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Comparative Assessment of Ecosystem Services: Analysing Dal and Wular Lake

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ABSTRACT

The study has conducted a comprehensive assessment of the economic value inherent in lake ecosystems, with a specific emphasis on the monetary valuation of water-related goods and services. Employing an integrated research approach that combines (Market Prices, Contingent Valuation, Travel Cost Method, Hedonic Pricing, Economic Input-Output Analysis, Ecosystem Service Production Functions, and Benefit Transfer Methods), our investigation reveals compelling insights into the substantial economic impact of these ecosystems. The findings quantify the monetary worth of lake resources and underscore the broader ecological and societal significance of preserving these vital environments. By bridging the gap between economic valuation and ecological health, our research contributes to the sustainable management of lake ecosystems. It advances our understanding of the intricate interplay between nature and economics. The study provides implications for policymakers, environmental practitioners, and researchers in lake water conservation and management.

Keywords: Economic valuation, ecosystem services, lake ecosystems, sustainability.

JEL codes: Q01, Q57

I

INTRODUCTION

Water is vital in sustaining life on earth by supporting and interconnecting global ecosystems (Jackson et al., 2001). Ensuring an ample food supply and a productive environment for all living organisms is contingent upon the availability of water and water resources (Wassie, 2020). The demand for freshwater worldwide has surged due to the rapid growth of human populations and economies (Jury and Vaux, 2007). This escalating demand threatens biodiversity in aquatic and terrestrial ecosystems, risking human food security (Rice and Garcia, 2011). Many countries are grappling with widespread water stress due to the adverse impacts of global population growth, climate change, and shifts in lifestyle (Schewe, 2014). Consequently, there is a growing awareness of the pressing need for water conservation. The significance of lake water ecosystems on a global scale is undeniable, as they intricately support and interconnect diverse ecosystems across the planet (Acharyya, 2021). From small ponds to vast freshwater expanses, these ecosystems are vital in providing the essential habitats and nourishment for many species (Sorensen et al. 2020). Within the worldwide context, lakes contribute essential ecosystem services, such as water purification, climate regulation, and support for fisheries, while also holding cultural and recreational value for human societies globally (Sterner et al., 2020). However, the global scenario

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surrounding lake water ecosystems is marked by opportunities and challenges. Positive contributions include crucial roles in maintaining biodiversity and providing valuable services (Brockerhoff et al., 2017). Yet, lakes face escalating threats, including pollution, over-extraction of water resources, habitat degradation, and the compounding impacts of climate change (Koff et al., 2016). Rapid global population growth and urbanisation further intensify the strain on freshwater resources, exacerbating the challenges faced by lake ecosystems (Ho and Goethals, 2019). Effectively addressing these complex issues necessitates collaborative, international endeavours and the adoption of sustainable management practices (Bodin, 2017). A comprehensive understanding of the intricate global dynamics of lake water ecosystems is indispensable for successfully implementing conservation strategies (Mooij et al., 2010). This approach ensures the continued delivery of crucial ecosystem services, safeguards biodiversity and contributes to the well-being of human and natural communities globally (Prip, 2018).

