shows the reduction in flood damages and how wetland functions are flood damages and flood depths adjacent to the wetland.

The activities and attractions associated with the wetlands' cultural services were also extraordinary. Fishing, boating, and birdwatching are all activities the wetlands offer, catering to the community's social and cultural recreational needs. Close to 10,000 people participate in these activities every year, and the community benefits from the tourism the activities bring. Other cultural services stem from the wetlands' spirituality, traditions, and local rituals and festivals, many of which focus on the water ecosystems.

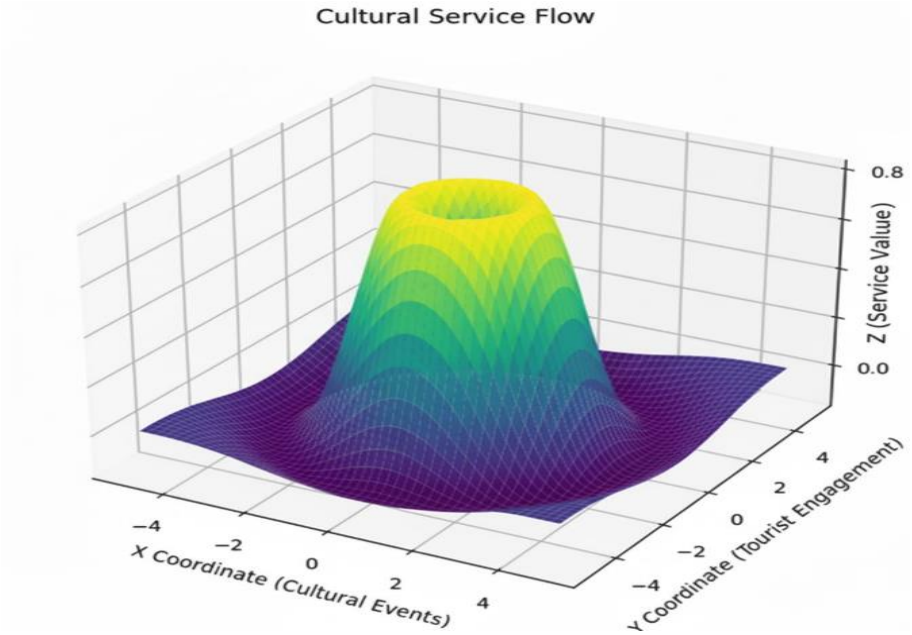


**Figure 3: Cultural service flow: recreational and touristic engagement.**

Figure 3 demonstrates the movement of cultural service benefits, displaying the economic value generated from tourism activities such as local crafts and food sales, as well as the number of recreational visits on a monthly basis.

Numerous indicators demonstrated the positive effects of aquatic ecosystem services on people's well-being. As the prevalence of waterborne diseases decreased and clean water became available, public health improved. Wetland-dwelling communities demonstrated 30% lower incidence of waterborne diseases, such as cholera and dysentery, than people living around areas devoid of such freshwater ecosystems. Domestic economic well-being, measured by income obtained from the services of the wetland and agriculture, was considerably greater in the households of the wetland's benefits. Such households earned 25% more than those having limited access to fish and freshwater from the wetland and used other, alternative, water sources. Table 2 illustrates the contrasting indicators of human well-being (health, income, social cohesion) in households with different levels of dependency on the wetland and the services it provides.

**Table 2: Human wellbeing indicators.**

| Month | Health Improvement (%) | Income Increase (%) | Social Cohesion (%) |
|---|---|---|---|
| Month 1 | 8.57 | 15.60 | 13.56 |
| Month 2 | 17.07 | 26.80 | 23.46 |
| Month 3 | 14.35 | 23.27 | 17.00 |
| Month 4 | 9.66 | 26.17 | 14.04 |
| Month 5 | 9.73 | 16.13 | 11.04 |
| Month 6 | 9.02 | 23.27 | 11.78 |
| Month 7 | 14.07 | 19.15 | 8.83 |
| Month 8 | 13.10 | 17.36 | 16.72 |
| Month 9 | 13.21 | 28.25 | 18.64 |
| Month 10 | 10.08 | 20.66 | 6.45 |
| Month 11 | 8.98 | 16.28 | 12.63 |
| Month 12 | 12.08 | 17.48 | 7.21 |

The impacts of various management and degradation scenarios on the sustainability of wetlands ecosystem services were assessed. Result showed that the wetland currently is offering substantial ecosystem services. However, the long-term sustainability of such services is compromised by increasing pollution and land-use changes. The moderate degradation scenario is predicted to incur a 20% loss on fish yield and available freshwater due to pollution and encroachment over the 10 subsequent years. Conversely, the active management and restoration scenario predicted a 15% improvement in service provision resulting in both ecological and human wellbeing.

