

Assessing the inter-linkage between ecosystem services and livelihood assets: case study of Deepor Beel Ramsar site in Assam, India

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ABSTRACT: The paper examines the significance of four essential ecosystem services—provisioning, regulating, cultural, and supporting services—in contributing to and enhancing livelihood assets, including physical, financial, natural, human, and social capital. Recognizing the intricate relation between wetland services and livelihoods is vital for improving resilience, sustainable development, and overall well-being. Deepor Beel, the lone Ramsar site in Assam, which supports livelihoods in nearby villages, has been considered a case study. The study explores the ecosystem services that the Deepor Beel provides and analyses how these could enhance livelihood assets. Using both qualitative and quantitative methods, the study employs Focus Group Discussions, Key informant interviews, and semi-structured questionnaires to interview 288 households. Results reveal that a substantial portion of the population significantly depends on the wetland. Fishing is a key livelihood source alongside farming, livestock rearing, and gathering resources like aquatic plants. The wetland serves as a crucial provider of varied services that can significantly improve people's livelihoods.

KEYWORDS: wetland, ecosystem services, livelihood, Deepor Beel, Ramsar site



1. INTRODUCTION

Wetlands are among the most valuable and diverse ecosystems on our planet, providing a plethora of essential services that benefit both nature and humanity (Cherry, 2011; Bassi et al., 2014). Ecosystem services are the benefits humans derive from natural ecosystems, ranging from tangible goods to intangible cultural values (Costanza et al. 1997; MEA, 2005). Wetlands provide numerous services and have essential roles in livelihood (Das et. al, 2022; Tecklie & Yosef, 2022; Tikadar et al., 2022; Sarmah & Mahanta, 2024; Sarmah et al., 2025). Recognizing the interplay between wetland ecosystem services and livelihoods is essential for fostering resilience, sustainable development, and improved quality of life (Sarmah & Mahanta, 2023). These services are categorized as Provisioning, Regulating, Supporting, and Cultural services, crucial in supporting and enhancing various aspects of human livelihoods.

Provisioning services provide tangible products from ecosystems, supporting human life and industries by improving nutrition, ensuring resource supply, and preserving traditional knowledge. Regulating services maintain essential environmental conditions, promote balance, reduce vulnerabilities, and conserve biodiversity. Supporting services, like soil formation and pollination, ensure ecosystem resilience and sustainability. Cultural services that offer recreation and spirituality enrich human capital, foster creativity, and deepen the connection between people and nature through art, literature, and research. In total, ecosystem services enhance livelihoods by providing both basic requirements and livelihood assets.¹ Livelihood assets are essential for building resilience and ensuring sustainable livelihoods. Assets help people cope with adverse situations and explore diverse livelihood options to mitigate risks (Mistri & Das, 2020). According to the Sustainable Livelihood Framework, these assets are classified into human, financial, natural, physical, and social assets/capital. Human capital involves individuals' knowledge, skills, and health in a community, where education and health play vital roles. Natural capital encompasses local resources like land, water, and biodiversity, essential for livelihoods. Sustainable management prevents degradation. Financial capital includes savings, assets, credit access, supporting investment, emergencies, and better living standards. Social capital is built on trust, relationships, and networks within a community, aiding information access and collective problem-solving. Physical capital, including infrastructure and tools, supports economic activities, trade, and productivity. Balancing these capitals is a key to sustainable development and well-being.

Though occupying a small fraction of the Earth, wetlands exert significant influence by fostering biodiversity, managing water resources, and providing vital ecosystem services. These areas are crucial havens for diverse wildlife, as nesting, feeding, and breeding sites, and stops for migratory birds on extensive journeys. Wetlands are also vital for maintain-

¹ Livelihood assets refer to the various resources and capabilities that individuals, households, or communities possess to secure their livelihoods and improve their overall well-being.

ing water quality by removing excess nutrients and pesticides that can degrade downstream water quality (Vymazal, 2017).

