

**IDENTIFICATION OF ECOSYSTEM SERVICES AND POTENTIAL THREATS OF
PONG RAMSAR SITE**

THESIS

Submitted To The

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Master of Science in Environment Management

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M.Sc. Environment Management

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DECLARATION

This is to certify that the thesis entitled “Identification of ecosystem services and potential threats of Pong Ramsar site”, was submitted to Forest Research Institute (Deemed to be) University, Dehradun for the fulfilment of the award of the degree of M.Sc. (Environment Management) is a record of my original piece of work carried out in Pong Dam under the guidance of Dr. Anvita Pandey, Co-ordinator at Centre for Ecology Development and Research (CEDAR) Himalaya and co-supervision of Dr. Anugrah Tripathi , Senior Technical Officer at Indian Council of Forestry Research and Education (ICFRE). No part of this work has been submitted for the award of any degree or diploma whatsoever.

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He bears very good moral character and is sincere and hardworking; I wish him success in all endeavors.

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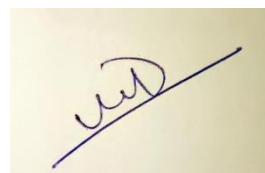
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A handwritten signature in blue ink on a light-colored background. The signature is stylized and appears to read 'Vedant Hanwat'.

(Vedant Hanwat)

ABSTRACT

Ecosystem services play a vital role in improving people's livelihoods, the environment, and the economy. These are the benefits that the ecosystem provides to us as humans thus making our lives majorly dependent on them. As stated by the Millennium Ecosystem Assessment these services are classified into four main categories: Regulatory services, Supporting services, Cultural services, and Provisional services. One of the biggest provisioners of these ecosystem services is "Wetlands".

Wetlands are among the most productive environments in the world and are critical for supporting human livelihoods. They account for 40.6% of the total global ecosystem services (ES).

The focus of this study is on one such wetland in India, located at a high altitude and also a wildlife sanctuary in the Himalayas, that is Pong Dam. Its name is on the list of Ramsar sites, and its developmental operations have grown quickly. Nearby communities have benefitted more from this site as they have direct access to resources and other essential ecosystem services.

However, the destruction of the site's ecosystem landscape is lately instigated by the change of forest cover into built-up areas and the need for urbanization. Due to changes in human activities around Pong Dam, it is exposed to threats that are lethal at present like reduction in fish species, flash floods, illegal grazing, habitat destruction, and water quality fluctuations. Hence, this study makes an effort to identify the ecosystem services provided by Pong, key driving factors of the threats to the site, examine their effects on different ecosystem services and also provide strategies to control the threats.

The outcome of this study could be a reference for decision-makers, planners, and administrators in formulating a suitable action plan and adopting relevant management and conservation practices to improve the overall status of the region.

Key Words: Wetlands, Eco-system, Ecosystem Services, Pong Dam, Ramsar

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CHAPTER 1: INTRODUCTION

Pong Dam, a water storage reservoir built in 1975 on the Beas River in the low foothills of the Indo-Gangetic plains known as Maharana Pratap Sagar, is a well-known wildlife sanctuary and wetland zone of the Shiwalik hills. Pong Dam is a wetland that provides various ecosystem services, which are essential for human survival and include the advantages humans receive from the ecosystem.



Figure 1 : Pong dam

These services are the most important products of an ecosystem because it contains components that are critical for human life and development, and it frequently plays a significant role in rural culture (Arico *et al.*, 2005).

Nearby communities benefit more from ecosystem services in a wetland setting because they have direct access to resources and services. These services have been identified and listed for decades or centuries, thus formally classifying them has become necessary. It benefits the wetland from both an economic and ecological standpoint. According to the Millennium Ecosystem Assessment report (MA, 2005), Provisioning services, regulating services, sustaining services, and cultural services are the four kinds of ecosystem services. Provisioning services include basic essentials such as food, water, fibre, and fuel, while regulating services include hydrology, climate, and water purification. In addition to the recreational aspect, cultural offerings provide a whole other layer of spirituality and aesthetic.