The lake water ecosystem in the Indian scenario is paramount, contributing significantly to the country's ecological, social, and economic fabric (Gadgil and Guha, 2013). Lakes in India cover a diverse range, from the iconic Himalayan lakes to those in the arid regions, each playing a unique role in sustaining biodiversity and providing various ecosystem services (Mandal et al., 2023). Approximately 14.8 per cent of India's land area is covered by wetlands, which include lakes (Brinkmann et al., 2020). These water bodies support a rich diversity of flora and fauna, acting as vital habitats for numerous species (Oertli et al., 2002). The cultural and spiritual significance of many Indian lakes further amplifies their importance, with lakes often being integral components of local traditions and beliefs (Nawre, 2014). However, the Indian scenario also reflects the challenges lake water ecosystems face. Rapid urbanisation, industrialisation, and agricultural expansion have led to increased pollution and encroachment, posing significant threats to the health of these ecosystems (Durga and Kumar, 2017). According to recent studies, approximately 45 per cent of India's lakes are polluted due to untreated domestic and industrial discharges (Tariq and Mushtaq, 2023). Water scarcity is another pressing concern, affecting more than 50 per cent of India's lakes, with irregular rainfall patterns and over-extraction of groundwater exacerbating the issue (Karimi et al., 2024). Climate change impacts, including altered precipitation and rising temperatures, further contribute to the vulnerability of these ecosystems (Knapp et al., 2008). In response to these challenges, the Indian government has initiated various conservation and restoration efforts. The National Lake Conservation Plan (NLCP), for example, aims to restore and conserve key lakes across the country (Mishra et al., 2023). Additionally, community-based initiatives and collaborations with non-governmental organisations are crucial in addressing the issues faced by Indian lake water ecosystems (Thara and Patel, 2010). Despite these efforts, ongoing vigilance, sustainable management practices, and community involvement are imperative to ensure the resilience and well-being of India's lake water ecosystems (Bawa et al., 2021). Integrating scientific research, policy frameworks, and community engagement is essential for navigating the complex dynamics and securing the future of these vital water bodies in the Indian context.

The degradation of ecosystem valuation is a pressing global concern with far-reaching implications for economies, societies, and the environment (Devi, 2024). On a global scale, the erosion of ecosystem services is associated with substantial economic losses, with estimates projecting potential annual damages of approximately $10 trillion by 2050, according to insights from the World Economic Forum. This underscores the urgent need for concerted global efforts to address the multifaceted challenges contributing to the decline in ecosystem services (Sindhu et al., 2023). In the Indian context, the loss of ecosystem services has profound implications, particularly in the agricultural sector (Dhakal and Kattel, 2019). The decline in crucial services like pollination and soil fertility directly threatens crop yields, impacting the livelihoods of millions of farmers and contributing to economic losses (Campbell, 2017). Water scarcity, affecting over 50 per cent of India's lakes, also compounds the challenges in sustaining ecosystems and supporting human needs.

Jammu and Kashmir (J&K), characterised by its unique Himalayan region, faces distinctive challenges related to ecosystem degradation. Glacial retreat in the Himalayas, a consequence of climate change, directly affects water resources and ecosystems, leading to shifts in freshwater availability. Biodiversity loss and habitat degradation further jeopardise the region's rich natural heritage, impacting the ecosystem's resilience and the communities dependent on it. Moreover, the tourism sector, a crucial component of J&K's economy, is intricately linked to the pristine environment (Majeed and Luni, 2019). The degradation of ecosystems threatens the region's biodiversity and impacts the appeal of J&K as a tourist destination. This, in turn, affects local communities reliant on tourism for their livelihoods, highlighting the intricate interplay between ecosystem health and economic sustainability.

In conclusion, the loss of ecosystem valuation is a complex and interconnected challenge manifesting globally and nationally in India, specifically in the unique context of Jammu and Kashmir. Sustainable management practices, conservation initiatives, and informed policymaking are imperative to mitigate these losses and ensure the resilience of ecosystems for the well-being of both nature and humanity.

