



CLIMATE CHANGE, VULNERABILITY AND SUSTAINABLE DEVELOPMENT: THE CASE OF WULAR LAKE FISHERS AND FISHERIES

Dissertation submitted in partial fulfillment
of the requirements
for the degree of

M.F.Sc. (Fisheries Extension)

by

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(FEX-MA7-02)

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(University Established Under Section 3 of UGC Act 1956)

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June, 2019

Atufa Regu, 2019. Climate change, Vulnerability and Sustainable Development: The Case of Wular Lake fishers and fisheries. M.F.Sc. Dissertation, ICAR-Central Institute Of Fisheries Education (Deemed to be University, Established Under Section 3 of UGC Act 1956) Panch Marg, Off Yari Road, Versova, Andheri (W), Mumbai – 400 061



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Dated: 30th June, 2019

CERTIFICATE

Certified that the dissertation entitled "CLIMATE CHANGE, VULNERABILITY AND SUSTAINABLE DEVELOPMENT: THE CASE OF WULAR LAKE FISHERS AND FISHERIES" is a bonafide record of independent research work carried out by Ms. Atufa Regu during the period of study from August, 2018 to June, 2019 under our supervision and guidance for the degree of **Master of Fisheries Science (Fisheries Extension)** and that the dissertation has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or any other similar title.

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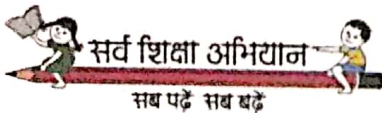
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***DEDICATED TO MY
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&

BELOVED MENTOR

(The fountain of inspirations...)

DECLARATION

I hereby declare that the dissertation entitled “**CLIMATE CHANGE, VULNERABILITY AND SUSTAINABLE DEVELOPMENT: THE CASE OF WULAR LAKE FISHERS AND FISHERIES**” is an authentic record of the work done by me and that no part thereof has been presented for the award of any degree, diploma, associateship, fellowship or any other similar title.

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ACKNOWLEDGMENTS

*At the very outset, I thank **Almighty Allah** for giving me more than I deserve, guiding me like a shadow and always becoming my shining light. I thank his willingness for the successful completion of work on time.*

*I am profoundly thankful to my chairperson **Dr. Pachampalayam Shanmugam Ananthan** for his sustained interest and genuine concern in my M.F.Sc. research programme. His logical and systematic approach has immensely enriched the present study. The warmth and friendliness he embodied have always been a constant source of confidence for me. His attitude, sagacity and the freedom he gave his students only made us more responsible and hard working.*

***Prof. Masood-ul-Hasan Balkhi**, Dean, Faculty of Fisheries, SKUAST-K, **Dr. Shivaji Dadabhau Argade**, Scientist, CIFE and **Dr. Neha Wajahat Qureshi**, Scientist, CIFE, all member of my advisory committee, were supportive through the course of my research work.*

***Dr. S.N. Ojha's** fatherly advice, **Dr. Arpita Sharma's** constant goading and the support of **Dr. Swadesh Prakash**, **Dr. Rama Sharma**, **Mr. Vinod Yadav**, and all technical staff have kept me in a good spirit during the two years of my post-graduate life at the Fisheries Economics, Extension and Statistics Division.*

*It gives me great pleasure to express my deep sense of gratitude to **Dr. Gopal Krishna**, Director, and Vice Chancellor, CIFE, Mumbai for providing me the platform to continue my work at this prestigious Institute.*

*The study would have not been possible without the help rendered by **Dr. Tasneem Keng**, **Dr. Majid Farooq**, DEARS, **Dr. Rashid Naqash**, Regional Wildlife Warden Kashmir, **En. Rashid Ahmad Dar**, PHE Srinagar, **Mr. Basit Ahmad** CPO DORD, **Rayees Ahmad**, Scientist, CGWB, **Firdous Ahmad**, Tehsildar, **Mr. Mudasir**, **Mr. Irfan** WUCMA, **Mr. Javaid Hyderi**, MET department, J and K.*

*The willing helpfulness of **Mr. Muntazir Irfan Rah**, **Mr. Arif Ahmad**, **Mr. Bilal Waza**, **Mr. Abdul Ahad Dar**, **Mr. Basharat**, **Mr. Parvaiz Ahmad**, **Mr. Shalla**, **Mr. Imtiyaz**, **Mr. Mateen**, **Ms. Insha**, and **Ms. Aneeka** of*

Directorate of Fisheries, Jammu and Kashmir, helped me to collect data from grassroots.

*I express my special thanks to **Dr. Sajad Hassan Baba, Dr. Rizwana Malik, Dr. Mansoor Ahmad Rather, Dr. Shabir Ahmad Dar, Dr. Peerzada Mohammad Iqbal, Mrs. Asmat Ara and Dr. Adnan Abubakr** at Faculty of Fisheries SKUAST-Kashmir for their timely help and suggestions.*

*I would like to convey my sincere gratitude to the Wular villagers for their love, hospitality and cooperation especially **Sameer** and **Rafiq** who helped me to explore Wular Lake in depth.*

*My heartfelt thanks to my respectable seniors **Mr. Velumani, T., Ms. Pooja Gautam, and Ms. Gomathy V.**, for their genuine help, constant encouragement and valuable suggestions. I also thank **Mr. Vidhya Sagar, Ms. Syed Aaliya, Ms. Tenzy and Mr. Chinmaya** for their support.*

*I acknowledge my classmates **Shakir, Napinder, Suchismita, Yateesh, Abinandhan, Saba, Shahid, Frencia, Vivek, Sandeep and Pown** for their cooperation.*

*I acknowledge the support of my juniors **Naila, Nidhi, Arti, Akila, Rida, Nahida, Ashraf, Dani, Betsi, Sham, Lucas, Abilash and Stephen.***

*I thank my dear brothers **Irshad, Ishfaq, Showkat, Ubaid, Zahoor, Hilal, Waseem and Haziq.** Similarly, I owe a lot to the friendship of **Aatirah, Nahida, Ifrah, Sumaira, Sanna, Asma, Maheen, Hafsa, Farah, Inain, Mehak, Nasheman, Junaid and Uzair.***

*The tireless help rendered by my sisters **Dijaan** and **Ayna**, and the unconditional support of my soul mate **Arafat Sidiq** during data collection and across study period could not be adequately thanked in words.*

*I consider it as a privilege to acknowledge the support and sacrifices of my **Abu** and **Ammi** who has always been my backbone. Without their prayers, love, care, and encouragement it wouldn't have been possible for me to complete this piece of work.*

Date: 30 June, 2019

Place: Mumbai



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सारांश

अंतर्देशीय मत्स्य पालन का वर्ष 2016- 2017 में , भारत के कुल मछली उत्पादन 11.41 मिलियन टन में 68% का योगदान है। अंतर्देशीय कैप्चर फिशरीज (नदियों, झीलों और आर्द्रभूमि) का हिस्सा अपेक्षाकृत कम है, लेकिन जैव विविधता और अन्य पारिस्थितिक सेवाओं के मामले में इन जलस्रोतों का मूल्य अविवेकीय है। वूलर झील, जो एशिया में 11,277 हेक्टेयर क्षेत्र के साथ सबसे बड़ी ताजे पानी की झीलों में से एक है, वहा एक अध्ययन किया गया था जिसमें जलवायु परिवर्तन, भेद्यता एवं मछुआरों और मत्स्य पालन का सतत विकास शामिल है। वुलर झील मछलीयों के लिए एक महत्वपूर्ण निवास स्थान है और वर्तमान में कश्मीर घाटी की झीलों में से मछली की उपज का लगभग 54% योगदान देता है और लगभग 29,000 परिवारों का समर्थन करता है। वुलर झील परिधि पर कुल 50 में से नौ गाँवों का दौरा किया गया जहां विस्तृत चेकलिस्ट / साक्षात्कार अनुसूची का उपयोग करते हुए, संसाधन प्रबंधकों के साथ चर्चा, विस्तृत प्रमुख मुखबिर साक्षात्कार, फोकस समूह चर्चा और सहभागी अवलोकन विधियों के माध्यम से जानकारी, अक्टूबर 2018 से फरवरी 2019 के दौरान एकत्रित की गयी। भारत की जनगणना 2011 और 1991 के विभिन्न डेटा, विभिन्न सरकारी विभागों द्वारा प्रकाशित साहित्य प्रमुख डेटा स्रोत बनाए गये। परिणामों से संकेत मिलता है कि बांडीपोरा और बारामूला जिलों में 50 वुलर मछली पकड़ने के गाँव, जनगणना (2011) के 23 गाँवों के अंतर्गत पाये गए। सभी 23 गाँवों के सामाजिक आर्थिक कमजोरता सूचकांक (SEVI) का मान निम्न से लेकर कमजोर स्तर पर पाया गया, साथ ही जिला बारामुल्ला की सोपोर तहसील में सीर जागीर गाँव कम कमजोर (0.25) और बांडीपोर तहसील के कुनास गाँव सबसे ज्यादा कमजोर पाया गया। वुलर गाँव की मछलियों के उतार-चढ़ाव पर निर्भरता के कारण, वुलर गाँवों के लिए अपेक्षाकृत उच्च सामाजिक संवेदनशीलता सूचकांक मूल्यों को छोड़कर, वुलर (23) और गैर-वुलर (115) गाँवों के बीच भेद्यता में कोई महत्वपूर्ण अंतर नहीं पाया जा सका। एक ग्राफिकल 2 डी निर्णय मैट्रिक्स एवं drivers and buffers की सहायता से संवेदनशीलता और अनुकूली क्षमता के आधार पर गाँवों की भेद्यता की स्थिति का एक द्रिश्य प्रस्तुत किया गया। झील मछली पालन की स्थिरता की स्थिति का मूल्यांकन संशोधित RAPFISH विधि का उपयोग करके किया गया जो 'कम'(40%) समग्र स्थिरता को दर्शाता है। जबकि पारिस्थितिक (58%) और आर्थिक (69%) आयामों में 'काफी' टिकाऊ विकास की स्थिति (51-75%) है, वुलर झील में स्थिरता के अतिरिक्त आयाम जैसे ,मछली पालन प्रौद्योगिकी (16%), सामाजिक (30%), और शासन के संदर्भ में खराब है (39%)। यह अध्ययन विभिन्न तरह की योजनाओं के हस्तक्षेप अर्थात् मछुआरों के शिक्षा स्तर और कौशल में वृद्धि, विशेष रूप से मछली और वाटर चेस्टनट मूल्य श्रृंखलाओं, craft और gear के तकनीकी उन्नयन (अनुकूलित FRP crafts और पर्यावरण के अनुकूल गियर), वुलर झील में मौसमी प्रतिबंध के कार्यान्वयन, वुलर झील में बहने वाले सीवरेज का उपचार, डीओएफ और उसके फील्ड स्तर के कर्मचारियों के पुनर्विकास और क्षमता निर्माण, और आजीविका के विकल्पों में विविधता लाने, समुदाय और ग्रामीण बुनियादी ढांचे को मजबूत करने का सुझाव प्रस्तुत करता है।

ABSTRACT

Inland fisheries contributed 68% of India's total fish production of 11.41 million tons in 2016- 2017. Share of inland capture fisheries (from rivers, lakes and wetlands) is relatively less but there have inestimable value in terms of biodiversity and other ecological services. A study was conducted in Wular Lake, one of the largest fresh water lakes in Asia with 11,277 ha area, on climate change, vulnerability & sustainable development of fishers and fisheries. Wular is an important habitat for fish and contributes about 54% of fish yield from lakes of the Kashmir Valley presently and supports about 2914 families. A total of nine out of 50 villages on Wular lake periphery were visited and information on variables collected through detailed key informant interviews, focus group discussions, and participant observation methods, discussion with resource managers using detailed checklist / interview schedule during December 2018 to Feb 2019. Secondary data from Census of India 2011 and 1991, various government departments, and published and grey literature formed data sources. Results indicated that 50 Wular fishing villages fell under 23 Census (2011) villages in Bandipora and Baramullah districts. Socio-Economic Vulnerability Index (SEVI) values of all 23 villages ranged from low to moderate with Seer Jagir village in Sopore tehsil of district Baramullah being least vulnerable (0.25) and Kunas village of Bandipore tehsil being the most vulnerable (0.42). No significant differences in vulnerability could be found between Wular (23) and Non-Wular (115) villages except for relatively higher social sensitivity index values for Wular villages due to their direct dependence on the fluctuating fortunes of Wular Lake fisheries. A graphical 2D decision matrix and identification of drivers and buffers provide a snapshot of the vulnerability status of villages based on sensitivity and adaptive capacity. Sustainability status of lake fisheries assessed using modified RAPFISH method indicated 'less' (40%) overall sustainability. While ecological (58%) and economic (69%) dimensions have a 'quite' sustainable development status (51-75%), Wular lake fisheries fared poorly in terms of technology (16%), social (30%), and governance (39%) dimensions of sustainability. The study suggests intervention plans namely enhancing education levels and skillsets of fishers especially on value addition cross both fish and trapa (water chestnut) value chains, technological upgradation of craft and gear (customised FRP crafts and eco-friendly gear), implementation of seasonal ban in Wular Lake, treatment of sewage flowing into Wular lake, reorientation and capacity building of DoF and its field level staff, and diversifying livelihood options, strengthening community and rural infrastructure.

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1. INTRODUCTION

Melting glaciers; rising temperature; dwindling fishes; shrinking lakes; unhealthy rulers; pinched fishers; hydrosphere pollution; drought crunches; flash floods, lake siltation, growing population; unsustainable livelihoods....This unending list of degradations no longer shocks us. Rather they have become mundane commonplace observations, especially in fisheries context (Brander, 2007).

Earth, the 'water planet', entails 14,108 cubic kilometers of water, 97.5% of which exists in the seas, and nearly all of the remaining fresh water is either locked up in the Antarctic and Arctic ice caps or as groundwater. Therefore, freely accessible water is present only in Lakes (0.007%) and Rivers (0.002%) (Earth Observatory, 2005). Of these, lakes are considered as the best available freshwater source on the Earth's surface. Lakes are not only valued as water sources and for water transport, recreation, tourism but are also cherished for their diverse functions including fishing and other important ecological services they provide.

Lake is a very general term used for any standing water body, large enough in area and depth, irrespective of its hydrology, ecology, and other characteristics. National Lake Conservation Program considers lake as a standing water body which has a minimum water depth of 3 meters and a water spread area of more than 10 hectares which have no or very little aquatic vegetation e.g. macrophytes (NLCP, 2010).

Wetland ecosystems are defined by the Ramsar Convention as a wide variety of habitats such as marshes, peat lands, floodplains, rivers and lakes, and coastal areas such as salt marshes, mangroves, and sea grass beds, coral reefs and other marine areas no deeper than six meters at low tide, as well as human-made wetlands such as wastewater treatment ponds and reservoirs (IUCN, 1971). Wetlands are regarded as waterlogged wealth (Maltby, 2013; Ghadimi *et al.*, 2014; Ajibola *et al.*, 2015). Wetlands representing an ecotone between terrestrial uplands and true aquatic bodies cover about 6% of the total earth surface (Williams, 1990). According to (Cowardin *et al.* 1979) Wetlands are transitional between terrestrial

and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. They support high densities and diversity of fauna, particularly birds, fishes, macro invertebrates, and therefore, have high value for biodiversity conservation. These also include shallow lakes which are rightfully categorized as 'Wetlands' (MoEFCC, 2008).

According to FAO (2016), globally, the inland capture fisheries contribute about 11.6 million tonnes (12.8%) to the total world fish production of 171 million tonnes. Globally, millions of people still rely on fisheries and aquaculture as their prime source of livelihood. Contribution from lake and reservoir fisheries forms of inland capture fisheries and is very significant, both globally and in the Indian context. In 1980 global production from inland system accounted for 11% whereas in 2008 over 30% of global production emanated from inland systems.

During 2016- 2017, fish produced in India has been recorded to be about 11.41 million tonnes with a contribution of 7.77 million tons (68%) from inland sector and 3.64 million tonnes (31.9) from marine sector (DAHD&F, 2018).

Inland Fisheries in India

India is blessed with the inland water resources in terms of 29,000 km of rivers, 0.3 million ha of estuaries, 0.19 million ha of backwaters and lagoons, 3.15 million ha of reservoirs, 0.2 million of floodplain wetlands and 0.72 million ha of upland lakes, which contribute about 1.05 million tonnes annually (Ayyappan *et al.*, 2012). Potential fish productivity from reservoirs and wetlands is estimated to be 250 kg/ha and 350kg/ha respectively. Inland aquatic resources are becoming increasingly important in global fisheries production.

About 10 million people depend on the inland fisheries resources of India for livelihood. However, the reported productivity from inland capture fisheries is very low and production has declined during the last 2-3 decades. The depletion in production is due to various anthropogenic interventions and multi-user conflicts (FAO, 2001). There are few other reasons attributed for depleting /degrading of inland fisheries resources as listed below:

- i. Inland fisheries resources are scattered and located in remote places - most of the reservoirs, rivers, and aquaculture ponds are located in remote areas, as a consequence making it challenging to bring them under scientific management effectively by inadequately staffed Fisheries Departments.
- ii. Inland fisheries resources are seasonal - most of the resources are seasonal and dry within a year. Seasonal variation in rainfall decides the water availability of these resources and days of the fish culture period.
- iii. Least priority - fisheries have been given scant policy and development attention so far due to lack of recognition of its potential as livelihood provider. Proper management of these resources was often neglected.

Lakes and wetlands have inestimable value and are more important and often easily available water resources. Lakes supply drinking water, food, irrigation, recreation, etc. These are cradles of vital biological diversity and provide the water and primary productivity upon which numerous species of plants and animals depend for survival. Preservation of lakes and wetlands is a life necessity for people in many regions of the world, given their cultural, ecological and socioeconomic value. Similarly, lake ecosystems are also degrading at a faster pace because of many problems of natural and anthropogenic origin that can be summarized as followed: (Prasad, *et al.*, 2002; Ruddiman, *et. at.*, 2016; Chopra, R., 2016)

- i. Population Pressure- It has resulted in widespread reclamation and drainage of the lake and its marshes for agriculture, settlements, and plantations have contributed to shrinkage of the lake area and degradation of the natural resources it provides to lake/wetland-dependent communities.
- ii. Increased frequency of droughts and floods- Climate Change coupled with shrinkage in the area as well as loss in the water-holding capacity of lakes, floods and droughts have also increased for both local and downstream communities.
- iii. Deteriorating water quality/ Eutrophication/ Pollution- The water quality of lakes is deteriorating drastically due to the discharge of high levels of

untreated sewage, industrial effluents, and runoff in the form of chemicals, fertilizers and pesticides from the agriculture land and horticulture orchids resulting in nuisance algal bloom. Lakes act as a recipient of point and non-point sources of pollution. Many lakes are being affected because of siltation for example,

- iv. Lake siltation: It refers to both increased concentration of suspended sediments and increased accumulation of fine sediments which may be temporary or permanent. It is considered undesirable because it leads to decreasing depth, shrinkage and low water levels which all together have led to the destruction of fish breeding grounds.

Climate change is also considered as a significant factor that influences the depletion of inland fisheries concerning water resources, biodiversity, and productivity. It has been widely accepted that the earth's temperature has increased at least by 0.6°C during the last 100 years primarily due to the emission of greenhouse gases by human activities. During this century, the world is expected to continue warming, between 1.4 and 5.8°C (Gregory *et al.*, 2007).

The climate-induced vulnerabilities of both resources and communities on inland fisheries have not been evaluated comprehensively so far. Small-scale fishers and small-scale aquaculture are more vulnerable to climate change. Their vulnerability is a result of both geographical location and poverty situation (IPCC, 2018).

Vulnerability is defined as the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes (IPCC).

Sustainability has also emerged as the research umbrella for climate and global environmental change, including its human dimensions. In this connection, Pitcher (2001) reported that the study of fisheries can be regarded as truly multi-disciplinary as because the human dimension is intertwined with all other factors of fisheries which include biological and economic sustainability, gear, markets, vessels, management, allocation and the rebuilding of depleted and collapsed stocks.

The aforesaid problems and scenarios determine the current inland fish production of India. After understanding the history and current status of Indian fisheries, especially in the view of increasing the country's overall fish production, one can't ignore inland fisheries potential of India particularly the lake fisheries.

Present status of Wular Lake

Wular Lake being one of the largest lakes in Asia which is of about 12,000 hectares (ha) in the area has been grossly ignored despite its rich biodiversity and significant role in the hydrography of north India and Pakistan. The lakes with their associated wetlands support rich biodiversity and provide important habitats for migratory water birds within Central Asian Flyway. Wular and Dal Lake serves as the largest fishery resource in Jammu and Kashmir supporting livelihoods of the large human population living along their fringes (Abubakr and Kundangar, 2008). Wular Lake is also an important habitat for fish contributing about 54% of fish yield of the Kashmir Valley during 2018-2019 (DoF, 2019). The wetland also generates revenue for the state government through fisheries and the sale of water chestnut (*Trapa sp.*), fodder, and other economically important species.

Distinguishing the ecological and socio-economic values of the Lake it was designated as a Wetland of International Importance under the Ramsar Convention in 1990. The lake is one of the 27 Indian wetlands designated as a Ramsar site (Ramsar, 2018).

The water quality is deteriorating drastically due to the discharge of high levels of untreated sewage into the wetland because of its geomorphological setting, Wular serves as a recipient of entire wastewater of the basin in the valley. Presently none of the settlements have been provided with sewage treatment facilities, the result is the discharge of wastewater directly in the water body leading to water quality deterioration. Once being emerald green, Wular Lake has now become eutrophic due to pollution from point and nonpoint sources including fertilizers, animal carcasses as well as human wastes which directly flow into the Lake as Wular serves the only drainage basin of Kashmir valley.

Population pressure within the Wular catchment has led to conflicting interests leading to land degradation hence sediment and nutrient loading into the

aquatic systems in the catchment, mainly from non-point source pollution. The effluents brought by the river Jhelum and runoff from agricultural fields subjected to a heavy dose of fertilizers get washed off into the lake leading to severe problems of eutrophication. Activities that diffuse pollution includes: high population growth, unplanned human settlement, deforestation, intensive farming, livestock keeping, wetlands encroachment, urban agriculture, quarrying and infrastructure (Hasan, 2013).

Wular has shrunk in size. Wetlands store and gradually release groundwater, melted snow, and flood water thus acting as sponges. However, during the period 1911-2008, the overall water spread area was found to have decreased by half thus reducing one-fifth of the areas storage capacity (CMAP, 2007). This is a major factor leading to the reduced capacity of the wetlands to regulate water in and outflow regimes. Additionally, the capacity has been further reduced due to willow plantations drive of the 1950s in order to supply firewood to the city which has now become a nuisance where these willow trees take up much of the lake water for growth and proliferation. Rapid degradation of forests due to over-extraction for fuelwood and overgrazing of the pastures in Wular catchment has led to soil erosion and consequent sedimentation and loss of water holding a capacity of the wetland.

The decrease in water levels and degradation of its quality has led to a decline in fish and migratory bird diversity, shifting of vegetation belts and dire loss in productivity of some economically important species. Invasive species in Lake have proliferated leading to a decline in native species particularly local *Schizothorax sp.* and *Nelumbo*.

Research Issues

Literature review and the scanning of news reports in recent times summarize certain problems in Wular Lake. They are declining fish production, increasing siltation, shrinkage of the lake area, increasing frequency of floods and droughts, pollution from fertilizer usage, use of Lake periphery as dumping sites, animal as well as human waste discharge, conversion of vast catchment into agriculture land, and hunting pressure on waterfowl and migratory birds. The

decline in resource base and limited opportunities for livelihood diversification have led to poverty and reduced quality of life of communities living around the lake and its catchments mainly the fishers who directly depend on it for livelihood. The prevalence of poverty between 41% – 52% within these communities is quite high compared to the state average of 3.91% (CMAP, 2007).

Current literature on Wular Lake covers mainly the geophysical-chemical quality of water, phytoplankton and zooplankton diversity, the biology of fishes, and to some extent on fisheries. Only a few studies address socio-economic aspects (Malik, *et al.* 2013; Qureshi, 2013; CMAP, 2007), etc. Fishers' livelihood, ecology, governance, and technology have not been studied within a holistic framework so far though all these elements are related in the context of lake fisheries. Similarly, no studies so far have addressed the issue of climate change, how it impacts fisheries and fishers, and their ability to cope up with the change.

With this justification and above considerations, the present study of “Climate change, vulnerability and sustainable development: the case of Wular lake fishers and fisheries” was attempted with the following research questions and objectives.

Research Questions

1. What is the present socio-economic status of the people who depend on the Wular Lake for their livelihood?
2. What is the relationship between fisheries, ecology, governance & livelihood in a lake fisheries ecosystem?
3. What is the influence of climate change on the Wular lake fishery?
4. How vulnerable are the people who are dependent on the Wular Lake?
5. What are the past efforts to restore/conservate the lake biodiversity and to what extent they have been effective/ successful?
6. Whether evidence-based and pragmatic intervention planning to improve adaptive capacity is possible at micro-level?

Objectives

1. To assess the socio-economic vulnerability of the communities dependent on Wular Lake
2. To analyze the sustainable fisheries development status of Wular Lake using modified RAPFISH methodology
3. To suggest fishery and village-specific intervention plans to improve community resilience

Scope and utility of the research

1. The study would provide a quantified benchmark about the present status of Wular lake fisheries management covering multiple dimensions – *ecological, fisheries, livelihoods, and governance*.
2. It would help the State in planning appropriate and effective measures to sustain and develop lake fisheries and livelihoods.
3. It would add on to designing strategies to improve community resilience by understanding the extent of sensitivity and adaptive capacity of dependent communities.

Limitation of the study

Lake fishery resources are embedded within complex management practices, diverse socio-economic aspects of stakeholders and the different hydrographical profile across the states and the country. So, results from this study can only be generalized based upon certain qualifications.

Presentation of the study

The study has been presented in six chapters as indicated below

Chapter-1 deals with the nature and importance of the present study and also the specific objectives of the study have been clearly indicated.

Chapter-2 describes a comprehensive review of the relevant research work done in the past related to the present study.

Chapter-3 outlines the features of the study area, sampling design followed by the collection of relevant data and analytical tools used in the study.

Chapter-4 is devoted to present the main findings of the study through tables, graphs, etc. and discussions of the results of the study are presented

Chapter-5 provides a summary of the whole study and also suggests the policy implication based on the finding of the study.

In the end, important references have been listed related to the present study.

2. REVIEW OF LITERATURE

Having stated the research problem and specific objectives of the study this chapter deals with the literature reviewed for the study. Review of literature can be called as a condensed version of an exhaustive literature survey hence forms an important aspect of any scientific endeavour. It is an account of what has been studied and published on a topic by scholars/researchers and helps the researcher to avoid repetition of work done, relate the empirical findings of those done in the past, to formulate appropriate research methodology as well as to establish a theoretical framework for the topic, define key terms, definitions, and terminology, etc. The review has been carried out encompassing all the objectives and is arranged accordingly under the following headings:

2.1 Wular Lake Fisheries

2.2 Climate Change

2.3 Vulnerability and its assessment

2.3 RAPFISH methodology

2.1 Wular Lake fisheries

According to the Ministry of Environment and Forests, J&K State has 291.07 Sq. Km of the area under the wetlands while as Space Application Centre, Ahmadabad, ISRO identified and mapped 42 wetlands in the State occupying an area of 4067.79 Km (SAC, 2016).

River Jhelum is the largest contributor of water inflow (88%) into the Wular Lake, the rest being from the immediate catchments and precipitation. Similarly, the outflows through river Jhelum is the highest (96.9%), the rest accounted for by human abstraction (1.7%) and evaporation (1.4%). It was also seen that there is high temporal variability in inflows and outflows. 80% of the inflows and 86% of outflows take place in Summer. They measured net outflow from

the Wular at Sopore which was found to be higher than the inflows. The wetland system is net absorber of water from September to February, which is released from March to June. During a flood year, the net outflow from the wetland systems is positive which is reverse in case of drought year leading to periodic floods and droughts. The storages are usually built during the winter months when the flows are already in the lean phase (CMAP, 2007).

Abubakr and Kundangar (2008) reported that predominated rotifer population and high content of chloride is indicative of the presence of organic matter while the progressive increase in nitrogen and phosphorus in all the lakes can be attributed to anthropogenic pressure and sewage contamination leading to Lake pollution.

Masoodi and Khan (2012) reported alligator weed i.e. *Alternanthera philoxeroides* for the first time from Wular lake Kashmir, which is a noxious invasive weed plant and its growth is assuming destructive levels.

Qureshi *et al.* (2013) studied stakeholders willingness to pay (WTP) for growth and sustainability of indigenous fish species in the lakes of Kashmir. The authors found that fish production in Wular Lake has witnessed wide variations over the period 1990-2012, which may be attributed to the heavy siltation in the Lake bottom and construction of the Uri power plant upstream of the river Jhelum. Sheikh *et al.* (2014) has studied weathering and anthropogenic influences on the water and sediment chemistry.

Jammu and Kashmir Flood report (2014) says Wular Lake is silting up at a fast rate, the chances of the flood are becoming more. There is a serious need to harness Remote Sensing and GIS technology to develop a flood risk/hazard zonation map for Jammu and Kashmir in terms of assessment of physical and socio-economical vulnerability.

Large proportions of the lake area have been converted for different land use purposes like plantations, paddy cultivation, and miscellaneous purposes. The effluents brought by the river Jhelum and a large number of villages located in the lakeshore area have resulted in deterioration of water quality and increased siltation. They have also reported that rapid degradation of Wular Lake has shown

an enormous impact on community health and livelihoods. (Ramsar, 2016; CMAP, 2007).

Syed *et al.* (2016) have studied design specifications and operational aspects of indigenous gears like lift nets, lines, cast net and spears used by Wular Lake fishers. They found lift net locally called as *Khuri zal* was one of the main gear operated in Wular Lake. The major catch from Wular Lake comprised of *Cyprinus spp.* and *Schizothorax spp.* The fishing operations were carried out throughout the lakes, mainly near to the identified landing centers and fishing villages except the areas inundated by aquatic vegetation.

Malik *et al.* (2017) have studied constraints preventing the growth and development of the fisheries of Wular.

The climatic characteristics of the Wular catchment have been considered the same as the mean of all the three closest meteorological stations of Gulmarg, Kupwara, and Srinagar. The mean maximum temperature is highest in the month of July (25.82°C), while as it is lowest in the month of January (4.60°C). This period is locally known as *Chillai Kalan* is harsh in terms of freezing temperature and heavy snowfall. The mean monthly rainfall has been recorded highest in the month of March (170 mm) while as the lowest mean monthly rainfall is recorded as 42.84 mm in the month of October (Kumar, 2018).

2.2 Climate Change

Climate is the statistical average of the prevailing weather conditions whether due to natural variability or as a result of human activity relating to the mean and variability of relevant quantities over a period of several decades; it includes variables, e.g., temperature, precipitation, and the wind (IPCC, 1997).

Climate change refers to a fluctuating climate condition that can be determined by variations in the mean and the variability of its properties, and that persists for an extended period, typically decades or longer (Hegerl *et al.*, 2007).

Climate variability refers to the divergences in the mean state and other statistics of the climate on all temporal and spatial scales surpassing individual weather events (Parry *et al.*, 2007).

Warming up climate system is unequivocal, evident from increasing global average air and water temperatures, extensive melting of snow and ice and rising global mean sea level (IPCC, 2007). Climate change is projected to bring significant changes in coastlines and inundation of low-lying areas due to the melting of polar ice sheets (Solomon *et al.*, 2007).

The globally average land and ocean surface temperature data show a warming of 0.85 °C (0.65°C to 1.06°C) over the period 1880 to 2012. The period from 1983 to 2012 was likely the warmest 30-year period of the last 1400 years in the Northern Hemisphere (IPCC, 2013). Also, global surface air temperature is set to increase with all scenarios, instead of constant greenhouse gases and aerosols concentrations (Solomon *et al.*, 2007).

Himalayan glaciers constitute an important proportion of fresh water of the major river systems of Asia such as Indus, Brahmaputra, and Ganges. The climate of the Himalayas is highly variable because of its wide range of geographical factors that contribute to variations in temperature and precipitation (Young & Hewitt, 1990).

The temperate glaciers are sensitive indicators of global change and have played a significant role in the sea level rise in the last century. The temperate glaciers are significant from the perspective that they play an important role in studying the basic physical processes governing the behaviour of all ice masses (IPCC, 2001).

A WWF (2005) report concluded that 67% of all Himalayan glaciers are retreating. Out of 612 glaciers in China between 1950 and 1970, 53% were retreating.

Kulkarni *et al.* (2007) used the topographical maps of 1962 and satellite images of 2001 and concluded that in the Himalayan region about 16% of the glaciers are lost.

Murtaza and Romshoo (2017) to assess the glacier recessions and the changes in the glacier geometry and dynamics for nine benchmark glaciers in the Lidder valley of Kashmir using a time series of Landsat satellite images during

the last 33 years (1980 to 2013). Analysis of the data showed that the smaller glaciers (<1 km) have lost 25% of their area, medium size glacier (1–5 km² area) have lost 23% and about 13% loss was shown by the glacier in the range of 5–15 km² area. Also, average temperatures are predicted to rise by 6.43°C (±1.72) in the Kashmir Himalayas

Indus, Ganga, and Brahmaputra river systems receive almost 30-50% of the annual flow from snow and glacier melt runoff and there has been a gradual decrease in the discharge of the rivers dependent on these glaciers. The study revealed that between 1980 and 2013, these glaciers have shrunk by 17% and the total glaciated area has been reduced from 29.01square km to 23.81 km (SAC, 2016).

Mushtaq and Nee Lala (2017) in their study assessed climatic variability in the catchments of Himalayan Lake, Jammu & Kashmir. The study analyzed the trends in hydrometeorological data and how these trends impact on the water extent of Wular Lake, Kashmir. Results suggest an overall decrease in extreme rainfall events and annual precipitation pattern with an increase in annual average temperatures.

Hameed *et al.* (2017) has studied impacts of climate change on surface water resources of Wular lake using discharge, temperature and precipitation data for 21 years and found that there is a rising trend in the ambient temperature from 1993 to 2013 of the Wular Lake. No significant trend was observed in the rainfall over the past 21 years and are in accordance with the global findings which depict rising global temperatures and decreasing precipitation.

2.3 Vulnerability and its assessment

Vulnerability is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt. The IPCC defines vulnerability as ‘the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes’. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed; its sensitivity; and adaptive capacity (IPCC, 2001). The IPCC definition characterizes

vulnerability (to climate change) as a function of a system's exposure and sensitivity to climatic stimuli and its capacity to adapt to their (adverse) effects (IPCC 2007).

The vulnerability is 'the degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes and is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity' (Parry *et al.*, 2007). In this definition, the components exposure and sensitivity exert potential impacts and increase vulnerability, while adaptive capacity decreases the vulnerability.

Blaikie *et al.* (2004) defined vulnerability as the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of natural hazards.

Many comparative studies have noted that the poor and marginalized have historically been most at risk from natural hazards and that this vulnerability will be amplified by climatic changes (Parry *et al.*, 2007)

Vulnerability depends on a combination of natural and socio-political attributes and geography. Non-climate factors such as poverty, inequality, food insecurity, conflict, disease, and globalization can increase vulnerability by affecting the exposure, sensitivity and adaptive capacity of systems, communities, and individuals (Adger *et al.*, 2001).

Vulnerability depends not only on the distribution of climate impacts (exposure) but also on their sensitivity and adaptive capacity. Therefore vulnerability is socially differentiated: virtually all weather-related hazards associated with climate variability, as well as human causes of vulnerability, impact differently on different groups in society (Daw *et al.*, 2009).

Exposure is the 'nature and degree to which a system is exposed to significant climatic variations' (Mccarthy *et al.*, 2001). The exposure to different shocks and stresses such as a rise in temperature and sea level, cyclones, floods, land erosion, and droughts is expected to be intensified due to climate change (Islam *et al.*, 2014).

Sensitivity is 'the degree to which a system is affected, either adversely or beneficially, by climate variability or change' (Parry *et al.*, 2007).

Allison *et al.* (2008) studied the vulnerability of national economies to the impacts of climate change with a specific focus on the fisheries sector in the 2009 report spearheaded by the World Fish Center. They found that the vulnerability was due to the combined effect of predicted warming, the relative importance of fisheries to national economies and diets, and limited societal capacity to adapt to potential impacts and opportunities.

Vulnerability to climate change depends upon three key elements: exposure (E) to physical effects of climate change, the degree of intrinsic sensitivity of the natural resource system or dependence of the national economy upon social and economic returns from that sector (S), and the extent to which adaptive capacity (AC) enables these potential impacts to be offset (IPCC, 2001).

Adaptive capacity is 'the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (McCarthy *et al.*, 2001). Adaptive capacity is referred to as the preconditions to enable adaptation to change. Adaptive capacity enhancement is done by practical means of coping with changes and uncertainties in climate, including variability and extremes (Smit and Pilifosova, 2003).