Soil formation and nitrogen cycling are among the variables that support services. These services are analyzed as a whole to classify the services obtained and used by communities since they provide a comprehensive view of how to plan and strategize things on a larger scale. Because of its unique biodiversity and environmental services, the Western Himalayas is an important region.

The goal of the research is to figure out how Pong Dam, a high-altitude wetland and wildlife sanctuary in Himachal Pradesh, affects vital ecosystem services. Continuous and rapid urban expansion, as well as the conversion of forest cover into the barren land, pose serious challenges to the ecological landscape and ecosystem functions (Das and Das, 2019). In a wetland setting like the Pong Dam, it's especially important to categorize these changes qualitatively because the region is undergoing rapid changes since its designation as a Ramsar site. As a result, land use and land cover change have become key tools for identifying and determining long-term changes. Changes in land cover had an impact on neighboring communities' reliance. Changes in land cover have an impact on the surrounding communities' reliance on ecosystem services, either directly or indirectly. Determining decadal changes in land use patterns bolsters the case for haphazard growth in the surrounding areas, which alters ecosystem services both geographically and temporally.

Pong Dam is unique in that it is both a wetland and a wildlife sanctuary, making it unlike any other wetland in India. The population's reliance on the environment is also significantly different. It was different before the forest department and wildlife sanctuary was established, and then the services changed once they were established. The wetland has changed dramatically since the sanctuary was established. Locals were forbidden to extract services from the sanctuary, which was originally their forest, as development occurred in and around the dam. Some villages within the catchment region are still totally or partially reliant on the sanctuary for ecosystem services such as food and fuel wood. The identification and variations within ecosystem services were observed using participatory rural appraisal (PRA) methods. To avoid the Forest Department's penalties, some members of the local community travel to the sanctuary at strange hours and take fodder. This had an influence on their livelihood, and some of them were forced to seek a few sources of fodder and fuel wood. The changes that occurred after the Pong was designated as a Ramsar site were fairly dramatic. Infrastructure development, such as road construction, caused a severe challenge in the form of soil erosion from the surrounding slope, which destroyed parts of the agricultural fields

closer to the wetland, with the silt eventually being absorbed by the wetland's basin. The wetland works as a barrier, preventing sediment from entering the Beas River's catchment.

The methodology requires the identification of relevant stakeholders, i.e. all persons, groups, and institutions willing to participate in the process of upgrading Pong Dam governance, which is important for this study. To save the site from Land use land cover deterioration and to understand the strategies for conservation of wetland we first need to understand the Instructional arrangements around the wetland and their management strategies. A stakeholder study should be conducted before developing and implementing the Wetland Rules in the Reserve area. The contract should be designed by stakeholders representing (1) governmental authorities, (2) knowledge providers, (3) civil society, and (4) the economic sector in order to ensure proper governance of the Wetland Restrictions implementation. This framework ensures that the principles of territorial consultation are upheld at every stage and throughout the final agreement, including the formulation of objectives, content, and justifications for its activities (Bravard, 2016).

CHAPTER 2: OBJECTIVES

This study aims to acknowledge how Pong Dam affects vital ecosystem services in accordance with the threat exposed due to the exploitation of these resources. Its goal is to comprehend the management practices undertaken and attempt to come up with conservational strategies that will provide concrete means to manage the future sustainably. The study is proposed with the following objectives:

1. To identify Ecosystem services provided by the Pong reservoir.
2. Identification of threats in Pong Dam and strategies to reduce its impact.
3. Understanding institutional arrangements and management strategies for conservation & sustainability of Pong Dam.