II

SCOPE OF THE STUDY

The present study seeks to explore the intricate dimensions of ecosystem services offered by lakes. With a global perspective, the study aims to quantify the economic impact of ecosystem service degradation on lakes, drawing insights from estimates provided by authoritative bodies such as the World Economic Forum. Simultaneously, it will delve into the biodiversity crisis on a global scale, examining the risks faced by around one million species, underscoring the interconnectedness of ecosystems. Transitioning to an Indian context, the research will investigate the economic repercussions of ecosystem service loss in Indian lakes, particularly emphasising its effects on agriculture and food security. Real-time challenges posed by water scarcity in Indian lakes, as evidenced by data from sources like the Central Water Commission, will be crucial focal points. Zooming in further to Jammu and Kashmir (J&K), the study will analyse the immediate impacts of glacial retreat on water resources and ecosystems in the unique Himalayan region, utilising real-time data from monitoring agencies. Additionally, the research will explore the implications of biodiversity loss and habitat degradation in J&K, considering their intertwined connection with the tourism sector. To provide a comprehensive approach, the study will integrate ongoing global and Indian initiatives, such as the Ecosystem Services Accounting for Development project, comprehensively mapping and quantifying ecosystem services. Recognising the immediate impacts of climate change, including temperature shifts and extreme weather events, will be crucial for understanding the resilience of lake ecosystems. Ultimately, "Water's Worth" aspires to offer a holistic understanding of the current state of lake ecosystems, shedding light on tangible consequences of ecosystem service degradation and proposing viable pathways for sustainable management and conservation at global, national, and regional levels.

III

METHODOLOGY

3.1 Sources of Data

The present study is based on both primary and secondary data. While secondary data were obtained from diverse sources, primary data were collected from sample respondents selected using an appropriate sampling design. Secondary data on indicators, including the present area of the lake and physiochemical features of lakes, were collected from various sources like journals, research reports, village records, the internet, previous research, annual reports and other related documents and various governmental/non-governmental agencies. The relevant primary data were collected from the respondents using a pretested questionnaire prepared in accordance with the objectives of the study. The primary data on the following indicators was collected from sample respondents at Dal and Wular by applying a scientific approach, including uses of water resources, extent of degradation, causes of degradation, impacts of degradation, governance issues relating to lake management, institutional impact on water resources and impact of tourism on water resources, etc.

The valuation of ecosystem services obtained from Dal and Wular Lake was done in the 1980s and 2020. As far as the valuation of the 1980s is concerned, it was based on a memory-based method. The respondents were categorised into different age groups for this method to be more efficient. Respondents with an age group> 65 years were selected to evaluate ecosystem services during the 1980s.

3.2 Sampling Design

The Kashmir division of Jammu & Kashmir Union Territory was purposely chosen for the present study owing to the majority of lakes in it. Dal and Wular Lakes have been studied based on the maximum eutrophic status *(Vass 1980)* of these lakes. Different stakeholders are directly or indirectly associated with these lakes, and due care was taken to choose a representative sample of respondents from each category around each lake. A sample of each kind of respondent was selected in the same proportion as exists in their actual population. As high as 125 respondents, constituting local households, fishermen, farmers, transporters/parking operators, shikara/houseboat owners and tourists (local, foreign, domestic) were selected randomly in proportion to their existence proportion and the site was chosen randomly from each lake. This way, we could have 250 sample respondents for the present investigation.

As a part of our major study, Anchar Lake was included alongside Dal and Wular Lake. Since Anchar Lake is hyper-eutrophic, according to Carlson's trophic state index (TSI), which ranges from 71 to 80.4, it was not possible to evaluate the ecosystem services present in 2020, as most of these services vanished over time. As a result, Anchar Lake was excluded from this comparative study.

TABLE 1. SAMPLING DESIGN

UT (1)	Jammu & Kashmir (2)	 (3)
District	Srinagar	Bandipora
	Dal	Wular
Respondent Type	Local Households (20) Fisherman (20) Farmers (15) Transporters/Parking Operators (10) Shikara/Houseboat Owners (15) Tourists (45)	Local Households (30) Fisherman (15) Farmers (25) Transporters/Parking Operators (5) Shikara/Houseboat Owners (10) Tourists (40)
Total respondents	125	125
Total sample Size	250	

***3**.3 Analytical Tools*

To meet the objectives of the present study, both tabular and functional/statistical approaches were employed for the analysis of the data and interpretation of the results.

3.4 Tabular method

The primary data collected through schedules were tabulated to workout averages, ratios and percentages. A tabular technique was employed to evaluate various goods and services obtained from the lake ecosystem.