Hahn *et al.* (2009) developed a Livelihood Vulnerability Index (LVI) for estimating the climate change vulnerability in the two districts of Mozambique. They used seven components as indicators of vulnerability, which included livelihoods, socio-demographics, social networks, health, natural disasters and climate variability, food, and water security. Further, an alternative approach was also proposed by them which included the IPCC's three factors of vulnerability (exposure, sensitivity, and adaptive capacity).

Turner *et al.* (2003) presented a vulnerability framework in which they highlighted the complexity of vulnerability assessment, and recommended the inclusion of elements, which included identifying the complexity, nesting of scales and potential new hazards. They also illuminated the importance of vulnerability

assessments to be open to quantitative and qualitative data and emphasizing on the coupled human-environment systems.

Most of the vulnerability assessment studies are based on the impact of climate change on the vulnerability and adaptive capacity of the fisheries sector and dependent communities at the macro scale, but macro-level study cannot provide specific findings applicable to the local or community scale (Hahn *et al.*, 2009).

Islam *et al.* (2014) conducted a vulnerability assessment study among the fishing communities of the Padma and Kutubadia Para of Bangladesh by using composite Livelihood Vulnerability Index (LVI). They found at the community scale, the highest livelihood vulnerability to climate variability and change does not coincide with the highest sensitivity and lowest adaptive capacity. However, an examination of differently vulnerable households within a community suggests that the higher sensitivity and lower adaptive capacity combine to create higher livelihood vulnerability.

Aryal, *et al.* (2014) studied the vulnerability of Himalayan trans human communities to climate change, using the IPCC framework and found that certain vulnerability dimensions were largely influenced by diversity in livelihood strategies, income sources, and crops, and access to food, water, and health facilities. The indigenous communities who primarily depend on natural resources for subsistence livelihoods are among the first and most affected by climate change.

Das *et al.* (2014) developed a composite vulnerability index for inland fisheries of state West Bengal through NICRA project. About 19 indicators were identified and used under the three components of vulnerability e.g. exposure, sensitivity and adaptive capacity; five districts of West Bengal were found to be highly vulnerable that was attributed to low adaptive capacity in district level.

Vulnerability assessments can be used for many different purposes, including improving adaptation planning (designing of policies and interventions), raising awareness of risks and opportunities, and advancing scientific research (Patt *et al.*, 2010).

Esteves *et al.* (2016) studied multi-scale vulnerability assessment for adaptation planning. The study covered 30 districts in Karnataka, 1,220 villages of Chickballapur district and the households of two villages Gundlapalli and Saddapalli. The study found that at the district, village and household levels, low levels of education and skills are the dominant factors contributing to vulnerability. At the village and household level, the lack of income diversification and livelihood support institutions are key drivers of vulnerability.

Nandini (2015) in her study on vulnerability and climate change impact on Bhadra reservoir dependent fishing communities in Karnataka found that the perceived impact is felt more by women than men. Temperature variation, drying up of reservoirs and the resultant decline in the fish catch is found to negatively impact livelihoods.

Sambit (2017) studied the impact of climate variability on fisher's livelihood in coastal Odisha. He found all the fishers household under study to be medium vulnerable. The study showed that variability is negatively affecting the livelihood of fishers and there is a need to adopt a target-specific approach.

Senapati and Gupta (2017) studied socio-economic vulnerability due to climate change among fishing communities in Mumbai. They concluded that fishermen have been observing the negative impacts of climate change on their fishing livelihoods.

Maleki, *et al.* (2018) have studied the vulnerability of the rural households around the Urmia Lake of Iran. The vulnerability was calculated based on IPCC definition and using vulnerability index (VI). Using game theory to understand the dynamics, it states that climate adaptation programs land in highly socio-political contexts from the national level down to the community/local level.

The climate-induced vulnerabilities of both resources and communities on inland fisheries pose grave threats to this scenario which have not been evaluated comprehensively so far. Small-scale fishers and small-scale aquaculture are more vulnerable to climate change. Their vulnerability is a result of both geographical location and poverty situation (IPCC, 2018).

Krishnan *et al.* (2018) in their study provide a robust framework for assessing the sensitivity and adaptive capacity of the coastal community to coastal hazards which would help in identifying the most vulnerable community for prioritized attention. They have proposed and estimated cumulative vulnerability index (CVI) and have constructed a socio-economic vulnerability index (SEVI). They conclude that coastal areas are vulnerable to development pressures as well as to climate change impacts, exposing both human populations and ecosystems.

2.4 RAPFISH (Rapid Appraisal for Fisheries)

RAPFISH is a novel multidisciplinary rapid appraisal technique, which employs attributes that are simple and easy to score and provide a cost-effective technique for evaluating and comparing fisheries in terms of sustainability which here is described quantitatively by a set of defined criteria called as attributes (Pitcher *et al.*, 1998). The RAPFISH method is very flexible with respect to the scope of fisheries included in the analysis, for example, the ordination can be of a set of fisheries, or the trajectory in time of a single fishery, or both (Pitcher, 1999).

It can help evaluate the status of fisheries separately using five evaluation fields with scoring done on a scale of zero to five within ecological, technological, economic, social and ethical evaluation fields and further to test the degree of compliance with the FAO Code of Conduct for Responsible Fisheries (Pitcher, 2001). The latest versions of attributes for the six fields in the standard sustainability analysis used scores on a scale of zero to ten. These enhancements are now available in RAPFISH web site for downloading (Pitcher *et al.*, 2013).

The RAPFISH technique is based on a statistical ordination of sets of attributes that are performed using multi-dimensional scaling (MDS) followed by scaling and rotation. It uses Leverage Analysis to examine attributes which influence the most in the ordination and Monte Carlo simulation to estimate errors in the analysis (Alder *et al.*, 2000)

Preikshot and Pauly (1998) used Multivariate Analysis to evaluate 17 small scale tropical fisheries under four main categories: ecology, economy, technology and social. Sustainability of a diverse set of 26 world fisheries from commercial, subsistence, artisanal and industrial sectors were studied by Pitcher *et*

al in 1998 using RAPFISH analysis and suggests that the technique is useful to study the health of fisheries and this technique may provide helpful diagnostics for parameters that do not rely on conventional stock assessment.

Preikshot *et al.* (1998) analyzed fishery status of 32 African lakes by using Multidimensional Scaling (MDS) under biological, economic, sociological, and technological dimensions and analysis showed that African lake fisheries are at risk of declining standards. This was the first study done in freshwater using RAPFISH methodology from 1998 till now and thus paved the way for further studies using this application and standardization. The diagnostic information may also be a product of such investigations as this research identified African lake fisheries at risk of declining standards. Indeed, many of the fisheries studied demonstrated similar interdisciplinary symptoms of fisheries decline as other small-scale tropical fisheries.

Baeta (2005) compared the sustainability of seven Tagus estuary fisheries – beam trawl, boat dredge, nets for glass eel, gill nets, eel basket, squid jig and octopus traps using RAPFISH. Fisheries were analyzed within each discipline and using all the attributes for an interdisciplinary approach. The analysis helped to conclude that the most sustainable fishery is octopus traps (57%) followed by squid jig (56%) that has the same results except for technological dimension. Eel basket and gill nets show the next best sustainability scores (55% and 53%, respectively). Glass eel fishery presents poor sustainability (46%), lying close to the boat dredge and beam trawl, the fisheries with the lowest sustainability (44% and 43%, respectively). The low leverage values showed that ordinations are truly multivariate and that the results are not dominated by any one attribute.

Murillas *et al.* (2008) used RAPFISH for the analysis of the ecological, economic and technological sustainability of the Basque trawl fisheries between 1992 and 2003. He showed that the obtained results are consistent with other bio-economic models and can be used as a complementary tool for fishery management options. Power and Pitcher (2008) assessed the ethical status of 24 commercial salmon fisheries in British Columbia, measured against eight ethical criteria representative of five types of justice. The results show that the trawl fishery

is the most ethically sustainable fleet in the commercial sector and the purse seine the least.

Sustainability of eight fishery production systems (FPS) in the state of Parana, Brazil was estimated by RAPFISH methodology, with 48 scored attributes, grouped in five evaluation fields such as ecological, economic, social, technological and political (Andriguetto-Filho *et al.*, 2009). Castello *et al.* (2009) evaluated the sustainability of 26 estuarine and marine fishing production systems (FPS) from the two southernmost states of Brazil, Santa Catarina, and Rio Grande do Sul by using the RAPFISH technique. The fishery systems were evaluated by 49 attributes divided into five fields: economic, social, ecological, technological and managerial and results shows that RAPFISH failed to produce clear pattern due to disagreement among the different dimensions of sustainability.

Isaac *et al.* (2009) estimated the performance of 20 fishery production systems off the state of Para in the northern region of Brazil and were compared using the RAPFISH methodology. He used a total of 57 attributes distributed among five evaluation fields: economics, sociology, ecology, technology, and politics. The results indicated that industrial and large scale artisanal fishery production systems are economically and socially greater sustainable, small-scale fisheries appeared to be more ecologically sustainable.

Sustainability of 17 fishery systems in the state of Pernambuco (Brazil) was estimated by Lessa *et al.* (2009) by using RAPFISH methodology with 57 attributes among five dimension such as economic, social, ecological, technological and management. Martins *et al.* (2009) used RAPFISH methodology to compare the ecological, economical, technological and social sustainability of 26 fishery systems in the state of Espirito Santo, Brazil. Pitcher *et al.* (2009) applied RAPFISH methodology to evaluate ecosystem-based fisheries management (EBM) performance of 33 countries in the three fields such as principles, criteria, and implementation.

Allahyari (2010) evaluated the sustainability status of 21 major Caspian Sea fisheries from Guilan province using 44 scored attributes in ecological, economic, social, technological and ethical fields and results revealed that more

than 76% of the studied beach seine fisheries cooperatives are in a moderate situation.

Bawole *et al.* (2013) used multi-dimensional analysis (RAPFISH) to evaluate the performance of coral reef management (CRM) within a marine protected area. The results showed that the sustainability of CRM, cumulatively, was 56.34% indicating a moderate level of management.

Syamsu *et al.* (2013) carried out the sustainability assessment of pelagic fisheries resources in the waters of the Tomini Gulf. He analyzed using modified RAPFISH methodology called Raps-Tomini and results indicated that the ethics, laws, and regulations do not support the sustainability of pelagic fishery resources.

Cisse *et al.* (2014) used RAPFISH to assess the sustainability of 11 French Guiana coastal fishery systems in the ecological, economic, social and technological fields through 27 attributes and overall results show that there is an average performance in the scale of sustainability.

Kholil and Dewi (2014) applied RAPFISH to assess the sustainability of fisheries resources in the Thousand Islands by five main fields such as ecology, economic, socio-cultural, legal & institutional and technology & infrastructure.

Murillas *et al.* (2008) applied the RAPFISH method to evaluate the socio-economic sustainability of Basque purse-seine fleet fishing tropical tuna in the Indian and Atlantic Oceans. He used eight key socio-economic attributes in analysis for a time period from 1998 to 2009 and results showed that sustainability Index for the fleet fishing in the Indian Ocean was above a critical sustainability threshold.

Edward *et al.* (1999) have studied the changes in the fisheries of Lake Malawi between 1976 and 1996 using ecosystem-based analyses in which the fisheries are evaluated by 'RAPFISH', to assess their health status in sustainability terms. This was the second worldwide freshwater study conducted using a multi-dimension scaling technique.

However, declining fish resources in the coastal wetland at Nijhum Dwip in Bangladesh have forced fishing communities to consider alternate livelihood

measures such as poultry, livestock and crop farming, handicrafts, and non-farm day labor (Rahman *et al.*, 2013).

Adiga *et al.* (2015) used RAPFISH and reported that this new multidisciplinary technique based on multivariate statistics is far better and easy to apply in Indian context than the existing Multi-Criteria Decision Models (MCDM) like Analytic Hierarchy process (AHP), Ordination techniques (multidimensional scaling), etc.

Lloyd C. Chrispin (2017) has further modified and validated RAPFISH method to assess the status of reservoir fisheries management in India. It consists of 5 evaluation fields/dimensions viz., ecology, economy, social, technology and governance and a total of 25 attributes, five under each dimension.

3. RESEARCH METHODOLOGY

This chapter shapes the key elements and components of the conceptual framework within which the research work has been steered. This is followed by a more thorough discussion on methods and steps adopted in conducting the research including the sampling plan, data collection and statistical analysis carried out. This Chapter is has been organized following the objective wise approach:

3.1 The locale of research

3.2 Socio-Economic Vulnerability Index Framework

3.3 RAPFISH technique and its modification

3.4 Data collection

3.5 Statistical tools used in the study

3.1 The locale of research: Wular Lake

The cold water resources of India are distributed mainly in the Himalayan corridor which has around 8,243 km long streams and rivers, 20,500 ha natural lakes, 50,000 ha of reservoirs which are distributed in the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, West Bengal and all North-Eastern States. These water bodies inhabit diverse kind of fish fauna of 258 cold water fish species. At present, the total fish production from upland areas constitutes only about 3 % of inland fish production (7.77 MMT) of India which is a very small share to the overall production (DAHD&F, 2018).

Jammu and Kashmir (J&K) particularly the Kashmir region is among the world famous tourist destinations and is often called as *Jannat e Benazir* (Paradise on Earth). The valley has rich culture descends from Iran and the beautiful landscapes in the shape of Mughal gardens, high and low altitude lakes, productive wetlands, meandering rivers, natural springs, snowy mountains, and

swampy lagoons. There are about 1248 water bodies / lakes in all the three provinces of state ranging from largest natural freshwater Wular Lake to largest brackish or salt water Pangong Lake in Asia Jammu & Kashmir has 0.30 lakh ha inland water resources in the form of rivers & canals 27781 kms, reservoirs 0.07 lakh ha, tanks & Ponds 0.17 lakh ha & flood plain derelict water bodies 0.06 lakh ha DAHD&F (2018) and contributes to about 31% of the total cold water fish production in the country (DCFR, 2010).

The most famous lakes in the state are Wular, Dal, Manasbal, Gilasar, Ahansar, Waskur, Nigeen, and Pangong lake. Out of all these, Wular and Dal are important in terms of governing livelihood and providing tourism opportunities to the dependent communities. Dal Lake has received a lot of care and attention as it is the main tourist attraction of the valley.

Wular is the largest freshwater Lake / Himalayan Wetland in India (ENVIS Newsletter, 2014) which has an area of about 12900 hectares (30 to 260 km²) area as per National Wetland Atlas (2013). Situated in the northern part of Kashmir, it is located about 65 km away from Srinagar city. The lake has a maximum depth of 14 meters, length of 16 km and a breadth of 10 km and is fed by Jhelum a major tributary of the Indus basin (Wular Conservation and Management Authority, 2016). It is located at an altitude of 1,570 metres above MSL between 34° 16'-34° 25'N latitude and 74° 29'E-74° 40'E longitude (Murthy *et al.* 2013) has been grossly ignored despite its rich biodiversity and significant role in the hydrography of Kashmir valley. Nazir (2010) pours out his heart in *Speaking Silence* by saying, 'What to Egypt is the Nile River. The same to Kashmir is sweet Wular'. Even the poetry of Dr. Sir Muhammad Iqbal gives an indication about the treasure beneath the Wular by saying '*Himalay kay chismay ubaltay hain kab tak, Khizar soochta hay Woolar kay kinaray*' (Khawaja Khizar, Lord of the seas, visits the Wular lake and waits for springs of Himalayas to boil), a couplet which Iqbal composed while sitting on the banks of Wular near the shrine of Baba Shakurddin.

The lakes with their associated wetlands support rich biodiversity and provide important habitats for migratory waterbirds within Central Asian Flyway. These lakes serve as the largest fisheries resource in Kashmir valley supporting livelihoods of the large human population living along their fringes (Abubakr, and

Kundangar, 2008).

Wular Lake holds a distinct position and status by delivering drinking water, fish, fodder, fuel, etc. Furthermore, it controls the rate of runoff in urban areas and constitutes an important resource for sustainable tourism, recreation and cultural heritage and thereby stabilizes local climate. Noted historian Khumani in his book 'Tarikh-Hassan' points out that during ancient times, water from 'Lake Prang' flowed into Kishen Ganga River. A huge avalanche from the 'Weighni mountains' blocked the passage of water and created a large reservoir called 'The Satisar'. Later owing to an earthquake, a crater developed in the capital city and the waters of Satisar gushed out through this, submerging the city and creating Wular Lake. Therefore Wular Lake is formed as a result of tectonic activity. In ancient times, Wular was called as Mahapadamsar (Kaul, 2007). Wular is also referred as 'Bolor' by Al-Biruni (a great Persian Muslim scholar of the 10th and 11th centuries). Wular Lake is best known for high waves in the afternoons, so it was also being called 'Ullola' (Sanskrit term meaning 'a large wave'). Its corrupted form saw its transition as 'Bolor' by Al-Biruni and over the centuries it may be corrupted as 'Wulor' or 'Wular'. The name Wular also derives its name from the local Kashmiri word 'Wul' meaning a gap or a fissure. The Kashmiri sultan 'Zain-ul Abideen' is reputed to have ordered the construction of the artificial island of Zaina Lank in the middle of the lake in 1444 (Raina, 2012). The water is calm and placid across most seasons of the year but, it is often flooded by melting snow and heavy volumes of water draining in from Pohru stream. The deepest part of Wular Lake is known as Mota Khon or Gulf of Corpses. Usually, local fishermen and boatmen avoid this area to reduce the risk of drowning.

Hydrological regimes of Wular Lake are primarily linked with Jhelum and its tributaries. River Jhelum, a part of the Indus River system, is a transnational river flowing through India and Pakistan. The river flows for 992 km before merging with the Chenab and subsequently into Indus River before draining into the Arabian Sea through the Indus Delta. Along its course, the river within its upper reaches is also known as Vyeth and Koshur Darya. River Jhelum is the largest contributor of water inflows (88%) into Wular, the rest being from the immediate catchments and precipitation (CMAP, 2007). The lake plays a significant role in securing the water in

the Kashmir valley by regulating the release of floodwaters from glaciers in the surrounding Himalayas and also by acting as a giant sponge for the annual floodwaters.

Apart from river Jhelum, the two important rivers draining the Catchment are Madumatti and Erin. The Madhumatti, or *Bod kol*, drains the northern slopes of the Harmukh Cliff with its feeder streams over a vast area between Nagmarg in the west and Sarbal Nag in the east. The Madhmatti empties itself into the Wular Lake near Bandipora after traversing a course of thirty-nine kilometers. The Erin River rises from the western flank of the Harmukh. After pursuing a course of about twenty-four kilometers through a neatly cascaded valley, it falls into the Wular Lake, south of Bandipora. The various other streams which drain the Catchment are Bohnar nalla, Malud nalla, Sukhnag nalla, Ningli nalla, Haritar nalla, Ajas nalla, Aragam (Gurur) nalla, Ashtengu nalla, Kinhim nalla, Potushi nalla, Ferozpora and Gadkhul nalla. However, the only distributory of the Lake is River Jhelum which flows through Sopore and Baramullah towns towards Pakistan.

Wular Lake is also an important habitat for fish and contributes about 54% of the Lake fish yield of the Kashmir Valley during 2018-2019. The dominant fish species found in the lake are: *Cyprinus carpio communis*, *Cyprinus carpio specularis*, *Schizothorax curvifrons*, *S. esocinus*, *S. niger*, *S. micropogon*, *S. longipinnis*, *Crossocheilus latius*, *Puntius conchoniis*, *Triplophysa sp.*, and *Gambusia affinis*. Besides these, the Lake also offers plenty of breaks for boating, fishing and water skiing and other ecotourism services. Containing a large variety of fish, the lake provides a livelihood to about 30,000 to 35,000 of fishermen in the Kashmir Valley. Hundreds of boats sail out daily on the lake in search of rosy barbs, common carp, and mosquito fish, snow trouts and other species. Also, Wetlands sustain habitats of aquatic flora and fauna, as well as numerous species of birds, including migratory species.

Wular Lake is also a sustainable wintering site for a number of migratory waterfowl species such as Little Egret (*Egretta garzetta*), Cattle Egret (*Bubulcus ibis*), Shoveler (*Anas clypeata*), Common Pochard (*Aythya farina*) and Mallard. Birds like Marbled Teal (*Marmaronetta angustirostris*) and Pallas's Fish-

eagle (*Haliaeetus leucoryphus*) are species listed in the Red List of IUCN. Many terrestrial bird species observed around the lake are Short-toed Eagle (*Circaetus gallicus*), Little Cuckoo (*Piaya minuta*), European Hoopoe, etc.

The wetland also generates revenue for the state government through fisheries and the sale of water chestnut (*Trapa sp.*), fodder, and other economically important species. Many families harvest plants such as the grass Phragmites and the water lily-like Nymphoides from the lake for animal fodder. The catchment of the lake supports coniferous forests and alpine pastures, adding to the natural beauty and biodiversity of the wetland area.

Recognizing the ecological and socio-economic values of the Lake, in 1986 Wular was considered as Wetland of National Importance under the Wetlands Programme of the Ministry of Environment and Forests, Government of India for intensive conservation and management purposes. Subsequently, on 23rd March 1990, it was designated as a Wetland of International Importance under the Ramsar Convention.

3.1.1 Brief description of the study area

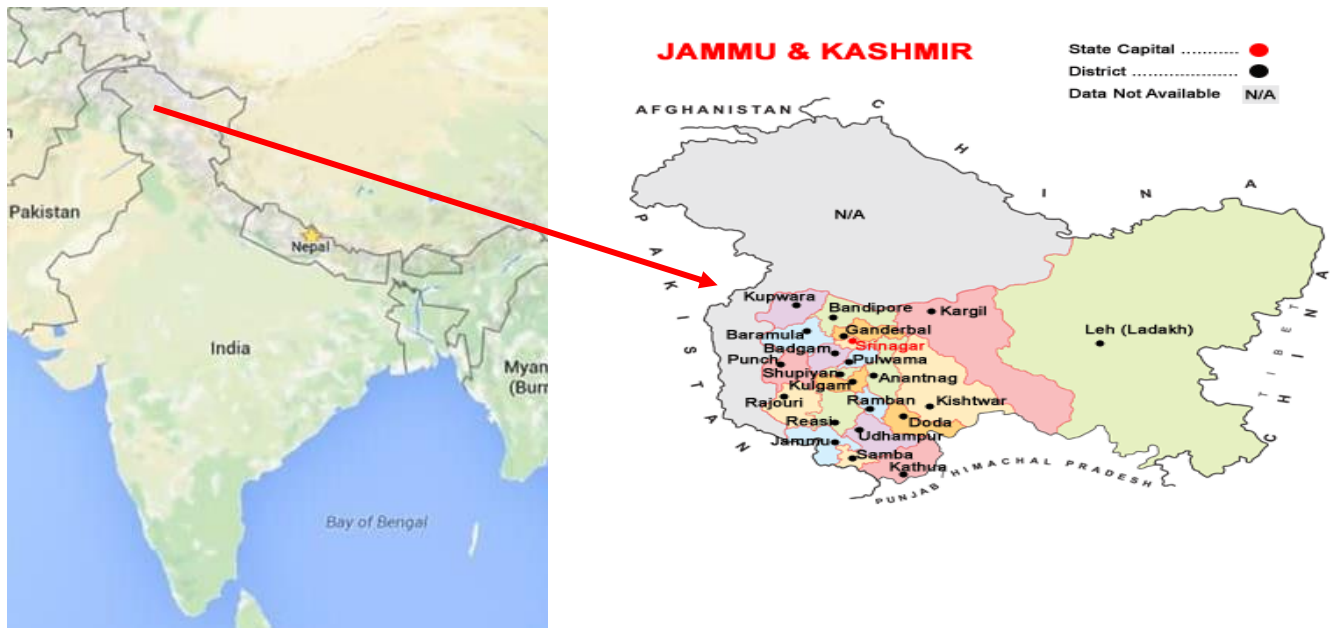


Fig. 3.1.1 Location of Wular Lake in Jammu and Kashmir, India



Fig. 3.1.2 Sampling villages around Wular Lake

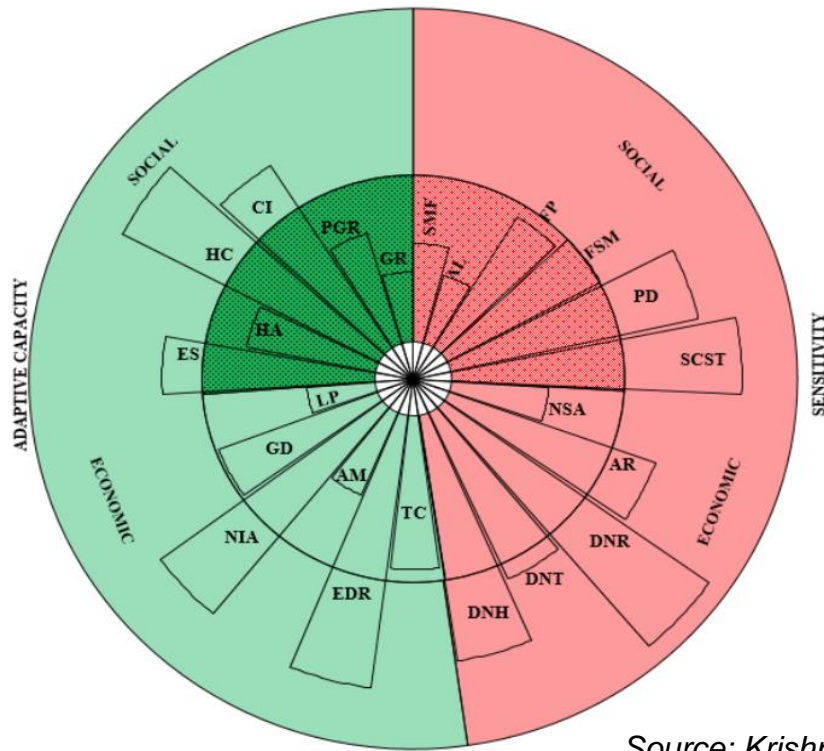
Table 3.1.1 General Information about Wular Lake

Location	Bandipora and Baramulla District, J&K, India
Major Inflowing rivers	Jhelum, Erin & Madumati
Minimum and Maximum water spread area	12.24- 61.6 Km ²
Maximum and Minimum depth	0.9 m to 5.8 m
Maximum Length	16 Km
Minimum Breadth	7.6
Average Volume	267.675×10 ⁶ m ³
Resources harvested	Fish, <i>Trapa</i> , Fodder etc.
Major fish species caught	Common Carp (Exotic), <i>Schizothorax</i> (Local)
No. of dependent communities	30,000 to 35,000 people
Fishing System	Licensing
Fishery Contribution to J& K	54% of Lake fish production
No. of fishing villages surrounding Wular	60
Elevation	1580 m (amsl)

Source: Fisheries Survey Report, 2012; Bhat and Pandit, 2014

3.2 Socio Economic Vulnerability Index (SEVI) - Framework

The methodological framework developed by National Center for Sustainable Coastal Management-NAARM-CIFE study (Krishnan *et al.* 2018) is used to assess the socio-economic sensitivity and adaptive capacity. They have proposed and constructed Socio-Economic Vulnerability Index (SEVI). The framework can be used in both hazard-specific and hazard-neutral scenarios. Framework is primarily meant for assessing the vulnerability of the coastal community to climate change, but it is scalable across geographies and hazards within the Indian context. SEVI framework is also flexible to include additional indicators specific to a given context. The framework is used for analysing the socio-economic vulnerability of the communities depending on Wular Lake which would help in identifying the most vulnerable community/ villages for prioritized attention.



Source: Krishnan et al., 2018

Figure 3.2.1 Framework for assessment of socio-economic vulnerability depicting the indicators based on their weightage for SEVI (Census Village)

SMF- Small and Marginal Farmers, **AL-** Agricultural Labourers, **FP-** Fisher Population, **FSM-**Food Sufficiency/Malnutrition, **PD-**Population Density, **SCST-** Schedule Castes/Schedule Tribes Population, **NSA-** Net Sown Area, **AR-** Annual Rainfall, **DNR-** Dependence on Natural Resources, **DNT-** Distance to Nearest Town, **DNH-** Distance to Nearest Hospital, **TC-** Transport and Communication, **EDR-** Economic Dependency Ratio, **AM-** Access to Market, **NIA-** Net Irrigated Area, **GD-** Groundwater Development, **LP-** Livestock Population, **ES-** Education Status, **HA-** Household Amenities, **HC-** Housing Condition, **CI-** Community Infrastructure, **PGR-** Population Growth Rate, **GR-** Gender Ratio

3.2.1 Vulnerability Indicators

Sensitivity (S) and Adaptive Capacity (AC) together with the Exposure are key factors that determine the vulnerability of households and communities to the impacts of climatic variability and change. However, vulnerability derived from S and AC indicators reflects the Vulnerability of people/household/ village to their **Social** and **Economic** conditions where interventions can be made to improve community resilience to external stressors (**Exposure**).

3.2.2 Compilation and Finalization of SEVI Indicators

In the study carried out by Krishnan *et al.*, (2018), the socio-economic vulnerability of the people as a function of their sensitivity and adaptive capacity. The indicators of sensitivity and adaptive capacity were further grouped based on the dimensions they were intended to measure, viz., social- sensitivity, economic-sensitivity, social-adaptive capacity, and economic-adaptive capacity (Fig. 3.2.1). The indicators for socio-economic vulnerability were collated through review of published and shortlisted based on expert consultations, statistical validation and expert judgment. The indicators thus identified were assessed for their appropriateness and relative weightage through an online expert survey (n=45) and measured on a 5-point Likert scale. The results of the expert opinion survey were analyzed using weighted sum model (WSM) (Smith and Theberge, 1987). The indicators with priority scores of >10 were subjected to analysis using the Analytic Hierarchy Process (AHP) (Saaty, 1990; Ramasubramanian *et al.*, 2014). WSM was used as the first stage in AHP to screen some of the shortlisted indicators based on the review.

WSM and AHP analysis were used to prioritize the final set of indicators (first level of hierarchy) along with their weights that constitute Sensitivity Index and Adaptive Capacity Index which in turn contributed in building the Socio-Economic Vulnerability Index (SEVI). The respective weights (Table 3.2.1) indicate their proportionate weightage in building the sub-indices for four intermediate dimensions that form the second level of the hierarchy.

However, equal weightage was assumed for social and economic dimensions in building both Sensitivity Index (SI) and Adaptive Capacity Index (ACI); and similarly, SI and ACI were considered equally important in constituting the overall Socio-Economic Vulnerability Index (SEVI).

Table 3.2.1 Data extracted for each the villages from various sources for set of 23 indicators and their weightage

Sub-Dimension	Social (Weightage in %)	Economic (Weightage in %)
Sensitivity (S)	Small & Marginal Farmers (10.96)	Net Sown Area (10.59)
	Agricultural labourers (8.64)	Annual Rainfall (20.08)
	Fishers Population (15.43)	Dependency on Natural Resources (28.40)
	Malnutrition/Food security (16.54)	Distance to nearest Town (17.83)
	Population Density (22.76)	Distance to Nearest Hospital (23.11)
	SC/ST Population (25.67)	
Adaptive Capacity (ACI)	Education Status (19.62)	Access to Market (10.25)
	HH Amenities (13.27)	Net Irrigated Area (24.50)
	Housing ownership and condition (25.55)	Stage of Groundwater Development (16.23)
	Community Infrastructure (20.58)	Livestock Population (8.32)
	Population Growth Rate (12.32)	Economic Dependency Ratio (25.24)
	Gender Gap (8.66)	Transport & Communication (15.46)

The twenty-three indicators their scope, measurement, and relationship is given in the following table (3.2.2).

Table 3.2.2 SEVI Indicators: Scope, Measurement and Relationship

Criteria / Indicators	Scope	Definition / Measurement	Rationale	Relation	Source of Data	Min & Max values
Dimension: Sensitivity Social Aspects						
1. Small and Marginal Farmers	Block	Extent of farm area owned by small and marginal farmers in relation to total sown area (%).	Smaller farm size limits marketable surplus and also the opportunity to diversify the cropping pattern and the low investment capacity of farmers make agriculture more sensitive to any climatic shock	Direct	Agricultural Census 2010-2011	0 & 100
2. Agriculture Labourers	Village	Proportion of agricultural labourers (main + marginal) in total workers' population (%).	Greater the proportion, greater is the significance of agriculture including fisheries as a livelihood option	Direct	Census 2011	0 & 100
3. Fishers Population	Village	Proportion of total fisher population in relation to total population in the census village (%).	Greater the number of traditional fishers, higher their sensitivity	Direct	Department of Fisheries, J& K for number of fishers in each village. Field visit to classify fishing villages in to census villages.	0 & 100
4. Food Sufficiency / Malnutrition	District	Proportion of underweight children (weight-age)	Higher the malnutrition, higher the sensitivity	Direct	NFHS, 2015-16	0 & 100

5. Population Density	Village	Average number of people living in a unit area, expressed as no. of people per km ² of village area.	Higher the density, greater the pressure on the land resources and thus higher sensitivity	Direct	Census 2011	1 & observed max in the whole ange
6. SC/ST population	Village	Proportion of SC & ST population in relation to the total population in the village (%)	SC/ST population, is in addition to being relatively being poor and also relatively less educated, poorly integrated with mainstream economy and heavily dependent on natural resources	Direct	Census 2011	0 & 100
Dimension: Sensitivity Economic Aspects						
7. Net Sown Area	Village	Extent of net sown area in relation to total geographical area of the village (%)	Higher area under cultivation implies higher relative importance of agriculture and more area could be affected	Direct	Census 2011	0 & 100
8. Annual Rainfall	District	Average annual rainfall (mm) from 2014 to 2018	Higher rainfall if better for crop health	Inverse	India Meterological Department, Srinagar, J&K	All India Min. (94.6 mm) & Max. (3570)
9. Dependence on Natural Resource	Village	Extent of total area (ha) under Common Property Resources namely the 3 land use categories 'forest area, permanent pastures & grazing land', 'land under misc. tree	CPRs help to reduce vulnerability and build resilience; provide alternative livelihoods;	Inverse	Census 2011	0 & 100

		crops', 'tank & lake areas' in relation to the total geographical area of village (%).				
10. Distance to Nearest Town	Village	Distance from village to the nearest town. A 3-point scale based on distance classes (Town – 1, <5 km - 2, 5-10 km - 3, >10 km - 4) available in Census is to be used.	Proximity to the amenities / better services reduce sensitivity	Direct	Census 2011	Scale Min. (1) & Max. (4)
11. Distance to Nearest Hospital	Village	Distance from village to the nearest hospital / health Centre. A 4-point scale based on distance classes (within village -1, <5 km - 2, 5-10 km - 3, >10 km - 4) available in Census is to be used.	Proximity to the amenities / better services reduce sensitivity	Direct	Census 2011	Scale Min. (11) & Max. (44)
Dimension: Adaptive Capacity Social Aspects						
1. Education Status	Village	Combined measure consisting of a) proportion of literate population and b) proportion of literate female population (%)	Better education status enables the people to adapt to the changing climate; indicator of better awareness and technology adoption	Direct	Census 2011	0 & 100
2. Household Amenities	Village	Combined measure consisting of proportion (%) of i) HHs with access to drinking water from all sources, ii) HHs with access to sanitation (latrine as well as	Better household amenities indicate the availability of basic and essential services and reduce the vulnerability of the population to climate vagaries	Direct	Census 2011	0 & 100

		<p>drainage),</p> <p>iii) HHs having electricity (in lighting),</p> <p>iv) HHs having clean fuel (Biogas, LPG & electricity)</p>				
3. Housing Ownership and Condition	Village	<p>Combined measure consisting of proportion (%) of</p> <p>i) Housing ownership (owned, rented, others),</p> <p>ii) No. of rooms (dwelling room, bathroom, kitchen),</p> <p>iii) Household type (Good, livable); and iv) material type (floor, wall, roof)</p>	Higher the housing ownership and condition score, lesser the chances of them being affected by climate vagaries	Direct	Census 2011	0 & 100
4. Community Infrastructure	Village	Data entered in numbers for i) Schools, ii) Colleges, iii) Hospitals (Govt., Non- Govt.), iv) community halls	Better community infrastructure strengthens the response of the community to changing climate	Direct	Census 2011	Scale Min. (0) & Max. (4)
5. Population growth rate	Village	Decadal growth rate in total population between 2011 and 2001. (%)	Population growth is an indirect indicator of fertility rate, pressure on natural resources, possible migration and reduced capacity.	Inverse	Census 2001 & 2011	Scale Min. (1) & Max. (5)

6. Gender Gap	Village	Ratio of number of females to 1000 males.	Higher score indicates lower capacity to cope with climate vagaries	Direct	Census 2011	Scale Min. (0) & Max. (1.2)
Dimension: Adaptive Capacity Economic Aspects						
7. Transport & Communication	Village	Combined measure consisting of proportion (%) of i) HHs having access to types of communication assets/accessories; and ii) HHs having transport facilities iii) All of them and None of them	Greater score for transport and communication indicates stronger connect with the outside world and thus better ability to deal with changing climate; Indirect indicator of social awareness; technology adoption and economic strength	Direct	Census 2011	0 & 100
8. Economic Dependency Ratio	Village	Ratio non-working population (age group <14 and > 60 + non-workers' population in working age group of 15-59) to working population in age group 15-59 years. In Census data, ratio of non- working population to workers	Higher economic dependency reduces the adaptive capacity	Inverse	Census 2011	Observed Min. & Max. in the data
9. Access to Market	Village	Distance from village to the nearest mandi/market/weekly haat. A 4-point scale based on distance classes (Yes – 4, <5 km - 3, 5-10 km - 2, >10 km - 1) available in Census is to be	Better access to markets helps farmers receive better prices and thus better incomes; also indicate better technology adoption	Direct	Census 2011	Scale Min. (1) & Max. (4)

		used.				
10. Net Irrigated Area	Village	Proportion of net sown area having access to irrigation (%)	Irrigation is an important adaptation-enabler as it enables farmers save crops during dry spells or droughts. It is also strongly related to technology adoption	Direct	Census 2011	0 & 100
11. Stage of groundwater development	District	Draft of groundwater in relation to availability (%). Block-wise groundwater extracted in relation to availability (%) during 2012-2014.	Groundwater is an alternative source of water for the farmers; Higher draft implies less scope for future	Inverse	CGWB, 2014 (Data 2012-2013)	Observed Min. & Max. in the data
12. Livestock Population	Village	Population of all types of livestock accounted in the census and expressed as number of animal equivalents	This indicates diversification of agriculture and livelihoods and enhances the ability to cope with climatic aberrations	Direct	Livestock Census 2012	Observed Min. & Max. in the data

Source: Krishnan *et al.*, 2018

3.2.3 Normalization of Indicators

In order to address the issue of incommensurability of the units in which the individual indicators were measured during their integration into aggregate vulnerability index, the data were normalized to a common (analogous) unit-less scale (0 to 1).