CHAPTER 3: REVIEW OF LITERATURE

3.1 Types of ecosystem services in wetlands and the importance of their identification

Wetlands are one of the world's most productive ecosystems. Although the usefulness of wetlands for fish and animal conservation has been known for a century, some of the other benefits have only lately been discovered, as outlined in Mitsch and Gosselink, 2015 and earlier editions: Because they operate as downstream recipients of water and waste from both natural and human sources, wetlands are sometimes referred to as the landscape's kidneys. They help to stabilize the water supply, reducing the risk of flooding and drought. It has been discovered that they can clean polluted rivers, safeguard shorelines, and recharge groundwater aquifers. Because of the wide food chain and diverse biodiversity that they support, wetlands have been dubbed "nature's supermarkets." They are important in the landscape because they provide unique habitats for a diverse range of flora and fauna. Some are describing wetlands as key carbon sinks and climate stabilizers on a global scale now that we are concerned about the health of our entire planet.

In ecosystem service assessments, wetlands are still considered as the most valuable aspects of our landscape (Costanza *et al.* 1997, 2014; Mitsch & Gosselink 2000; De Groot *et al.* 2012; McInnes 2013). Using ecological unit estimators, Costanza *et al.* (1997) found that wetlands, particularly inland swamps and floodplains, were significantly more valued than lakes and rivers, forests, and grasslands (Table 1).

Table 1. Comparison of unit values of selected ecosystems

Ecosystem	1997 estimate unit (US\$ ha ⁻¹ yr ⁻¹)	2011 estimate unit value (US\$ ha ⁻¹ yr ⁻¹)
Estuaries	31,509	28,916
Inland swamps/floodplains	27,021	25,681
Tidal marshes/mangroves	13,786	1,93,843
Lakes/rivers	11,727	12,512
Forests	1338	3800

Table 1. Comparison of unit values of selected ecosystems

Ecosystem	1997 estimate unit (US\$ ha ⁻¹ yr ⁻¹) ¹⁾	2011 estimate unit value (US\$ ha ⁻¹ yr ⁻¹)
Grasslands	321	4166

Data sources: 2011 estimates are from Costanza et al. (2014); 1997 estimates are from Costanza et al. (1997), but revised to 2007 US\$

In the 1997 study, only coastal estuaries had greater unit values than inland and coastal wetlands. Costanza *et al.* (2014) reassessed the 1997 paper's computations, using updated unit values from De Groot et al (2012). Table 1's last column lists the new unit values for chosen ecosystems. The inland swamps/floodplains unit value remained mostly unchanged from the 1997 article, whereas the tidal marsh/mangroves unit value grew 14-fold, owing to "new studies of the storm protection, erosion protection, and waste treatment values" of these coastal wetlands (Costanza *et al.* 2014).

The ecosystem services provided by wetlands can be classified in a variety of ways. The Mitsch and Gosselink (2015) textbook classified wetland values into three stages of biological hierarchy over the first 21 years: population, ecosystem, and global. Providing habitat for animals taken for pelts, water birds and other hunted and got to watch birds, fish, and shellfish harvesting, timber and peat harvesting, and support of rare and threatened species are all examples of population values. To improve water quality, alleviate storm and flood damage, recharge aquifers, and even maintain human cultures, the complete wetland ecosystem is required, not just a few species of plants, animals, or bacteria, is required. Maintaining water and air quality effects on a much larger scale than the ecosystem level, especially in regional and global nitrogen, sulphur, and carbon cycles, are examples of global values.

With the publication of the Millennium Ecosystem Assessment (2005), an alternate category for ecosystem services emerged, with provisioning, regulating, cultural & supporting.

- 1) **Provisioning** ecosystem services includes food, water, timber, fibre, and genetic resources derived from ecosystems.

- 2) Air quality management, climate regulation, water purification, disease regulation, insect regulation, pollination, and natural hazard regulation are all examples of ecosystem services that are **regulated**.
- 3) **Cultural** ecosystem services include spiritual enhancement, recreation, tourism, aesthetics, institutional education, encouragement, and cultural heritage benefits that people gain from ecosystems.
- 4) **Supporting** ecosystem services include fundamental ecological processes such as nitrogen cycling and primary productivity, which can lead to the other three services mentioned above.

Table 2 provides a summary of many of the ecosystem services offered by wetlands, based on the Millennium Ecosystem Assessment (2005) categories. Several of these wetlands' ecological services are discussed further in-depth in this paper in this special issue.