3.5 Lake Degradation Function

To capture the determinants of lake degradation, the following function was fitted and estimated;

LWD= *f* (LL, LE, AL, IDW, SW, IW, IFP, BIO, EHG, IT…… U)

Where;

LWD = Lake Water Degradation (%), LL = Land on Lease for lotus stem cultivation (in kanals), LE = Land encroachment by local households (in kanals), IDW = Improper dumping of solid and plastic waste (binary 1 for yes and 0 otherwise), AL = Agricultural land conversion by local households (in kanals), SW = Sewage water discharge by local households (binary 1 for yes and 0 otherwise), IW = Industrial wastewater (binary 1 for yes and 0 otherwise), IFP = Intensive use of fertilisers and pesticides by local farmers (binary 1 for yes and 0 otherwise), BIO = Blockage of various inlet and outlets (binary 1 for yes and 0 otherwise), EHG = Extensive harvesting of goods from lakes (binary 1 for yes and 0 otherwise), IT = Irresponsible Tourism (binary 1 for yes and 0 otherwise)

Several variables were attempted to estimate this function; however, the final model retained only those variables which gave the best fit to its estimates.

TABLE 2. METHODS USED FOR CALCULATING GOODS/SERVICES PROVIDED BY LAKES

Goods/Services	1. Regulating Services		
(1)	Brief Description (2)	Method Used (3)	Reference Used (4)
Air Quality Regulation	The lake/wetland ecosystem has the ability to maintain air quality by extracting aerosols and chemical compounds from the atmosphere.	Replacement Cost Method/Contingent Valuation Method (*Replacement cost was used in calculating the regulating services as the replacement cost method gives the actual figure in replacing that service in the present market).	Marcus & Kelly 2014
Climate Regulation	Lakes/wetlands through their biologically mediated processes stabilise the micro climate of the region; however, at global scale they moderate climate vagaries through the land cover and other processes.		
Hydrological Regimes	Lakes/wetlands regulate hydrological cycle and regulate water regime through groundwater recharge, evapotranspiration and by capturing and gradually releasing the water.		
Pollution Abatement & Detoxification	Lakes/wetlands drastically reduce the nutrient input from flowing surfaces and sub-surface run-offs. The biotic and abiotic factors in the lakes/wetlands lead to the detoxification of the pollutants and xeric compounds carried into the ecosystem.		
Erosion Control	Lake/wetland vegetation and biota reduce the erosion of soil through sediment binding and reducing velocity.		
Natural Hazard Mitigation	Lakes/wetlands help to lessen the negative impact of flooding by soaking up the water and reducing the speed at which flood water flows.		
Biological Regulation	Lakes/wetlands regulate population structure of the ecosystem through trophic relation.		

(CONTD.)

(TABLE 2 CONCLD.)

2. Provisioning Services			
Food	Production of edible plants like Nelumbo nucifera and animals like fish, etc.	Market Price Method/Replacement Cost Method (*Market Price Method was used in calculating the provisioning services as market prices provided the real market value of these goods and services).	Xiang (2016) Qiuyan (2021)
Fresh Water	The biotic and abiotic processes taking place in the lake/wetland ecosystem enhances water quality. Lakes/wetlands have a vast ability to meet municipal water supply in the neighbouring areas.		
Fuel & Fibre	Lakes/wetlands are home to a number of species or abiotic components with potential use for fuel or raw materials.		
Biochemical Products and Medicinal Resources	Lakes/wetlands act as huge reservoirs of potentially beneficial chemical compounds with medicinal and cosmetic properties.		
Genetic Materials	Lakes/wetlands represent areas of high biological diversity and support gene pools of the most diverse assemblages of a wide variety of flora and fauna		
Ornamental Species	Lakes/wetlands provide vital habitats for many species and other abiotic resources with ornamental value.		
3. Socio-Economic Resources			
Cultural Heritage & Identity	Lakes/wetlands symbolise the culturally significant landscape by creating a sense of belongingness for certain features and species it beholds.	Willingness to pay Method/Travel Cost Method (*Willingness to Pay Method was used in calculating the cultural services as WTP directly measured people's preferences and choices in monetary terms. It provided a more accurate reflection of how individuals value ecosystem services because it captured what they are actually willing to give up in terms of money to obtain these services.)	Seyoum *et al.*, 2022
Tourism & Recreational	Lakes/wetlands provide panoramic views of landscape having humongous recreational potential for tourism.		
Aesthetic	The aesthetics provided by the lakes and wetlands is based on greenness, tranquillity and diversity.		