Deepor Beel², the lone Ramsar site of Assam, also serves enormous services (Dutta, 2017) and acts as a vital lifeline for the adjacent Rani and Garbhanga Reserve forests, especially for the endangered Asiatic Elephants (*Elephas maximus*) (Mitra & Bezbaruah, 2014). Besides its significance to elephants, Deepor Beel is also a sanctuary for many fish species, making it a critical breeding ground and fostering high fish productivity in the surrounding water bodies (Roy & Majumder, 2022). Despite the wetlands immense ecological importance, yet it confronts threats like habitat destruction, pollution due to urban waste dumping, illegal construction, transfer of land to private parties and various anthropogenic pressure contributing to significant ecological loss (Saikia, 2019; Dewan, 2011; Saikia, 2017, Saikia, 2005; Kopnina et al., Baranowski, & Russell, 2025). Thus, conservation efforts are vital to safeguard these ecosystems, ensuring sustainable coexistence.

The paper delves into the profound impact of four fundamental ecosystem services—provisioning, regulating, cultural, and supporting services—on enriching livelihood assets, encompassing physical, financial, natural, human, and social capital. By examining existing research, the study sheds light on the valuable ecosystem services the wetland provides and underscores the critical interlinkages they share with human well-being. It emphasizes the vital role of sustainable management practices in safeguarding the persistence of these ecosystem services for both present and future generations.

1.1 FOUR ECOSYSTEM SERVICES: PROVISIONING, REGULATING, SUPPORTING, AND CULTURAL

Ecosystem services benefit people from nature's ecosystems, providing essential contributions to human well-being and overall environmental health. These services can be categorized into four main types: provisioning, regulating, supporting, and cultural.

Provisioning Services

Provisioning services encompass the tangible products from ecosystems, such as food, freshwater, diverse crops, fish, timber, and medicinal plants. These services are directly linked to the production of natural resources that sustain human life and economic activities. It mainly contributes to physical capital by improving nutritional and health outcomes, ensuring a continuous supply of resources, supporting various industries and livelihoods, financial capital through trade and economic activities, and human capital by promoting traditional knowledge and cultural practices associated with resource utilization.

² In local language of Assam, wetlands are called Beel.

Regulating Services

Regulating services refer to the processes through which ecosystems regulate and maintain environmental conditions essential for life. These services contribute to ecological balance and stability, benefiting both natural ecosystems and human societies. Examples include climate regulation, water purification, and natural disaster mitigation. These services are crucial for safeguarding physical capital by reducing vulnerability to natural hazards, supporting financial capital through reduced healthcare and infrastructure costs, and enhancing natural capital by preserving biodiversity and ecological integrity.

Supporting Services

Supporting services are the underlying processes and functions enabling other ecosystem services. These services are not directly provided to humans but are fundamental for the functioning of ecosystems. It includes soil formation, nutrient cycling, and pollination. These services are vital for maintaining natural capital by ensuring ecosystem resilience and biodiversity, which, in turn, contributes to the sustainability of physical, financial, and human capital.

Cultural Services

Cultural services refer to ecosystems' non-material benefits, such as recreational opportunities, spiritual and cultural values, and aesthetic experiences. It significantly enriches human capital by improving mental health, fostering creativity, and strengthening cultural identities. Nature's beauty and diversity have inspired art, literature, and creative expressions across cultures, fostering a deeper connection between people and the environment. An ecosystem also offers opportunities for scientific research and educational experiences that contribute to our understanding of the natural world.

1.2 LIVELIHOOD ASSETS FOR SUSTAINABLE LIVELIHOOD

Livelihood assets are essential for building resilience and ensuring sustainable livelihoods (Sarmah et al., 2025). Livelihood assets are classified into five categories, namely, human, financial, natural, physical, and social capital. These are not mutually exclusive, and one compensates for the other for the deterioration of the same. Assets help people cope with adverse situations and explore diverse livelihood options to mitigate risks. (Mistri & Das, 2020). The five common livelihood assets are:

Human Capital

Human capital refers to the knowledge, skills, and health of individuals in a community. Education, vocational training, and health are vital components of human capital. Well-educated and skilled individuals are more likely to find better job opportunities and adapt to changing economic conditions. Good health is also crucial for productive work and overall well-being.