Table 2. Ecosystem services of wetlands

Provisioning services	Regulating services	Cultural services	Supporting services
Fisheries support	Water quality improvement	Landscape aesthetics	Functions like hydric soil development
Peat production for fuel and horticulture	River flooding mitigation	Sites for human relaxation	Primary productivity
Furbearer and other animal harvesting	Protection of coastlines from tsunamis, cyclones, and other coastal storm surges	Ecology education	Serving as chemical sources
Timber production	Carbon sequestration	Sustenance of human cultures	Carbon sink and other sinks, transformers
Direct food production	Habitat for rare and endangered species	Ecotourism, bird-watching	Water storage

Ecosystem services of wetlands based on the Millennium Ecosystem Assessment (2005) categories.

3.2 Deterioration of ecosystem services due to Threats of present and future

Few life survival components, such as ecosystem services, must be protected in order to continue to exist on our planet. These ecosystem services are particularly essential in the Himalayan landscape since their loss indicates general ecosystem degradation. The loss of ecosystem services is frequently noted as a result of recent rapid urbanization and a reduction in forest cover (Singh, 2007).

According to a study conducted in the Western Himalaya, the Himalayan mountains have suffered adverse consequences of deforestation, encroachment of agricultural fields, and soil erosion as a result of population growth (Ma, Maohua, et al, 2012). In the states of Himachal Pradesh and Uttarakhand, this is occurring on a big scale. The increase of built-up land that replaces other forms of land is mostly to blame for the reduction in ecological services. The functioning of an ecosystem is degraded when land use types change frequently (Hu *et al.*, 2019). This has a direct impact on the livelihood of those who are involved.

According to another study, changes in land use and land cover have a direct impact on ecosystem services since they alter the ecosystem's structure and functions (Yuan *et al.*, 2019). At a local level, the repercussions of land cover change for ecological services and human well-being have received very little consideration (Reyers *et al.*, 2009). For socioeconomic growth and ecological conservation, quantifying land-use change and its impact on ecosystem services is critical (Grenyer *et al.*, 2009). The decrease in a particular class indicates that people are no longer able to use an ecological service to which they previously had access.

Wetland ecosystems are particularly vulnerable to changes in land use and land cover, which can affect overall service quality and offer a greater risk due to the promotion of regional development (Valdez, et al, 2016). In the case of Renuka Wetland, the scenario is nearly comparable. Because of its recent popularity, the site has grown sensitive to anthropogenic alterations and activities occurring close the wetland's and sanctuary's edges.

However, the current problem is to transition from a conceptual to an operational framework. The literature on the effects of land-use change on ecosystem services is only now emerging, yet it is already outdated within a wetland system (Raudsepp-hearne, et al, 2010). Due to natural or human-induced changes in the ecosystem, ecosystem services vary both geographically and temporally (Grenyer *et al.*, 2009). The low availability of data on the

distribution of services near a lake habitat is a major obstacle to overcome (Anderson, et.al, 2011).

Direct drivers such as land-use change produce changes in the ecosystem and its services, which are influenced by indirect drivers such as demographic, economic, and cultural changes (Sharma and Sharma, 2019). It is a significant factor that affects an ecosystem's hydrology. The hydrological cycle is mainly influenced by an inland wetland, while the hydrological cycle is influenced by the wetland (MA, 2005).

Based on these sources, it is obvious that land-use change has a direct impact on ecosystem services, which has to be examined and analyzed further in the context of Pong Dam.

3.3 Role of Institutional arrangements and management strategies for conservation of wetland.

The manipulation of an ecosystem to ensure the preservation of all functions and characteristics of a certain wetland type is known as management. When a wetland ecosystem is lost or damaged, it usually means irreparable loss of both significant environmental functions and amenities that are useful to society (Zentner, 1988). To restore and safeguard the physical, chemical, and biological integrity of wetland ecosystems, appropriate management and restoration techniques must be applied. From a biological and hydrological standpoint, a full examination of wetland management and socio-economic ramifications is essential in this environment.