Normalization was carried out for each indicator depending on the relationship with the broad categories as provided in the formulae.

$$Z_i = \frac{X_i - X_{min}}{X_{max} - X_{min}} \quad (\text{Eq.1})$$

$$Z_i = \frac{X_{max} - X_i}{X_{max} - X_{min}} \quad (\text{Eq.2})$$

Eq. 1 and Eq. 2 were applied for directly and inversely related indicators respectively. Z_i is the normalized value of i th village with respect to the indicator X , X_i is the value of the indicator in original units for the i th village. X_{min} and X_{max} denoted the universal minimum and maximum values. An absolute scale was used against a relative scale, so as to enable a national level comparison of indices.

3.2.4 Sensitivity Index (SI) and Adaptive Capacity Indices (ACI)

Village wise (Census villages) indices for social and economic sensitivity (SI) / adaptive capacity (ACI) were determined by taking the average of the normalized indicators assigned for each dimension. SI & ACI for villages were constructed by taking the average of social and economic sensitivity/ adaptive capacity indices, respectively.

Sensitivity Index and Adaptive Capacity Index for Wular for villages and Block level were estimated by using the following indices:

$$\text{Sensitivity Index (Village) } (SI_v) = \sum_{v=1}^V (WPI_i * SI_i)$$

$$\begin{array}{l} \text{Adaptive} \\ \text{Capacity Index} \\ \text{(Village) } (ACI_v) \end{array} = \sum_{v=1}^V (WPI_i * ACI_i)$$

Where v denotes the village, V denotes the total number of villages, WPI_i is the proportion of i th village population to the total population, SI_i is the Sensitivity index of the i th village and ACI_i denotes the Adaptive Capacity index of the i th village.

$$\begin{array}{l} \text{Sensitivity} \\ \text{Index} \\ \text{(Block) } (SI_B) \end{array} = \sum_{b=1}^B (WPI_i * ACI_i)$$

$$\begin{array}{l} \text{Adaptive} \\ \text{Capacity Index} \\ \text{(Block) } (ACI_B) \end{array} = \sum_{b=1}^B (WPI_i * ACI_i)$$

Where b denotes the village, B denotes the total number of villages in the Block, WPI_i is the proportion of i th village population to the Block total population, SI_i is the Sensitivity index of the i th village in the Block and ACI_i denotes the Adaptive Capacity index of the i th village in the Block.

3.2.5 Socio-Economic Vulnerability Index (SEVI)

In order to discern greater variability to enable grassroots level (village/blocks) planning and interventions, SI, ACI and SEVI were rescaled on a relative basis, keeping an observed minimum and maximum as X_{min} and X_{max} values. For all indices viz., SI, ACI and SEVI, five-point ordered scale was used to rank from very low (0 to 0.2) to very high (0.81-1.0), according to their functional relationship with vulnerability.

Socio-economic vulnerability index (SEVI) for all villages, from the re-

scaled socio-economic sensitivity (SI-R) and socio-economic adaptive capacity (ACI-R) using the following formula.

$$SEVI = \frac{\textit{Sensitivity Index}}{1 + \textit{Adaptitive Capacity Index}}$$

3.2.6 Wular Villages

Wular Lake falls in two districts Bandipora and Baramullah of Jammu and Kashmir state. Bandipora District has 3 tehsils viz., Bandipore, Sonawari and Gurez while Baramullah District has 8 tehsils namely Sopore, Rafiabad, Pattan, Tangmarg, Baramulla, Kreeri, Boniyar, and Uri. Wular Lake falls in three tehsils of Bandipora and Baramullah districts viz., Bandipora, Sonawari, and Sopore. There are 138 census villages in all these three tehsils that is 40 villages in Bandipore tehsil, 42 villages in Sonawari tehsil and 56 villages in Sopore tehsil.

Total number of fishing hamlets that dot the Wular periphery are 60 out of which 10 are urban and are not included in the present study due to data constraint and they are Maharajpora, Muslim peer, Teliyan, Kraltang, Pathiabal, Hatisha, Ningle payeen, Sher colony, Chan khand.

Therefore remaining 45 fishing villages are located in Bandipora (Sonawari and Bandipore tehsil) and rest of 15 villages are located in Sopore tehsil of Baramullah District. Overall there are fifty fishing villages which come under 23 census villages and the total number of fishers in these villages are 2918 (Table 3.2.3).

As there is no inland fisheries census data available for most of the states in India except few e.g. Tamil Nadu, the number of fishing villages around the Wular Lake were as collected during the field visit. The fishing villages and census village differ considerably. Some fishing villages are census villages also, those were taken as such otherwise fishing villages were then classified in census villages as per its proximity to census village. The same information was cross-checked with the Department of Fisheries and Department of Revenue officials for validation and reliability.

Table 3.2.3 District wise Fishing Villages under Census villages of Wular Lake

Sl.No.	District	Tehsil	Block	Census Village	Fishing Village	License holders in each fishing village	Total licenses In census villages
1.	Bandipore	Bandipora	Bandipore	Kunas	Kehnoosa Kanbatti Khudlab	47 71 32	150
2.	Bandipore	Sonawari	Hajan	Sadrakote Pain	SK Payeen	60	60
3.	Bandipore	Sonawari	Hajan	Watal Hanji	Gulamwari Naidkhi	15	15
4.	Bandipore	Sonawari	Hajan	Rakh Hajin	Hajin Kathpora	140 15	155
5.	Bandipore	Bandipora	Bandipore	Ashtongu	Badyari Aishtangoo	17 107	124
6.	Bandipore	Bandipora	Bandipore	Aloosa	Kema Kanker Mohalla Paribal Kanilbagh Aaloosa	65 12 86 17 26	206
7.	Bandipore	Bandipora	Bandipore	Garoor	Lankreshipora Nusoo Garoor	226 19 33	668

					Kulhama	390	
8.	Bandipore	Sonawari	Hajan	Gund Prang	Bathibal Batagund Chringapora	26 1 1	28
9.	Bandipore	Sonawari	Hajan	Madwan	Mukdamyari	5	5
10.	Baramula	Sopore	Sopore	Sangrama	Zurimanz Ningle bala	184 95	279
11.	Bandipore	Sonawari	Sumbal	Tirgam	Trigam Wangipora	1 0	1
12.	Bandipore	Sonawari	Sumbal	Gund Khalil	Shilvat Waskura	11 2	13
13.	Bandipore	Sonawari	Hajan	Shah Gund	Shah Gund	2	2
14.	Bandipore	Sonawari	Hajan	Gundi Jahangir	Kanyari	9	9
15.	Baramula	Sopore	Zaingeer	Watlab	Watlab Ghat	89	89
16.	Bandipore	Sonawari	Sumbal	Shadi Pora	Shadipora	1	1
17.	Bandipore	Sonawari	Hajan	Sadhunara Hasti Khan	Gulamyari Sadunaara Jadalpora Sumbal Watalpora Banyari	11 28 9 13 47 56	165
18.	Bandipore	Bandipora	Bandipore	Nadihal	Naidhal	8	8

19.	Bandipore	Bandipora	Bandipore	Qazipora Patushi	Laherwalpora	556	556
20.	Bandipore	Sonawari	Sumbal	Hilal Abad (Nisbal)	Tengapora Nainar Sumbal Nainara	35 70 45	150
21.	Baramula	Sopore	Sopore	Rakh Haigam	Haritar Okhan pora Nussu Ghat	57 98 7	162
22.	Bandipore	Sonawari	Hajan	Bahar Abad (Amcha Kundal)	Khanamoh Bharabad	3	3
23.	Baramula	Sopore	Sopore	Seer Jagir	Bakrapora Seer	21 48	69

3.3 RAPFISH Technique and its modification

RAPFISH is globally acknowledged as a multi-disciplinary assessment method to understand the complexities of a particular fishery. Considering its ease and comprehensiveness (Pitcher *et al.*, 1998), the methodology was recently adapted in the Indian context to demonstrate the status of fisheries sustainability in marine and reservoir fisheries sub-sectors (Adiga, 2015; Lloyd, 2017). Keeping this in view, this study attempts to assess the level of sustainable development of Wular lake fisheries of India in a multi-dimensional perspective by further adapting the RAPFISH methodology to suit the context of Lake fisheries.

Hence, to understand and use this modified 'RAPFISH' which would suit the Lake ecosystem, 25 indicators (Fig. 3.3.1) were shortlisted under 5 evaluation fields, five attributes under each dimension of ecology, economy, social, technology and governance (Lloyd, 2017).

3.3.1 Definition of Fisheries to be evaluated

For RAPFISH analysis, it is mandatory to define the fishery which is to be assessed for sustainability. It was defined in the original RAPFISH and hence will be necessary to do so in the modified RAPFISH as well since it is directly linked with the analytical part of the technique. To elaborate further, one may define/classify different type of fishery by species type, trophic level or even the market price or the gears employed in each ecosystem. However, unlike the marine sector, there are no similar economically exploited fishery groups or the extent of diversity in terms of the commercial fishery in reservoirs or lakes. Hence, based on the total fish landings/market price, the Wular lake fisheries were categorized into two fishery (**LOCAL** – Schizothoracines, **CC**- Common Carps) types. This typology is expected to provide an easy understanding of factors influencing the fisheries management in a particular lake context. It has to be also noted that, these 'fishery' will be examined individually. If there are no noticeable differences as a whole or appropriate merging of the fishery groups will be considered as the case may be and accordingly RAPFISH analysis will be carried out.

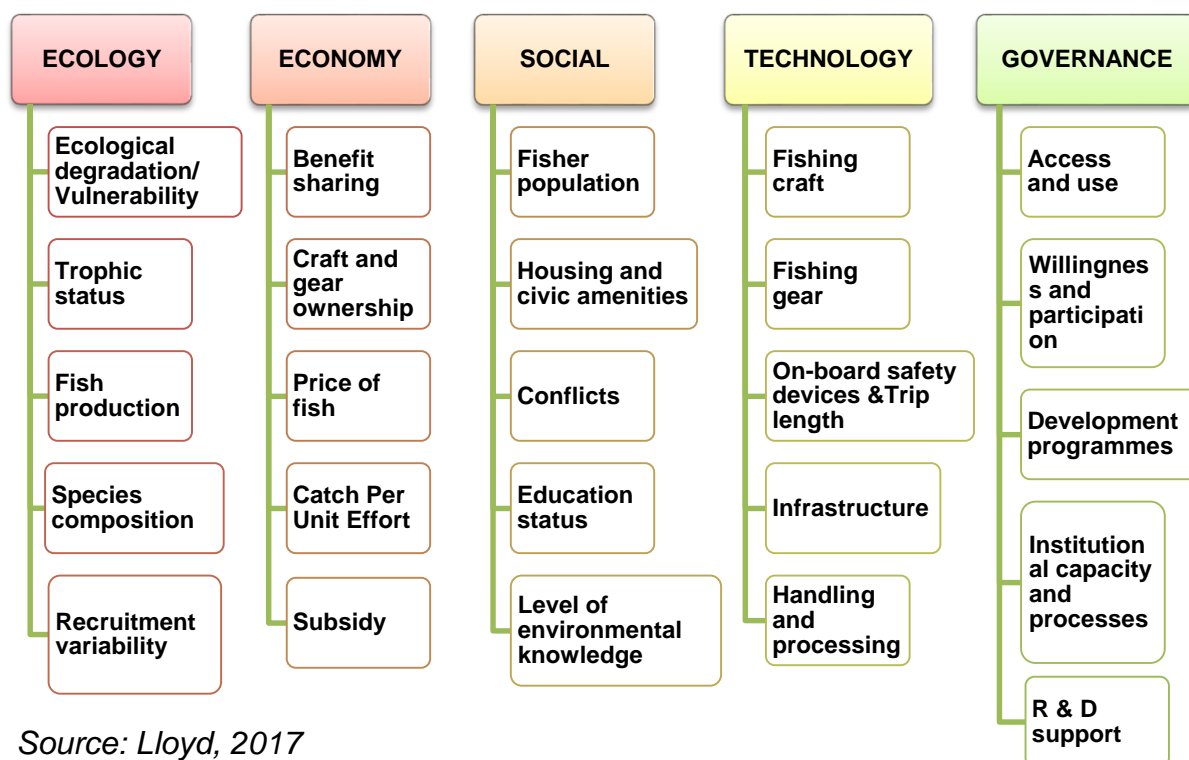


Figure 3.3.1 Modified RAPFISH Method for Assessment of Sustainable Reservoir Fisheries Development

3.3.2 Attributes and Scoring

An attribute is a characteristic of the fisheries which reflects a certain feature / aspect of the sustainability within each dimension (Pitcher and Preikshot 2001). Criteria for qualifying as attributes are chosen in such a way that they are easy, can be objectively scored and also applied for all fisheries. Keeping all of this in view, a uniform five-point 'Likert' scoring pattern is followed (as it will ease analysis as well as comparison between the attributes if needed) to reflect the sustainability status of a fishery had been decided accordingly. Five point scale [for e.g., Very good (4), Good (3), Average (2), Poor (1), Very poor (0)] is used to score all the attributes in which four and zero represent the maximum and minimum score respectively as shown in (3.3.1).

3.3.1 Table Modified RAPFISH attributes under different dimensions for present study

S.No.	Attributes	Description	Score	Scoring description
1.	ECOLOGY Trophic Status (TST)	Cumulative score of trophic status of a Wular Lake measured in three different ways namely Trophic State Index (calculated based on abundance and distribution pattern of plankton assemblages with respect to important water parameters), Phosphorus content and pH range of the reservoir water.	4	all three measures indicate high productivity
			3	only two measures indicate high productivity
			2	one measure indicate high and other two measures indicate medium productivity
			1	all three measures indicate medium productivity
			0	all three measures indicate low productivity
2.	Species Composition (SCO)	To know the extent of fish species diversity in Wular through the total fish caught per year collected from published and grey literature. The identified fish species will be again classified based on their trophic level value to know the contribution of each trophic level in the total catch of the Wular.	4	All the fish trophic levels are in proportion and resemble a pyramidal structure (besides Omnivores, Herbivores and Detritivores, significant presence of mid-level carnivores and noticeable presence of high-level carnivores)
			3	Significant presence (around 20%) of mid-level carnivores whereas high-level carnivores may or may not be present
			2	Dominated by Omnivores, Herbivores and Detritivores which form above 90% of total catch and noticeable presence (at least 5%) of mid-level carnivores; absence of high-level carnivores

			1	Dominated by Omnivores, Herbivores and Detritivores which form above 90% of total catch and negligible presence (less than 1%) of mid-level carnivores; absence of high-level carnivores
			0	Only Omnivores, Herbivores and Detritivores form almost 100% of total catch
3.	Fish Production (FPR)	Exploitation level of a particular fishery / fish species or change in total catch of a target fishery over last twenty nine years in Wular Lake.	4	Increasing
			3	Was decreasing now increasing
			2	Constant/Stable
			1	Was increasing now decreasing
			0	Decreasing
4.	Recruitment Variability (RVA)	Percentage variation in new fishery arriving at the fishery (= recruits), year to year (or) Recruitment of particular fishery can be measured in terms of landing variation (calculated on total catch for last 29 years).	4	low <25%
			3	medium = 25- <50%
			2	high = 50- <75%
			1	very high = 75- <100%
			0	Extreme = >100%
5.	Ecological degradation / Vulnerability (VUL)	Extent of environmental degradation due to pollution and other anthropogenic activities such as discharge of urban sewage, run off from agricultural fields, indiscriminate fishing practices etc. and their effect on the Wular Lake fishery.	4	None
			3	low
			2	medium
			1	high
			0	very high
6.	ECONOMIC Craft and Gear	It refers to the extent of ownership of fishing	4	Almost everyone (about 95%) owns

	Ownership (CGO)	equipment by the active fishers in Wular Lake	3	Most of them (about 75%) own
			2	Half of them own (about 50%)
			1	Some owns (about 25%)
			0	Almost no one (about 5 %) owns
7.	Catch Per Unit Effort (CPUE)	Change in the quantity of average fish caught by the fishing units during the last 29 years (kgs/unit/year) in Wular Lake	4	Increasing
			3	Was decreasing now increasing
			2	Fluctuating around mean
			1	Was increasing now decreasing
8.	Price of Fish (POF)	Increase in real unit price (inflation adjusted price) of fish sold at the first point of sale by fishers or DoF during the last 3 decades from 1998 to 2019). The extent to which the price of fish sold at first point of sale is closer to the market price (consumer price at the last point of sale) is also taken into account.	4	A great extent
			3	A lot
			2	Some extent
			1	Very little
9.	Benefit Sharing (BSH)	To what extent the benefit sharing system between the holder of fishing rights and fishing units is equitable in terms of instituted benefit sharing arrangements and its field implementation is taken into account. It takes in to account whether fishers as a primary producers gets a fair share of consumer rupee.	4	Much more (more than 50%)
			3	More (within 50%)
			2	The same/No change
			1	Less (within 50%)
10.	Subsidy (SUB)	Are subsidies (including hidden) provided to	4	A great amount

		support the fishery and fishers?	3	A lot
			2	Some
			1	Very little
			0	None
11.	SOCIAL Fisher population (FPO)	The relation between the total number of active fishers and extent of area (in ha) available for them to support their livelihood. Precisely, it exhibits the status of fishing pressure in Wular Lake fishery.	4	4.1 - 6 = optimum population
			3	6.1 - 8 = somewhat under populated
			2	2.1 - 4 = somewhat over populated
			1	>8.1 = under populated
			0	<2 = over populated
12.	Local Environmental Knowledge (LEK)	Level of knowledge of a Wular Lake fisher about their local fishery resources, ecosystem, weather and fishing equipment (craft & gear).	4	Excellent
			3	Good
			2	Average
			1	Poor
			0	Very poor
13.	Education Status (EST)	Education level / literacy rate of fishers of a Wular Lake, based on the total number of years of schooling	4	$\frac{3}{4}$ of the fishers have completed above 12 years of schooling
			3	$\frac{3}{4}$ of the fishers have completed 9-12 years of schooling
			2	$\frac{3}{4}$ of the fishers have completed 6-8 years [middle level] of schooling

			1	¾ of the fishers have completed 5 years of schooling
			0	¾ of the fishers have not completed 5 years [primary level] of schooling
14.	Housing and Civic Amenities (HCA)	Status of fisher households with essential and important civic amenities like electricity, drinking-water source, sanitation facility, clean fuel for cooking, coverage under a health scheme or health insurance, Infant Mortality Rate and type of housing	4	Excellent (81-100%)
			3	Good (61-80%)
			2	Average (41-60%)
			1	Poor (21-40%)
			0	Very poor (0 - 20%)
15.	Conflicts (CON)	Working nature of fishermen i.e. whether they fish as individuals or in families or community groups and its relation to any kind of conflicts i.e., licensed fishers vs. poachers; Existence of political/caste/occupation based factions in the fishing villages	4	Highly cohesive & No conflicts both internal and external
			3	Highly cohesive and no internal conflict but external conflict is there
			2	Somewhat cohesive and some degree of conflicts
			1	Less cohesive and lot of conflicts
			0	No cohesion and great deal of conflicts
16.	TECHNOLOGY Fishing Craft (FCR)	To find whether fishers have altered fishing craft to increase catching power/safety over past 25 years. It also considers the fishing capacity in terms of number of units increased/declined during the past 25 years.	4	A great amount, rapid increase (tubes to motorized FRP)
			3	a lot (more than 50% FRP)
			2	Somewhat
			1	a little
			0	Not at all

17.	Fishing Gear (FGE)	To find whether fishers have altered gear to increase catching power/selectivity over past 25 years. It also considers whether a gear is active or passive, primitive or modern/specialized.	4	A great amount
			3	A lot
			2	Some
			1	Very little
			0	None
18.	Handling and Processing (HAP)	Does fishers use any handling (Handling = icing after fishing) methods (salting, boiling, freezing, ice storage etc.) on board or near landing center to preserve the fish or using live tank, sophisticated freezing or usage of ice during pre-sale processing like gutting, filleting etc.	4	Always
			3	Great deal/most times
			2	A lot/often
			1	Some/Sometimes
			0	None/Never
19.	On-Board Safety Devices and Trip Length (OBS)	Does fishers use safety devices and other equipment on-board the vessel like Mobile, lifejacket, etc. It also considers the average fishing hours spend in a Lake.	4	Completely reliant on safety devices
			3	Some reliance as only some of the recommended safety devices are used though trip length is higher (<6hrs.)Some reliance
			2	Completely reliance on safety devices
			1	Some reliance as only some of the recommended safety devices are used though trip length is higher (>6hrs.)Some reliance
			0	Not used though necessary
20.	Infrastructure (INF)	Presence of centralized/minimal landing sites with concrete structure/hall including washing, icing and loading/transport facilities	4	Centralized and with all facilities
			3	Centralized but only with some facilities
			2	Centralized but without any facilities

			1	Dispersed but with some facilities
			0	Dispersed and without any facilities
21.	GOVERNANCE Access and Use (AAU)	Presence of comprehensive and effective licensing policy and regulatory framework for sustainable development of fisheries and fishers in Wular Lake. It also includes extent of enforcement and adoption of seasonal fishing ban and mesh size regulation to help the breeding of major fishery and as a management measure to avoid the juvenile catch respectively in a Lake.	4	effective framework balancing all objectives
			3	predominantly development <production based> oriented
			2	predominantly welfare oriented
			1	predominantly revenue oriented
			0	No effective legal framework
22.	Willingness and Participation (WAP)	Indicates the degree to which primary stakeholders (Fishers) are willingly / voluntarily participate in planning as well as adopt various fisheries resource management measures including access and use rules / guidelines etc. It also includes traditional management measures used by fishers or community (in relation to fishing, fishing equipment or legal aspect) for sustaining the fishery resources, and its integration in State regulations.	4	Almost Everyone (~95%) willing and participate
			3	Most (~75%) willing and participate
			2	Only Half (~50%) willing and participate
			1	Only Some (~25%) willing and participate
			0	Almost None (~ 5 %) willing and participate
23.	Development programmes (DPR)	Indicates <i>existence as well as effective implementation</i> of reservoir fisheries development programmes/schemes like stock enhancement	4	Very good
			3	Good
			2	Average

		programmes (including functioning of fish seed production and rearing centres), cage/pen culture programmes, species/fishery-wise schemes, any other innovative schemes, etc.	1	Poor
			0	Very Poor
24.	Institutional capacity and processes (ICP)	Indicates overall capacity & effectiveness of Fisheries Dept. and related institutional mechanisms including various procedures and processes in providing good governance. It includes available human resources (adequacy & competency); transparency, equity and fairness in application including gender mainstreaming; effective coordination with concerned agencies; functioning of fishers coop. societies; conflict resolution; etc.	4	Very good
			3	Good
			2	Average
			1	Poor
			0	Very Poor
25.	Research and Development (R& D)Support (RDS)	Extent and quality of research based inputs and credible information from R&D system to sustainably manage the resources. It also indicates the extent of evidence based planning including availability of reliable catch data, marketing database / statistics.	4	Very good
			3	Good
			2	Average
			1	Poor
			0	Very Poor

3.3.3 RAPFISH Analysis

RAPFISH analysis was done using the latest RAPFISH version (3.1) for Windows that is available for use as an add-on in open source R software. The aforesaid version can be downloaded for free from the www.rapfish.org website. Once the tool and R software is downloaded, to work in it the following information should be ready:

1. The names of all the data files to be analyzed (i.e. number of fields) has to be entered.
2. It has to be done carefully because the names of the data files are automatically used for naming the output files and in the Radar plots.
3. Even the same has to be followed carefully for the number and names of fisheries being analyzed as the names of the fisheries are automatically used in the RAPFISH plots.
4. The authors of RAPFISH have kept all the scores between 0 and 10 where 0 is 'Bad' and 10 is 'Good'. In this case, to suite with the RAPFISH scoring pattern, scoring pattern (0-4) used in this study have been normalized as suggested.
5. Once the above information is ready, the main functions as given below can be initiated following the given procedure:

Step 1: Open R

Step 2: Inside R window → go to File → Change dir → Browse to this folder

Step 3: To Run RAPFISH

- a. go to File → Source R code →
- b. choose 'rapfish_execution.r' and observe the results
- c. choose 'leverage.r' and observe the results

RAPFISH Execution:

- (a) Produces RAPFISH plots
- (b) Number of plots is equal to the number of fields analyzed
- (c) Produces Radar plots
- (d) Produces csv files (labeled: Results_Field1.csv) which contain the scores for each dimension of overall fisheries.

(e) Number of csv files is equal to the number of fields analyzed

Leverage:

(a) Produces leverage estimates for each field: Leverage_Field1

(b) Number of .csv files is equal to number of fields analysed

3.3.4 Sustainable Development Category

Finally, fishery (Wular Lake) is categorized based on the sustainability score obtained from RAPFISH analysis as shown in (Table 3.3.2). Score estimation of each dimension is expressed by the worst scale (bad) 0% to the best (good) 100%. Sustainability index is the value of each dimension that describes the level of sustainability.

Table 3.3.2 Sustainable development category of fisheries resources management

Index value (%)	Sustainable Development Status
0-25	Poor
25.1-50	Less
50.1-75	Quite
75.1-100	Good

Source: Fauzi and Anna, 2005

3.4 Data Collection

3.4.1 Secondary Data Collection

The data sources for computing first objective (SEVI) were chosen based on their accuracy, credibility and availability at the village level, to enable aggregation at the state and country levels. Census of India (2011 and 2001) data for Baramulla and Bandipora districts of Jammu & Kashmir State were used for measuring 17 indicators, while Livestock Census (2012), the Agricultural Census (2010–2011), reports of the Central Ground Water Board (2011–2012), National Family Health Survey (2015–2016), Rainfall data (2014-2019) collected from Indian Metrological Department, Srinagar were relied upon for measuring the rest of indicators. Data ranges and scales used were different among the indicators and in

order to compare and perform arithmetical operations on them, they were normalized during their integration into aggregate vulnerability index within a dimensionless range (0–1).

With respect to the second objective, the lake fisheries management performance was estimated using modified and validated RAPFISH methodology following Llyod C., (2017) using 25 shortlisted indicators. Scores for most of the attributes were given based on various relevant studies conducted during the recent years to get a comprehensive picture of the present status of ecological, economical, social, technological and governance dimensions of Wular Lake. Thus, an extensive review of literature, both published (e.g. research journals) and unpublished/ grey documents of Government (Central and State), DoF, WUCMA, independent researches, relevant newspaper articles which can comprehensively reflect the sustainable development status of Wular Lake forms the core component for modification of RAPFISH technique. As current literature available on Wular Lake fisheries is scanty, to score certain indicators e.g. price of fish, conflict, fishing craft, handling and processing, local environment knowledge, ecological degradation, dimension of governance, primary data was also collected.

3.4.2 Primary Data Collection

Primary Data was collected through Focus Group Discussions, Key informants interviews and participant observation methods in 9 villages viz., *Naininaara, Lankreshipora, Laherwalpora, Kanibathy, Zurimanz, Watlab Muslim Peer, Maharajpora* and *Ningli Bala* of Bandipora and Baramullah district which are located in Lake periphery. The villages were selected on the basis of the presence of a higher number of fishers and intense fishing activity. The data collected from field was done from December 2018 to Mid-February 2019. During these visits, fishing activities were observed during the lean winter seasons. Participants were identified for the meetings either by the researcher or they nominated themselves on hearing announcements made by a local leader. Meetings were held in each of village, in informal settings, i.e., in locations where fishers normally gather to work together, to make the participants feel comfortable enough to engage in a dynamic discussion. Each meeting took 2-3 hrs.

3.4.3 Tools of Data Collection

3.4.3.1 Focus Group Discussions (FGD)

The format for FGDs consisted of introductions by researcher and discussion around several guiding topics related to fisheries activities, fishers' livelihood and governance. Topics included inland resource use, species sought and gear used, time spent conducting activities, daily household works, incomes and contributions from fishery-related activities, post-harvest and marketing activities. Nine meetings were conducted and each meeting took about 2 – 3 hours. Number of fishers in each meeting ranged between 15 and 30. These meetings were attended by larger numbers of fishers, especially in *Watlab* village. The researcher applied a number of methods to ensure that the information gathered during the FGDs was objective and representative of the livelihood activities of the population in each location. In cases where a few participants were less inclined to contribute, the lead researcher approached the reluctant participants later to discover whether they did agree or not with the outcomes of the discussions. Where the latter case prevailed, further information was sought on issues highlighted in the group discussions. The facilitator adopted a neutral role.

3.4.3.2 Key Informant Interviews (KII)

These are qualitative in-depth interviews with people who know what is going on in the community. The term "key informant" refers to anyone who can provide detailed information and opinion based on his or her knowledge about a particular issue. Key informant interviews seek qualitative information that can be narrated and cross-checked with quantitative data. The purpose of the key informant interview is to collect information from a wide range of people who have first-hand knowledge about the community. KII was carried out with Wular conservation and Management Authority (WUCMA) staff members, officials of revenue department, few scientists, local village leaders, field operators of DOF and fishers who have first-hand knowledge about the community.

3.4.3.3 Participant Observation

Participant observation, whereby the researcher interacts with people in everyday life while collecting information, is a unique method for investigating the

enormously rich, complex, conflictual, problematic, and diverse experiences, thoughts, feelings, and activities of human beings and the meanings of their existence. Use of this distinctive method emerged with the professionalization of anthropology and sociology where it gradually was formalized and later spread to a full range of human studies fields. Observation methods include all data collection in which participants are monitored, rather than being asked to give experimenters data directly. Collection can be covert or overt, participatory or not, and can vary in degree of invasiveness to the participants' lives.

Certain summary statements can be made regarding the role of participant's observer on the basis of research findings already reported:

- a) Participant observer shares in the life activities and sentiments of people in face to face relationships
- b) Role of the participant observer requires both detachment and personal involvement.

3.4.3.4 Triangulation

Triangulation is a powerful technique that facilitates validation of data through cross verification from two or more sources. This technique has been used to verify the data collected from literature, key informants and field observations e.g the technique was used to verify the fishing villages which fell in census villages.

3.5 Statistical tools used in the study

3.5.1 Percentage Analysis

Frequency and percentage analysis were done wherever required in the study.

3.5.2 Compound Annual Growth Rate (CAGR)

CAGR is a useful measure of growth over multiple time periods. It is a specific term for the geometric progression ratio that provides a constant rate of return over the time period. It is a measure of annual growth rate over time, with the effect of compounding taken into account. It is often used to measure and compare the past performance of investments / trends or to project the expected future returns.

3.5.3 Coefficient of Variation (CV)

The coefficient of variation is a statistical measure of the dispersion of data points in a series around the mean. It is the ratio of the standard deviation to the mean, and it is a useful measure for comparing the degree of variation from one data series to another, even if the means are drastically different from one another.

3.5.4 Trophic State Index (TSI)

The Carlson (1997) developed a numerical trophic state index for lakes that incorporates most lakes in a scale of 0 to 100. To predict the status of lakes the index number can be calculated from several parameters including Secchi disk transparency, chlorophyll, and total phosphorus. As TSI formed one of the components of Trophic Status of Wular Lake under Ecology dimension for RAPFISH analysis, therefore, it was also calculated for the study.

4. RESULTS AND DISCUSSION

This chapter presents the results obtained from the study on the socio-economic vulnerability of the communities dependent on Wular Lake using Socio Economic Vulnerability Index (SEVI) framework, sustainable fisheries development status of Wular Lake using modified RAPFISH methodology, and the fishery and village specific intervention plans to improve community resilience. In order to avoid repetition, both the results and discussion aspects were combined under each objective and presented sequentially.

Changing Climate Scenario

Wular Lake is surrounded by hills on north eastern and western sides and is liable to the action of sudden and furious hurricanes that sweeps over it with extraordinary violence. On the eastern and southern sides are low lying areas of Sonawari which gets inundated every year (Project Report, 2016). The hydrological importance of this fresh water Lake is understood by the fact that it acts as an absorption basin for flood waters of River Jhelum and its adjoining streams. It can be aptly said 'had there not be Wular Lake, the whole valley of Kashmir would have been devastated by floods on regular basis. Excluding the catchments of River Jhelum, the Lake's water shed constitutes an area of more than 83,000 hectares. Wular is surrounded by mountains rising to a height of 5000 m and thus the terrain is marked with a series of high ridges and narrow deep valleys, which have a pronounced effect on climate. The salient features of this climate are severe winters (partly due to geographical features and partly due to western disturbances), considerable precipitation in winter (snow in higher reaches and rain in plains) and a rainy season (March & April) during onset of summer as winds blowing through mountain gaps emerge out as strong currents.

The Wular Lake is frequently subjected to these types of winds causing strong turbulence and stormy condition in the Lake. This is a characteristic feature of the Wular Lake geographical area, in sharp contrast to the Dal Lake and other Lakes of the valley, which are relatively calm. Also studies carried out on

receding Himalaya glaciers in recent times is well documented by (Kulkarni *et al.*, 2007; Murtaza and Romshoo, 2017). The frequent floods and droughts, prolonged rainfall, and longer winter months have an implication of climate change in Jammu and Kashmir, and the worst hit could be those in north, the Wular Lake fishers.

This study has attempted to contextualize both human and fisheries dimensions of Wular Lake. The findings of the research are arranged under the following sub-heads:

- 4.1 Socio-economic Vulnerability of the Wular Lake Dependent Communities
- 4.2 Sustainable Fisheries Development status of Wular Lake
- 4.3 Fishery and Village Specific Intervention Plans for Community Resilience

4.1 Socio-Economic Vulnerability of the Wular Lake Dependent Communities

Wular Lake falls in 3 tehsils (138 census villages) of Bandipora and Baramullah districts. There are fifty fishing hamlets that dot the lake periphery belonging to 23 census villages. Total geographical area is 8976.3 ha. About 30,000 fishers depend on Wular Lake for their livelihood which form about 29.5 % of total census village population. Average annual rainfall is 843.47 mm according to IMD, Srinagar.

Table 4.1.1 Socio-Economic Vulnerability Status of Wular and Non-Wular Villages

Villages	Social (SI)	Economic (SI)	Social (ACI)	Economic (ACI)	SI	ACI	SEVI
Non Wular	0.38	0.55	0.49	0.42	0.47	0.46	0.32
Wular	0.44	0.52	0.48	0.42	0.48	0.45	0.33

Table 4.1.1 presents the Sensitivity Index (SI) and Adaptive Capacity Index (ACI) values that indicate moderate levels (0.4-0.6) of vulnerability for both Wular and Non-Wular census villages. Economic SI border the high vulnerability (0.6 – 0.8) status while the economic ACI of 0.42 indicate relatively low / poor ability

to adapt to negative events and externalities. No significant differences were found between Wular (23) and Non-Wular (115) villages in terms of vulnerability though relatively higher Social SI values for Wular villages due to direct dependence on the Wular Lake is a cause of concern. Socio-Economic Vulnerability Index (SEVI) values for Wular Lake villages range from low to moderate i.e., 0.25 for Seer Jagir village in Sopore tehsil of district Baramullah to 0.42 in Kunas village of Bandipore tehsil of Bandipora district of Jammu and Kashmir.

4.1.1 Social Sensitivity of Wular Lake Villages

Social Sensitivity of Wular Lake villages ranges between 0.29 (low) in *Gund Jahangir* village and 0.60 (high) in *Garoor* village. Overall social sensitivity indicates moderate levels (0.44) due to the higher proportion of (SMF) Small and Marginal farmers (87.3%) indicating limited marketable surplus and opportunity to diversify the cropping pattern. This in turn leads to low investment capacity of farmers thus making agriculture more sensitive to any climatic shock. Being the river valley, this region is among the most densely populated with 1671 people living per km² which is 13 times the state average of 124 / km².