Natural Capital

Natural capital encompasses the natural resources available to a community, such as land, water, forests, minerals, and biodiversity. These resources provide the foundation for many livelihood activities, including agriculture, fishing, and forestry. Sustainable management of natural capital is essential to ensure long-term availability and prevent environmental degradation.

Financial Capital

Financial capital includes the financial resources available to individuals or households, such as savings, assets, and access to credit. Financial capital enables people to invest in income-generating activities, cope with emergencies, and improve their standard of living. Access to credit and microfinance can be particularly beneficial for small-scale entrepreneurs and farmers.

Social Capital

Social capital refers to the networks, relationships, and trust within a community or social group. It includes social support systems, community organizations, and informal networks. Substantial social capital can lead to better access to information, resources, and opportunities. Social connections are crucial for finding jobs, securing assistance during difficult times, and collectively addressing everyday challenges.

Physical Capital

Physical capital comprises the infrastructure, tools, and equipment necessary for livelihood activities. This includes transportation systems, communication networks, machinery, and technology. Improved physical infrastructure can facilitate trade, reduce transaction costs, and enhance productivity in various economic sectors.

Successful livelihood strategies often involve leveraging and combining these different assets effectively. For example, a farmer with human capital in the form of agricultural knowledge (know-how) can make use of natural capital (land and water) to grow crops and earn income. The farmer might also need financial capital to purchase seeds and tools, while social capital may help them access markets or share knowledge with other farmers in the community. Individuals and communities can build resilience and improve their overall quality of life by considering and nurturing these livelihood assets.

2. SIGNIFICANCE OF THE STUDY AREA—DEEPOR BEEL

Deepor Beel earned the title of Ramsar site in 2002. In 1971, it was named a Wetland of International Importance by the Ramsar Convention on Wetlands. In 1981, the Government of Assam recognized it as a Bird Sanctuary. In 2004, it was designated as an Important Bird and Biodiversity Area (IBA), situated at 91°39'E longitude and 26°08'N

latitude in the Kamrup Metropolitan district of Assam (Baruah, 2020). It is a freshwater lake in the southern tributary of the river Brahmaputra (Deka & Goswami, 1992; Saikia et al., 2014). According to the Ramsar site of India- Factsheets, Deepor Beels is a hotspot with a species richness of 219 birds, 50 fishes, 38 reptiles and amphibians, and 448 plants (MoEFCC, 2020).

Its strategic location makes it a crucial element in managing flood impacts, functioning as a stormwater reservoir and providing substantial advantages to the surrounding regions and Guwahati (Kalita et al., 2018; Saikia, 2019). This freshwater wetland not only serves as a habitat for various local wetland birds and migratory species (Dewan, 2011) but also sustains a diverse array of fish species that are vital for the livelihoods of nearby villages, including those involved in the ornamental fish trade (Dutta, 2017). A remarkable event in Deepor Beel is the community fishing, generally done on the first Sunday of the year. The entire community goes fishing on the same day. The fish caught are shared between relatives and sold in the market, which is a local festival in the community. The villages in and around Deepor Beel derive direct and indirect benefits from the Beel (Sarmah & Mahanta, 2024). The livelihood of the local people is dependent mainly on the wetland (Dutta & Sharma, 2020), like fishing, farming, livestock rearing, and collection of natural resources such as vegetables, *Nymphaea* nuts and flowers, along with medicinal plants (Saikia, 2005), enhancing its ecological and economic significance. Moreover, Deepor Beel can potentially develop wetland-based ecotourism, attracting nature enthusiasts and generating income for local economies. However, the wetland has been facing serious anthropogenic threats in recent times. A major issue recognized is the lack of a single authority responsible for managing the wetland. There is no specific department to manage wetlands. The Forest Department monitors the core area of the wetland, whereas the fringe areas are often ignored.