Human activities (changing land use in the watershed area, pollution from point and non-point sources, soil compaction, loss of interconnectivity, solid waste dumping, and so on) create environmental pressures on wetlands, affecting their natural functions. Protecting and preserving their functions is extremely difficult, as it necessitates forming partnerships among various agencies, coordinating efforts, and focusing on the common goal of minimizing human-induced changes that affect the hydrology, biogeochemical fluxes, and water quality of these lakes. Wetland issues in India may be characterized as follows:

- Hydrologic changes, such as changes in the hydrologic structure and function of a wetland due to direct surface drainage, de-watering due to consumptive use of surface water inputs, and unregulated removal of unconfined aquifers for different human activities.

- Increased sedimentation, nutrients, organic matter, metals, pathogens, and other water pollutant loading from both storm-water runoff and wastewater discharges (non-point source) (point source).
- Pollution is deposited in these lakes mostly from traffic and industrial pollution from both within cities and from suburban industrial complexes.
- Introduction or change in distinctive wetland flora and fauna (exotic) as a result of changes in neighboring land uses, which modify the water quality intentionally or naturally, and so on.

Wetlands in India have been overexploited, since they have been used to dispose of untreated sewage, runoff from urban and agricultural regions, changing land use within the watershed, and so on. All of these haphazard, short-sighted manmade actions have put the ecosystem's integrity in jeopardy. Polluted water has also resulted in the spawning of mosquitos in the absence of predators such as *Gambusia affinis* and killifishes (*Fundulus spp.*) that prey on mosquito larvae (Buchsbaum,1994). It has been suggested that rather than draining wetlands, an Integrated Pest Management technique using bio-regulation may be used to manage mosquitoes.

A wetland management program often entails efforts to preserve, restore, modify, and provide for functions and values, with a focus on both quality and acreage, while promoting their long-term use (Walters, 1986). Wetland ecosystem management necessitates close monitoring and increased interaction and collaboration among various agencies, including state departments responsible for the environment, soil, agriculture, forestry, urban planning and development, and natural resource management; public interest groups; citizen groups; research institutions; and policymakers.

Such management objectives should include not just protecting wetlands from direct human pressures that might compromise their normal functioning, but also preserving vital natural processes that may be harmed by human activity. Wetland management must be a holistic strategy in terms of planning, implementation, and monitoring, needing professional knowledge in a variety of fields such as ecology, hydrology, economics, watershed management, and local expertise, as well as people, planners, and decision-makers. All of this would aid in a better understanding of wetlands and the development of more extensive and long-term management and conservation plans.