Indicators such as lower proportion of Agriculture Labourers (AL) (22.4%) to total workers population shows less significance of agriculture including fisheries as an alternative livelihood option. Prevalence of children (<5 years) who are underweight (weight for age) and are suffering from malnutrition is about 11% according to National Family Health Survey 2015-2016 and lower SC/ST (3%) and fishers population (3.25%) indicates less sensitivity of overall census villages indicating relatively favourable demographic and social conditions.

4.1.2 Economic Sensitivity of Wular Lake Villages

Economic sensitivity of Wular Lake villages ranges between 0.35 (low) in *Qazipora* village and 0.65 (high) in *Kunas* village. Overall economic sensitivity indicated moderate level of vulnerability (0.52).

Net Sown Area (NSA) i.e. geographical area under cultivation is 71.3% indicating predominance of agriculture and thus simultaneous exposure to stressors like drought and flood. The region receives a low average annual rainfall of only 844

mm. Lower Dependency on Natural Resource (DNR) (0.3%) value indicates lesser presence of forests, pastures, and other cushioning resources thus implying increased sensitivity to cope up in building resilience and providing alternate livelihood. The fact that majority of villages in the region are located within the distance of 5 to 10 kms to nearest town and hospital (0.6) indicates moderate proximity to essential services in the region.

4.1.3 Social Adaptive Capacity of Wular Lake Villages

Social Adaptive Capacity of Wular Lake villages ranges between 0.34 (low) in *Watal Hanji* village and 0.578 (moderate) in *Seer Jagir* and *Sangrama* village. Overall social adaptive capacity indicates moderate levels (0.47).

The results show poor Education Status (46.7%) as against the overall state average of 67.16%. *Garoor*a village has the highest literacy rate (65%) while *Gund Prang* (25%) village had the least. In the Wular villages, the proportion of literate population with respect to total population is a slightly higher 51.6%. The female literacy was even lower (41.8%) with the same *Garoor*a (59.7%) and *Gund Prang* (20.8) villages having the honour of most and least female educated villages in the region.

Only 22% of Wular Lake villages have access to safe drinking water, as majority depend on river / canal water (31%), rest depend on tap water from treated (22.3%) and untreated sources (29%), lakes/ponds (5.8%), and other sources (10.5%). While 72.4% have latrine within premises, almost all (93.5%) the households have electricity access. However, only 12% have access to clean fuel (LPG, electricity / bio gas) as per Census 2011.

Housing ownership and housing condition (HC) score is a poor 38% indicating less than favourable condition. Only 55% of households have housing ownership while only 35% have 'good and liveable' housing condition in terms of number of dwelling rooms, bathrooms and kitchen, roof and wall. Thus, the poor household amenities (44%) and housing condition (38%) indicate lack of basic assets as well as basic services, and these alarming situations imply increasing vulnerability to climatic impulses.

Results show the overall presence of better Community infrastructure (CI) (90%) in terms of schools, colleges, community health centres, charitable non-govt. hospitals / nursing home and community halls indicating better building strength in community's response to changing climate among Wular Lake villages.

Population in Wular villages grew by 23.4% which is higher than the decadal growth rate of India (17.64%) between 2001 and 2011 which indicates higher pressure on natural resource, possible migration and decreased adaptive capacity. As per 2011 census, the population in three tehsils located around Wular Lake was 1,01,384 with female to male sex ratio of 937 which is worse than national average (971) but better than the state average (889) indicating significant gender gap.

An assessment of gender roles indicated active involvement of women fishers of Wular Lake in income generating livelihood activities. Their involvement can be seen in pre-harvest, post-harvest and marketing of fishes and also with Trapa (water chestnut) related activities which is summarized in Figure 4.1.0. However, there are number of problems fisherwomen of Wular Lake region encounter namely absence of proper markets and market facilities, poor roads which prevent their mobility and access to outside world, generic problems like overburden of work particularly in harsh winter due to drying of clothes on traditional *chullahs*, and having to manage the households on their own when men go for several days for fishing due to dwindling fish catches, etc. The involvement of children to gain fishing experience because of familism is also quite common among Wular Lake fishers making children of school going age, especially girls, drop out of school (Regu and Ananthan, 2019).

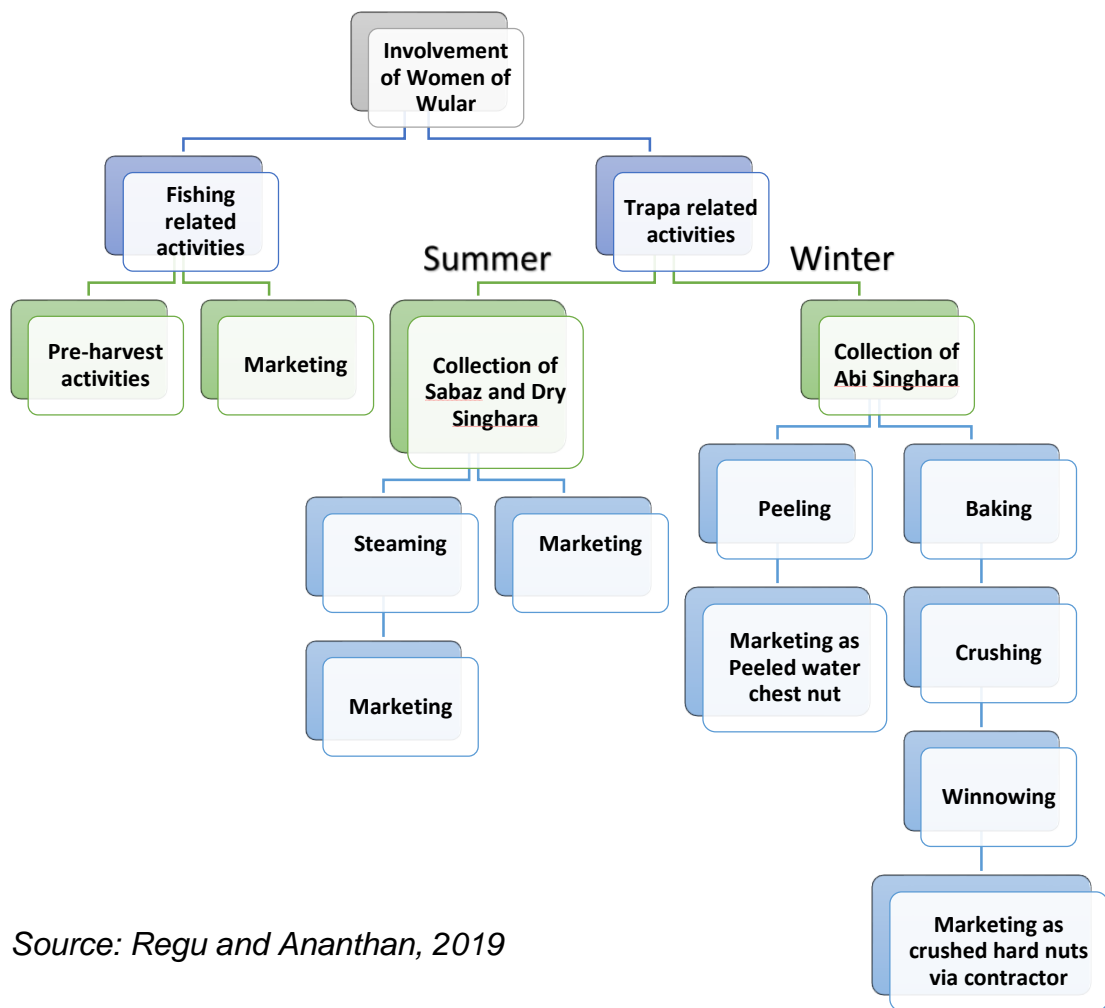


Fig. 4.1.0 Flow chart representing involvement of women in Wular Lake

4.1.4 Economic Adaptive Capacity of Wular Lake Villages

Economic Adaptive Capacity of Wular Lake villages ranges between 0.27 (low) in *Sadarkoot village* and 0.55 (moderate) in *Sangrama village*. Overall economic adaptive capacity indicates moderate levels (0.42).

Meagre Transport and Communication (TC) index value of 12% for Wular Lake villages indicate very poor communication assets (Radio, TV, computer, mobile, telephone) and even lower transport facilities (5%) like cycle, two wheelers, four wheelers. This indicates weaker connection with the outside world and thus poor ability to deal with changing climate. It also indicates less social awareness, technology adoption and economic strength.

Economic dependency ratio (EDR) expressed in terms of ratio of non-working population to working population was found to be 1.7 for the Wular villages, showings moderate levels of dependency and moderate capacity to adapt. The results indicated that only 16% of villages have access to nearby market - haat, mandi / market (AM) within a 10 km distance. For e.g. villages like Kunas, Watal Hanji, Rakh Hajin, Ashtongu, Gund Prang, Madwan, Gund Jahangir, Watlab, Shadipora, Sadhunara have to travel long distance to market due to their remote location thus putting them at a disadvantage to receive better price and thus better income.

A Net Irrigated Area (NIA) of 69% indicates assured and successful crops and less dependence on rainfall. Irrigation is an important adaptation-enabler as it enables farmers save crops during dry spells or droughts in case of Wular Lake census villages. Stage of groundwater development (GD) is expressed in terms of groundwater in relation to availability. For Wular villages, it is 38.2% implying less exploitation of underground water resource and thus ensuring future availability to act as an alternative source of water. Wular Lake dwellers depend on rivers and lakes for water usage as district Bandipora and Baramullah are rich in natural water resource.

Livestock population (LP) in terms of possession of animals like buffaloes, cattle, goat, sheep, poultry, etc. among the households in the region was found to be very less indicating poor diversification of agriculture based livelihoods and hence relatively poor ability to cope with climatic aberrations.

4.1.5 Socio-economic Sensitive Index (SI)

Socio-economic sensitivity indices for census villages that correspond to the identified fishing villages of Wular Lake varied from 0.395 (low) for *Bahar Abad (Amcha Kundal)* village to 0.572 (moderate) for *Kunas* village with the overall SI value indicating moderate sensitivity i.e 0.481. Wular Lake dependent villages hence belong to low to moderate socio-economic sensitivity category.

Indicators such as higher number of Small and Marginal Farmers (87%), high population density (1398 persons / km²), larger area under crops (71%), less rainfall (843.77) and lower dependency on (i.e. availability of) natural resources

are known as drivers which have pushed the index values up and are responsible for higher sensitivity.

Whereas the indicators such as lower percentage of agricultural labourers (22%), low number of fishers population (3.5%), lower percentage of children (10%) having malnutrition, lower share of SC/ST population (3%) are known as buffers which pulled the index value down and are responsible for lower sensitivity.

4.1.6 Socio-economic Adaptive Capacity Index (ACI)

Socio-economic adaptive capacity indices for the census villages corresponding Wular Lake fishing villages was found to be moderate (0.449). The range varied from 0.329 (low) in Sadarkoot village to 0.566 (moderate) in Sangrama village which is located close to Sopore town. Values indicate low to moderate socio-economic adaptive capacity index for Wular villages.

While the indicators such as low livestock population (13%), low education status (46%), poor households amenities (44%), poor housing and ownership conditions (0.38%), low transport and communication (12%), poor access to market (16%) act as drivers that pulled down (lowered) the adaptive capacity.

The indicators such as better community infrastructure facilities (0.90), low exploitation of ground water (38.2%) and the presence of higher net irrigated area (69%), relatively higher population growth rate (23.4%) and high sex ratio (937) (gender gap) are known as buffers that helped push the index values up thus increasing adaptive capacity.

4.1.7 Rescaling of Indices

In order to discern greater variability to enable grassroots level (village/blocks) planning and interventions, SI, ACI and SEVI were rescaled on a relative basis, keeping observed minimum and maximum as Xmin and Xmax values. For all indices viz., SI, ACI and SEVI, five-point ordered scale was used to rank from very low (0 to 0.2) to very high (0.81-1.0) according to their functional relationship with vulnerability.

Figure 4.1.1 shows the rescaled values of villages based on their Sensitivity (S) and Adaptive Capacity (AC) indices where the Kunas and Sangrama villages ranks 1st in terms of S and AC respectively among all Wular Lake census villages. Similarly Bahar Abad and Sadrakote Pain ranks last in terms of S and AC respectively among all Wular Lake census villages.

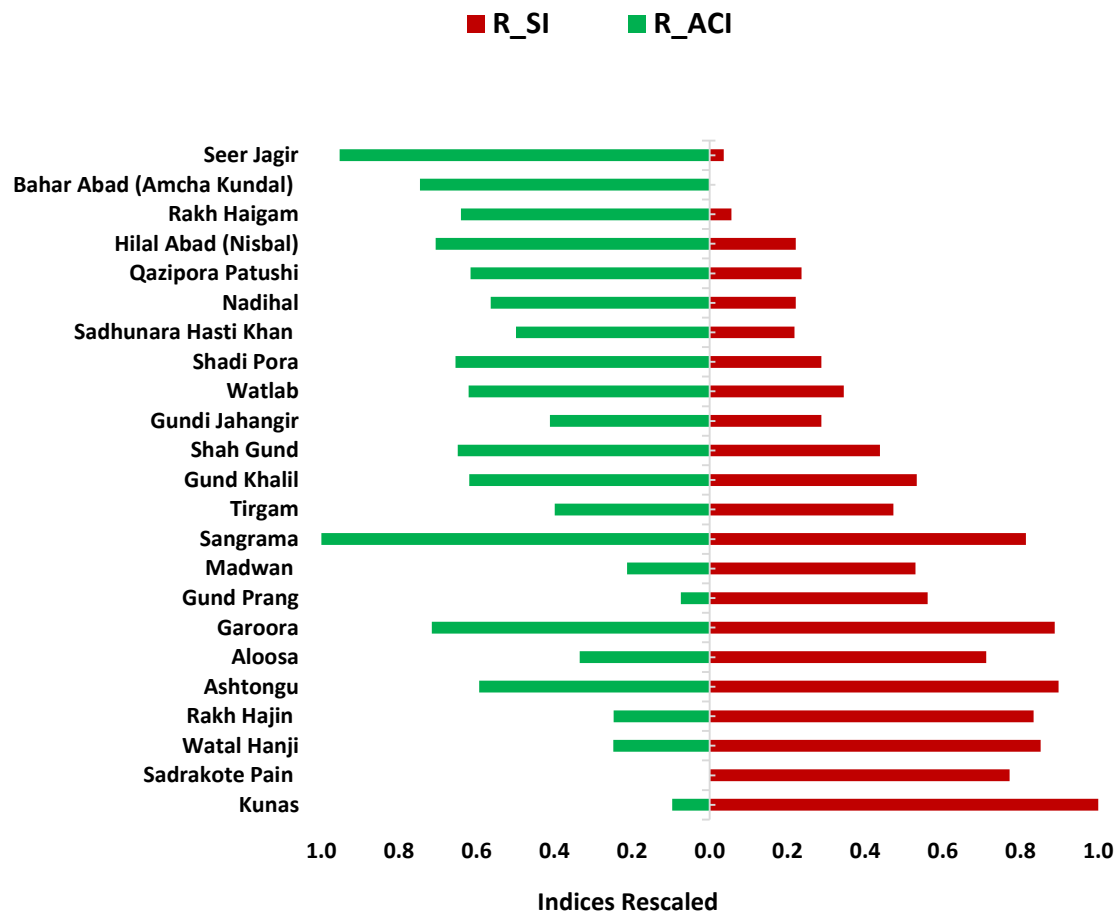


Fig. 4.1.1 Rescaled Sensitivity (R_SI) and Adaptive Capacity (R_ACI) Indices for 23 Wular (Census) villages

4.1.8 Rescaled Socio-Economic Vulnerability Index (SEVI)

Socio-economic vulnerability index (SEVI) for all villages and blocks were constructed from the re-scaled socio-economic sensitivity (SI-R) and socio-economic adaptive capacity (ACI-R) index values using the following formula:

$$SEVI = \frac{\text{Sensitivity Index}}{1 + \text{Adaptitive Capacity Index}}$$

Table 4.1.2 Ranking of Wular villages based on their Rescaled (R) SEVI value

District	Tehsil	Block	Village	R_SI	R_ACI	R_SEVI	Rank
Bandipora	Bandipore	Bandipore	Kunas	1.00	0.10	1.00	1
Bandipora	Sonawari	Hajan	Sadrakote Pain	0.77	0.00	0.86	2
Bandipora	Sonawari	Hajan	Watal Hanji	0.85	0.25	0.82	3
Bandipora	Sonawari	Hajan	Rakh Hajin	0.83	0.25	0.81	4
Bandipora	Bandipore	Bandipore	Ashtongu	0.90	0.59	0.72	5
Bandipora	Bandipore	Bandipore	Aloosa	0.71	0.33	0.68	6
Bandipora	Bandipore	Bandipore	Garooru	0.89	0.72	0.67	7
Bandipora	Sonawari	Hajan	Gund Prang	0.56	0.07	0.66	8
Bandipora	Sonawari	Hajan	Madwan	0.53	0.21	0.58	9
Baramulla	Sopore	Sopore	Sangrama	0.81	1.00	0.52	10
Bandipora	Sonawari	Sumbal	Tirgam	0.47	0.40	0.47	11
Bandipora	Sonawari	Sumbal	Gund Khalil	0.53	0.62	0.45	12
Bandipora	Sonawari	Hajan	Shah Gund	0.44	0.65	0.37	13
Bandipora	Sonawari	Hajan	Gundi Jahangir	0.29	0.41	0.33	14
Baramulla	Sopore	Zaingeer	Watlab	0.35	0.62	0.31	15
Bandipora	Sonawari	Sumbal	Shadi Pora	0.29	0.65	0.26	16
Bandipora	Sonawari	Hajan	Sadhunara	0.22	0.50	0.25	17
Bandipora	Bandipore	Bandipore	Nadihal	0.22	0.56	0.23	18
Bandipora	Bandipore	Bandipore	Qazipora Patushi	0.24	0.62	0.23	19
Bandipora	Sonawari	Sumbal	Hilal Abad (Nisbal)	0.22	0.71	0.19	20
Baramulla	Sopore	Sopore	Rakh Haigam	0.06	0.64	0.09	21
Bandipora	Sonawari	Hajan	Bahar Abad	0.00	0.75	0.02	22
Baramulla	Sopore	Sopore	Seer Jagir	0.04	0.95	0.00	23

The results of the study show that 8 out of 23 villages which are socio-economically most vulnerable were from Bandipore and Sonawari tehsils of district Bandipora (0.8 to 0.1). It implies that enhancing the socio-economic status would

have a significantly higher impact in vulnerability reduction in Bandipora, as compared to Sopore tehsil. Table 4.1.2 shows the ranking of Wular villages based on their rescaled SEVI values.

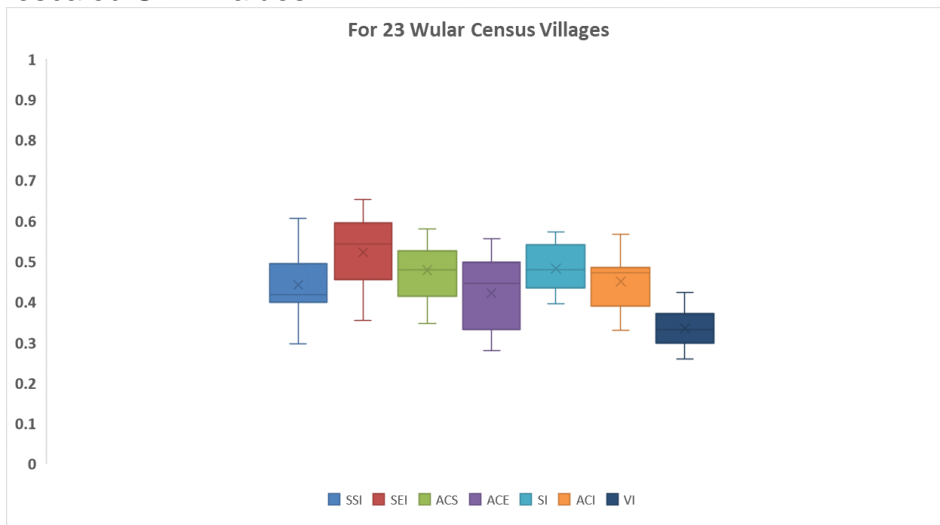


Fig. 4.1.2 Box & Whisker Plot showing SEVI values for 23 Wular Lake Villages

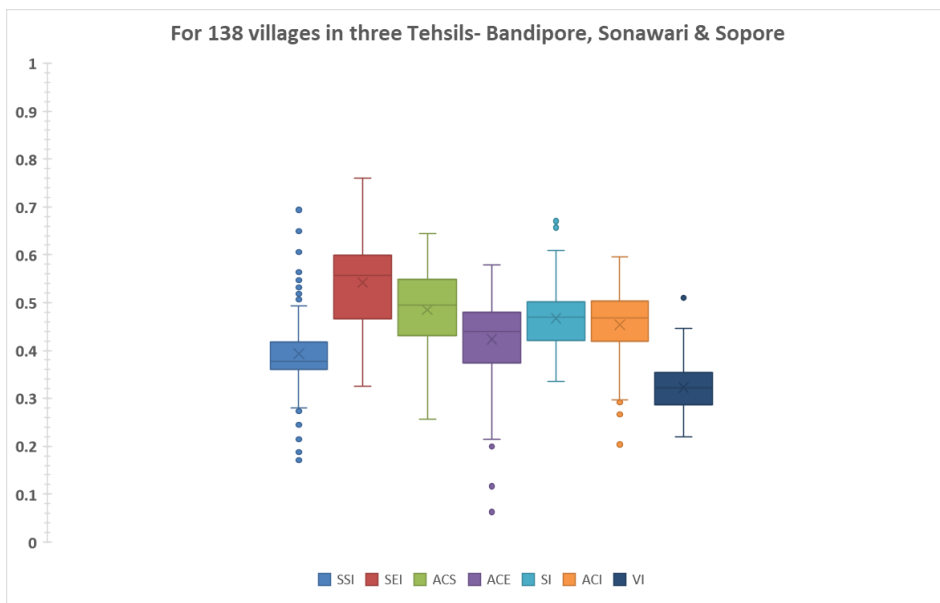


Figure 4.1.3 Box & Whisker Plot showing SEVI values for 138 Census Villages

(SSI= Sensitivity Social Index, SEI= Sensitivity Economic Index, ACS= Adaptive Capacity Social, ACE= Adaptive Capacity Economic, SI= Sensitivity Index, ACI= Adaptive Capacity Index and VI= Social and Economic Vulnerability Index)

Above Fig 4.1.2 and Fig. 4.1.3 provides a graphical representation of distribution of villages for Wular lake region and for 3 tehsils together with respect to their S, AC, and SEV. The boxes indicate the 25th to 75th percentile range and lower and upper bands indicate minimum and maximum values respectively.

4.1.9 SEVI Decision Matrix

A decision matrix was developed by plotting SI-R against ACI-R for villages in each block to identify socio-economically vulnerable areas so as to aid in planning appropriate interventions. Villages in the quadrant with $SI-R \leq 0.50$ and $ACI-R > 0.50$ were recognized as those with low vulnerability. Villages in the quadrant with $SI-R > 0.50$ and $ACI-R \leq 0.50$ were classified as villages with high socio-economic vulnerability. Further analysis of various sub-indicators (23 No.) in such villages would help in identifying the drivers (> 0.50 for sensitivity indicators, ≤ 0.50 for adaptive capacity indicators) and buffers (≤ 0.50 for sensitivity indicators, > 0.50 for adaptive capacity indicators) of inland vulnerability of Wular Lake tenants.

The results showed that highly vulnerable villages accounted for 18% (7 villages) in Bandipore block, 15% (4 villages) in Hajin block and 3% (1 village) in Zaingeer block which indicates that location specific interventions need to be planned to strengthen their adaptive capacity. Decision matrix was separately drawn for Wular Villages which indicate that 30% (7 villages) fell in highly vulnerable category. Decision matrix for each block, overall and for Wular Villages is given in the subsequent figures.

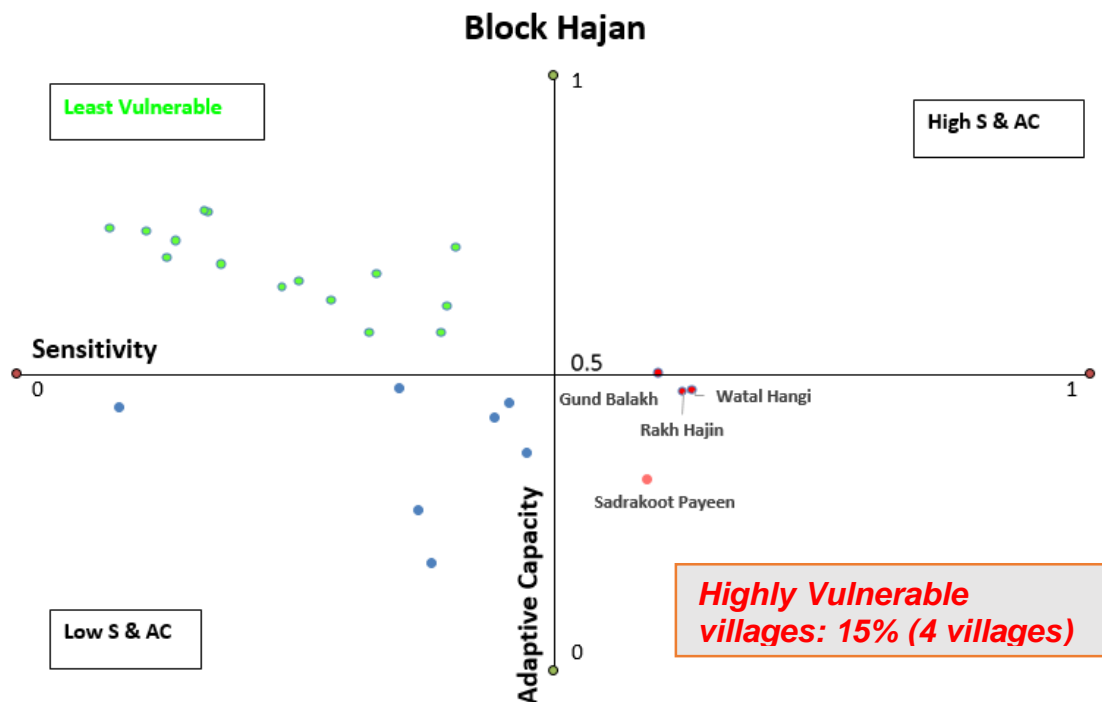


Fig. 4.1.4 Decision matrix for Hajan Block

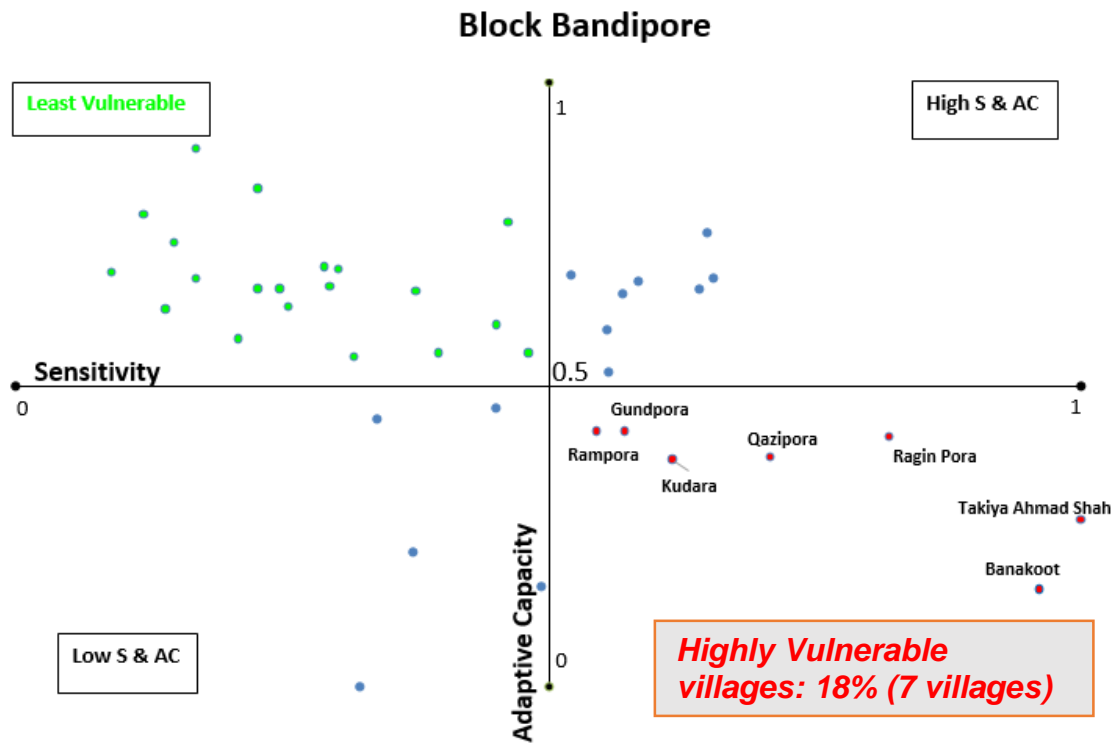


Fig. 4.1.5 Decision matrix for Bandipore Block

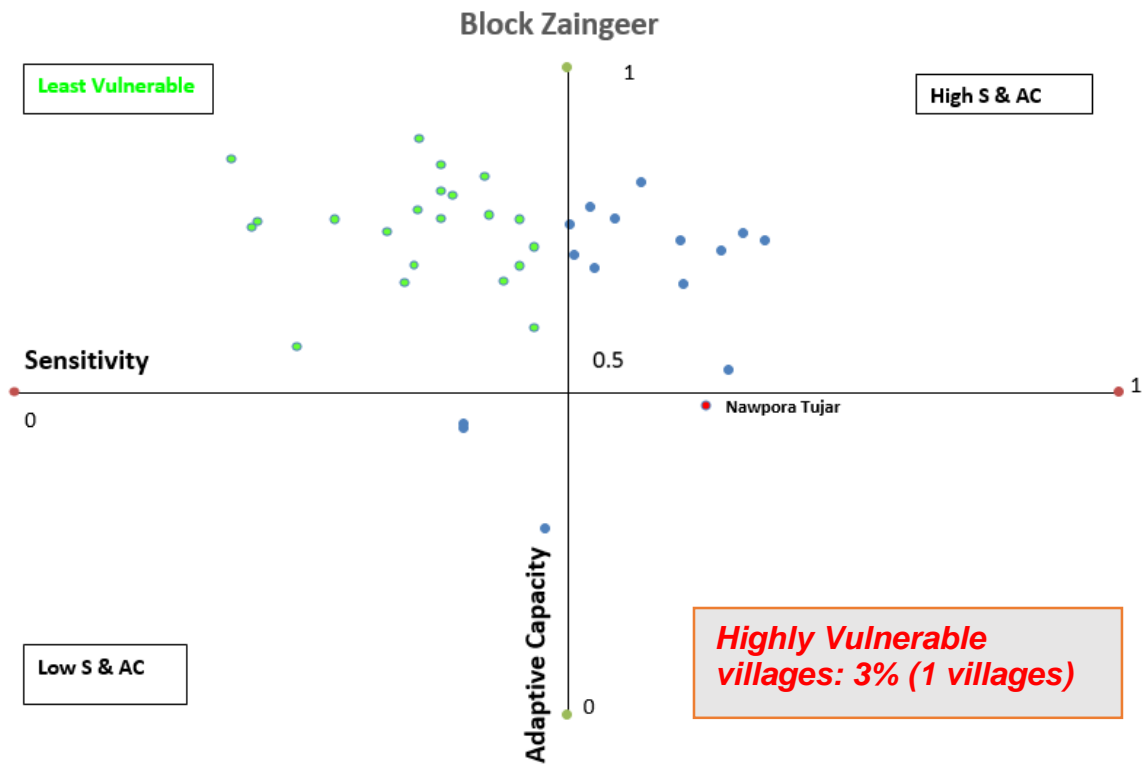


Fig. 4.1.6 Decision matrix for Zaingeer Block

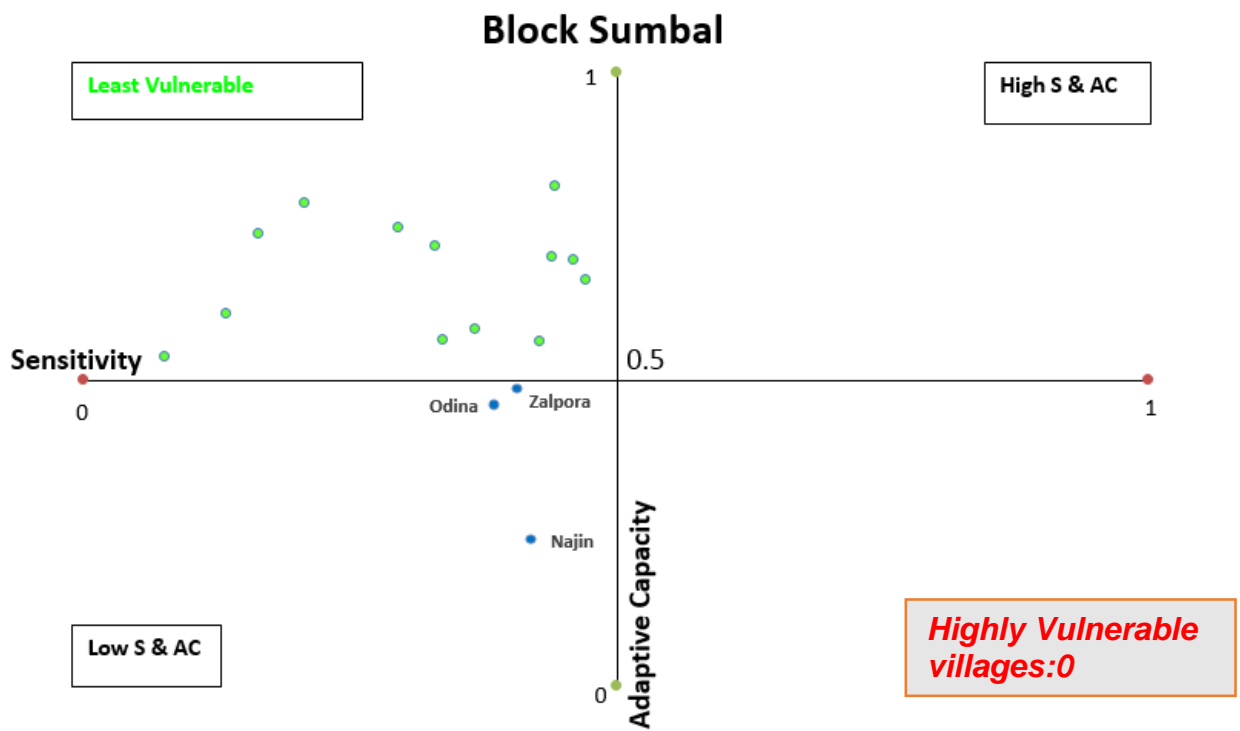


Fig. 4.1.7 Decision matrix for Sumbal Block

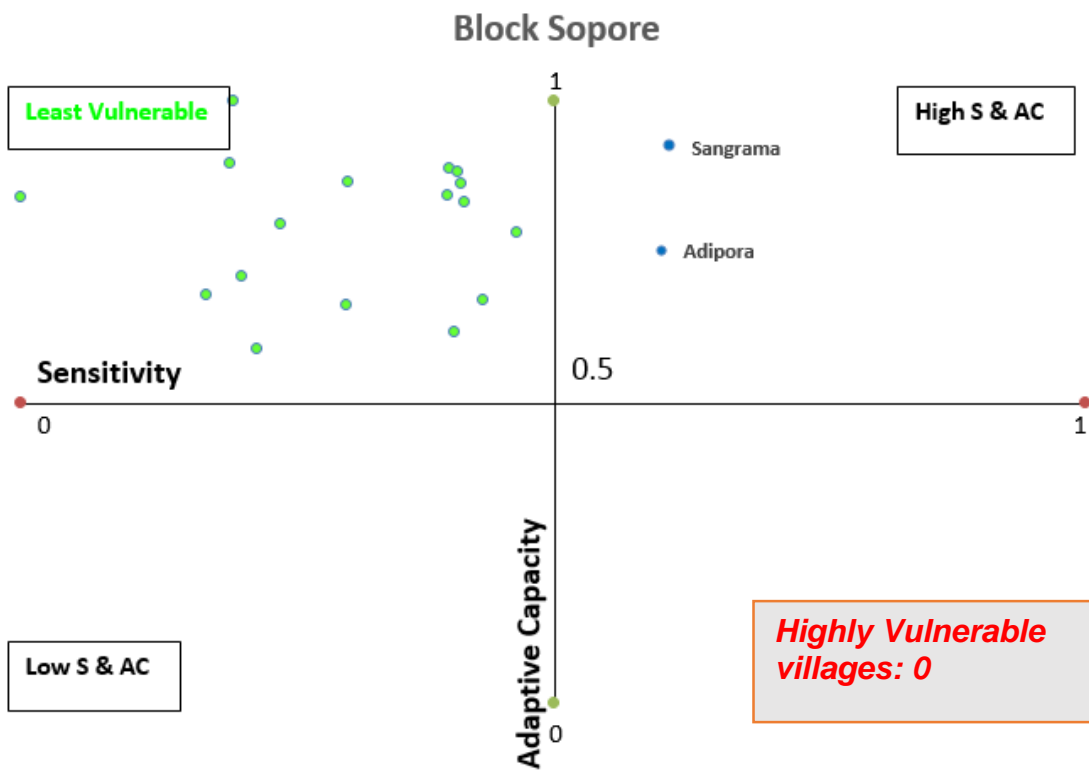


Fig. 4.1.8 Decision matrix for Sopore Block

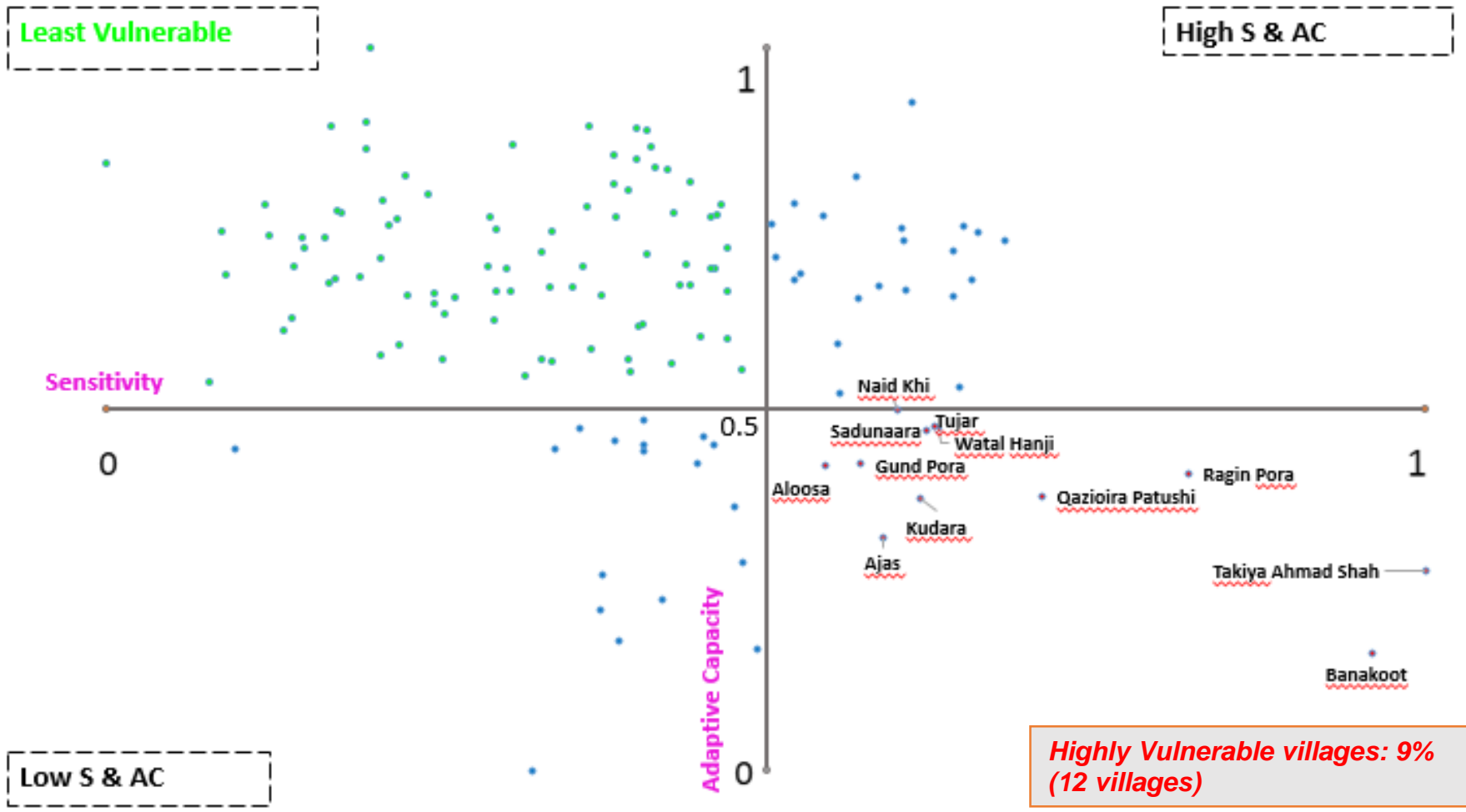


Fig. 4.1.9 Decision matrix for all 138 study villages in 3 Tehsils viz., Bandipore, Sonawari and Sopore