3. METHODOLOGY

By conducting an extensive literature review on Deepor Beel and engaging in direct interviews with the local community, valuable insights were gathered about the offerings and services provided by Deepor Beel. This study highlights the services provided by the Beel and classifies them according to the four ecosystem services: provisioning, regulating, supporting, and cultural services. To know the importance of these ecosystem services in enhancing local people's well-being through livelihood assets (natural, physical, financial, social, and human capital), they are classified based on regional perceptions of dependency and usage as high, medium, and low (Table 1). Thus, it reflects how vital they are to the community's livelihoods. This classification helps prioritize which ecosystem services most significantly contribute to enhancing the quality of life and sustaining the livelihoods of local populations, ensuring that resources are managed and utilized effectively in alignment with community needs.

Categories	Meaning
High	Goods and services that are widely used and essential for local subsistence.
Medium	Goods and services that are preferred could be done without it if unavailable.
Low	Goods and services whose use is considered optional.

Table 1. Criteria for ranking services based on dependency

Source: Adapted from Millennium Ecosystem Assessment, 2005 (Finlayson et al. 2005 and de Groot et al., 2018)

3.1 DESCRIPTION OF THE SAMPLE VILLAGE

The study takes into consideration six sampled villages (Keotpara, Tetelia, Deusotal, Chakardeo Mikirpara, Hirapara, and Borbori). The village Keotpara lies in the West of the Beel and basically consists of SC, especially the 'Koibortta' community engaged in fishing by profession. Similarly, Tetelia, in the East of the Beel, is also dominated by people whose livelihood depends on fishing. Hirapara on the West consists of the 'Hira' community, skilled and expert in pottery. They basically collect clay from Tetelia (Mahanta, 2018). Pottery making was a subsidiary occupation along with agriculture, but the art of pottery making has been declining in recent times. Deusotal and Chakardeo are located on the south-west fringe of the Beel and are inhabited mainly by tribal people. These villages are in the spotlight as they are the center of tourist visits. Deepor Beel bird watch tower, Office of the Forest Ranger, Deepor Beel Viewpoint is the focal point. Borbori, on the west, has people from diverse communities engaged in various livelihoods, including agriculture, fishing, petty business, and casual work.

3.2 DATA SOURCES AND SAMPLING DESIGN

Multi-stage purposive sampling was used to select the respondents. Six villages were selected out of 14 villages surrounding the wetland based on their dependence on the wetland. Secondly, 20% of the total households from each of the six villages were selected randomly. Thus, a total of 288 households were considered for the study. The study uses a mixed method using both qualitative and quantitative data. Household data was collected using a structured questionnaire modified after the pilot survey.

On the other hand, qualitative data were collected through Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) using a semi-structured questionnaire to complement the quantitative findings. For FGDs, a neutral environment was selected conducive for conversation with discussions for 1-2 hours with a diverse group of participants representing the target population. Open-ended questions were formulated to stimulate discussions among participants. Participants were free to discuss with minimal interference, and the key points were noted. Findings from FGDs are used to validate and justify the quantitative data and draw conclusions for better understanding.