CHAPTER 4: MATERIALS AND METHODS

4.1 STUDY AREA :

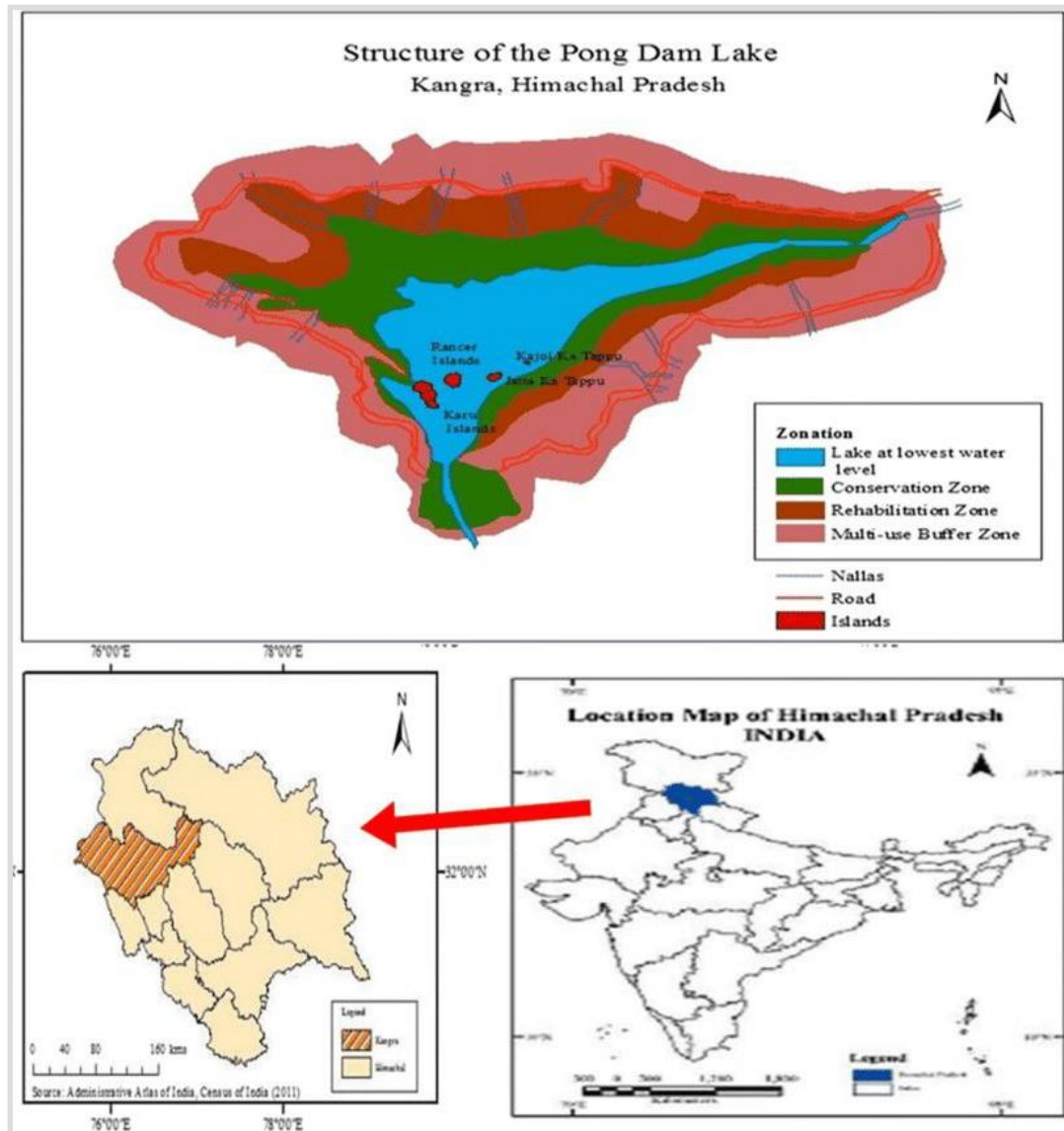


Figure 2: Location of Pong

The Pong Dam wetland also called as Maharana Pratap Sagar reservoir was built as an earthen management dam across the river Beas at a site called pong. The Pong Dam reservoir has a catchment area of 12,562 km² that spans the Kangra, Mandi, and Kullu districts. It is the largest man-made wetland in northern India, with latitudes of 31° 80' to 32.7° 26' n and longitudes of 75° 80' to 76° 25' e, with an altitude of 335 to 435 m msl. It is located in the Kangra district of Himachal Pradesh, and covers an area of roughly 307 km² (fig. 2). It measures 42 kilometers in length and 19 kilometres in width.

The water level drops to roughly 384 m msl during the summers, and the area varies seasonally. Outflows range from 8215 to 15,334 million m³ and are highest in July and lowest in February. To prioritise conservation efforts, the wetland has been separated into three zones (fig. 1). In 1994, the wetland was designated as a national importance site, and in 2002, it was added to the Ramsar convention's list of wetlands of international importance. It is the first significant wetland in the trans-Himalayan zone to provide a transient resting area for migratory water birds (Dhadwal, 2011).

According to the 2015 summer bird census, the pong dam wetland is home to 423 bird species, 18 snake species, 90 butterfly species, 24 animal species, and 27 avian species (Malik, 2017). The area's subtropical environment supports a diverse range of flora and wildlife. The average annual rainfall is approximately 1780 mm. *Acacia* (*Acacia* sp., *Acacia latifolia*), mango (*Mangifera indica*), mulberry (*Morus alba*), and gooseberry (*Morus alba*) are the most common tree species (*Embilica officialis*). While the wetland supports a diverse range of floral species, the forest surrounding the reservoir supports a diverse range of animals and reptiles.