IV

RESULTS AND DISCUSSION

4.1 Valuation of Lake Ecosystem

Appropriate methods, as discussed under the sub-heading in the ensuing section, have been adopted for the valuation of goods and services flowing from selected Lake Ecosystems.

4.1.1 Valuation of Dal Lake ecosystem – Stakeholder-wise

Valuing the goods and services provided by Dal Lake is important for several reasons, including economic and environmental perspectives. Dal Lake, located in Srinagar, is a natural asset and a cultural and historical symbol. Values are obtained from Dal Lake mainly in provisioning, supporting, regulating and cultural forms. The value of these goods & services was calculated for 1980 and 2020, and a change in valuation was observed over these years. The value of these goods and services varies from respondent to respondent, as depicted in Table 3.

TABLE 3. VALUING GOODS & SERVICES IN DAL LAKE AMONG DIFFERENT STAKEHOLDERS (RS/HAC) (N=125)

Type of Respondents	Provisioning		Supporting		Regulating		Cultural		Total	
	1980	2020	1980	2020	1980	2020	1980	2020	1980	2020
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Local Households	429345 (70.98)	338023 (69.90)	39260 (6.49)	58021 (12.00)	72500 (11.99)	47900 (9.91)	63800 (10.55)	39620 (8.19)	604905 (100)	483564 (100)
Fishermen	322560 (66.31)	250530 (65.61)	32450 (6.67)	54644 (14.31)	71860 (14.77)	43050 (11.27)	59595 (12.25)	33610 (8.80)	486465 (100)	381834 (100)
Farmers	512540 (74.32)	410125 (74.93)	42840 (6.21)	52850 (9.66)	78245 (11.35)	49495 (9.04)	56050 (8.13)	34850 (6.37)	689675 (100)	547320 (100)
Transporters/Parking Operators	51840 (23.92)	24745 (16.55)	39960 (18.44)	55245 (36.95)	62830 (28.99)	34045 (22.77)	62080 (28.65)	35480 (23.73)	216710 (100)	149515 (100)
Shikara/Houseboat Owners	129750 (42.43)	96155 (39.01)	42810 (14.00)	63120 (25.61)	75410 (24.66)	49220 (19.97)	57850 (18.92)	37970 (15.41)	305820 (100)	246465 (100)
Tourists	30400 (12.73)	13790 (7.56)	43180 (18.08)	63070 (34.59)	72090 (30.19)	37040 (20.32)	93100 (38.99)	68410 (37.52)	238770 (100)	182310 (100)
Total	1476435 (100)	1133368 (100)	240500 (100)	346950 (100)	432935 (100)	260750 (100)	392475 (100)	249940 (100)		

The value of provisioning services was higher compared to all other ecosystem components. The supporting and cultural services provide values, which are other important items after provisioning services. The value availed and observed by different stakeholders varies significantly. The value of provisioning services, as revealed by farmers, was found to be as high as 75 per cent, followed by local households' 70 per cent, as seen in Table 3. The provisioning services mainly include water resources, food materials, commercial fish, raw materials, and fodder for livestock; tourists have put relatively lower values on these services. Similarly, the values of supporting services, including waste regulation, biodiversity conservation, and increase in land valuation, were higher for tourists, transporter/parking operators and shikara/houseboat owners. Different stakeholders also valued regulating and cultural services. The value of supporting services was relatively less for Dal Lake. Values for cultural services were higher for shikara/houseboat owners and tourists and relatively lower for farmers. The present study supports the study by Wani et al. (2019), which also concluded that the selected water bodies have economic value worth millions of US dollars. Most people living in the valley rely on these water sources for their daily needs.