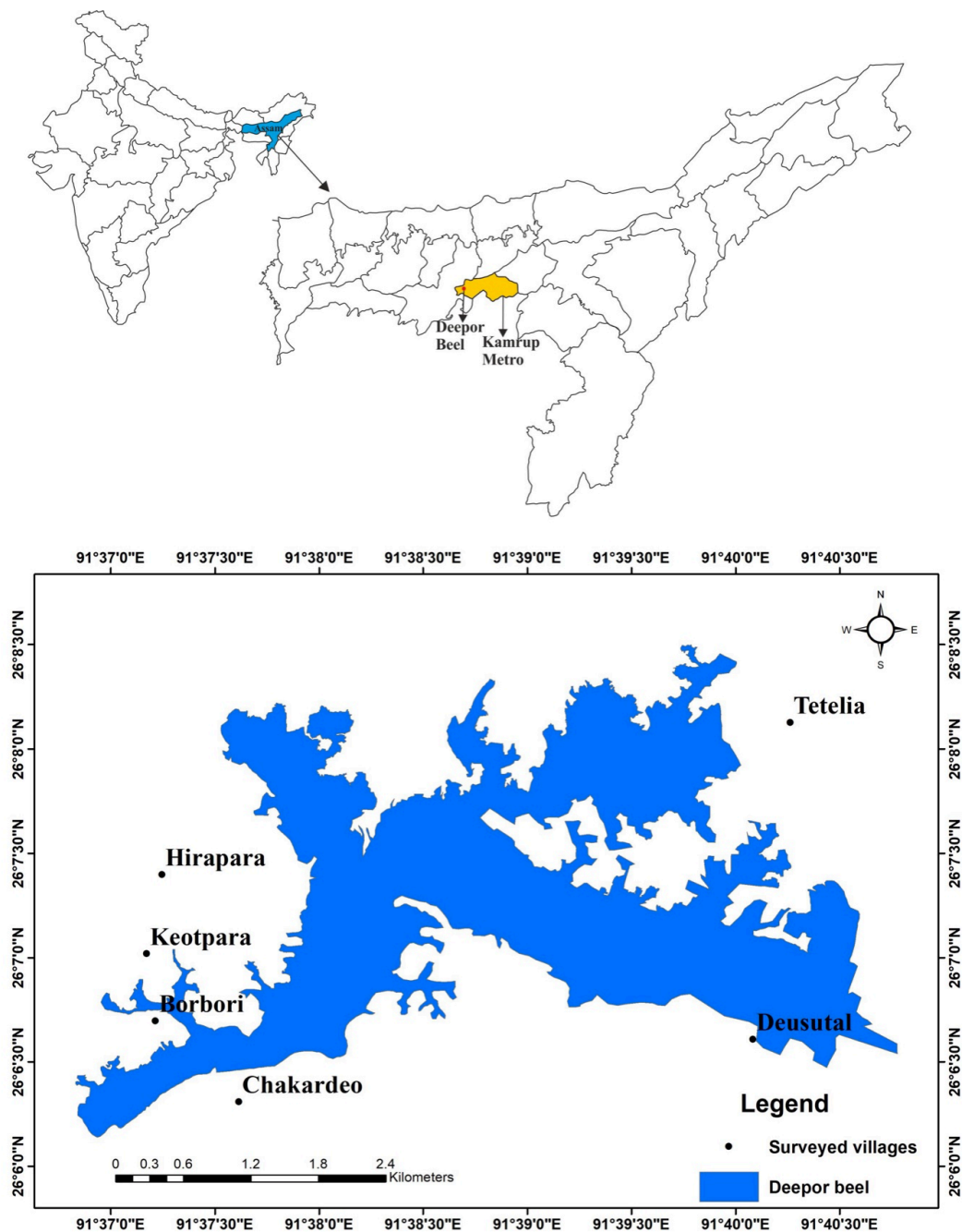


Figure 1. Map of the study area
 Source: Authors' own creation using GIS

4. ANALYSIS AND DISCUSSION

The study draws insights from focus group discussions (FGD), key informant interviews, and questionnaire surveys, which reveal a significant dependence on the wetland by a substantial portion of the population. The wetland serves as a crucial provider of provisioning services, including fish for consumption and sale, water for irrigation, crops, timber, medicinal plants, and water lilies. Moreover, it offers regulating and supporting

services, such as water purification, flood protection, and habitat provision for diverse flora and fauna, acting as a nursery for fish species. Cultural and aesthetic services, such as ecotourism, bird watching, boating, and sightseeing, also contribute to its value.

These services contribute to both financial and natural capital, forming the foundation for livelihoods like agriculture, fishing, and forestry. Additionally, the wetland serves as a source of physical capital, as its resources serve as raw materials for various industries, exemplified by water lilies' utility across multiple sectors, alongside water, medicinal plants, and timber. In addition to their direct benefits, wetlands contribute indirectly to human well-being by enhancing mental and physical health. Access to these natural environments has been linked to reduced stress, improved mental health, and increased opportunities for recreation and outdoor activities. Wetlands provide opportunities for bird watching, nature walks, and other recreational pursuits that promote physical activity and foster a sense of connection with the natural world.