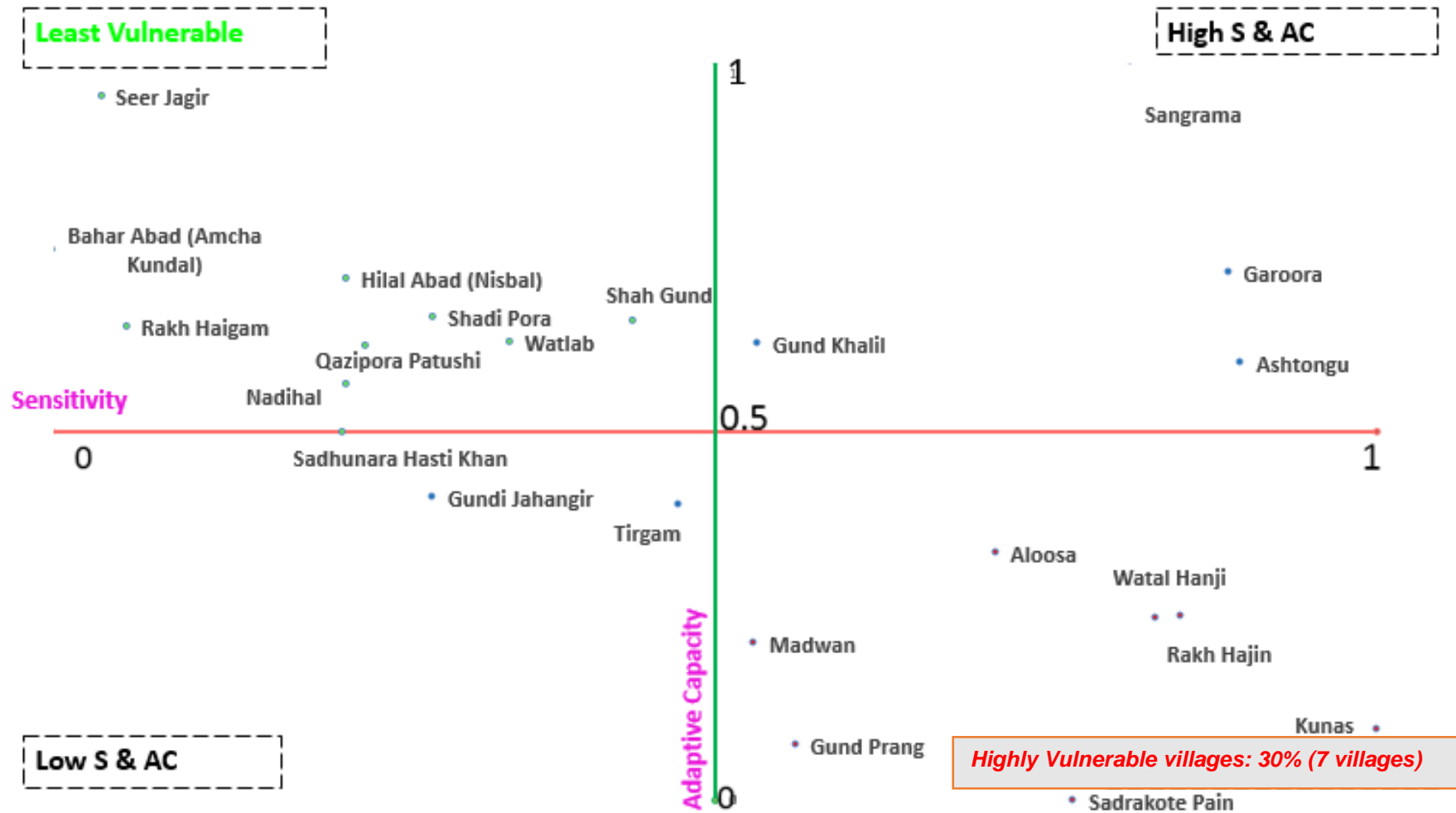


Fig. 4.1.10 Decision Matrix for only 23 Wular fishing villages

4.1.10 Vulnerability, Drivers and Buffers

In the identified highly vulnerable villages, the variable which had significant high index values, thus upping the vulnerability due to high sensitivity and low adaptive capacity, were designated as DRIVERS, thus to be intervened on priority. The variables contributing to high adaptive capacity and low sensitivity in a given village were considered as BUFFERS.

There was no major / significant difference between identified Drivers and Buffers among the 23 indicators for 5 blocks and Wular villages though the later showed a slightly higher SEVI value for Wular Lake villages (Annexure 4).

Six *drivers* influencing high sensitivity in 3 tehsils in which Wular Lake falls were *proportion of small and marginal farm(ers) (SMF)*, *population density (PD)*, *net sown area (NSA)*, *distance to nearest town (DNT)*, *distance to nearest hospital (DNH)* and *dependence on natural resources (DNR)*. The low values for dependence on natural resource could be attributed to data constraint pertaining to the indicator (it was reported as zero in census data). It was clear that high vulnerability is structured to an extent due to predominately agrarian economy with relatively smaller farm size and higher population density which is exacerbated by hilly terrain leading to distant location (>5km) of villages from nearby town and health facilities.

Nine *drivers* responsible for low adaptive capacity were population growth rate (PGR), gender ratio (GR), education status (ES), household assets (HA), housing condition (HC), transport and communication (TC), economic dependency ratio (EDR), access to market (AM), and livestock population (LP).

Five *buffers* responsible for low sensitivity were agricultural labour (AL), fishers' population (FP), food sufficiency (FSM), schedule caste/tribe (SC/ST), and annual rainfall (AR). The low values for FP indicator could be attributed to larger population dependent on agriculture as indicated by higher number of small and marginal famers.

Three *buffers* responsible for high adaptive capacity were community infrastructure (CI), net irrigated area (NIA), and groundwater development (GD).

4.2. Sustainable fisheries development status of Wular Lake

This section presents and discusses the results of multi-dimensional RAPFISH based sustainable assessment of Wular Lake fisheries.

4.2.1 Ecological Sustainability of Wular Lake fisheries

Ecological sustainability status was assessed as a function of 5 ecological attributes. The RAP score of 57.68% is classified as 'quite' status of sustainable development (51.1 to 75%) in a scale of 1 to 100%. Ecological sustainability value of each fishery is represented in a two dimensional ordination plot (Fig. 4.2.1).

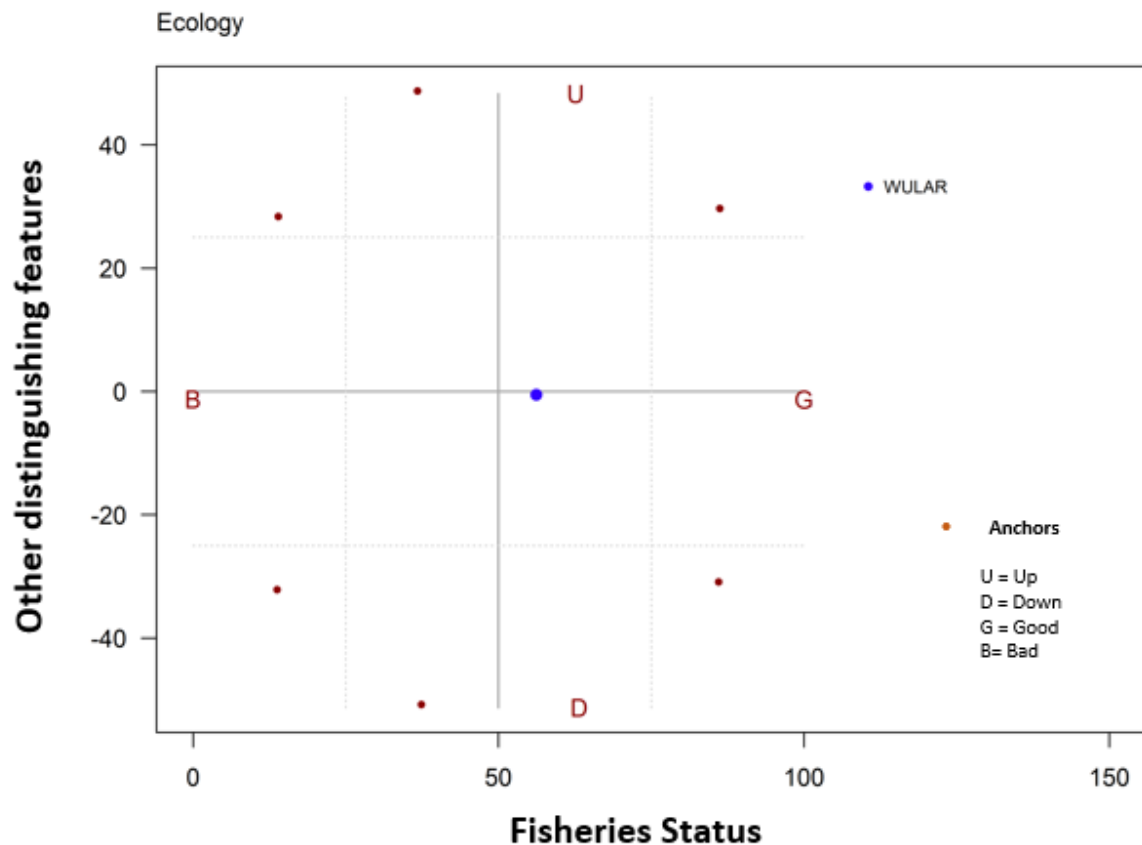


Fig. 4.2.1 Ecological sustainability of Wular Lake

It helps in understanding the ecological sustainability status especially the distances in the vertical dimension of the ordination plot are interpreted as differences between fisheries that are not related to the sustainability axis.

4.2.1.0 Leverage analysis of ecological attributes

Leverage analysis of individual attributes on ecological sustainability ordination was carried out to determine the extent of each attribute's influence in overall ordination. This is calculated as a standard error of difference between the ordinations obtained with and without including the attribute. Fig.4.2.2 illustrates a leverage analysis carried out for the five attributes defining the ecological evaluation field of RAPFISH analysis

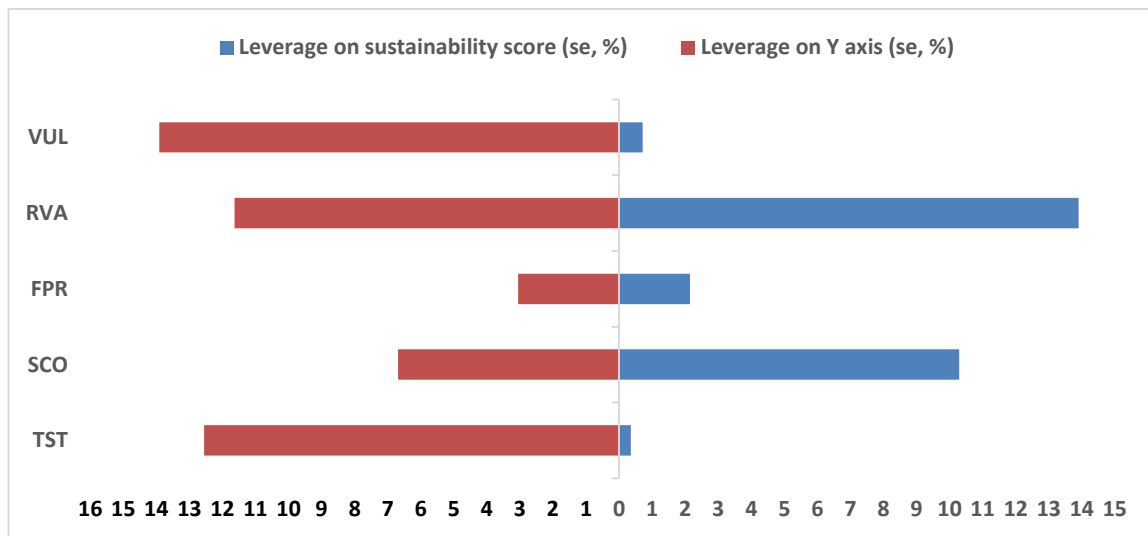


Fig. 4.2.2 Attribute leverage analysis of the ecological dimension

The results show that 'recruitment variability (RVA)' attribute has the maximum influence (S.E. about 14%). The next largest influencing attribute is 'species composition (SCO)' having a S.E. range of about 10% which is more than others like fish production (FPR), vulnerability (VUL) and trophic state index (TST) which are in the range of 2-0.3%. This can be interpreted as indicating that the status of recruitment variability in the Wular Lake has the greatest influence on sustainability, followed by other attributes. However, no single attribute plays a dominant/deterministic role in deciding the ordination outcome as all values are <15%, and rather multiple of attributes influence the outcome.

Leverage of attributes on the RAPFISH y-axis, differences among fisheries not related to sustainability is shown in the bars on the left side of the plot and in general the two sets of influences are weakly correlated. In the case of y-

axis, 'VUL' has the highest influence followed by 'TST'. The interpretation of these y-axis influences is less important for fishery management than those on the sustainability axis; they merely show the amount each attribute influences position on an axis of difference unrelated to sustainability.

The following five attributes constitute the ecological dimension of sustainable development status for the Wular Lake fisheries:

- (a) Trophic Status (TST)
- (b) Species Composition (SCO)
- (c) Fish Production (FPR)
- (d) Recruitment Variability (RVA)
- (e) Environmental degradation / Vulnerability (VUL)

4.2.1.1 Trophic status (TST)

A composite measure consisting of Trophic State Index (TSI), Phosphorus and pH range for trophic status of the Wular Lake were determined based on comprehensive review of literature as tabulated below (Table 4.2.1).

Table 4.2.1. Trophic status classification of Wular Lake

Parameter	Value	Status	References
Trophic State Index	60.93	Eutrophic	Dar <i>et al.</i> , (2013) Carlson., (1977) Melcher., (2013)
Phosphorus (mg/l)	0.15	Eutrophic	Mushtaq., (2017)
pH	7.65	Medium productive	Mushtaq., (2017)

TSI value for indicators were taken from the study carried out by Dar *et al.* (2013) in Wular Lake during March to November 2011 wherein sampling was done during three seasons of Spring, Summer and Autumn, and chlorophyll a concentration, total phosphorous and transparency were recorded. The average values were taken and TSI was calculated as per Carlson (1977) and was found to

be 60.93. The study carried out by Melcher (2013) has classified the trophic status of the lakes based on the calculated TSI values as Mesotrophy (40-50), Eutrophy (51-70) and Hypertrophy (71 - >80).

Hence, the trophic status of the Wular Lake was inferred directly from the same classification, which indicated *eutrophic* status.

For classification based on phosphorous content, study done by Lee et al., (1981) was referred, in which an alternative approach was attempted to classify the water bodies on the basis of phosphorus content as Oligotrophic (< 0.0079 mg/l), Oligo-mesotrophic (0.008 to 0.011 mg/l), Mesotrophic (0.012 to 0.027 mg/l), Meso-eutrophic (0.028 to 0.039 mg/l) and Eutrophic (> 0.040 mg/l).

For classification based on pH range, classification given by Jhingran (1988) was taken, in which he has classified Indian water bodies as low productive (<6), medium productive (6-8.5) and highly productive (>8.5) on the basis of pH range. Keeping the table 4.2.1. as base and using the pre-determined scoring pattern, scores obtained by Wular Lake fisheries in relation to its trophic status are given in table 4.2.2.

Table 4.2.2 Attribute score for trophic Status of Wular Lake

Wular Fishery	Score	Inferred Productivity Statistics
	3	Medium to High trophic status

Studies have indicated higher levels of water pollution due to severe anthropogenic stress over the years in the form of point and non-point sources that eventually drain into Wular Lake. A recent study by Kaur (2018) revealed that the other Lakes of Kashmir for example Nigeen Lake has already attained hyper-eutrophy status (TSI value ranges between 65.7 and 67.7) as it underwent a severe environmental degradation. It gives a clear-cut inference, that external factors play a major role in determining the trophic status of any water body. Krishnagiri reservoir is one classic example of the case as it went from eutrophy to hyper-eutrophy status within a decade (Ambujam *et al.*, 2016).

4.2.1.2 Species composition (SCO)

Species diversity as well as trophic level of fishes available in the Wular Lake will definitely help in understanding its ecosystem, especially the utilization of its ecological niche. Keeping this in view, species-wise composition in total fish caught per year was collected from the District Fisheries office of Bandipora and Baramulla (DoF) records as well as from other published / grey literature (Table 4.2.3). Fish species present in Wular Lake were taken from the studies carried out by Qureshi, 2014, Rumysa *et al.* 2016; Brraich and Malik, 2016; Mushtaq *et al.* 2017; Qadri *et al.* 2018. Then each species was categorised into respective trophic level based on their feeding habits, and position in the food web as ascertained from the literature e.g, Fish Base, FAO, and journals etc. (Table 4.2.5)

Table 4.2.3 Species-wise composition in total fish caught per year

Contribution of Common Carps to total fish catch in biomass	Contribution of Schiozothorax (local) to total fish catch in biomass	Contribution of miscellaneous catch to total in biomass	Source
82.52 %	15.56 %	1.86 %	Mushtaq <i>et al.</i> (2017)
60 %	40 %	-	DoF, Annual report (2012)

After compiling the species diversity in Wular Lake (table 4.2.5), the trophic level value for each of the fish species in the composition was obtained from the trophic analysis of River Indus (Fig. 4.2.3) available online in the fishbase.org website. Trophic level value of a particular fish species indicates place in the food web existing in the Lake. It is calculated as: trophic = 1+mean troph of the food items.

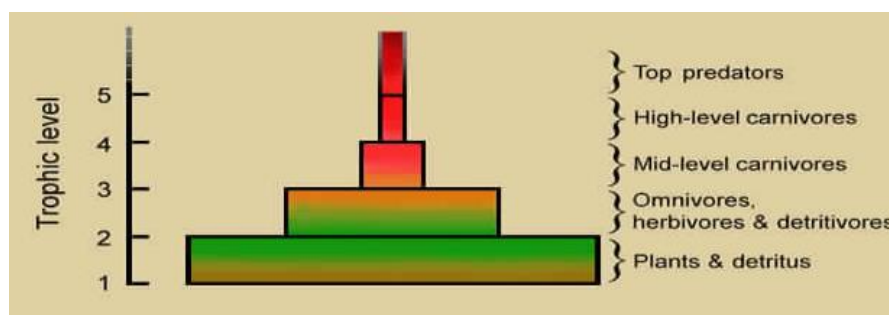


Fig. 4.2.3 Trophic analysis of Indus River

Trophic analysis of Indus is chosen because it can be a very good ecosystem representation in relation to the Wular Lake. In the analysis, based on their trophic level values, fishes are classified into four categories: Omnivores, Herbivores, Detritivores (2-2.9); Mid-level Carnivores (2-3.9); High-level Carnivores (4-4.9); Top predators (5 and above).

Table 4.2.4 Percentage of trophic level contribution and the inferred score in Wular Lake

Wular Fishery (Source)	Trophic level contribution (in %)			Scores	Inferred status
	2-2.9	3- 3.9	4 and above		
Mushtaq <i>et al</i> (2017)	100	0	0	1	Dominated by Omnivores, Herbivores and Detritivores which form above 90% of total catch and negligible presence (less than 1%) of mid-level carnivores; absence of high-level carnivores
DoF, Annual report (2012)	100	0	0		

From the collected fish production data, each fish species were brought into the four categories of trophic level based on their trophic level value. Contribution of fish species in each trophic level to the total fish catch per annum were calculated using percentage analysis. According to the pre-determined scoring pattern, scores obtained by each of the selected fishery on basis of percentage of trophic level contribution of fishes and its related inference is shown in table 4.2.4.

Table 4.2.5 Species diversity in Wular Lake and their feeding habit

SI.No.	Species diversity	Common name	Feeding habit
1.	<i>Puntius conchoni</i>	Techal gad/ safaid button	Herbi omni
2.	<i>S. esocinus</i>	Churu	Herbivore- omnivoce
3.	<i>S.plajostomus</i>	Khont	Benthic herbivorous/ phytophagus
4.	<i>S.richardsonii</i>	Khont	Bottom feeder herbivorous
5.	<i>Crossochilus diplocheilus</i>	Tethur	herbivorous
6.	<i>Crossocheilus latius</i>	Zub, Stone Roller	Herbivorous aufach dweller
7.	<i>Triplophysa kashmirensis</i>	Ara gurun	Herbi omni
8.	<i>Ctenopharyngodon idella</i>	Grass carp	Herbivorous
9.	<i>Cyprinus carpio var. specularis</i> <i>Cyprinus carpio var. communis</i>	Gang gad, punjaeb gad, chini gad	Detritus Bottom sediments
10.	<i>Schizotherox niger</i>	Ale gad	Bottom detritus Herbivore
11.	<i>S. Curvifrons</i>	Satter gad	Detritus
12.	<i>S.micropogon</i>	Chattir gad	Detritus
13.	<i>S.longipinnis</i>	Dape gad	Illiphagic- detritivorous(54% of food) and herbivorous
14.	<i>Carassius carassius</i>	Gang gad	omnivorous
15.	<i>Triplophysa marmorata</i>	Ara gurun	Omnivorous
16.	<i>S.labiatus</i>	Chush, kunar	Mixed plant animal diet, omni.
17.	<i>Glyptothorax kashmirensis</i>	Nayid gad	Omnivorous and bottom feeder
18.	<i>Botia birdi</i>	Rama gurun	Carni omnivorous
19.	<i>Gambusia affinis</i>	Mahi gad	Highly carnivorous
20.	<i>Glyptothorax pectinoptus</i>	Nayid gad	Carnivorous

4.2.1.3 Fish production (FPR)

To understand the fish production status of the Wular Lake, an attempt was made to capture the status of fishery based on catch / landing data for the recent 29 years (1991-2019).

4.2.6 Table Fish production and CPUE in Wular Lake from (1990-2019)

Sl.No.	Year	Carp catch in tons	<i>Schizothorax</i> catch in tons	Total catch in tons	Total Licenses	CPUE in tons
1	1990-91	2700	1110	3810	1400	2.72
2	1991-92	2900	1130	4030	1625	2.48
3	1992-93	3100	1150	4250	1650	2.57
4	1993-94	3300	1170	4470	1675	2.66
5	1994-95	3500	1190	4690	1700	2.75
6	1995-96	3220	1560	4780	1725	2.77
7	1996-97	2580	760	3340	1750	1.90
8	1997-98	3530	1470	5000	1775	2.81
9	1998-99	3310	1420	4730	1800	2.62
10	1999-00	3780	1000	4780	1825	2.61
11	2000-01	3650	1200	4850	1850	2.62
12	2001-02	3910	1020	4930	1875	2.62
13	2002-03	3510	1170	4680	1900	2.46
14	2003-04	3390	1310	4700	1950	2.41
15	2004-05	3510	1410	4920	1975	2.49
16	2005-06	4100	1050	5150	2000	2.57
17	2006-07	3920	1900	5820	2000	2.91
18	2007-08	2624	1326	3950	1766	2.23
19	2008-09	2569	1381	3950	1783	2.21
20	2009-10	2576	1424	4000	1834	2.18
21	2010-11	1866	1035	2900	1889	1.53
22	2011-12	1419	791	2210	1889	1.16
23	2012-13	2704	1786	4489	2611	1.71
24	2013-14	3257	1816	5073	2749	1.84
25	2014-15	2279	1331	3611	2845	1.26
26	2015-16	1959	1195	3155	3009	1.04
27	2016-17	1774	1019	2793	3106	0.89
28	2017-18	2468	1260	3728	3245	1.14
29	2018-19	3497	2065	5562	3147	1.76

Source: DOF, 2019

Since the original (raw) catch / landing data (Table 4.2.6) showed too much of short term variation which posed a challenge in capturing the long term trend clearly, Compound Annual Growth Rate (CAGR) was calculated for three decades i.e. from 1990 to 2000, 2001 to 2010, and from 2011 to 2019 (Table 4.2.8)

providing a comparatively more discernable trend for Wular Lake fishery. Further, for better representation and to quantify the status, a five scale scoring pattern was developed as follows: decreasing (0), was increasing now decreasing (1), fluctuating around mean (2), was decreasing now increasing (3) and increasing (4). Based on the status of each fishery, the score obtained and inferred status is given in table 4.2.7

4.2.7 Table Attribute score for fish production status in Wular Lake

Wular Fishery	Score	Inferred Status
	2	Fluctuating around mean

Analysing the fish production status of Wular Lake from 1990 to 2019 (Fig. 4.2.4), it was found that the overall catch is fluctuating. While the catch increased during 1990-1995, it declined between 1995 and 1997, the reason being militancy and internal disturbances during that time limited fishing as well as proper data collection. From 1998 to 2006, the catch has shown an increasing trend and then since 2007, it started fluctuating again mainly because of the construction and developmental works related to Kisanganga hydro electricity power plant upstream disturbing water flow and fish stock.

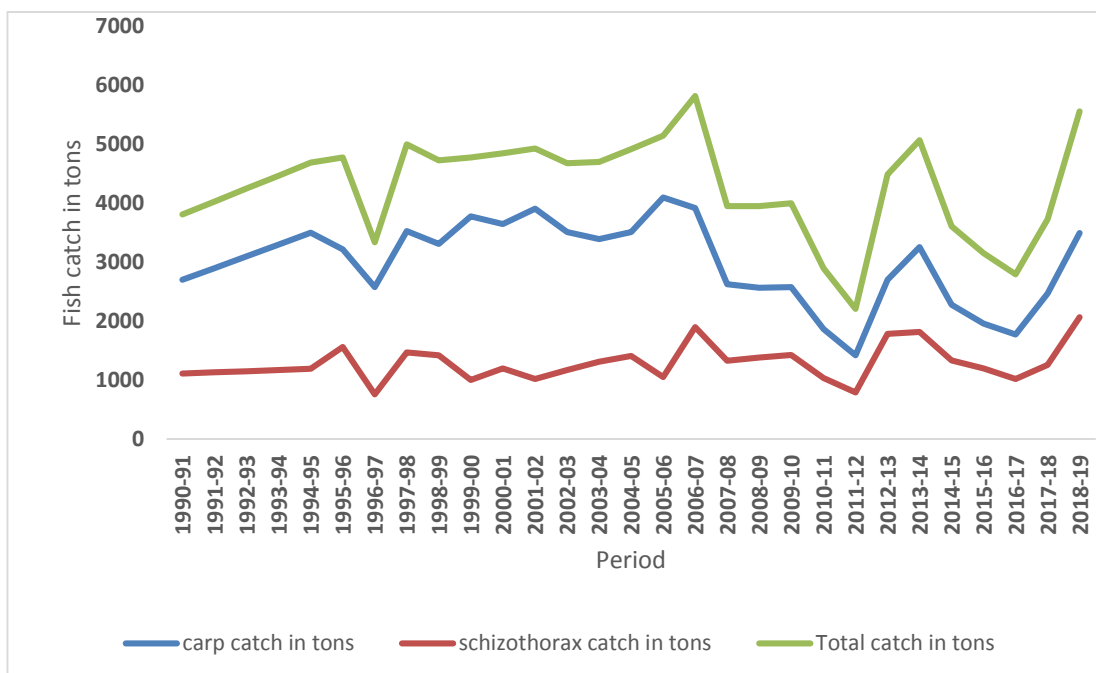


Fig. 4.2.4 Fish Production of Wular Lake in tons (1991-2019)

This result contradicts with the study carried out by Qureshi *et al.* (2013) where the author has reported that fish production has decreased over years because of construction of Uri power project upstream. It is also to be noted that Uri power plant is located on the downstream of the Wular Lake on the river which exits the Wular towards Pakistan.

Over the period from 1990 to 2019, CAGR shows the negative growth rate. When looked closely decade wise, growth rate was found positive except during 2nd decade (1990-2000). It is interesting to note that the growth rate has declined for carps only but is found stable for local (*Schizothorax spp.*) species (Table 4.2.8). The reason may be attributed to construction works at upstream which blocked around 12% of water reaching to Wular. For the recent years, the catch trend is increasing probably due to increased stocking of carps and desilting and dredging works carried out by Wular Conservation and Management Authority (WUCMA).

Table 4.2.8 CAGR (1990-2019) for Wular Lake fishery

Period	Carp	Local	Overall
1990-2019	-1.40	0.78	-0.72
1990-2000	2.31	0.52	1.90
2000-2010	-4.11	3.14	-2.06
2010-2019	4.81	4.46	4.68

4.2.1.4 Recruitment variability (RVA)

Recruitment variability refers to percentage variation in new fishery arriving at the fishery (= recruits), year to year. Recruitment of particular fishery can be measured in terms of landing variation. Hence, to know the recruitment variability in Wular Lake, coefficient of variation in total fish catch was calculated for the period of 29 years species wise. Status of recruitment variability in Wular Lake is shown in table 4.2.9.

Table 4.2.9 Attribute score for recruitment variability in Wular Lake

Recruitment variability (in %)			Score	Inferred Status
Common Carp spp.	Local (<i>Schizothorax spp</i>)	Overall	4	Low (<25%) recruitment variability
23.36	23.953	19.83		

Source: DoF, 2019

4.2.1.5 Environmental degradation / Vulnerability (VUL)

Extent of environmental degradation refers to the pollution and other anthropogenic activities such as discharge of urban sewage, run off from agricultural fields, indiscriminate fishing practices etc. and their effect on the Wular Lake fishery.

Wular Lake is severely polluted with the domestic sewage and agricultural runoff finding their way into the lake. The fertilizers, insecticides and pesticides used in the adjoining areas are drained into the lake thereby deteriorating its water quality. Another major problem in lake is siltation. The inflow of heavy silt load is contributed by its tributaries. The annual sediment deposits range from 50000 to 170000 cm/100 square meters as per the Fisheries Survey Report (2012). It has considerably reduced the depth of the lake hence its storage capacity. To overcome this problem, the lake requires dredging which is also going on in the Lake (WUCMA, 2016).

Mushtaq *et al.* (2015) assessed the pollution level in Wular Lake using geomatics approach. Based on the value of Water Quality Status Index (WQSI), it has been found that 60 km² (77%) of total lake area constitutes the moderate to extremely polluted zone and only 18 km² (23%) of the total lake area constitutes the least polluted zone, which is in the north-west region of the lake. The study reveals that the world-famous Wular Lake is undergoing the eutrophication process and as a result of which the lake is losing its water holding capacity to deal with the disastrous flood problem in Kashmir region.

Sheikh *et al.* (2014) studied weathering and anthropogenic influences on the water and sediment chemistry of Wular Lake and found that Geo accumulation index (Igeo) and US Environmental Protection Agency sediment quality standards indicate that there is no pollution effect of heavy metals (Zn, Mn, Pb, Ni and Co) in the Lake.

Bhat *et al.* (2014) statistically analyzed the deteriorating water quality of the Sukhnag stream, one of the major inflow stream of Lake Wular and found that the increasing level of pollution from the head of the stream to the tail indicated progressive anthropogenic pressure in the downstream areas.

Sofi (2018) reported that resident of Nusoo fishing village claim that local municipalities are dumping at least 100-120 tonnes of waste daily near the lake bank and into the Wular Lake including polythene and garbage and animal carcasses.

Also all the main drainage pipes from South Kashmir, Srinagar and other parts of the valley open directly or indirectly into the lake via Jhelum river, bringing in tonnes of untreated sewage.

Based on the review of literature and author’s field visit, the Wular Lake’s extent of environment degradation is scored according to the aforesaid scoring pattern and the scores obtained is as follows:

Table 4.2.10 Attribute scoring for level of environmental degradation / vulnerability in Wular Lake

Wular Lake Fishery	Score	Inferred status
	1	High level of environmental degradation

Thus, understanding the five attributes by definition and the score obtained by Wular Lake in relation to the attributes revealed the present status of Wular Lake in the ecological sustainability dimension to be in the ‘quite’ category.

4.2.2 Economic sustainability of Wular Lake fisheries

Result of the economic sustainability analysis using modified RAPFISH methodology showed Wular Lake fishery is found to have (69.33%) 'quite' (50.1-75%) sustainable development status. Economic sustainability value of each fishery is represented in a two dimensional ordination plot (Fig. 4.2.5). It helps in understanding the uniqueness of each fishery in relation to economic sustainability status especially the distances in the vertical dimension of the ordination plot are interpreted as differences between fisheries that are not related to the sustainability axis.