4.1.2 Valuation of Dal Lake ecosystem – Ecosystem Service-wise

Although different stakeholders have availed and put different values for services flowing out in Dal Lake, farmers aiming to their close association with Dal have main values for this Lake followed by Local households. Tourists have availed relatively lower values for Dal Lake. Farmers have also valued provisioning services more compared to others. Other respondents have relatively better values for supporting services. The value of provisioning services was as high as 36 per cent for farmers, followed by local households at 30 per cent, as seen in Table 3. These services were valued highest (Rs 4,10,125) among farmers, followed by local households (Rs 3,38,023). All the respondents observed a decline in the ecosystem values for this lake, though the decrease was yet more prominent for Shikara/Houseboat owners. Schulz et al. (2017) outline the complex relationships between values and water governance and propose a novel conceptual framework that integrates insights from various disciplines, including psychology, economics, philosophy and geography.

4.1.3 Valuation of Wular Lake ecosystem – Stakeholder-wise

Wular Lake, located in the Union Territory of Jammu and Kashmir, is one of the largest freshwater lakes in Asia. It holds significant ecological, economic and cultural importance for the region. This expansive freshwater lake has ecological significance and serves as a wellspring of goods and services that sustain local communities and enrich the region's economy. During the present study, these goods and services were valued over the years to determine the change in valuation of these services. As depicted in Table 4, the value of provisioning services was found to be as high as 71 per cent for farmers, followed by local households (26%). The key components of provisioning services include water resources, food supplies, commercial fish, raw materials and cattle feed. Similarly, supporting services include waste regulation, biodiversity conservation and an increase in land valuation, with farmers, tourists and owners of shikaras and houseboats finding the value to be highest (29%). Other services, such as regulating and cultural services, were also valued among different stakeholders, adding to the services provided by the lake water ecosystem. The cultural services have relatively less value for farmers, and the value is higher for tourists. The study was consistent with the investigation carried out by (Kavi Kumar et al., 2022), which estimates the values of several provisioning, supporting, regulating and recreational services using a combination of valuation methods, constituting about 2.4 per cent of India's net national product that year. Recreational services account for the largest share at 45 per cent, followed by regulating services at 35 per cent and provisioning services at 20 per cent.

4.1.4 Valuation of Wular Lake ecosystem – Ecosystem service wise

Farmers seeking a close relationship with Wular Lake have the highest values for this Lake, followed by local households, even though many stakeholders have utilised and placed varying values on the services coming out of Wular Lake. For Wular Lake, tourists have gotten relatively lower prices. In comparison to other people, farmers also value provisioning services more. Other respondents place a higher emphasis on supporting services. As shown in Table 4, the value of provisioning services was determined to be as high as 37 per cent for farmers and 26 per cent for local households. Farmers placed the highest value on these services (Rs 2,92,620), followed by local families (Rs 2,05,015). While the loss was more pronounced for Shikara/Houseboat, all responders had noticed a decline in the ecosystem values for this lake. Hao et al. (2013) estimated the magnitudes and economic values of the water ecosystem services in a river basin and observed a general loss due to the factors also identified in our study.