4.1 TYPE OF SERVICES RECORDED FROM DEEPOR BEEL

Provisioning—Fishing for own use, Fishing for sale, Crops, Vegetables, Livestock, Fuel-wood, Fodder, Timber/poles, Medicinal plants, Ornamental plants, Wild edible fruit and vegetables, Mushrooms, Water for domestic, livestock and agricultural use, Clay collection, and Water lily (Makhana in local language) and Water Hyacinth (Meteka in local language).



Figure 2. Fishing in Deepor Beel

Source: Authors' photo. The authors hold the rights to publish this photo



Figure 3. Community fishing in Deepor Beel,

Source: Authors' photos. The authors hold the rights to publish these photos

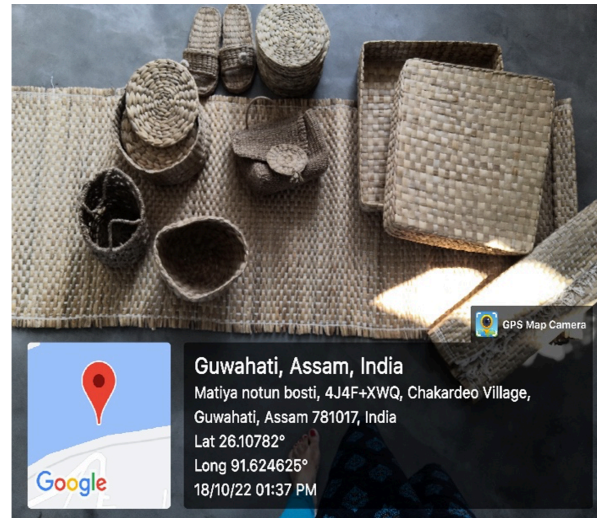


Figure 4. Products made from water hyacinth

Regulating—Carbon sequestration (capturing/storing atmospheric carbon dioxide), Climate regulation, Flood control, Groundwater recharge, Nutrient enrichment, Water purification and retention, Erosion protection, Natural hazard protection.

Supporting—Ecosystem resilience (ability to maintain regular pattern), Habitat for various plant and animal species, Breeding, Hydrological cycle, Nutrient cycling, and Soil formation.



Figure 5. Habitat for diverse species

Source: Authors' photo. The authors hold the rights to publish this photo

Cultural—Aesthetic beauty, Ecotourism, Education and research, Recreational opportunities, nature worship, and spiritual enrichment.

Eco-system Services	Categories	Services from Deepor Beel	Total Beneficiaries	Natural	Financial	Physical	Social	Human
Provisioning Services	Fish for own use	Source of nutrition for the locals	99%	High	Medium	Low	Low	Low
	Fish for sale	Source of livelihood for the Koibortra community/SC community from ancestral times	67.4%	Medium	High	Low	Low	Low
	Fodder for Livestock	Nutrition for the domesticated animals kept for the use of diversified products and profit	38%	High	Medium	Medium	Low	Low
	Crops	Cultivation of rice in the fringe areas of the wetland. Type- Bau, Boro, and Hali paddy	30.3%	High	Medium	Medium	Low	Low
	Vegetables	Production of Potato, carrot, Cabbage, mustard, etc.	47%	High	High	Medium	Low	Low
	Plants and herbs	Collection of Nymphaea nuts, Flowers, water lily seeds, Water Hyacinth, medicinal plants, and fruits	37.5%	High	Medium	Medium	Medium	Low
	Fuel wood and Timber	Collection of fuel wood for cooking and Timber for construction	11%	High	Medium	Medium	Low	Low
	Water	Source of irrigation, water for the wild animals from the Rani-Garbhanga reserved forests	18%	Low	Low	Medium	High	Low
Regulating Services	Climate Regulation	Regulation of Climate, temperature	27%	Low	Low	Low	High	Low
	Water Regulation	Deepor Beel is the only major storm water storage basin of Guwahati city, which helps in ground water recharge	40%	Low	Low	Low	High	Low