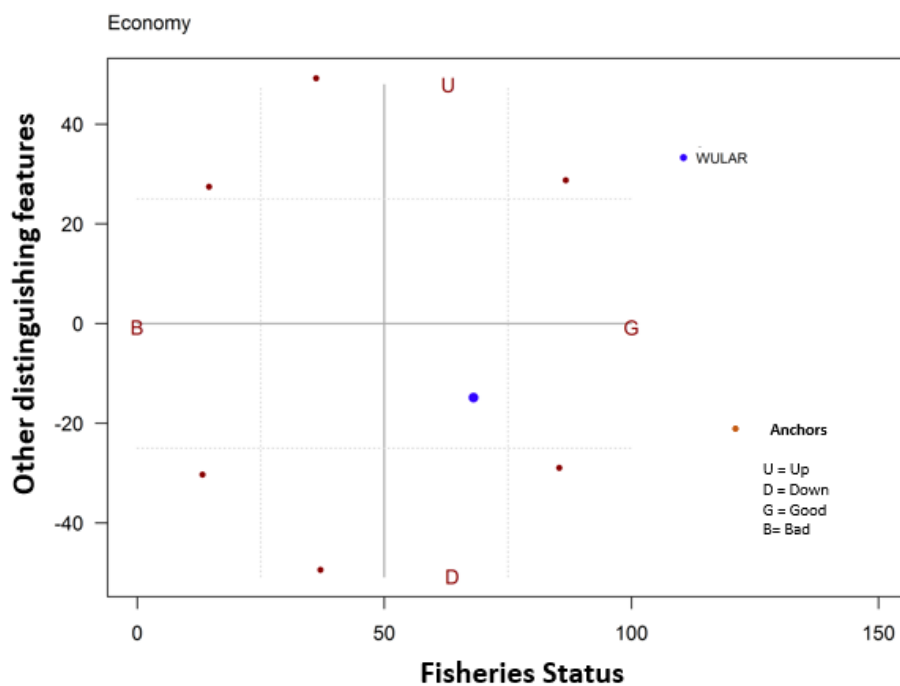


Fig. 4.2.5 Economic sustainability of Wular Lake

4.2.2.0 Leverage analysis of economic attributes

Leverage analysis of individual attributes on economic sustainability ordination was carried out to determine the extent of each attribute's influence in the overall ordination. As discussed earlier, it is calculated as a standard error of difference between the ordinations obtained with and without including the attribute. Fig.4.2.6 illustrates a leverage analysis carried out for the five attributes defining the economic evaluation field of RAPFISH analysis.

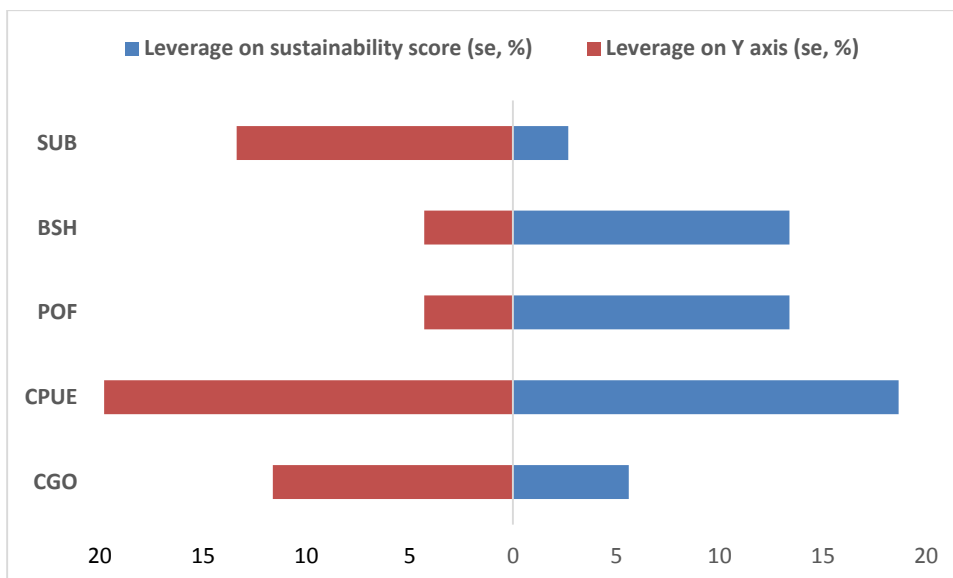


Fig. 4.2.6 Attribute leverage analysis of the economic dimension

Leverage analysis results show that 'catch per unit effort (CPUE)' attribute has the maximum influence (S.E. about 18.6%), about thrice as great as 'craft and gear ownership (CGO)' (S.E. about 5.6%) on the ordination position of fisheries on the sustainability axis. The next largest influencing attribute are 'benefit sharing (BSH)' and price of fish (POF) with a S.E. of about 13%. It is followed by subsidy '(SUB)' attribute whose standard errors is 2.5%. This can be interpreted as indicating that the catch per unit effort in Wular Lake has the greatest influence on economic sustainability, followed by other attributes. However, no single attribute plays a dominant/deterministic role in deciding the ordination outcome as all values are <20%, and rather multiple of attributes influences the outcome.

In the case of y-axis, 'CPUE' has the highest influence followed by 'SUB'. However, as discussed earlier the interpretation of these y-axis influences is less important for fishery management than those on the sustainability axis; they merely show the amount each attribute influences position on an axis of difference unrelated to sustainability.

Following are five attributes which determined the economic sustainability status of the Wular Lake fisheries:

- a) Craft and Gear Ownership (CGO)
- b) Catch per Unit Effort (CPUE)

- c) Price of Fish (POF)
- d) Benefit Sharing (BSH)
- e) Subsidy (SUB)

4.2.2.1 Craft and Gear Ownership (CGO)

It refers to the extent of ownership of fishing equipment by the active fishers in Wular Lake. Secondary literature including DoF records and interactions with fishers were used to determine the extent of ownership of craft and gear. Most of active fishers (about 75%) owned craft and gear. It is because historically Wular Lake fishers are pioneers in devising suitable craft and gear to fish in the Lake. In addition to it, even with comparatively assured availability of subsidy to buy craft and gear from DoF, they don't wait for or rely completely on any kind of subsidies to buy essential fishing equipment due to continuous fishing operations. Syed and Mohite (2016) studied design aspects of fishing craft in Wular and Dal Lake and reported that majority of the fishermen owned only one craft and they are not registered with VRC (Village Registration Certificate) but licenses are issued for different fishing gears by DOF.

However, all fishers registered with the DOF do not own craft and gear as they fish in groups of two in most of the cases. There were also non-bonafide fishers licenced by DOF but who don't fish. Status of craft and gear ownership among the fishers in Wular Lake is shown in table 4.2.11.

Table 4.2.11 Attribute score for craft and gear ownership in Wular Lake

Fishery	Score	Inferred Status
Wular Lake	3	Most of the fishers (about 75%) own craft and gear

4.2.2.2 Catch Per Unit Effort (CPUE)

It deals with the change in the quantity of average fish caught by the fishing units during the last three decades (kg/man hour) in Wular Lake. Fish catch data over the years for the Wular Lake shows the declining overall catch per fishing unit over years (Table 4.2.6). Mushtaq (2017) in her study of ecology and fish

biodiversity of Wular Lake also estimated about catch per unit effort (CPUE) of Wular Lake and found that CPUE varies seasonally and ranged between 0.3 kg/man hour to 1 kg/man hour and highest CPUE was recorded in July which was about 3.4 kg/man hour corresponding to greater water spread. Status of CPUE in Wular Lake is shown in table 4.2.12 and inferred score is given in table 4.2.13.

Table 4.2.12 Status of CPUE in Wular Lake (1995-2019)

Period	Average Catch/year (in tons)	Average no. of Licenses issued	CPUE / yr. (in tons)	CPUE/ yr. in Kg	Per day catch assuming 21 fishing days per month	Per hour catch assuming 6 hrs. of fishing / day
1995-99	4462	1762	2.5	2532.35	10.04	1.67
2005-09	4717	1887	2.49	2499.73	9.91	1.65
2015-19	3769	3126	1.20	1205.69	4.78	0.79

Source: DoF,2019

Table 4.2.13 Attribute score for catch per unit effort in Wular Lake

Wular Lake Fishery	Score	Inferred Status
	0	CPUE has been decreasing

4.2.2.3 Price of fish

It refers to increase in real unit price (inflation adjusted price) of fish sold at the first point of sale by fishers or DoF during the last 3 decades (1998-1991, 2008-2009, 2018-2019). The extent to which the price of fish sold at first point of sale is closer to the market price (consumer price at the last point of sale) is also taken into account. Present and past market prices were ascertained through FGD, KII with the fishers and personal observations. The records revealed that two factors in major determined the change in fish price over the years in the Wular Lake: Benefit sharing system (discussed under 4.2.2.4); and Demand and supply dynamics.

It refers to marketable surplus of and demand for a particular fish species. It has been observed that price of the stocked varieties like Common Carps (*Cyprinus carpio communis* and *Cyprinus carpio specularis*) and indigenous local species (*Schizothorax sp.*) have increased over the years. While there was not much increase in supply (catch) over the years, the local demand for fishes has increased considerably irrespective of the species preferences. Especially during the winter season (October- February) demand for fish is more, when the supply (catch) is lowest as fishing activity remains dormant as a result of inclement weather, decreased water level / inflow in the Wular Lake (Regu and Ananthan, 2019). It was found that the inflation adjusted price has increased by 107% during 1998-2009 and by 70% in recent decade during 2009-2019 and is given in table 4.2.14.

Table 4.2.14 Inflation adjusted price from 1998-2019

Period	Price/kg	Average price/kg	% Increase in price	Inflation % for 10 years, in 90's= 7% and now 5%	Inflation adjusted price in %
1998-99	40-50	45	-	-	-
2008-09	100-150	125	177	70	107
2018-19	200-350	275	120	50	70

Based on the foregoing discussion, the inferred status with regard to the attribute 'fish price change' (1998-2019) in Wular Lake is given in table 4.2.15

Table 4.2.15 Attribute score for fish price change (1998-2019) in Wular Lake

Fishery	Score	Inferred fish price change
Wular Lake	4	Fish price has increased to a great extent

4.2.2.4 Benefit sharing (BSH)

It refers to the fairness and equity of benefit sharing arrangements and its field implementation between the holder of fishing rights and (DoF) and the fishers. In the case of licensing (as in Wular), it refers to the whether or not fishers as primary producers get a fair share of consumer rupee.

For the judicious use of natural resources and providing a source of income, licenses are issued to the fishers (*mahigheers*) on annual basis. The various license fees are @ ₹ 600/-, ₹ 500/- and ₹ 300/- for different tackles of fishing in different waters. The waters of Kashmir have been categorized into four types (a) the trout waters (b) the reserve waters (c) the protected waters and (d) sanctuary. In trout water, only fishing through angling is permitted. In sanctuary, fishing by all means is prohibited. In reserve waters like Wular Lake, licenses @ ₹ 500/- are provided to the fishermen and in protected waters like Jhelum, licenses @ ₹ 600/- are issued to the fishermen. The licenses @ ₹ 300/- are issued for fishing with rod in these protected and reserve waters.

Table 4.2.16 Benefit sharing system 2018-2019 @ ₹ 500 license fee/ annum

Season	Price at first point of sale /Kg	Retail price/ Kg	Fishers share in consumer rupee in %
Summer	200	250	80
Winter	350	425	82

Hence, one can infer that the status of benefit sharing attribute in Wular Lake is in the category 'Much more' wherein more than 50% of market price goes to the fishers (Table 4.2.17).

Table 4.2.17 Attribute score for benefit sharing in Wular Lake

Fishery	Score	Inferred benefit sharing
Wular Lake	4	Fishers receive more than 50% of market price

4.2.2.5 Subsidy (SUB)

It captures the different kind of subsidies (including hidden) available or provided to support fisheries and fishers of a Wular Lake. It is understood that Central/State Govt. subsidies of any kind are distributed only through the Department of Fisheries who have their sub divisions functioning at district and sub

district levels. They are being provided low cost houses, free insurance cover, free nylon twine thread, etc.

Hence, to receive any kind of subsidy provided by Central/State Govt. a fisher should be registered with DOF. It has also to be kept in mind that mere presence of license also doesn't guarantee subsidy to fishers in equitable manner. Active fishers reported that subsidy is received by non-bonafide fishers who obtain license just to receive subsidy benefits but don't fish.

Table 4.2.18 Schemes distribution during 2017-2018 among Wular Lake fishers

S.No.	Schemes	Achievements during 2017-18 (in No.'s)
1.	Nylon distribution to registerd fishers	800
2.	Insurance cover to registered Mahigheers	2368
3.	Housing units	15

Source: Annual Report, DOF, 2018-19

The lottery system of distributing subsidy has eliminated the need based approach that too when subsidies are inadequately distributed e.g., during 2018-19 only seven and eleven Fiberized Reinforced Plastic (FRP) boats have been distributed in Bandipora and Baramullah districts respectively. Status of subsidies provided in Wular Lake is shown in table 4.2.19

Table 4.2.19 Attribute score for available subsidies in Wular Lake

Fishery	Score	Inferred status of available subsidies
Wular Lake	2	Some amount of subsidies availed

Thus, understanding the five attributes by definition and the score obtained in relation to the attributes revealed the present status of Wular Lake in the economic sustainability dimension.

4.2.3 Social Sustainability of Wular Lake

Result of social sustainability values for Wular Lake fisheries indicate 'less' 30.39% (Fig. 4.2.7) sustainable development. The status of sustainable development from social attributes was inferred based on the classification mentioned in the methodology chapter. It helps in understanding the uniqueness of Wular Lake fishery in relation to social aspects.

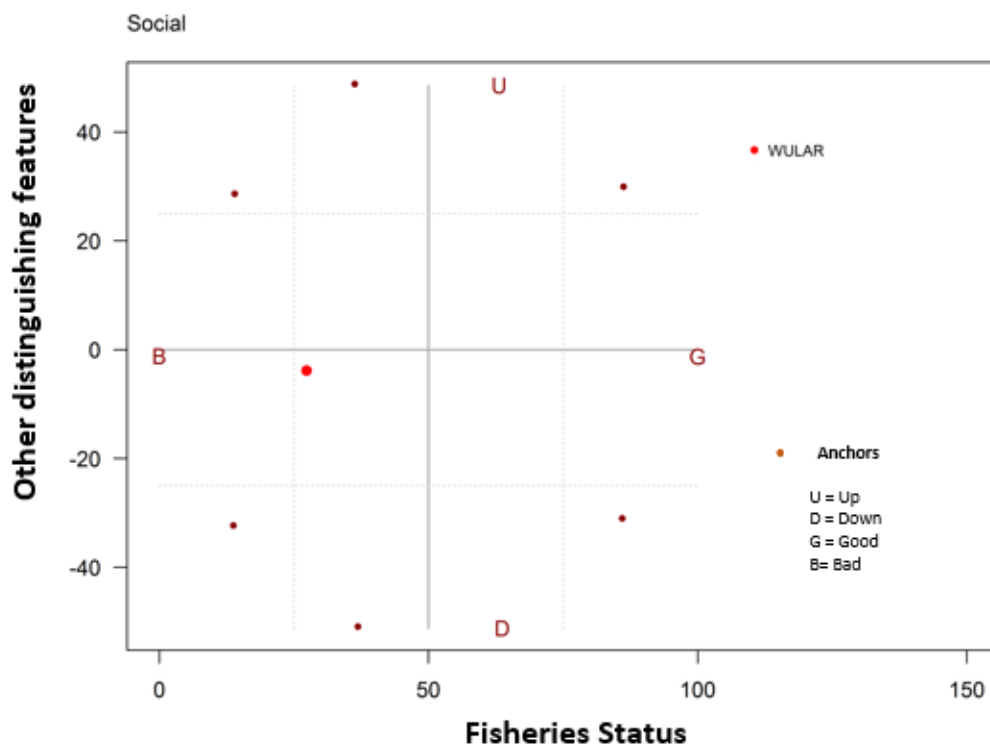


Fig. 4.2.7 Social sustainability of Wular Lake

4.2.3.0 Leverage analysis of social attributes

Leverage analysis of individual attributes on social sustainability ordination was carried out to determine the extent of each attribute's influence in the overall ordination. As discussed earlier, it is calculated as a standard error of difference between the ordinations obtained with and without including the attribute. Fig.4.2.8 illustrates a leverage analysis carried out for the five attributes defining the social evaluation field RAPFISH analysis.

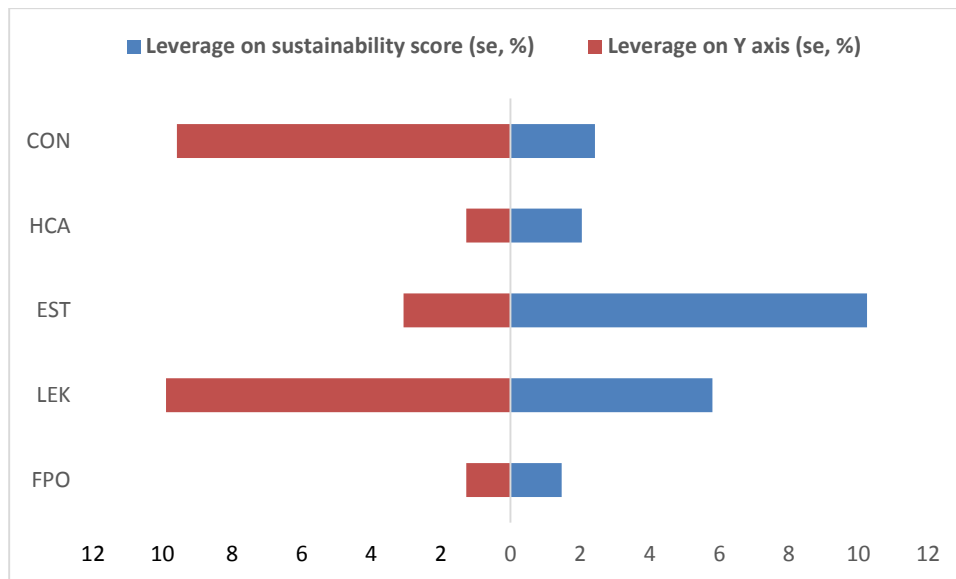


Fig 4.2.8 Attribute leverage analysis of the social dimension

Leverage analysis results show that the 'education status (EST)' attribute has the maximum influence (S.E. about 10%) about five times as great as 'housing and civic amenities (HCA)' and 'conflicts (CON)' whose S.E. is only 2% on the ordination position of fisheries on the sustainability axis. The next largest influencing attribute is 'local environment knowledge (LEK)' with a S.E. of about 5.8%. fisher population (FPO) have least S.E of 1.47%. This can be interpreted as indicating that education status of fishers in the Wular Lake has the greatest influence on social sustainability, followed by other attributes. However, no single attribute plays a dominant/deterministic role in deciding the ordination outcome as all values are <15%, and rather multiple of attributes influence the outcome.

In the case of y-axis, 'LEK' has the highest influence followed by 'CON'. However, as discussed earlier the interpretation of these y-axis influences is less important for fishery management than those on the sustainability axis; they merely show the amount each attribute influences position on an axis of difference unrelated to sustainability.

Following five attributes were scored to determine the social sustainability status of the Wular Lake:

- (a) Fisher Population (FPO)
- (b) Local Environmental Knowledge (LEK)

- (c) Education Status (EST)
- (d) Housing and Civic Amenities (HCA)
- (e) Conflicts (CON)

4.2.3.1 Fisher population (FPO)

It refers to the relation between the total number of active fishers and extent of area (in hectares) available for them to support their livelihood in Wular Lake. Precisely, it exhibits the status of fishing pressure in the Lake.

Based on World Bank and WHO recommendations, one must earn a minimum of US\$ 1.25 a day (basis purchase power parity) to sustain one's living. This norm was taken to estimate the average area (in hectares) one has to fish daily in order to earn the means to sustain oneself.

As per Kalhana's Rajatarangini (1989) and directory of Wetlands in India (MOEF) the area of the lake has been shown as 189 sq km, whereas as per the Survey of India Maps of 1978, the lake area is shown as 58.7 sq km during lean period. As per Murthy *et al.* (2013) Wular Lake is spread on an area of about 129 sq kms. However, the lake area appears empirically 173 sq kms during peak flow as per the highest flood level of 1579 m recorded by Irrigation and Flood Control Department, Kashmir in the same year. As per the revenue records, the area of the lake is shown to be 130 sq kms (Keng *et al.*, 2006). The department of Public Health and Engineering department report that Lake has now been reduced to only 24 sq kms.

Considering varied and often conflicting area estimates, the effective water spread area (EWSA) was calculated, as is done in the case of reservoirs for fisheries purposes, by taking half of sum of maximum and minimum area reported. The estimated EWSA is about 106 sq kms that is 10,600 ha. During 2018-2019 there are about 3,147 registered fishers of Wular Lake from district Bandipora and Baramullah as per DoF, Jammu and Kashmir. Here, the status of fisher population measured as the average fishing area (in ha) in the lake for each fisher to indicate the extent of fishing pressure.

Table 4.2.20 Attribute score for fisher population in Wular Lake

Fishery Wular Lake	Effective water spread area (ha / fisher)	Score	Inferred Status
	3.36	2	Somewhat over populated

4.2.3.2 Local Environmental knowledge

This attribute refers to the extent of Wular Lake fishers' knowledge about their local fishery resources, ecosystem, weather and fishing equipment (craft & gear). Discussion with the fishers revealed that all Wular Lake fishers being involved in traditional capture fisheries have fair knowledge about the breeding ground, important aspects of species biology, ecosystem, weather conditions, etc. but only some have information modern gears and craft like Fibre Reinforced Plastic (FRP) boats, possibilities of hygienic handling and value addition, etc. Moreover fishers comprise of different age groups and there existed a difference between the age of fishers and their knowledge level. Accordingly their inferred local environment knowledge status is shown in table 4.2.21

Table 4.2.21 Attribute score for local environmental knowledge about Wular Lake

Fishery	Score	Inferred Status
Wular Lake	2	Only some fishers know about all the aspects of fisheries while every fisher had some degree of local knowledge

4.2.3.3 Education status

It refers to education level / literacy rate of fishers in Wular Lake region. Three-fourth (75%) was used as reference point for scoring this attribute considering the present average literacy rate of India. Hassan (2013) found that literacy rate in Wular catchment is a low 42.74%, with the highest of 69.37% and lowest of 27.46 %. Also the results of first objective (4.1.3) concluded that Wular Lake fishers residing in 23 Census village had a lower education status (46.7%).

Table 4.2.22 Attribute score for education level of fishers in the Wular Lake

Fishery	Score	Inferred Status
Wular Lake	0	Not more than 75% of the fishers have not completed 5 years (primary level) of schooling

4.2.3.4 Housing and civic amenities

It refers to status of fisher households in a Wular Lake region with essential and important civic amenities like electricity, drinking-water source, sanitation facility, clean fuel for cooking and housing condition like number of rooms, bathroom, etc. The values for above said indicators were extracted for Wular Lake villages from Census 2011 data and are given in table 4.2.23 below.

Table 4.2.23 Housing and Civic amenities of Wular Lake fishers

House Hold(HH) amenities				Housing Ownership and Housing Condition		
% HHs access to safe drinking water	% HHs access to sanitation	% HHs access to electricity	% HHs access to clean fuel	% HH ownership	% HH conditions	Average value (In %)
22.05	32.2	93.5	12.5	55.3	0.38	35

Source: Census of India, 2011

Table 4.2.24 Attribute score for civic amenities and housing of Wular Lake fishers

Fishery	Score	Inferred Status
Wular Lake	1	Poor (21-40%)

Based on the table 4.2.23, the inferred status of housing and civic amenities of Wular Lake fishers for RAPFISH analysis is given in table 4.2.24.

4.2.3.5 Conflicts

It refers to the working nature of fishers i.e. whether they fish as individuals or in families or community groups and its relation to any kind of conflicts among fishers as well as between fishers and other stakeholders to understand the

intra-cohesiveness and inter-cohesiveness. It also takes into account the existence of political/caste/occupation based factions in the fishing villages hindering fishing activities and management. Since Wular is a common property resource with almost open access system, there are bound to be conflicts. Regu and Ananthan (2019) found that Wular Lake fishers get involved in certain conflicts over the resource access and use which are discussed below:

- I. **Conflict over various fish tackling methods:** Different and multiple gears / traps (dars) like hook and line (*wael raz*), cast nets (*gilwan za*), small hooked spears (*naruch* and *panzer*) are employed. One user group blames another for being responsible for overfishing. Fishers complain about each other as a result government has spent Rs. 3.5 lakhs to remove the indigenous traps (*dar bandi*) at many places particularly in Ningli part of Wular.
- II. **Among fishers:** Conflict also occurs among the fishers on use of gill nets which is banned. The ban is strictly followed by majority of fishers as they feel gill net is a destructive gear trapping all fishes at once. But, some unregistered fishers were reported to use gill net illegally at night leading to conflict. Women also get engaged in conflict with the hook and line (*wael raz*) fishers who use poles to tie lines on the same land where fisherwomen go for *trapa* (water chest nut) collection.
- III. **Conflict also occurs between mahigeers (fishers) and DoF:** with regard to claims over insurance and subsidy benefits, penalty chargers for use of inappropriate mesh size and gears, licensing process (on bonafide and non-bonafide fishers), etc.
- IV. **Between Central Reserved Police Force (CRPF) and DoF :** At *Ningle bala* bridge CRPF has taken control over fisheries quarters where Tulbul Project (Hush Hush Project) is expected to start but it is believed that the construction of same violates Indus Water Treaty of 1960. DoF officials are of opinion that ward and watch function would have been improved if they were allowed to exercise control on those quarters. CMAP (2007) also reports that lack of well-defined policy and regulatory mechanisms for integrated management has led to cross-sectoral conflicts and overall degradation of Wular wetland and its resources. Based on the above, the attribute score for conflicts in Wular Lake is inferred and given in table 4.2.25.

Table 4.2.25 Attribute score of conflicts in Wular Lake

Wular Lake Fishery	Score	Inferred Status
	2	Somewhat cohesive and some degree of conflict

Thus, understanding the five social attributes, and the score obtained for Wular Lake in relation to the attributes revealed its present status in the social sustainability dimension.

4.2.4 Technological Sustainability of Wular Lake

Result of technological sustainability analysis using modified RAPFISH methodology for Wular Lake fisheries indicate ‘poor’ 15.77% status of sustainable development. Technological sustainability value of Wular Lake is represented in a two dimensional ordination plot (Fig.4.2.9).

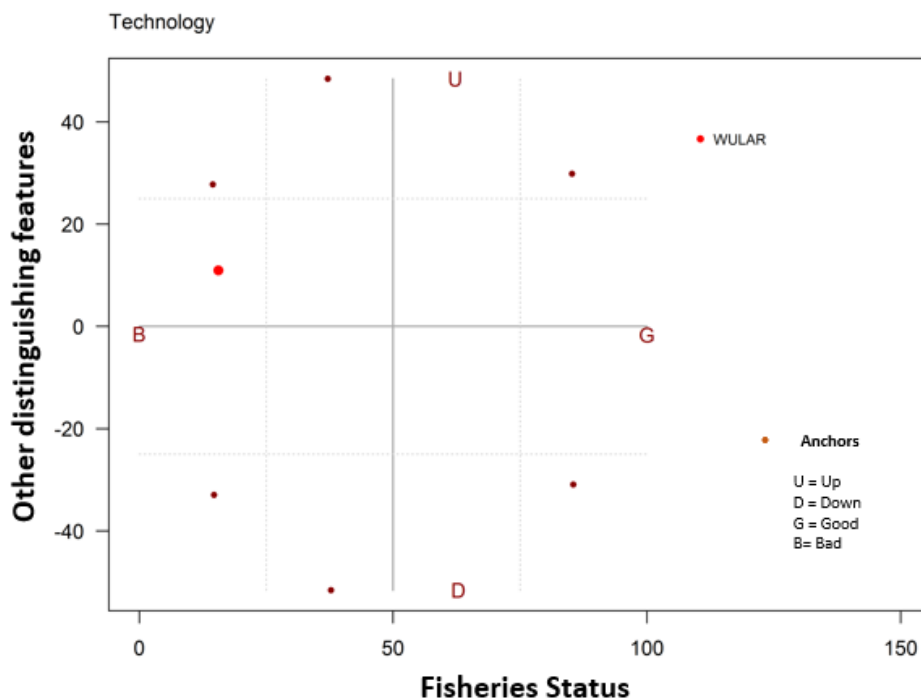


Fig. 4.2.9 Technological sustainability of Wular Lake

It helps in understanding the uniqueness of Wular Lake fishery in relation to technological aspects / dimension of sustainability. The location of Wular fishery in the vertical dimension of the ordination plot is interpreted as aspects that are not related to the given sustainability attributes.

4.2.4.0 Leverage analysis of technological attributes

Leverage analysis of individual attributes on technology sustainability ordination was carried out to determine the extent of each attribute's influence the overall ordination. This is calculated as a standard error of difference between the ordinations obtained with and without including the attribute. Fig.4.2.10 illustrates a leverage analysis carried out for the five attributes defining the technology evaluation field of RAPFISH analysis.

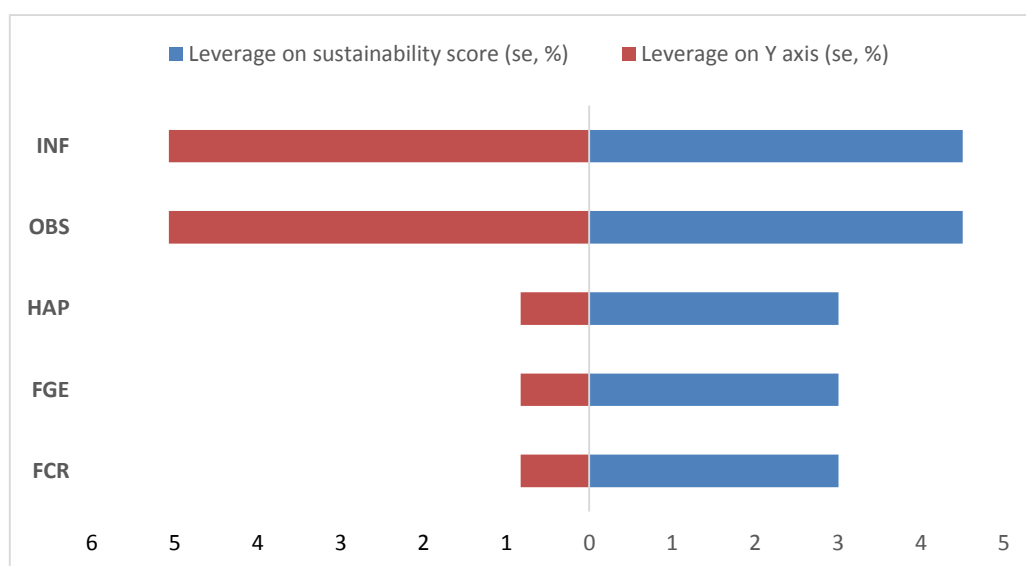


Fig. 4.2.10 Attribute leverage analysis of the technology dimension

Leverage analysis results show that 'Infrastructure (INF)' and 'On-board safety devices (OBS)' with a S.E of 4.5%. It is followed by 'Fishing craft (FCR)', 'Fishing gear (FGE)' and Handling and Processing (HAP)' attribute that has the influence (S.E. about 3%). This can be interpreted as indicating that INF and OBS in the Wular Lake has the greatest influence on technological sustainability, followed by other attributes. In similar line with the leverage analysis discussed in previous dimensions, no single attribute plays dominant/deterministic role in deciding the ordination outcome as all values are <15%, and rather multiple of attributes influence the outcome. In the case of y-axis In case of attribute, though it has a medium S.E.in the sustainability axis, it has the minimum value in Y-axis. As discussed earlier the interpretation of these y-axis influences is less important for fishery management than those on the sustainability axis; they merely show the

amount each attribute influences position on an axis of difference unrelated to sustainability.

Following five attributes constitute the technological sustainable development status of the Wular Lake fisheries:

- a) Fishing Craft (FCR)
- b) Fishing Gear (FGE)
- c) Handling and Processing(HAP)
- d) On-Board Safety Devices and Trip Length (OBS)
- e) Infrastructure (INF)

4.2.4.1 Fishing Craft (FCR)

The attribute tries to find whether fishers in the Wular Lake have altered fishing craft to increase catching power / safety over the past 25 years. It also considers the fishing capacity in terms of number of units that have increased / declined during the past 25 years.

Fishers of Kashmir particularly Wular have been using wooden plank built boats since ages. There has not been much improvement in the type of craft employed for fishing. However, some fishers have altered minor aspects of design over the years. For example, increased the length / space (20 to 22 feet) as well as the provision of fish hold in the boat. Also there are 4 types of modified wooden boats which are different in their capacity and operation that is *Kamai* boat for harvesting trapa, *Naav* for harvesting fish, *Sekhi boat* for sand extraction and *Boat* (<10 feet in length) for short duration fishing operations (Plate 1) . Syed and Mohite (2016) studied design aspects of fishing crafts of Wular and Dal lake and concluded that boats are still of indigenous type and there is no major modification as such and found that crafts in Wular belong to three categories of size and capacity viz., boats having size between 2 to 5 meters, 5-8 meters, 8-11 meters with fish hold capacities of 32 Kgs, 73 Kgs and 106 Kgs respectively.

Recently in June 2018, DOF distributed seven and eleven FRP boats in Bandipora and Baramullah respectively on lot basis among the fishers on norms

of SHG's where 20% of the unit cost (Rs. 20,000) was borne by fishers. However, it was found that most of the fishers didn't turn up to collect the boats nor deposit the share, and it was decided by committee headed by District Development Commissioner that each SHG selected shall have to deposit only Rs.1,900 as a beneficiary share to clear the liability of boat (Report on Gear and Crafts distribution, 2018). FGD with the fishers in Bandipora and Baramullah revealed a different story with majority of fishers feeling FRP boats not being suitable for fisheries operation in Wular Lake, and may not be able to withstand during weather disturbances and harsh winters. Inferred status of the fishing craft over last 25 years in Wular Lake is given in the following table.

Table 4.2.26 Attribute score for fishing craft in Wular Lake

Wular Lake Fishery	Score	Inferred status
	1	Very little change has happened in fishing craft over the last 25 years

4.2.4.2 Fishing gear (FGE)

The attribute tries to find whether fishers have altered fishing gear to increase catching power / selectivity over the past 25 years. It also considers whether a gear is active or passive, primitive or modern / specialized.

By nature, Lakes tend to have diversity in fish species necessitating different gears. Two types of primitive wounding gears (spears) are used in Wular i.e. multiple head spear, locally called as *Panzar* and double pronged spear, locally called as *Narchoo*. Use of *Panzar* causes multiple injuries to fishes and is banned by DOF but enforcement is ineffective at the ground level. It has been observed that cast net, a non-selective gear, is the commonly used fishing gear in Wular Lake during winter season. In summer, its usage is minimal because *Trapa* and other vegetation disturbs the operation of cast net. Scoop net, locally called as *Khashop* and *Kranz zal* is usually operated as a secondary gear. Hook and line (*Wael raz*) is used mostly for carps and small sized fishes locally known as *guran*. Various fish tackling / luring methods are practiced by fishers to attract fishes e.g., spreading rice/ grains, flour balls, use of indigenous traps (*locally known as dar bandi*) are also employed by fishers. Some fishers also use illegal gear like gill nets in Wular Lake

during night but majority of fishers do not support the use of gill nets in Wular Lake. Also night fishing is prohibited between the hours of sunset and sunrise as per amendment in fisheries act of J&K (2018). Status of changes in the fishing gears used in Wular Lake is shown in table 4.2.27.

Table 4.2.27 Attribute score for fishing gears in Wular Lake

Wular Lake Fishery	Score	Inferred Status
	1	Very Little changes in fishing gear over the last 25 years

4.2.4.3 Handling and processing (HAP)

The attribute captures whether fishers use any handling and storage methods (e.g. icing after fishing, salting, boiling, freezing, ice storage etc.) to preserve the fish or use live tank, sophisticated freezing or gutting, filleting etc. methods on board the vessel to preserve the fish.

It has to be noted that fishers of Wular, when they go for fishing don't carry ice with them to preserve fish in the craft as in marine sector. Some fishers have altered fishing craft design to provide a live fish hold / storage inside boat. As the fishery is seasonal in Wular Lake with peak summer season and lean winter season (October to February) when fishers mostly depend on Trapa related activities (Regu and Ananthan, 2019). Fishers of Laherwalpora have built small mud ponds in village to store excessive catch (Plate 3).

Each fisher has a plank built box (*peet*) held with locks to store fishes after harvest. During glut season the fishers process excess catch using traditional methods of salting, drying and smoking. Status of handling and processing of fishes by fishers of Wular is shown in table below.

Table 4.2.28 Attribute score for handling and processing in Wular Lake

Wular Lake Fishery	Score	Inferred status of handling and processing
	1	Only sometimes handling and processing is followed

4.2.4.4 On-board safety devices and Trip length (OBT)

The attribute tries to capture whether the fishers use safety devices and other equipment on-board the vessel like Mobile, life jacket, etc. Fishing in large water bodies is dangerous to some extent as there are lots of chances that the fishing crafts can easily capsize. In Wular Lake, it is observed that fishers don't go for fishing with sophisticated life saving devices. It may be due to the following reasons:

- a) Prolonged experience has instilled a sense of confidence in navigating their craft for fishing.
- b) Fishers are good swimmers and more importantly they know their fishing grounds and weather conditions.