TABLE 4. VALUING GOODS & SERVICES IN WULAR LAKE AMONG DIFFERENT STAKEHOLDERS (IN RS/HAC) (N=125)

Type of Respondents	Provisioning		Supporting		Regulating		Cultural		Total	
	1980	2020	1980	2020	1980	2020	1980	2020	1980	2020
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Local Households	287740	205015	30230	35860	61530	43250	48340	39620	427840	323745
	(67.25)	(63.33)	(7.07)	(11.08)	(14.38)	(13.36)	(11.30)	(12.24)	(100)	(100)
Fishermen	293030	202015	31030	33570	65490	45130	45400	33610	434950	314325
	(67.37)	(64.27)	(7.13)	(10.68)	(15.06)	(14.36)	(10.44)	(10.69)	(100)	(100)
Farmers	358025	292620	31720	37960	65590	49005	41665	34850	497000	414435
	(72.04)	(70.61)	(6.38)	(9.16)	(13.20)	(11.82)	(8.38)	(8.41)	(100)	(100)
Transporters/Parking Operators	31740	15140	31780	33690	52620	33870	42875	35480	159015	118180
	(19.96)	(12.81)	(19.99)	(28.51)	(33.09)	(28.66)	(26.96)	(30.02)	(100)	(100)
Shikara/Houseboat Owners	102370	57930	33320	33730	62900	43140	42135	18875	240725	153675
	(42.53)	(37.70)	(13.84)	(21.95)	(26.13)	(28.07)	(17.50)	(12.28)	(100)	(100)
Tourists	31360	20600	35496	38040	65660	43310	70785	44690	203301	146640
	(15.43)	(14.05)	(17.46)	(25.94)	(32.30)	(29.53)	(34.82)	(30.48)	(100)	(100)
Total	1104265	793320	193576	212850	373790	257705	291200	207125		
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)		

4.2 Loss of Valuation of Lake Ecosystem between 1980-2020

The loss of valuation in the lake water ecosystem in Kashmir, particularly in the Dal Lake and Wular Lake, has been a growing concern contingent upon a combination of environmental, social and economic factors. These lakes have significant ecological and cultural importance but have faced various challenges that have led to a decline in these values.

4.2.1 Loss of Valuation in Dal Lake

Dal, an Urban Lake, provides several goods and services to different stakeholders. Over the years, there has been a change in the valuation primarily due to changes in the quality of water as well as due to changes in its area. An attempt was made to observe the changes in the valuation of Dal Lake due to these reasons. All valuations of the ecosystem goods & services declined between 1980 and 2020 except for supporting services. Figures presented in Table 5 revealed that the maximum decline in the valuation of goods and services was due to a change in the lake area (Rs 216.22 crores) followed by a change in the water quality (Rs 554892). The decline in valuation was the highest in provisioning services, followed by regulatory services.

The supporting services increased by Rs 130814500 between 1980 and 2020.

TABLE 5. LOSS OF VALUATION IN DAL LAKE BETWEEN 1980-2020

(*crores)*

Services (1)	Due to change in quality (2)	Due to change in area (3)	Overall change (4)
Provisioning Services	-0.034 (62.47)	-130.71 (60.45)	-130.74 (60.45)
Supporting Services	+0.010 (-19.18)	+13.08 (-6.05)	+13.09 (-6.05)
Regulating Services	-0.017 (31.03)	-53.21 (24.61)	-53.22 (24.61)
Cultural Services	-0.014 (25.68)	-45.38 (20.99)	-45.39 (20.99)
TOTAL	-0.055 (100)	-216.22 (100)	-216.26 (100)

4.2.2 Loss of Valuation in Wular Lake

As Wular Lake lost the maximum area from 1980 to 2020, the loss of valuation was found to be highest in the case of Wular Lake, mainly due to changes in water quality and loss in the lake water area. The figures in Table 6 depict that the loss due to change in water quality was observed to be Rs 539886, and a loss of about Rs 1247.96 crores was observed due to loss in the lake area. Among all the services, provisioning services had the maximum loss in valuation.