	Flood Protection	It has the capacity to protect Guwahati city from floods if maintained properly.	75%	Low	Low	High	High	Medium
Supporting Services	Species habitat	Species live and derive food and shelter	98.9%	High	Low	High	High	Low
	Transportation	Mode of communication for humans and animals	27.8%	Low	Low	Medium	Medium	Low
Cultural Services	Recreational and Tourism	Ecotourism facilities like Boating, sight-seeing, etc.	40.7%	Low	Medium	Medium	Medium	Low
	Educational	Enormous species of flora and fauna	30.6%	Low	Low	Low	High	High
	Aesthetic	Appreciation of nature and its beauty or art	67%	Low	Low	Low	High	High

Table 2. Ecosystem Services from Deepor Beel and its relevance to Livelihood Assets

Source: Primary Data

The majority of the occupation pattern in the study area revolves around the primary activities. It includes fish catching, fish trade, fishing gear making, collection of other resources from the Beel, agriculture, as well as business, and daily wage laborers are the main occupations. The data presented in the Table 2 underscores the pivotal role of the Beel, highlighting its significant contribution in provisioning fish for both personal consumption and sale. This function not only fulfills essential nutritional needs but also enhances the local economy by adding to both natural and financial capital. The wetland also serves as a crucial resource for providing sustenance to communities, as they rely on it for grazing fodder essential for their livestock's nourishment and well-being. Another product that can add to the financial capital is water hyacinth. Water hyacinth is an aquatic plant thriving in freshwater habitats. This invasive species has a propensity to create thick mats on water surfaces, exhibiting rapid growth, often multiplying within a mere week, impeding natural processes.

Nevertheless, its commercial viability holds promise for mitigating environmental concerns and fostering the development of sustainable goods. Few established industries have successfully transformed invasive weeds into beautiful commercial products like bags, mats, handicrafts, etc. If these industries grow successfully, they could serve as a model for other regions, demonstrating how such plants can be turned into valuable resources rather than environmental liabilities. Simultaneously, its role as a flood regulator, i.e., functioning as a storm water storage basin, positions the Beel as a key player in mitigating flood risks. They act as natural sponges, absorbing excess rainfall and runoff during storms. By doing so, they help reduce the impact of floods. This not only safe-

guards the surrounding communities from potential calamities but also contributes to enhancing social capital. The Beel becomes an integral part of the social fabric by fostering resilience and stability within the community. Its protective barrier against floods builds a sense of shared security and cooperation, strengthening social bonds. Beyond its utilitarian functions, the Beel serves as a thriving ecosystem, providing essential support to diverse species that find sustenance and shelter within the Beel. Moreover, the Beel offers intangible but invaluable aesthetic services, fostering an appreciation for nature and its intrinsic beauty among those interacting with this vital ecosystem. This aesthetic dimension adds not only to the social capital by creating shared spaces for enjoyment and connection, but also to human capital, enhancing the well-being and mental health of individuals within the community (Baranowski, 2023a, 2023b). The Beel, therefore, contributes not just to the ecological diversity and economic sustenance but also to the broader enhancement of social and human aspects of the community.

5. CONCLUSION

The paper underscores the critical importance of the four ecosystem services and explores their significance in bolstering different livelihood assets, including physical, financial, natural, human, and social capital. A vital source of provisioning services, the wetland offers fish for sale and consumption, water for irrigation, crops, lumber, medicinal plants, and water lilies. In addition, it provides regulatory and auxiliary functions, including flood control, water filtration, and habitat supply for various animals and plants, including fish. Services related to culture and the arts, like boating, ecotourism, bird viewing, and sightseeing, also add to its worth. These services support natural and financial capital, the basis for industries including forestry, fisheries, and agriculture.

Furthermore, Deepor Beel supports numerous economic activities, enhancing livelihoods and offering valuable resources and opportunities to local communities. The wetland is extremely valuable, yet it faces risks such as habitat destruction, pollution from dumping urban garbage, illegal development, and other anthropogenic pressures that lead to considerable ecological loss. By recognizing the multiple benefits that Deepor Beel ecosystems provide, policymakers and stakeholders can work together to conserve the ecosystem of the Beel and strengthen the livelihood aspects of the wetland-dependent community.

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