Although the aforesaid reasons may be valid, but still there exists a risk of life as seen in some water bodies (Tol, 2015), where fishers lost their valuable life due to capsizing of craft by strong winds. Mobile phones are widely considered to be one of the modern day on-board safety devices which will at least help them to communicate with their peers or authorities for any of kind of assistance during fishing.

In the Wular Lake, it was observed that low socio-economic status of fishers and breakdown / lack of mobile communication infrastructure hindered mobile usage. Therefore, it was documented that usage of mobile phones during fishing as some reliance on on-board safety device. Keeping all this in view, the inferred status of usage of on-board safety devices by fishers in Wular Lake is shown in table 4.2.29

Table 4.2.29 Attribute score for usage of on-board safety in Wular Lake

	Score	Inferred status
Wular Lake Fishery	0	Fishers do not use on-board safety devices though necessary

4.2.4.5 Infrastructure (INF)

The attribute tries to capture the presence of centralized / minimal landing sites with concrete structure / hall including washing, icing and loading / transport facilities in the Wular Lake. There are approximately 9 fishing landing centres of Wular lake viz., *Jamia Sopore, Aishtingoo, Kanabathy, Watlab, Laharwalpora, Lankreshipora, Kulhama, Kanyari* and *Ningli Bala* (Fisheries Survey Report, 2012). Of these *Laharwalpora* is the largest and major fish landing centre. All landing centres are dispersed without any facilities of concrete structure/hall including washing, icing and loading/transport facilities. Status of infrastructure facilities available in nine landing centres of Wular Lake is shown in table 4.2.30.

Table 4.2.30 Attribute score for infrastructure facilities available in Wular Lake landing centers

Wular Lake Fishery	Score	Inferred status
	0	Dispersed and without any infrastructure facilities

Thus, understanding the five attributes by definition and the score obtained by each fishery in relation to the attributes revealed the present status of each fishery in the technological sustainability dimension.

4.2.5 Governance Sustainability of Wular Lake

Result of governance sustainability analysis using modified RAPFISH methodology for Wular Lake fisheries indicate 'less' 39.09 % status of sustainable development.

The sustainable development status from governance perspective were inferred based on the classification mentioned in the methodology chapter. Governance sustainability value of Wular Lake is represented in a two dimensional ordination plot (Fig. 4.2.11).

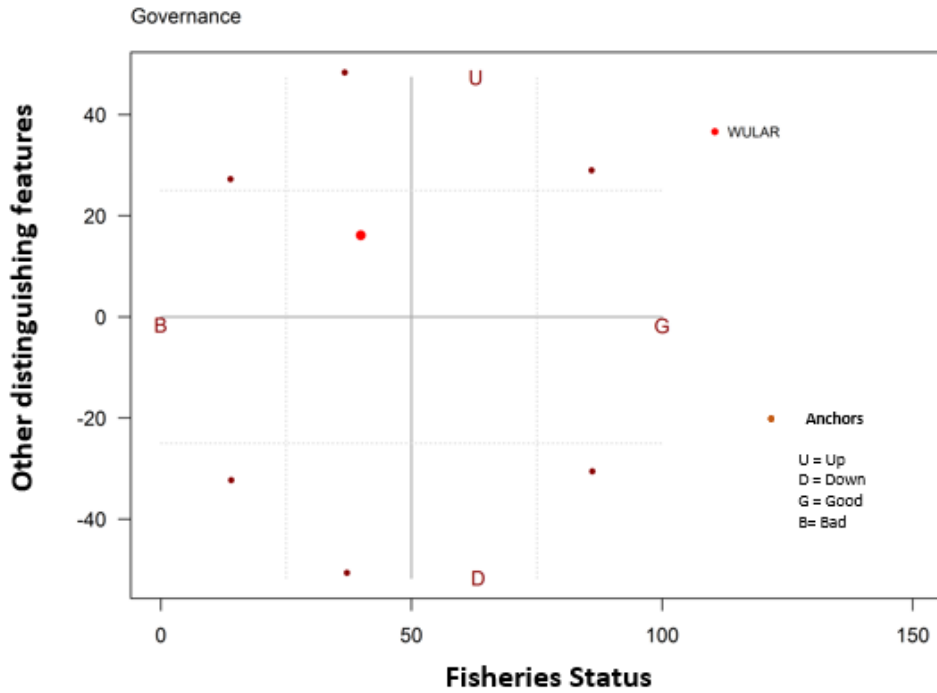


Fig.4.2.11 Governance sustainability of Wular Lake

4.2.5.0 Leverage analysis of governance attributes

Leverage analysis of individual attributes on governance sustainability ordination was carried out to determine the extent of each attribute's influence in the overall ordination. As discussed earlier, it is calculated as a standard error of difference between the ordinations obtained with and without including the attribute. Fig.4.2.12 illustrates a leverage analysis carried out for the five attributes defining the governance evaluation field of RAPFISH analysis.

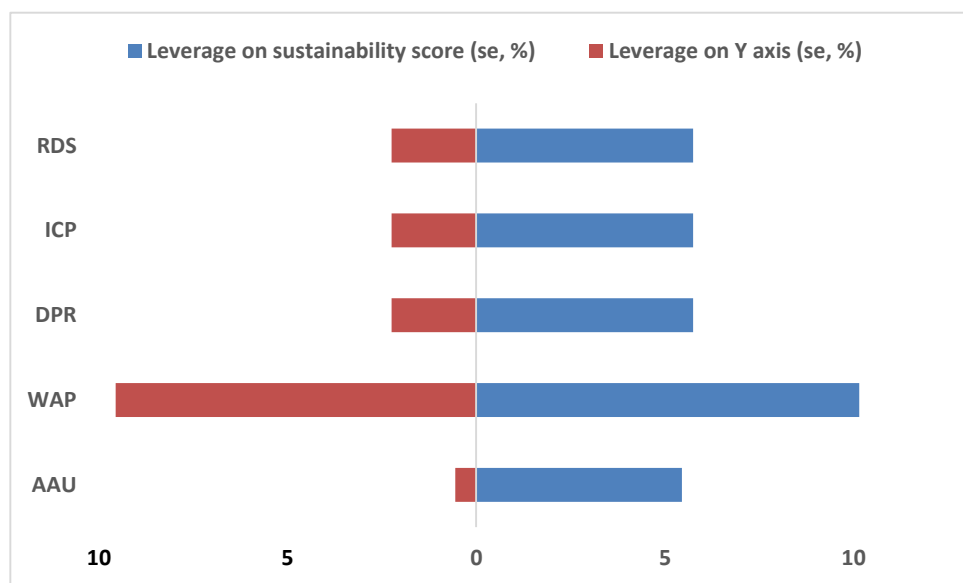


Fig.4.2.12 Attribute leverage analysis of the governance dimension

Leverage analysis results show that the 'willingness and participation (WAP)' attribute has the maximum influence (S.E. about 10%) about twice as great as development programmes` (DPR)', 'research and development support (RDS)', 'access and use (AAU)' and 'institutional capacity and process (ICP)' which have a S.E. of about 5.7% on the ordination position of fisheries on the sustainability axis. This can be interpreted as indicating that the status of willingness and participation in the Wular Lake has the greatest influence on sustainability as compared to other attributes.

In similar line with the leverage analysis discussed in previous dimensions, no single attribute plays dominant/deterministic role in deciding the ordination outcome as all values are <15% rather multiple of attributes influences the outcome. In the case of y-axis, also 'WAP' has the highest influence followed by 'DPR', 'RDS' and 'ICP'. Despite being the penultimate attribute in its influence on sustainability axis, 'AAU' was having the lowest influence on Y-axis. However, interpretation of these y-axis influences is less important for fishery management than those on the sustainability axis; they merely show the amount each attribute influences position on an axis of difference unrelated to sustainability.

Following are the five attributes which determine the governance sustainable development status of the Wular Lake:

- (a) Access and Use (AAU)
- (b) Willingness and Participation (WAP)
- (c) Development Programmes (DPR)
- (d) Institutional Capacity and Processes (ICP)
- (e) Research and Development Support (RDS)

4.2.5.1 Access and use (AAU)

It tries to capture the presence of comprehensive and effective leasing / licensing policy and regulatory framework for sustainable development of fisheries and fishers in Wular Lake. It also includes extent of enforcement and adoption of

seasonal fishing ban and mesh size regulation to help the breeding of major fishery and as a management measure to avoid the juvenile catch respectively in a Lake.

Access and use focuses only on the existing regulations in practice that directly / indirectly affects the fisheries management. The study confirm the welfare of fishers who are completely dependent on the Wular Lake for their livelihood. The State department maintained an optimum benefit sharing system when the fishery ownership is licensed to fishers. The (1903 A.D) state fisheries act of Jammu and Kashmir was amended during May 2018. According to Section 10 of Jammu and Kashmir State Fisheries Act of 1960 (amended in 2018), any person desirous of fishing in an area where such fishing is permitted has to take an application to the Licensing Office for the grant of license which shall be valid for a specific period of one financial year.

The Act also prohibits leasing out public water resources for a specified period and to charge fees for such lease. Wular Lake comes under 'reserve' water body and a fee of ₹ 500 is charged annually. The licenses @ ₹ 300 and @ ₹ 600 are issued for fishing with rod and in Jhelum (inlet & outlet) in Wular Lake. Surprisingly, there is no seasonal fishing ban in Wular Lake and fishers have free access throughout year. But fishers voluntarily avoid fishing during May-June which is the breeding season and also monitor to ensure no one catches of fry / fingerling that time. Also DoF field officers enforce mesh size regulation through levy and collection of penalty charges.

DoF collects revenue from other penalty such as for use of fixed engine (gill net), sand excavations during breeding season, etc. Licensing revenue realized by DoF from 2006-2018 is given in the table 4.2.31.

Fishers have to maintain mesh size so that fishes of less than 5 inch can escape. But it was found that fishers use both optimum (1½") and small mesh size (½") nets and everyone do not follow mesh size regulation/ protocol properly as enforcement is weak due to inadequate man power for field work. Inferred status of access and use in Wular Lake is shown in table 4.2.32

Table 4.2.31 Licensing Revenue realized from 2006-2018

Year	Revenue realized In ₹
2006-07	1,40,000
2007-08	5,60,000
2008-09	6,07,350
2009-10	17,91,650
2010-11	8,08,150
2011-12	5,74,500
2012-13	7,53,130
2013-14	4,95,960
2014-15	5,33,300
2015-16	4,22,320
2016-17	3,93,950
2017-18	3,78,870

Table 4.2.32 Attribute score for access and use in Wular Lake

Fishery	Score	Inferred status
Wular Lake	2	Predominantly welfare oriented access and use policy is in vogue

4.2.5.2 Willingness and participation (WAP)

It indicates the degree to which primary stakeholders (Fishers) are willingly / voluntarily participate in planning as well as adopt various fisheries resource management measures including access and use rules / guidelines etc. It also includes traditional management measures used by fishers or community (in relation to fishing, fishing equipment or legal aspect) for sustaining the fishery resources, and its integration in State regulations.

From the study, it is observed that in Wular Lake most are willing to participate either in conservative/fisheries development measures taken. However, some among fishers are unwilling to participate as poaching still exists as a main problem. Poaching not only causes revenue losses to Government but its prolonged

existence will make even the willing fishers to lose interest in conservancy / development measures.

One who fishes in the Lake without DoF granted licence are said to be involved in illegal fishing. But in case of Wular Lake some fishers also are involved in poaching by using the banned 'fixed net' gear (gill net). Several local and National newspapers have already reported the illegal fishing and their negative impact over the livelihood of the licenced fishers of the waterbodies (The Hindu, 2014). Lack of adequate field level DoF staff has meant continued illegal fishing in the Lake. Many a times, fishers chase these illegal fishers and caught their highly destructive fishing nets and have also staged a mass protest against this illegal netting rampant in Wular Lake (GK, 2016). Even fishers cite some incidents in which the captured illegal fishers escaped later due to political intervention. On the other side, DoF officials allege that such illegal destructive fishing happens with prior knowledge and aid of the licenced fishers (if not all, at least some) and licenced fishers criticise DoF as irresponsible only for the sake of criticising.

Though licence for fishing in the lake is expected to be an effective regulatory / conservancy measure, the fishers said because of the unaccountability of DOF officers and dwindling fish catches they are least willing to pay for the license, whereas for DOF field officers are given target of 10% increase in license number every year. This has often led to non-bonafide fishers being given licenses who siphon the subsidy and also collude with poachers.

Table 4.2.33 Attribute score for fishers willingness and participation

Wular Lake	Score	Inferred Status
Fishery	3	Most (~ 75 %) of the fishers are willing to and participate in resource management

The revenue amount realized from fishers from 2007-2018 is given in a table 4.2.34 and it may be noted that a fisher can possess more than one license based on his fishing activity. Inferred status of fishers' willingness and participation in Wular Lake is given in the table 4.2.33.

Table 4.2.34 Status of the license recovery and revenue generation from 2007-2018

Year	Total Nos @ ₹ 500	Amount realized in ₹	Total No. @ ₹ 400	Amount realized in ₹	Total Nos @ ₹200	Amount realized in ₹	Total No. recovered	Amount realized in ₹
2007-08	47	23500	1697	678800	22	4400	1766	7,06,700
2008-09	47	23500	1702	680800	34	6800	1783	7,11,100
2009-10	58	29000	1724	689600	52	10400	1834	7,29,000
2010-11	66	33000	1780	712000	43	8600	1889	6,19,800
2011-12	68	34000	1814	725600	45	9000	1927	7,68,600
	(Revised @ ₹ 600)		(Revised @ ₹ 500)		(Revised @ ₹ 300)			
2012-13	66	39600	1877	938500	51	15300	1994	9,93,400
2013-14	71	42600	1931	965500	58	17400	2060	10,25,500
2014-15	85	51000	2036	1018000	83	24900	2204	10,93,900
2015-16	73	43800	2133	1066500	91	27300	2297	11,37,600
2016-17	66	39600	2190	1095000	90	27000	2346	11,61,600
2017-18	70	42000	2298	1149000	114	34200	2482	12,25,200

Source: Annual Fisheries Report, 2019

4.2.5.3 Development programmes

Indicates existence as well as effective implementation of Lake fisheries development programmes / schemes like stock enhancement programmes (including functioning of fish seed production and rearing centres), cage / pen culture programmes, species / fishery-wise schemes, any other innovative schemes, etc.

Jammu and Kashmir has its National Fish Seed Farm at Manasbal that supplies seed to whole state as per the quota of each district. Then at district fisheries office, it is decided how much to allocate for different resources in a district. Wular is stocked in the month of July to August and during 2018-2019 approximately 6 lakh seeds are stocked in Wular Lake by DOF in presence of District level officer and Sarpanch. As Wular comes in two districts (Bandipora & Baramullah), accordingly it is stocked in both districts. In Wular Lake only Common carps (scale and mirror carps) are stocked however golden carp (*Carrasius carassius*) and grass carp (*Ctenopharyngodon idella*) are also reported in the catch data (Table 4.2.4). Development programmes for Wular Lake only exist in terms of stocking that too for common carps only and there is no actionable steps taken to rejuvenating fishing and fisheries particularly for indigenous local species of *Schizothorax*. Other developmental programs like cage / pen culture or innovative species specific schemes hardly exist despite being the largest fresh water Lake in Himalayan region. As per the evidence above, the inferred score for Wular Lake in terms of development programmes is given in table 4.2.35 below.

Table 4.2.35 Attribute score for development programmes in Wular Lake

	Score	Inferred Status
Wular Lake Fishery	1	Poor status in terms of both no. and type of development programs and their implementation

4.2.5.4 Institutional capacity and processes

It indicates overall capacity and effectiveness of Fisheries Department and related institutional mechanisms including various procedures and processes in providing good governance. It includes available human resources (adequacy &

competency); transparency, equity and fairness in application including gender mainstreaming; effective coordination with concerned agencies; functioning of fishers cooperative societies; and presence and effectiveness of conflict resolution mechanisms (CRM) etc.

Wular Lake is primarily managed by Department of Wildlife and Protection, and only the fishing rights are vested with DoF. In DoF, there are at present 4 Inspectors, 4 Dy. Inspectors, 4 Supervisors, and few field level workers. The DoF staff number appears to be adequate as far as Wular Lake region is concerned, but their field level presence is limited. Although DoF has recruited female workers as well, they are confined to office premises only leading to shortage of human resource at the grassroots.

There are various stakeholders of the Lake viz., Department of Wildlife and Protection, Department of Forestry, Social Welfare Department, Department of Rural Development, Department of Revenue and Planning, Flood and Irrigation Control Department, Public Health Engineering Department, Fisheries Department, Department of Ecology, Environment and Remote Sensing, Department of Tourism. Field level interactions have revealed no effective coordination between the various departments and concerned agencies like WUCMA and Wular Manasbal Development Authority (WMDA). Surprisingly, WUCMA has no members from fisheries department. It may also be noted that there are no SHGs/ FPOs / Cooperative Societies among the Wular Lake fishers although fishers themselves have formed some sort of informal association.

Table 4.2.36 Attributed score for institutional capacity and processes in Wular Lake

Wular Lake Fishery	Score	Inferred Status
	1	Poor institutional capacity and processes in place

4.2.5.5 Research and Development (R&D) Support

It explores the extent and quality of research based inputs from Research and Development (R&D) system to sustainably manage the resources. It tries to include the extant of evidence based planning including availability of

reliable catch data / statistics and credible information on marketing data base in relation to Wular Lake. The status of Wular Lake in terms of research and development support can be summarized as follows:

- (a) **Extent and quality of research based inputs from R&D:** there are many studies related to Wular Lake which mainly covers physical-chemical quality of water, phytoplankton and zooplankton diversity, biology of fishes, geology, environment, and remote sensing aspects and to some extent on fisheries. Only few studies are related to fishers and fishery that addressed socio-economic aspects e.g., study conducted by Wetland International on Wular Lake framed Comprehensive Management Action Plan in 2007 and as a result of which WUCMA was formed.
- (b) **Availability of reliable catch data / statistics:** Data collected from DoF regarding catch data for Wular Lake shows more or less stable trend while personal observations on ground and FGD with fishers reflect that catch over the period has decreased drastically because of the various developmental works upstream, pollution levels and excessive siltation giving rise to credibility of reported data.
- (c) **Information on marketing data base:** There are no official information and reports on fish markets in the region, its size, structure, conduct and performance. Also no data on fish price is neither collected nor recorded till now.

Table 4.2.37 Attribute score for research and development support in Wular Lake

Wular Lake Fishery	Score	Inferred Status
	1	Poor status of research and development support

Therefore, the inferred status of Wular Lake in terms of Research and Development support can only be suggested as poor (Table 4.2.37)

4.2.6 Overall Sustainability of Wular Lake fisheries

Overall sustainability of Wular Lake is obtained by taking average (Table 4.2.38) of sustainability value in each of the five dimensions. Understanding overall sustainability will help in identifying the dimension in which the fishery has to be strengthened through necessary interventions. It has also been observed that low / high value in one dimension will affect the overall sustainable status.

Table 4.2.38 Overall sustainability of Wular Lake fisheries

Dimension / Evaluation	Sustainability Score (%)	Overall Status
Ecology	57.68	Quite
Economy	69.33	Quite
Social	30.39	Less
Technology	15.77	Poor
Governance	39.09	Less
Wular SS	40.04	Less

The overall sustainability values for Wular Lake fisheries ranged from 15.77% for Technology dimension to 69.33% for Economy dimension. The respective sustainable development status for each dimension were inferred based on the classification mentioned in the methodology chapter (3.3.4). Results of ecology (57.68%) and economic (69.33%) dimension is found to have 'quite' sustainable development (50.1-75%). Result of social (30.39%) and governance (39.09 %) sustainability values for Wular Lake fisheries indicate 'less' sustainable development. Result of technological sustainability analysis of Wular Lake fisheries indicate 'poor' 15.77% sustainable development.

Overall results show that sustainable development of Wular Lake is 'less' (40%). Rapfish analysis for overall dimensions range from 'Poor' to 'Quite' sustainable status.

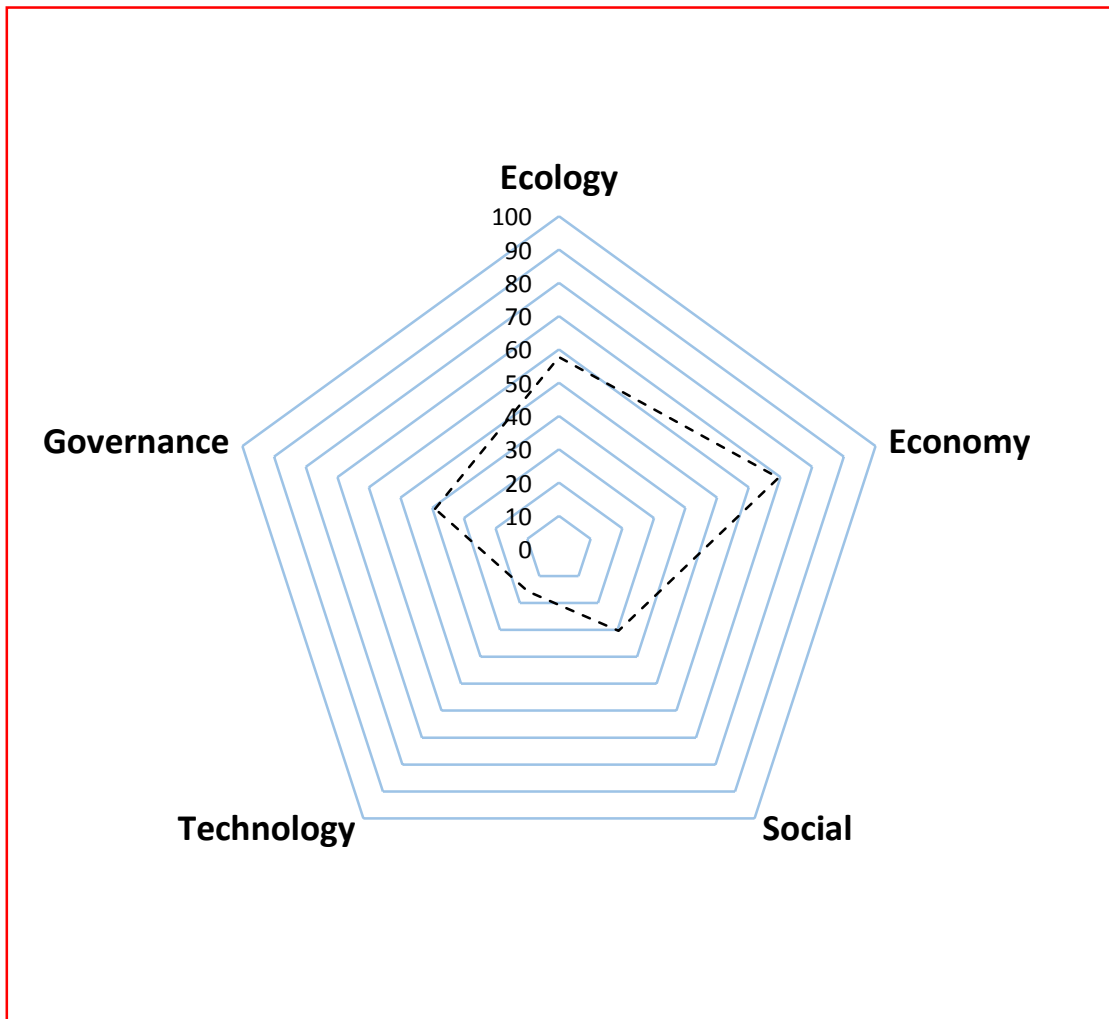


Fig. 4.2.13 Comparative sustainability status of five dimensions of Wular Lake fisheries

Among 5 dimensions, technology was found to have least sustainable development status while economy was found to have comparatively more sustainability status (Fig. 4.2.7). It has to be noted that none of the fishery have attained 'Good' (75.1-100%) sustainable development status. It shows that there is lot of scope for overall fisheries development in the Wular Lake by strengthening the dimension in which it got low score in sustainable development.

4.3 Fishery and village specific intervention plans to improve community resilience

4.3.1 Fishery specific intervention plans

- 1. Reduce pollution and eutrophication:** Sewage treatment plants (STP) shall be constructed to reduce pollution levels. As an immediate remedy wire meshes can be placed at *Asham* (inlet to Wular) to trap macro pollutants like animal carcasses, polythene etc. Municipal Corporation can be given the responsibility to perform the job. Local people should be mobilized to support conservation measures. NGOs can be encouraged to come up as there are no NGO working on ground with fishers. Media, both online and offline, can be used to create greater awareness and bring positive change.
- 2. Improving fish catch:** The number of fish seed being stocked can be increased for Wular considering its vastness and the number of people dependent on it. As Wular is a wetland supporting diverse vegetation stocking need to be done carefully ensuring no grass carps are stocked in Wular. As a resource manager, DoF shall execute these steps for fisheries development.
- 3. Training programs on alternative livelihood options:** It is very important to train fishers on alternative livelihood options like eco-tourism, hygienic handling and value addition of fish and water chest nut, pen and cage culture programs, backyard poultry, integrated farming systems, etc. DoF / ATMA / KVK's can be roped in for these initiatives.
- 4. Organising fishers and reducing conflicts:** Anyone of the modes of organisations such as Cooperatives/ Self Help Groups/ Farmers Producer Organisation can be thought of which will not only enable them in group formation but will also increase their bargaining power particularly in case of *Trapa* based products.
- 5. Target beneficiaries should be increased:** If subsidy or any scheme is given to fishers, for it to be need based, bottom up approach can be followed where ground staff and local fishers should be given power to decide e.g. life jackets, uniform for fishers should be given to all that will not only result in ease of doing their work but will significantly reduce the work burden on

fisherwomen particularly during winter months. DoF, Department of Rural Development (DORD), Department of Social Welfare along with other line departments can perform this job.

- 6. License should be provided only to bonafide fishers:** DoF administration should rethink their target based approach for increasing the number of fishers by giving licenses which has led to non-bonafide people to fish in reserve waters like Wular. However, rod licenses can be given to any one that will also generate the revenue of the state in general. Providing license to registered bonafide fishers only will safe guard their identity and perhaps reduce conflict as well.
- 7. FRP boats should be redesigned:** Technology upgradation in terms of providing FRP boats can be popularized but need to be redesigned to suite fishing and fishers requirements. Introducing coracles which are relatively cheaper than wooden boats may also be thought of.
- 8. Gill nets and wounding gears should be completely banned:** Considering the levels of fish stocks particularly in cold water regions, gill nets are perhaps not suitable for capture fisheries. Also use of spears like *Panzar* and *Naruch* should be used in a limited scale as they cause injuries to the fishes thus making their appearance dull. DoF can play a major role in effective implementation and monitoring.
- 9. Seasonal fishing ban is recommended:** As of now there is no ban season in Kashmir. It is suggested for Wular because most of the fishers are also involved with water chest nut, and fodder related activities apart from fishing. To rejuvenate stock, fishers recommend ban at least near *Ningle Bala* bridge which is an outlet of Wular and acts as a gateway for brooders during breeding season. Suitable hoardings can be placed and then monitoring can be done by DoF field level staff.
- 10. Developmental activities:** Wular Lake offers immense potential for tourism and the plan is also prepared (CMAP, 2007) but action is missing on those lines. It will secure the livelihoods of the people particularly fishers who depend on Wular Lake. Landing centers and suitably planned fish market developmental work needs to be carried out. Department of Tourism (DoT), Department of Revenue and Planning, and Public Works Department jointly with representative fishers can plan and execute the work.

11. Riverside pen culture and cage culture of carps can be recommended:

As for fishers, it is expensive for them to afford a cage but through SHGs or Public Private Partnership (PPP) basis it can be advised to progressive fishers and non-active but licensed fishers.

12. Capacity building and accountability of DoF personnel: It is suggested to increase the transparency, equity and fairness in implementation of welfare schemes as demanded by fishers. Training of staff needs to be done on other important aspects of extension like capacity building of fisheries, providing informal education, market led extension services rather than only being involved in watch & ward and license recovery. ICAR and SKAUST can provide necessary support.

13. Recruiting Professional Staff: for strengthening the fisheries data base by instituting credible fish catch and price data collection mechanism is very essential.

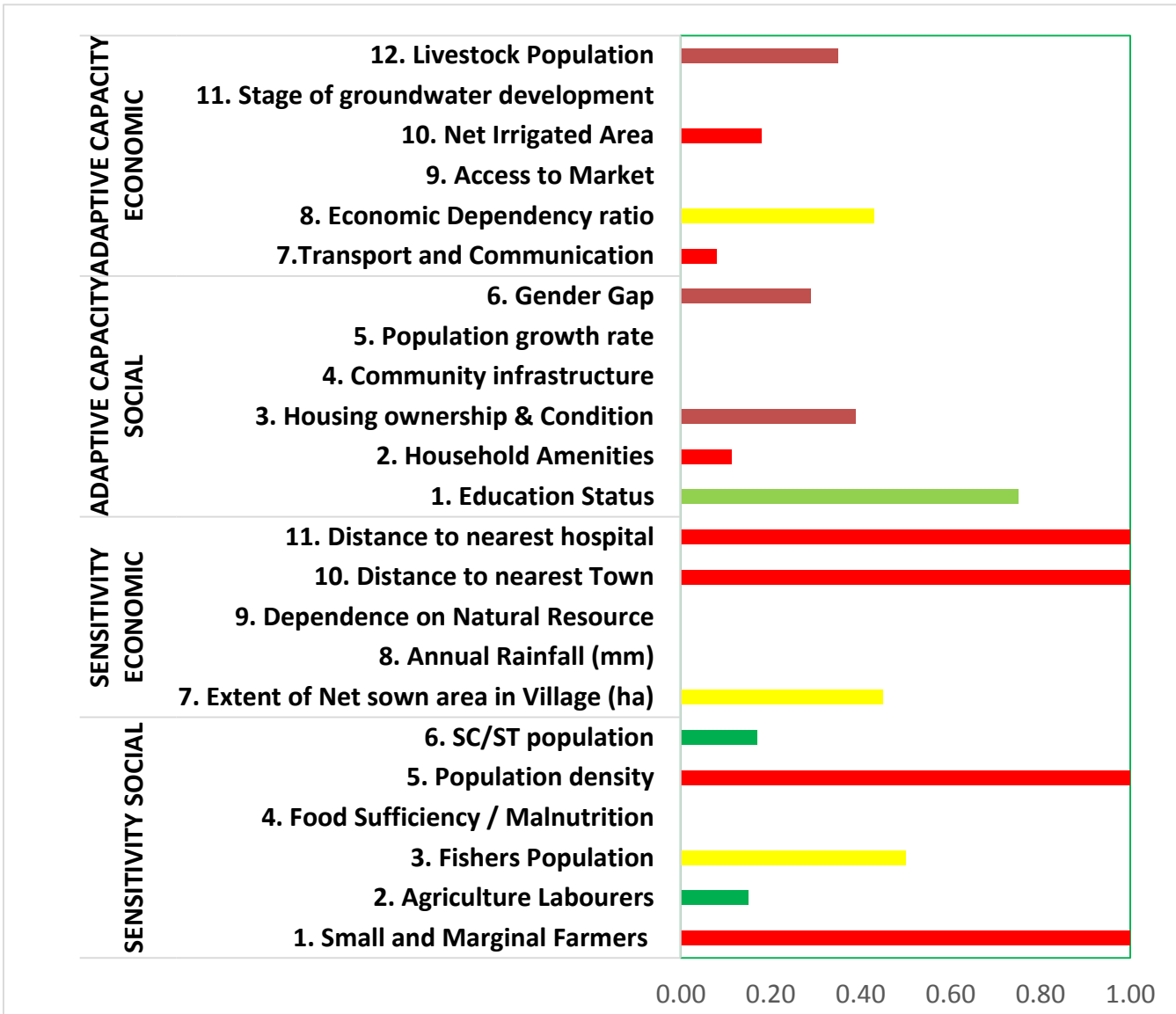
14. Formation of Wular Fishers Development Authority (WFDA): WFDA is suggested where one person from each of the line department can be brought together under one umbrella for comprehensive fisheries development. Although WUCMA is already functioning, it covers only catchment conservation and water management in general. WFDA would serve as a body working specifically for fishers' livelihood and fisheries development in particular.

4.3.2 SEVI based village specific intervention plan

As already discussed (4.1.10), a decision matrix can be used to identify socio-economically vulnerable villages by identifying different drivers and buffers in order to aid in planning appropriate interventions.

Kunas village tops the list of most vulnerable villages among the 23 Wular fishing villages. The indicator wise SEVI values for Kunas village were taken to illustrate identifying specific drivers and planning appropriate and specific key interventions.

All indicators have direct relations except AR, DNR, PGR, EDR, GD which have inverse relations



Red: Most Important (drivers)
Green: Least Important (buffers)

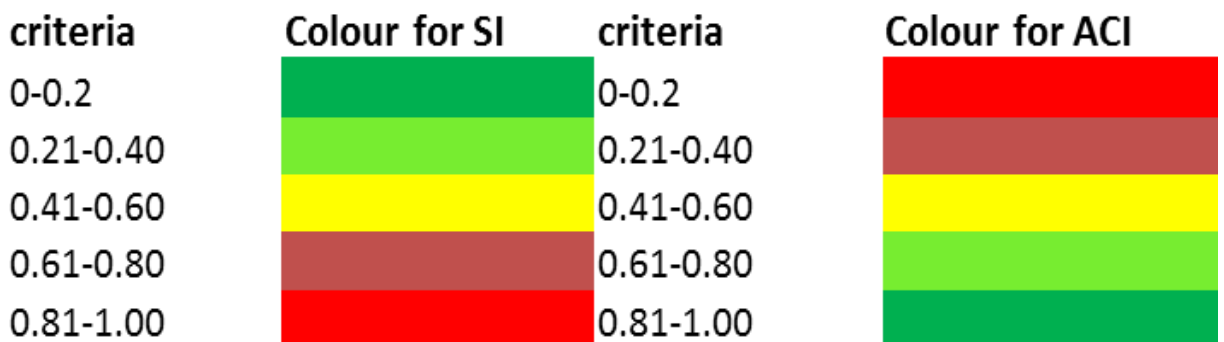


Fig. 4.2.14 SEVI Indicator values for *Kunas* fishing village (Wular)

4.3.2.1 Key drivers and interventions to address High Sensitivity

The following 3 indicators are identified as key drivers responsible for very high sensitivity values of the Kunas fishing village:

- a. ***Small and Marginal Farmers (SMF) (98%)***: It may be noted that sensitivity indicators provide a larger and limiting socio-economic context that offers little scope for change in the short term i.e. it is a given structural condition alteration of which is only possible in the long term. Little can be done to alter the higher proportion of small farmers in the village. What would be feasible is mobilising the farmers into some farming collectives so as to overcome the limitations of small scale farm.
- b. ***Distance to Nearest Town (DNT) (>10 Kms)***: Shortening the distance to nearest town can be feasible in terms of reducing the time taken to travel by improving the road network and transportation facilities.
- c. ***Distance to Nearest Hospital (DNH) (>5 Kms)***: Time can be shortened by building primary health centres in the village or nearby as it's an essential service and an important factor for social well-being.

4.3.2.2 Key drivers and interventions to address Low Adaptive Capacity

The following 6 indicators are identified as key drivers responsible for very low adaptive capacity values of the Kunas fishing village:

- a. ***Household Amenities (HA) (35%)***: Most households have poor amenities which is mainly the function of household income, and to some extent awareness and education. Income can be increased by strengthening both fisheries based and *trapa* based livelihoods. Value addition holds the key. Simultaneously, awareness campaigns about sanitation, clean drinking water and clean fuel would improve the amenities at household level.
- b. ***Community Infrastructure (CI) (60%)*** and c. ***Transport and Communication (TC) (66%)***: Strengthening and developing community infrastructure such as schools and colleges, hospitals, community halls

are basic requirements for human development. Local government shall place greater priority on fulfilling this.

- d. Access to Market (Poor):** Time taken to reach market can be shortened by better road and public transport which are very poor as of now (Plate 5). Developing weekly markets and other infrastructure in the village might be a costly exercise and needs a ground level feasibility study.
- e. Education status (55%):** Opening of Anganwadi centers and a primary school in Kunas or nearby village, creating awareness about importance of education are the steps required to be taken.
- f. Livestock Population (10%):** This indicator is a measure of livelihood (income) diversification at the household level which seems to be almost nil at Kunas village. Options like backyard poultry, rearing of sheep and ducks are both feasible and viable in Kunas which can supplement household income and cushion uncertainties and cover risks.

5. SUMMARY AND CONCLUSION

Eighty-seven percent of the global wetland resource has been lost since 1700. Wetlands are lost three times faster than natural forests. Wetland-dependent species are in severe decline. Since 1970, declines have affected about 81% of inland wetland species populations and 36% of coastal and marine species (Global Wetland Outlook, 2018).