TABLE 6. LOSS OF VALUATION IN WULAR LAKE BETWEEN 1980-2020 (IN CRORES)

Services (1)	Loss due to change in Quality (2)	Loss due to change in Area (3)	Overall Change (4)
Provisioning Services	-0.031 (57.60)	-714.61 (57.26)	-714.64 (57.26)
Supporting Services	+0.0019 (-3.57)	+2.37 (-0.19)	+2.37 (-0.19)
Regulating Services	-0.011 (21.50)	-260.63 (20.90)	-260.64 (20.90)
Cultural Services	-0.013 (24.47)	-275.09 (22.04)	-275.10 (22.04)
TOTAL	-0.053 (100)	-1247.96 (100)	-1248.01 (100)

4.3 Estimates of Degradation Model

Regression analysis examined the impact of independent variables (predictors) on lake degradation. The regression analysis presented in Table 7 revealed that the R^2 ranges from 0.77 for Dal Lake to 0.79 for Wular Lake, indicating that the variations in the lake degradation were significantly explained by the explanatory variables included in the model. Table 7 reveals that land encroachment by local households, improper damping of solid and plastic waste, agricultural land conversion by local households, sewage water discharge by local households, intensive use of fertilisers and pesticides by local farmers, blockage of various inlets and outlets were showing significant negative impact on the lake water ecosystem. Other variables, such as the extensive harvesting of goods from lakes, industrial wastewater, and land on lease for lotus stem cultivation, turned non-significant and did not have any significant impact on the degradation of the lake water ecosystem.

TABLE 7. REGRESSION ANALYSIS USING PRIMARY DATA

Variable (1)	Dal (2)	Wular (3)
LL	-0.241 (0.024)	-0.163 (0.017)
LE	0.760** (0.034)	0.061** (0.045)
ID	0.258** (0.031)	0.471** (0.026)
ALC	0.580** (0.025)	0.512** (0.031)
SWD	0.811** (0.037)	0.894** (0.014)
ID	-0.917 (0.027)	-0.134** (0.62)
IF	0.689** (0.069)	0.074** (0.82)
BIO	0.562** (0.020)	0.307** (0.28)
EGS	-0.287 (0.79)	-0.682 (0.39)
IR	0.367** (0.023)	0.023** (0.087)
R^2	0.77	0.79
Adjusted R^2	0.71	0.73

Note: N= 125, **Significant at 1 per cent level,

V

CONCLUSIONS

The present study was conducted in Kashmir Valley of J&K UT in consideration of the existence of several small and large lakes in it. Two major lakes, viz. Dal and Wular were selected based on the maximum change in area and the trophic state index of these lakes *(*Vass. 1980*)*. Significant and favourable changes have occurred in the area of Dal, Wular Lake from 1980 to 2020. The change in the area of Dal Lake was reported to be 3.9 sq. km, while in Wular Lake, it is about 16 sq. km, which necessitates ascertaining the restoration process among these lakes. Sewage/septic discharges, one of the sources of degradation, were found to contribute as much as 20 per cent to the degradation of Dal Lake and 18 per cent to the degradation of Wular Lake. These sources mainly affected the various ecosystem services and drastically decreased their value. Among multiple services obtained from the lake water ecosystem, the value of provisioning services contributed the highest (Rs 11,33,368) towards the household economy among different stakeholders of Dal Lake, followed by supporting services (Rs 3,46,950). These results show the dependency of different stakeholders on lake water ecosystem goods & services. Similarly, the valuation of provisioning services was highest in Wular Lake (Rs 7,93,320). From 1980 to 2020, there has been a tremendous change in the valuation of Lake Water goods and services, mainly due to changes in the area. The overall change reported in Dal Lake was estimated at 2.16 billion. The decline in the valuation of goods & services from 1980-2020 was found to be highest in the case of Wular Lake (12.48 billion) because the maximum change in area was reported in Wular Lake. Restoring the lake water ecosystems in Kashmir requires a comprehensive approach that addresses ecological, social and economic aspects. Implement an integrated management approach that brings together relevant government departments, local communities, environmental experts and stakeholders to collaborate on lake restoration efforts.

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