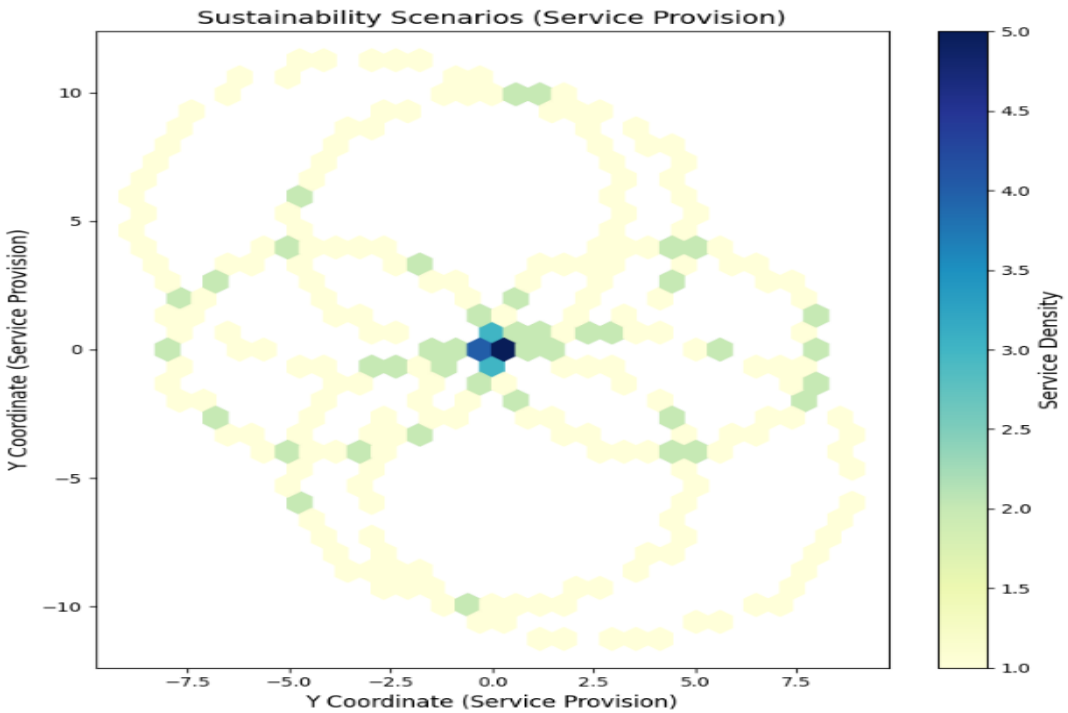


**Figure 4: Sustainability scenarios: service provision under different conditions.**

As depicted in Figure 4, the predicted results relating to the provision of ecosystem services and the interconnectedness of human beings with the ecosystem are contrasting across the different sustainability scenarios in focus. This graphical representation shows the different projected results based on the differing management practices.

## Discussion

The research articulates the wetlands the Chalan Beel Wetland Complex plays in enhancing human wellbeing and professional sustainability. The research reveals how the wetland's provisioning services yield fish and freshwater. The fish yield is twelve thousand metric tons annually and the freshwater is five

million liters per capita. It also generates an estimated income of annually of 1.5 million dollars. The freshwater fish yield is also fundamental for food security and regional economic stabilization. The wetland also provides flood control which lowers flood levels by 2.5 meters. This flood control protects resources and purifies fifteen million cubic meters of water annually saving around 2 million dollars. This also provides and regulates health. Public health is also regulated by the flood control. The wetland also provides and regulates health. The wetland also facilitates cultural activities and recreational activities. This floods community identity and stimulates local businesses and tourism. The research correlates with multiple previous research which advocate for wetlands also correlates with the support of the community. These researches advocate for these wetlands to be protected.

Despite this fact, there is advancing research showcasing the 15% uplift in service delivery in a restoration scenario which is more than the cautious optimism from previous studies (Kondolf, 2015). This is most likely due to the largely unmodified hydrology and ecological composition of Chalan Beel. Moreover, the positive association of social capital with the cultural services of the wetlands demonstrates the greater dependency of the community on the wetland for social and cultural practices and provides further insights into the human-wellbeing-aquatic ecosystems nexus. This study probably further informs the management and policy considerations of the Chalan Beel Wetland Complex in particular to preserving and improving the ecological services of flood control and water purification, which is critical due to climate change. Policymakers must prioritize sustainable wetland management that meets the dual objectives of maintaining the ecological integrity of ecosystems and community needs by encouraging the habitat restoration, sustainable, and pollution and land encroachment threat mitigation activities. Additionally, the study supports certain integrated water management policies that do not ignore the necessary relationships that exist between water bodies and ecosystems and the people that rely on them, and reminding that protective measures against over-exploiting certain ecosystems can enhance the supply of ecosystem services. Lastly, policies that promote community participation in wetland conservation such as the participatory workshops in this research can increase local awareness of the issues and promote desirable sustainable behavioral changes. The study's greatest strength is multi-faceted and the seamless incorporation of the ecological data along with the socio-economic variables and respective indicators which shows the interconnectedness between the role of the aquatic ecosystems and human well-being. The use of a mixed methods approach to ecosystem services and community impact of the ecosystem services also created an analytical framework to study the service of ecosystem. Studies that focus on participatory cases specifically designed to study the socio-cultural aspects and interrelationships with water bodies are necessary to improve management systems. The focus of the study are the socio-economic activities in the dry land around the wetland ecosystems. The use

of a case study also limits the study which purely focus on the Chalan Beel Wetland Complex. Other studies need to illustrate the detailed longitudinal data that this study lacks to clarify the culturally defined services of the ecosystem.

## Conclusion

The research outlines the value of the Chalan Beel Wetland Ecosystem in sustaining the wellbeing of the people and the planet. These wetlands support the provision of 12,000 metric tons of fish and 5 million liters of freshwater per capita, which are beneficial for food, income, and economic wellbeing. They also support the community in reducing floods and purify large volumes of water which help the community in mitigation and water regulation. These wetlands also improve community social cohesion and community mitigation through recreational and tourism opportunities. Healthy aquatic ecosystems are critical for the wellbeing of the society, the economy, and social systems. Conversely, aquatic ecosystems. ecosystems degradation through pollution and over-exploitation threatens these services and the communities reliant on them. The Chalan Beel Wetlands Ecosystem study advocates for comprehensive and participatory managed wetlands whereby Ecosystem healthy resource use and people support the continued services which support wellbeing and sustainable development of the region.

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