Healthy, functioning wetlands are essential to deliver a range of global targets, including the UN Sustainable Development Goals, the Aichi biodiversity targets, the Paris Agreement on Climate Change and Land Degradation Neutrality. The world famous picturesque lake namely Wular is one of the largest freshwater lakes in Asia with 11,277 ha area. Wular Lake is an important Himalayan wetland / Lake in India located in north Kashmir region and serves a vital role in biodiversity maintenance and providing numerous ecological services, the important one being the fisheries. The lake is one of the 27 Indian wetlands designated as a Ramsar site. At present, the fish production from upland areas (cold water fisheries) constitute only about 3 % of India's total inland fish production of 7.77 million tonnes (DAHD&F, 2018).

The present study was conducted on climate change, vulnerability and sustainable development of Wular Lake fishers and fisheries. Wular Lake is an important habitat for fish and contributes about 54% of fish yield from lakes of the Kashmir Valley presently, and supports about 2914 families. A total of nine out of 50 villages on Wular lake periphery were visited and information on variables collected through detailed key informant interviews, focus group discussions, participant observation, and discussion with resource managers using detailed checklist / interview schedule during December 2018 to February 2019. Secondary data was collected and collated from Census of India 2011 and 1991, various government departments especially DoF, published as well as grey literature.

Socio-economic Vulnerability Index (SEVI) for Wular Lake villages

The socio-economic vulnerability of communities depending on Wular Lake to external stressors like climate change was assessed using the

methodological framework developed by NCSCM-NAARM-CIFE study (Krishnan *et al.* 2018). Block and village wise Socio-Economic Vulnerability (SEV) was assessed in terms of social-economic sensitivity and social-economic adaptive capacity from 23 indicators which are *small and marginal farmers, agricultural labourers, fisher population, food sufficiency / malnutrition, population density, schedule castes / schedule tribes population, net sown area, annual rainfall, dependence on natural resources, distance to nearest town, distance to nearest hospital, transport and communication, economic dependency ratio, access to market, net irrigated area, groundwater development, livestock population, education status, household amenities, housing condition, community infrastructure, population growth rate, and gender ratio.*

In order to address the issue of incommensurability of the units in which the individual indicators were measured during their integration into aggregate vulnerability index, the data were normalized to a common (analogous) unit-less scale (0 to 1). Sensitivity Index (SI) & Adaptive Capacity Index (ACI) for villages were constructed by taking the average of social and economic sensitivity/ adaptive capacity indices, respectively. Further to discern greater variability to enable grassroots level (village/blocks) planning and interventions, SI, ACI and SEVI were rescaled on a relative basis, keeping an observed minimum and maximum as X_{min} and X_{max} values. For all indices viz., SI, ACI, and SEVI, five-point ordered scale was used to rank from very low (0 to 0.2) to very high (0.81-1.0), according to their functional relationship with vulnerability. It is important to note that Sensitivity has a direct relation to SEVI while Adaptive Capacity has an inverse relation to SEVI.

Results indicated that 50 Wular fishing villages fell under 23 Census (2011) villages belonging to 3 tehsils viz., Bandipore, Sonawari and Sopore in Bandipora and Baramullah districts.

SEVI, SI and ACI

Sensitivity Index (SI) and Adaptive Capacity Index (ACI) values indicated moderate levels of vulnerability for both Wular and Non-Wular census villages. Economic SI border the high vulnerability (0.6 – 0.8) zone while the

economic ACI of 0.42 indicates low / poor ability to adapt to negative events and externalities. No significant differences were found between Wular (23) and Non-Wular (115) villages in terms of vulnerability though relatively higher Social SI values for Wular villages due to direct dependence on the Wular Lake is a cause of concern. Socio-Economic Vulnerability Index (SEVI) values for Wular Lake villages range from low to moderate, i.e., 0.25 for *Seer Jagir* village in Sopore tehsil of district Baramullah to 0.42 in *Kunas* village of Bandipore tehsil of Bandipora district of Jammu and Kashmir.

Socio-economic sensitivity and Socio-economic adaptive capacity indices

Socio-economic sensitivity indices for census villages that correspond to the identified fishing villages of Wular Lake varied from 0.395 (low) for *Bahar Abad (Amcha Kundal)* village to 0.572 (moderate) for *Kunas* village and the overall villages were found to have moderate sensitivity i.e. 0.481. Social Sensitivity of Wular Lake villages ranged between 0.29 (low) in *Gund Jahangir* village and 0.60 (high) in *Garoor* village. Overall social sensitivity indicated moderate levels (0.44). Economic Sensitivity of Wular Lake villages ranged between 0.35 (low) for *Qazipora* village and 0.65 (high) for *Kunas* village. Overall economic sensitivity indicated moderate levels (0.52) of vulnerability.

Socio-economic adaptive capacity indices for the census villages corresponding Wular Lake fishing villages was found to be moderate (0.449). The range varied from 0.329 (low) in *Sadarkoot* village to 0.566 (moderate) in *Sangrama* village which is located close to Sopore town. Values indicated low to moderate socio-economic adaptive capacity index for Wular villages. Social adaptive capacity of Wular Lake villages ranged between 0.34 (low) in *Watal Hanji* village and 0.578 (moderate) in *Seer Jagir* and *Sangrama* village. Overall social adaptive capacity indicated moderate levels (0.47). Economic adaptive capacity of Wular Lake villages ranged between 0.27 (low) in *Sadarkoot village* and 0.55 (moderate) in *Sangrama village*. Overall economic adaptive capacity indicated moderate levels (0.42) of vulnerability.

Rescaled values for SI, ACI, and SEVI

Rescaled vulnerability values of villages based on their Sensitivity (S) and Adaptive Capacity (AC) indices has shown *Kunas* and *Sadarkote Pain* villages as most vulnerable villages (1st and 2nd ranks) in terms of S and AC respectively among all Wular Lake census villages. Similarly, *Seer Jagir* and *Bahar Abad* were found to be the least vulnerable (ranked 23rd and 22nd) in terms of S and AC respectively among all Wular Lake census villages (Table 4.1.2). Socio-economic vulnerability index (SEVI) for all villages, blocks were constructed from the re-scaled socio-economic sensitivity (SI-R) and socio-economic adaptive capacity (ACI-R). The results of the study also showed that 8 out of 23 villages which are socio-economically most vulnerable, were from Bandipore and Sonawari tehsils of district Bandipora. It implies that enhancing the socio-economic status would have a significantly higher impact in vulnerability reduction in Bandipora, as compared to Sopore tehsil.

Decision matrix for 5 blocks (138 census villages) and 23 Wular census villages

A 2D decision matrix was developed by plotting SI-R against ACI-R separately for overall 138 villages, for each block (5) belonging to 3 tehsils to identify socio-economically vulnerable villages to aid in planning appropriate interventions. 2D Decision matrix was separately drawn for Wular Villages which indicated that 30% (7 villages) fell in the highly vulnerable category.

The results showed that highly vulnerable villages accounted for 18% (7 villages) in Bandipore; 15% (4 villages) in Hajin and 3% (1 village) in Zaingeer block whereas Sumbal and Sopore blocks didn't have villages that fell in the highly vulnerable quadrant. This can be attributed to the geographical proximity of the blocks to towns of Srinagar and Sopore respectively. Know-how about highly vulnerable villages will indicate that location-specific interventions need to be planned to strengthen their adaptive capacity.

Identification of Drivers and Buffers

In the identified highly vulnerable villages, the variables which had significant high index values due to high sensitivity and low adaptive capacity were designated as DRIVERS, thus to be intervened on priority. The variables contributing to high adaptive capacity and low sensitivity in a given village were considered as BUFFERS. There identified Drivers and Buffers were almost common for the five blocks as well as Wular villages (Annexure 4).

Six *drivers* influencing high sensitivity in 3 tehsils in which Wular Lake falls were proportion of small and marginal farm(ers) (SMF), high population density (PD), high net sown area (NSA), farther distance to nearest town (DNT) and to nearest hospital (DNH) and low dependence on natural resources (DNR). The low values for dependence on natural resource could be attributed to data constraint about the indicator (it was reported as zero in census data). It was clear that high vulnerability is structured to an extent due to the predominately agrarian economy with relatively smaller farm size and a higher population density which is exacerbated by hilly terrain leading to distant location (>5km) of town and health facilities.

Nine *drivers* responsible for low adaptive capacity were population growth rate (PGR), gender ration (GR), education status (ES), household assets (HA), housing condition (HC), transport and communication (TC), economic dependency ratio (EDR), access to market (AM), and livestock population (LP).

Village-specific interventions – *Kunas* village as representative

Among Wular census villages, indicator wise SEVI values were illustrated for the most vulnerable *Kunas* village to demonstrate how village-specific evidence based interventions can be planned. Key drivers for *Kunas* village responsible for high sensitivity were small and marginal farmers (98%), distance to the nearest town (>10 km) and distance to the nearest hospital (>5kms). Key drivers for low adaptive capacity were Household Amenities (35%), Community Infrastructure (60%), Transport and Communication (66%), Access to Market (Poor), Education status (55%), and Livestock Population (10%).

Shortening the distance to nearest town can be feasible in terms of reducing the time taken to travel by improving the road network and transportation facilities. Time can be shortened by building primary health centres in the village or nearby as it's an essential service and an important factor for social well-being.

Most households have poor amenities which is mainly the function of household income, and to some extent awareness and education. Income can be increased by strengthening both fisheries based and trapa based livelihoods. Value addition holds the key. Simultaneously, awareness campaigns about sanitation, clean drinking water and clean fuel would improve the amenities at household level.

Strengthening and developing community infrastructure such as schools and colleges, hospitals, community halls are basic requirements for human development. Local government shall place greater priority on fulfilling this. Time taken to reach market can be shortened by better road and public transport which are very poor as of now. Developing weekly markets and other infrastructure in the village might be a costly exercise and needs a ground level feasibility study.

Opening of anganwadi centers and a primary school in Kunas or nearby village, creating awareness about importance of education are the steps required to be taken. Poor livelihood (income) diversification at the household level can be addressed by encouraging backyard poultry, rearing of sheep and ducks so as to supplement household income and cover risks.

Sustainable development status of Wular Lake fisheries

RAPFISH is globally acknowledged as a multi-disciplinary assessment method to understand the complexities of a particular fishery. Considering its ease and comprehensiveness (Pitcher *et al.*, 1998), the methodology was recently adapted to Indian context to successfully demonstrate the status of fisheries sustainability in marine and reservoir fisheries sub-sectors in the Indian context (Adiga S., 2015; Lloyd C., 2017). Keeping this in view, this study has attempted to assess the level of sustainable development of Wular lake fisheries of India in a multi-dimensional perspective by adapting the 5 dimensional 25 attribute modified RAPFISH methodology to suit the context of Lake fisheries

Under ecological dimension *fish production, trophic status, environmental degradation, species composition and recruitment variability* were the attributes. Similarly, five attributes under economic dimension were the *craft and gear ownership, benefit sharing, catch per unit effort, price of fish and subsidy*. Under social dimension are *fisher population, housing and civic amenities, conflicts, education status and local environmental knowledge* attributes. Similarly, technological evaluation field of RAPFISH consisted of *fishing craft, fishing gear, infrastructure, on-board safety devices- trip length and handling and processing* attributes as a measure of sustainability. Finally, under governance dimension, the five attributes were *access and use, willingness and participation, development programmes, institutional capacity and processes, research and development support*.

Scoring of indicators and RAPFISH analysis

A uniform five-point 'Likert' scoring pattern namely very good (4), good (3), average (2), poor (1), very poor (0) was followed to score the 25 attributes to reflect the sustainability status of a Wular Lake fisheries. Scores for most of the attributes were given based on hard evidence i.e. based on extensive review of literature, fish catch records, census data, field observation and stakeholder discussions. Since current literature available on Wular Lake fisheries is scanty, to score attributes like price of fish, conflict, fishing craft, handling and processing, local environment knowledge, ecological degradation and many governance attributes, primary data was also collected by the researcher.

RAPFISH analysis was done using the latest RAPFISH version (3.1) for Windows that is available for use as an add-on in open source R software. The main functions performed were RAPFISH analysis (sustainability) and leverage analysis. Sustainable development status for each dimension was inferred based on the classification given by (Fauzi and Anna, 2005).

Sustainability Status (SS) of Wular Lake fisheries

Sustainability value of each dimension is represented in a two-dimensional ordination plot. While the more important x-axis provides the sustainability status of a particular fishery (Wular lake fishery), the vertical

dimension of the ordination plot are an indication of factors not related to the sustainability axis.

The sustainability values for Wular Lake fisheries ranged from the low 15.77% for technology dimension to the high 69.33% for economic dimension. Results of ecology (57.68%) and economic (69.33%) dimension place the Wular fishery under 'quite' sustainable development category (50.1-75%). Result of social (30.39%) and governance (39.09 %) sustainability values for Wular Lake fisheries indicate 'less' sustainable development. Result of technological sustainability analysis of Wular Lake fisheries indicate 'poor' 15.77% sustainable development status.

When all the five dimensions are taken together, the overall status of sustainable development of Wular Lake is found to be 'less' (40%). It has to be noted that none of the fishery has attained 'Good' (75.1-100%) sustainable development status. It shows that there is a lot of scope for overall fisheries development in the Wular Lake by strengthening the governance and technological aspects in which it scored very poorly.

The study also suggests various fishery specific intervention plans like increased fish seed stocking efforts, hygienic handling and value addition of both fish and trapa (water chestnut) value chains, technological up gradation of craft and gear (customised FRP crafts and eco-friendly gear), implementation of seasonal ban in Wular Lake, increase of the target beneficiaries, treatment of sewage flowing into Wular lake, reorientation and capacity building of DoF and its field level staff, and diversifying livelihood options, development of landing centers, organization of fishers through Cooperatives/ SHGs / FPO and formation of Wular Fisher(ies) Development Authority (WFDA).

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Plate 1: Indigenous plank built boats in Wular Lake



Plate 2: Oar, traditional scoop net and wooden boxes to store catch



Plate 3: Traditional small mud pools to store catch during surplus in *Laharwalpora* fishing village



Plate 4: Fish hold provision in few boats, redesigned fishing craft



Plate 5: Bad road leading to *Laharwalpora* landing center



Plate 6: Gill nets (fixed engine) used in Wular Lake



Plate 7: Unregulated smaller mesh size of cast net



Plate 8: A typical household of a Wular Lake fisher



Plate 9: Focused Group Discussion with WUCMA



Plate 10: Focused Group Discussion with District Fisheries Officers, Bandipora



Plate 11: Road side fish retail market in Bandipora



Plate 12: Common carp juveniles in Bandipora fish market



Plate 13: Focused Group Discussion, *Kanibathy* village



Plate 14: Focused Group Discussion, *Laharwalpora* village



Plate 15: Focused Group Discussion, *Naaninara* village



Plate 16: Focused Group Discussion, *Lankrishipora* village



Plate 17: Focused Group Discussion, *Watlab* village



Plate 18: Focused Group Discussion, *Muslim Peer* village



Plate 19: Key Informant Interviews, *Lankreshipora* village



Plate 20: Cast net operation in Wular Lake



Plate 21: Fishing fleet of Wular Lake, *Kanibathy* side of Lake



Plate 22: Key Informant Interview, DoF, Bandipora



Plate 23: Water level in Wular Lake, *Kulhama* side of Lake



Plate 24: Women of Wular Lake, *Watlab* fishing village



Plate 25: View of Wular Lake from *Ningli Bala* village side

Annexure 1: Interview Schedule for scoring Modified RAPFISH attributes.

S.N	Attributes	Score	Scoring description	
1	Ecology Trophic status: Trophic State Index, P content & pH range	4	all three measures indicate high productivity	
		3	only two measures indicate high productivity	
		2	one measure indicates high and other two measures indicate medium productivity	
		1	all three measures indicate medium productivity	
		0	all three measures indicate low productivity	
Reason(s)				
2	Species Composition , To know the extent of fish species diversity in Wular through the total fish caught per year collected from published and grey literature. The identified fish species will be again classified based on their trophic level value to know the contribution of each trophic level in the total catch of the Wular	4	All the fish trophic levels are in proportion and resemble a pyramidal structure (besides Omnivores, Herbivores and Detritivores, significant presence of mid-level carnivores and noticeable presence of high-level carnivores)	
		3	Significant presence (around 20%) of mid-level carnivores whereas high-level carnivores may or may not be present	
		2	Dominated by Omnivores, Herbivores and Detritivores which form above 90% of total catch and noticeable presence (at least 5%) of mid-level carnivores; absence of high-level carnivores	
		1	Dominated by Omnivores, Herbivores and Detritivores which form above 90% of total catch and negligible presence (less than 1%) of mid-level carnivores; absence of high-level carnivores	
		0	Only Omnivores, Herbivores and Detritivores form almost 100% of total catch	
Reason(s)				
3	Fish production	4	Increasing	Reason(s)
		3	Was decreasing now increasing	
		2	Fluctuating around mean	

		1	Was increasing now decreasing	
		0	Decreasing	
4	Recruitment variability	4	low <25%	
		3	medium = 25- <50%	
		2	high = 50- <75%	
		1	very high = 75- <100%	
		0	Extreme = >100%	
5	Ecological degradation: urban sewage, run off from agricultural fields, indiscriminate fishing practices etc. and their effect on the Wular Lake fishery	4	None	
		3	low	
		2	medium	
		1	high	
		0	very high	

6	Economy Craft and gear ownership	4	Almost everyone (about 95%) owns	
		3	Most of them (about 75%) own	
		2	Half of them own (about 50%)	
		1	Some owns (about 25%)	
		0	Almost no one (about 5%) owns	
7	Catch per unit	4	Increasing	
		3	Was decreasing now increasing	
		2	Constant/Stable	
		1	Was increasing now decreasing	
		0	Decreasing	
8	Price of fish : Increase in real unit price (inflation adjusted price) of fish sold at the first point of sale by fishers or DoF during the last 20 years	4	A great extent	
		3	A lot	
		2	Some extent	
		1	Very little	
		0	None	
9	Benefit sharing: To what extent the benefit sharing system between the holder of fishing rights and fishing units is equitable in terms of instituted benefit sharing	4	Much more (more than 50%)	
		3	More (within 50%)	
		2	The same/No change	
		1	Less (within 50%)	
		0	Much less (more than 50%)	

	arrangements and its field implementation is taken into account			
10	Subsidy: Are subsidies (including hidden) provided to support the fishery and fishers?	4	A great amount	
		3	A lot	
		2	Some	
		1	Very little	
		0	None	

11	Social Fisher population, The relation between the total number of active fishers and extent of area (in ha) available for them to support their livelihood(status of fishing pressure)	4	4.1 - 6 = optimum population	
		3	6.1 - 8 = somewhat under populated	
		2	2.1 - 4 = somewhat over populated	
		1	>8.1 = under populated	
		0	<2 = over populated	
12	Level of knowledge of Wular Lake fisher, about their local fishery resources, ecosystem, weather and fishing equipment (craft & gear)	4	Excellent	
		3	Good	
		2	Average	
		1	Poor	
		0	Very poor	
13	Education status	4	$\frac{3}{4}$ of the fishers have completed above 12 years of schooling	
		3	$\frac{3}{4}$ of the fishers have completed 9-12 years of schooling	
		2	$\frac{3}{4}$ of the fishers have completed 6-8 years [middle level] of schooling	
		1	$\frac{3}{4}$ of the fishers have completed 5 years of schooling	
		0	$\frac{3}{4}$ of the fishers have not completed 5 years [primary level] of schooling	
	Reason(s)			
14	Housing and civic amenities	4	Excellent	
		3	Good	
		2	Average	
		1	Poor	
		0	Very poor	
15	Conflicts	4	Highly cohesive & No conflicts both internal and external	

		3	Highly cohesive and no internal conflict but external conflict is there
		11 2	Somewhat cohesive and some degree of conflicts
		1	Less cohesive and lot of conflicts
		0	No cohesion and great deal of conflicts
	Reason(s)		

16	TECHNOLOGY Fishing craft , whether fishers have altered fishing craft to increase catching power/safety over past 25 years, also considers fishing capacity.	4	A great amount, rapid increase (tubes to motorized FRP)
		3	a lot (more than 50% FRP)
		2	Somewhat (at least 66% wooden)
		1	a little (at least 33% wooden)
		0	Not at all (Tubes/Catamarans)
	Reason(s)		
17	Fishing gear : To find whether fishers have altered gear to increase catching power/selectivity over past 25 years. It also considers whether a gear is active or passive, primitive or modern/specialized	4	A great amount
		3	A lot
		2	Some
		1	Very little
		0	None
18	Handling and processing: Does fishers use any handling (Handling = icing after fishing) methods (salting, boiling, freezing, ice storage	4	Always
		3	Great deal/most times
		2	A lot/often
		1	Some/Sometimes
		0	None/Never

	etc.) on board the vessel to preserve the fish or using live tank, sophisticated freezing			
19	On-board safety devices and trip length	4	Completely reliant on safety devices	
		3	Some reliance as only some of the recommended safety devices are used though trip length is higher(<6hrs.)Some reliance	
		2	Completely reliance on safety devices	
		1	Some reliance as only some of the recommended safety devices are used though trip length is higher(>6hrs.)Some reliance	
		0	Not used though necessary	
20	Infrastructure	4	Centralized and with all facilities	
		3	Centralized but only with some facilities	
		2	Centralized but without any facilities	
		1	Dispersed but with some facilities	
		0	Dispersed and without any facilities	

21	GOVERNANCE Access and use: Presence of comprehensive and effective leasing/licensing policy and regulatory framework for sustainable development of fisheries and fishers in Lakes	4	effective framework balancing all objectives
		3	predominantly development <production based> oriented
		2	predominantly welfare oriented
		1	predominantly revenue oriented
		0	No effective legal framework
	Reason(s)		
22	Willingness and participation, in planning as well as adopt various fisheries resource management	4	Almost Everyone (~95%) willing and participate
		3	Most (~75%) willing and participate
		2	Only Half (~50%) willing and participate
		1	Only Some (~25%) willing and participate

	measures including access and use rules / guidelines	0	Almost None (~ 5 %) willing and participate	
	Reason(s)			
23	Development programmes , Lake fisheries development programmes/ schemes like stock enhancement programmes (including functioning of fish seed production and rearing centres), cage/pen culture programmes, species/fishery-wise schemes, any other innovative schemes, etc.	4	Very good	
		3	Good	
		2	Average	
		1	Poor	
		0	Very Poor	
24	Institutional capacity and processes ,. Available human resources (adequacy & competency); transparency, equity and effective coordination with concerned agencies; functioning of fishers coop. societies; conflict resolution; etc.	4	Very good	
		3	Good	
		2	Average	
		1	Poor	
		0	Very Poor	
25	Research and Development (R&D) Support , Extent and quality of research based inputs from R&D, availability of reliable catch data / statistics	4	Very good	
		3	Good	
		2	Average	
		1	Poor	
		0	Very Poor	

Annexure 2 : Check List for Collection of Secondary Data and Discussion with Key Informants

Geography & Hydrography of the Lake (WULAR)

1. Locational aspects/details of lake – locational map, lake, dist., no. of villages on the periphery, etc.
2. Hydrographic features like capacity , depth / height, length, slope, catchment & command area, inflow and outflow dynamics, average rainfall
3. **Demographic details** of lake region: no. of villages, village wise population of fishers, general population and fishers population, caste / community composition, major fishing villages, Number of fishing/Non fishing households, importance of fishing in local economy
4. Historiography of lake: local history, changed /Diversified occupation, replacement of people / villages, rehabilitation, etc.

Production Aspects

5. Landing centre, fish production details from lake for as many years as per availability (if not possible then at least for few years)
6. Overall fish production of state?
7. Contribution of Wular lake production to total production.
8. What is the average fish production per year? Any fluctuations in last five or ten years?
9. When is the peak fishing period/season? No. of fishing days in a year?

Catch composition:

10. What are the species present and caught in the Wular Lake and their contribution to total catch?
11. What are the species captured in last 5 or 10 years and at present? Any new species found apart from shizothoracids, major and minor carps?
12. For which species demand is more? Why?
13. Total species wise catch details of lake for at least last five years

S.N.	Species / Group	Total Catch (Kg /year)	External Market Sale (Kg)	Local Market Sale (Kg)	Fish processing unit (kg)
1					
2					
	Total catch				

Fishing effort:

14. What type of gears used by fishers in this lake? Details – name of the gear, no and weight of gears, no of fishers using each gear type, approx. cost of gear/kg.
15. What type of crafts used for fishing? Mechanized or non-mechanized (tubes, boat or any other), no of boats and no of fishers using each boat type and approx. cost of boat types
16. How many no of fishers are staying in and around lake? Any migrant fishers staying on this lake and from which place each group belongs to?
17. How many no of members from your family involved in fishing? What is the average catch/person?
18. How many times you fish in a week or in a month? What is the average catch/trip? What time generally you go for fishing?
19. Any subsidy on the crafts and gears? From whom? What is the process?
20. Total gear / craft wise catch details of Lake for at least last five years

S.N.	Type of Craft	Total Catch (in Kg /year or in % terms)	Type of gear	Total Catch (in Kg /year or in % terms)
1			1 Cast net	
2			2	
3			3	
4			4	
	Total catch	100%	Total catch	100%

Stocking pattern:

21. Who is stocking the seed? i) DoF ii) Contractor iv) Other?
22. What is the source of seed? Purchasing from other state or district, at what price? Specie wise and category wise details, stocking size.
23. Is there any fish seed farm? If yes, details - area, No. of ponds, W.S.A., date of estb. Production capacity
24. How many stocking done within a year? One or two? Total seed required per year.
25. Stocking details of Lake during last five or ten years.
26. Any fluctuation in fish caught in last year and this year? What are the reasons for fluctuations?

27. How many landing centres present around the periphery of Lake? Any demarcation of Lake made for fishing?

28. Does anybody monitor stocking of seed or does seed stocked in fishers / anyone's presence?

Leasing / licensing policy / regulations, procedures & practices

29. Institutional Framework: Owner Agency: Irrigation Dept. /

30. Which type of management practice is followed? Either it is leasing / licensing / sharing system?

31. Leasing/licensing Agency & authority for fisheries: DOF / Any other (Organizational chart)?

32. Since when the lake is under lease for fisheries?

33. Did the leasing system change over years? How?

34. Details of lease / license / sharing system

35. If licensed, then, what is the license fee (per person) / gear wise / craft wise

36. Are the fishers fishing in a group or individually?

37. Details of Co-operative Societies:

S.N.	Name of the Co-operative society	No. of villages	Total fisher population	No. of active members	Establishment date
1					
2					

38. How many of the fishers fishing in the lake belong to co-operative societies?

39. Why some are members and some are not members?

Roles and responsibilities of DoF/WUCMA, Co-operatives, fishers and other institutions:

40. What are the detailed terms and conditions governing lease or licensing?

41. What is the role and function of DOF / WUCMA / NGO

42. What is the role / responsibilities and function of a Co-operative society?

43. What are the rights and responsibilities of individual fisher (member & non-member)?

Fishing Arrangements:

44. Harvesting system (wage system / owner-operator fishing / any other..?)

Fish Species	Schizothoracids	Local Major	Local Minor	Others
Wages/Kg				

45. Is wage is provided on the basis of large/small size of fish or on total catch?

46. In case of licensing, do the fishers sell their catches directly in the market or through any contractor?

47. Or Fishers sell their catches illegally in the market without coming to the landing centre?

Marketing arrangement:

48. What is the total amount fish sold in the market?

49. How much of the fish (% of total catch) is locally consumed by fishers?

50. How much of the total catch is sold in the market (local & outside)?

51. How much of the total catch is used in fish processing plant?

52. List /name of fish market nearby village.

53. List major Marketing channels including % of total catch being sold in that channel.

54. How fishers sell their catch

	Yes/no	At what price
Community		
Co-operative society		
Local market		

Benefit sharing arrangement: (by cooperatives)

55. Is there any monetary benefit shared by the cooperatives to the fishers?
Yes/No, if yes, then, what % of Profit is shared with the fishers?

56. Is there any non-monetary benefit shared by the co-opetatives? Yes/No, If yes, then what are these (Transportation facilities for marketing/Health service/education or all)?

Welfare measures:

57. General availability of DoF scheme and programs of DOF/ Others?

- I. Any welfare scheme (yes/no)
- II. Craft and gear subsidy (yes/no)
- III. Accident insurance (yes/no)
- IV. Saving cum relief scheme (yes/no)
- V. Fishers housing scheme (yes/no)
- VI. Other scheme /state package. (yes/no)
- VII. Schemes for willow plantation

58. Whether the DoF programs are being made available to fishers here?

59. What % of fishers are getting benefit from the DoF programs?

Conflict resolution mechanisms:

60. Is there any conflict among the cooperatives? Yes/No, if Yes, then what is it & how it is managed?

61. Is there any conflict among the fishers fishing in different stretches of Lake or in different sector of Lake? Yes/No, if yes, then what is the reason?

62. Are there any conflict among fishers and DoF? Or Fishers & Contractors/Marketing agents? Or among fishers and farmers downstream i.e. water for fisheries and water for irrigation?

63. Are there any legal / litigations pending / filed in courts of law among stakeholders in the lake

64. How the overall management is carried out by the DoF/ NGO/WUCMA

Monitoring arrangements:

65. Is mesh size regulation is followed or not? If Yes, then it is followed for all fishes or for few important fishes?

66. What is the average size of fish to be caught?

67. Is closed season followed or not? Yes/No. If Yes, then

a) Period of close season (days)

b) Close season activity

c) Any support during ban period to fishers? Is it providing rice, oil, money etc.?

68. How many nets & how many fishers operate per day (Average)?

69. What is the particular time for fishing in a day? What are the reasons in that?

70. If they do not comply with the regulations, why not?

71. Has community/co-operative society made its own rule and regulations?

72. If yes, what are the important ones related to functioning of co-op, fishing in Lake, etc?

73. What are the problems faced by fishers in terms of overall management of Lake, in co-operatives, fishing and fisheries, etc.?

Graduated sanctions (regulation) / DO's & DON'Ts:

74. Is there any other conservation method followed by DoF/ others?

Ban season

Details about trapa / lotus stem (nadroo)

75. Who are involved in trapa , nadroo, capture?

76. How does it affect the existing fishing/ production?

77. What is relationship between trapa, nadoo and fish production?

78. Economic aspects / average production / ?

79. Leasing / licencing period/ fee?

Presence and role of Church / Temple / NGOs / political parties / caste organisations

Overall Socio-economic condition: Road connectivity and conditions; nearest town; general living standards in the village as seen from over all housing conditions, drinking water facility, sanitation, etc.

Institutional Development and Capacity Building

Supplementary Information:

Annexure 3: Fishing villages around Wular Lake

SI.No.	Beat	Fishing Villages around Wular Lake	SI.No.	Beat	Fishing Villages around Wular Lake	
1	Laherwalpora	Laherwalpora	31	Zurimanz	Shilvat	
2		Aaloosa	32		SK Payeen	
3	Ajas	Aishtangoo	33	Sumbal	Sumbal	
4		Badyari	34		Tengapora	
5		Kanbatti	35		Trigam	
6		Kanilbagh	36		Wangipora	
7		Kanker Mohalla	37		Waskura	
8		Kehnoosa	38		Zalwan	Nathpora
9		Kema	39			Banyari
10		Khudlab	40	Garoor		
11		Nussu Ghat	41	Kulhama	Kulhama	
12		Paribal	42		Lankreshipora	
13		Zurimanz	Zurimanz		43	Naidhal
14			Bakrapora		44	Nusoo Ghat
15	Bathibal		45		Watalpora	
16	Batagund		46		Sopore	Watlab Ghat
17	Chringapora		47	Haritar		
18	Gulamwari		48	Okhan pora		
19	Naidkhi			Nigle bala		
20	Gulamwari		49	Seer		
21	Hajin		50	Maharajpora		
22	Jadalpora		51	Muslim Peer		
23	Kanyari	52	Teliyan			
24	Kathpora	53	Kraltang			
25	Khanamoh Bhar.	54	Pathiabal			
26	Mukdamyari	55	Hatisha			
27	Nainar Sumbal	56	Ningli Payaan			
28	Nainara	57	Sher Colony			
29	Sadunaara	58	Kulhama	Chan khand		
30	Shadipora	59		Dachigam		
		Shahgund	60			

(Note: Villages from 51 to 59 belong to Sopore town, and Dachigam falls in River village)

Annexure 4: Drivers and Buffers separately for Wular villages and for 138 villages which fall in 5 Blocks of 3 tehsils of Bandipora and Baramullah district.

Block	Bandipore	Hajan	Sumbal	Zaingeer	Sopore	Only Wular Villages	
DRIVERS	HIGH S	HIGH S	HIGH S	HIGH S	HIGH S	HIGH S	
	SMF=0.98	SMF=0.85	SMF=0.85	SMF=0.76	SMF=0.76	SMF=0.87	
	PD=0.96	PD=0.90	PD=0.89	PD=0.89	PD=0.87	PD=0.92	
	NSA=0.65	NSA=0.73	NSA=0.74	NSA=0.77	NSA=0.76	NSA=0.71	
	DNT=0.58	DNT=0.58	DNT=0.58	DNT=0.79	DNT=0.57	DNT=0.62	
	DNH=0.61	DNH=0.65	DNH=0.70	DNH=0.63	DNH=0.57	DNH=0.62	
	DNR=0	DNR=0	DNR=0	DNR=0	DNR=0	DNR=0	
	LOW AC	LOW AC	LOW AC	LOW AC	LOW AC	LOW AC	
	PGR=0.09	PGR=0.03	PGR=0.10	PGR=0.09	PGR=0.26	PGR=0.10	
	GR=0.32	GR=0.37	GR =0.33	GR=0.40	GR =0.45	G R =0.34	
	ES=0.55	ES=0.40	ES=0.37	ES=0.60	ES=0.58	ES=0.46	
	HA=0.40	HA=0.45	HA=0.44	HA=0.49	HA=0.51	HA=0.44	
	HC=0.35	HC=0.38	HC=0.35	HC=0.43	HC=0.44	HC=0.38	
	T C=0.09	T C=0.12	T C=0.11	T C=0.13	T C=0.17	T C=0.12	
	EDR=0.60	EDR=0.76	EDR=0.73	EDR=0.41	EDR=0.49	EDR=0.69	
	AM=0.36	AM=0.12	AM=0.18	AM=0.13	AM=0.23	AM=0.16	
	LP=0.10	LP=0.09	LP=0.16	LP=0.11	LP=0.07	LP=0.13	
	BUFFERS	LOW S	LOW S	LOW S	LOW S	LOW S	LOW S
		AL=0.32	AL=0.24	AL=0.14	AL=0.32	AL=0.24	AL=0.22
FP=0.09		FP=0.12	FP=0.05	FP=0.01	FP=0.10	FP=0.46	
FSM= 0.1		FSM=0.1	FSM=0.1	FSM=0.11	FSM=0.11	FSM=0.10	
SC/ST=0.24		SC/ST=0	SC/ST=0.01	SC/ST=0.00	SC/ST=0	SC/ST=0.03	
AR=0.18		AR=0.18	AR=0.34	AR=0.34	AR=0.34	AR=0.21	
HIGH AC		HIGH AC	HIGH AC	HIGH AC	HIGH AC	HIGH AC	
CI=0.83		CI=0.81	CI=0.85	CI=0.88	CI=0.85	CI=0.90	
NIA=0.68		NIA=0.71	NIA=0.87	NIA=0.51	NIA=0.58	NIA=0.69	
GD =0		GD=0	GD =0	GD = 1	G D =1	GD = 0.17	

(Note: S stands for Sensitivity and AC stands for Adaptive Capacity)

Annexure 5: Data sources for few indicators used in SEVI framework

Parameters	Direction	URL
Demographic parameters (Census of India, 2011)	Home / 2011 Census Data/ Population Enumeration Data (Final Population)/ Primary Census Abstract Data Tables (India & States/UTs - Town/Village/Ward Level)/select district.	
HH amenities and assests. (Census of India, 2011)	Home / Houselisting and Housing Census Data – 2011/Percentage of Households to Total Households by Amenities and Assets (India & States/UTs - Village and Ward Level)/ select state then district.	
Community infrastructure (Census of India, 2011)	Home / District Census HandBook/ Select state then district/ inset tables/ largest size file.	
Food sufficiency/ malnutrition	NFHS-4(15-16)/Publications/ district fact sheet.	
Livestock data (2011-12)	State/livestock census/ animal-bird/filter /tehsil/village wise	https://farmer.gov.in/livestockcensus.aspx?SCode=07
Agriculture census data (2011-12)	Agricultural census , 2010-11 Table : number and area of holding by size group State : jammu & kashmir District : baramulla / bandipora Tehsil : select Social group : all social groups Gender : total	http://agcensus.dacnet.nic.in/TL/TehsilT1table2.aspx
Food sufficiency/ malnutrition (2015-16)	NFHS/ 2015-2016/ Publication/ district fact sheet/page no. 3/Children under 5 years who are underweight (weight-for-age) / Rural	http://rchiips.org/NFHS/FCTS/JK/JK_Factsheet_9_Bandipore.pdf http://rchiips.org/NFHS/FCTS/JK/JK_Factsheet_8_Baramula.pdf
Stage of Ground water development in % (2012-13)	CGWB, 2012-13/ Table given at end	Pdf Dynamics of ground water resource

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