4.2 METHODOLOGY

The study conducted in the Pong lake of Himachal Pradesh. The study is based on mixed-method research in which qualitative data and questionnaire is used and analysed. The mixed-method approach used is based on the dual design in which questionnaire, qualitative data were analysed and interpreted.

For identification of Ecosystem services and anthropogenic pressure on the pong dam following methods were followed:

A) Population and Study Sample

Research was conducted in the villages which are within the catchment of Pong Lake. For this, a buffer area consisting of a sanctuary area and villages that are surrounded near the Pong wetland was considered. The target population was the community from villages and tourists which are indirectly or directly associated with Pong Lake.

B) Sources of Data:

1. Primary Data

The data was obtained through Questionnaire exercises which was Google form based and 50 responses were recorded.

2. Secondary Data

The data was obtained from Research papers, articles, and reports. Based on the 4 types of ecosystem services categories (provisioning, regulating, cultural, and supporting) that were found through secondary literature review, focused group discussions were conducted with the community.

CHAPTER 5: RESULTS AND DISCUSSION

5.1 Identification of Ecosystem services

Pong wetland offers a number of ecosystem services mainly provisioning services (water for hydropower generation, water for downstream irrigation, drawdown area for agriculture and grazing, fish), regulatory services (flood buffer, climate regulation), cultural services (tourism, spiritual significance, education and research) and supporting services (habitat for myriad species).

5.1.1 Provisioning services

Water for Generation of hydropower

Hydropower generation of nearly 15000 million kWh is achieved by releasing the water through turbines before it is diverted to the irrigation fields in the downstream areas.

Water for irrigation to downstream areas and the drawdown areas

Active storage capacity of the reservoir is 7290 MCM. Pong dam stored water is primarily used for meeting irrigation water demands for which a total of 7913 MCM is released annually to irrigate 1.6 Mha of land. The major crops cultivated in the entire catchment are rice, wheat, maize and cotton. The local people have been cultivating the drawdown area since the inception of this pong lake as soon as water recedes. They not only earn their livelihood by doing so, but they also provide food to the migratory birds. The migratory birds also help the farmers in many ways such as manuring the fields by their excreta, yielding the double or triple production when the succulents of the wheat, gram are eaten and then sprouting them twice or thrice.

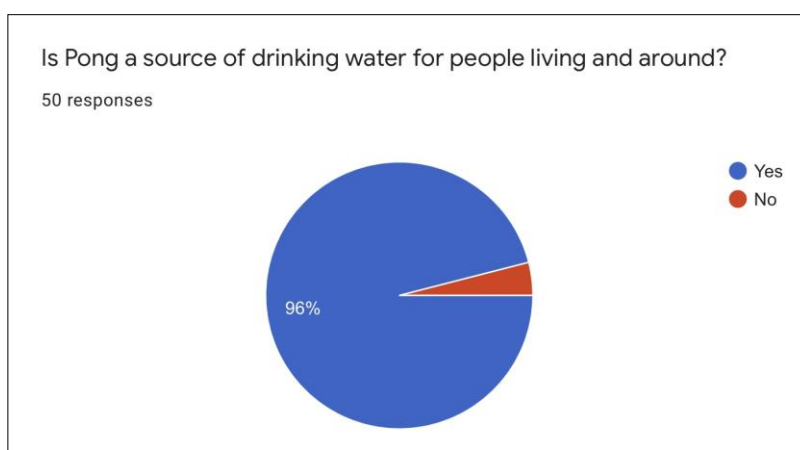


Figure 3: Percentage of People using Pong Dam's water for drinking purpose as ecosystem service

Food and fodder for grazing



Figure 4: A large number of cattle graze in the drawdown area

The draw down area of the Pong reservoir is used by the nomadic grazers and Gujjars mostly during the month of April to July every year. People from other areas have left many stray cattle in the fringe area. More than 20000 cattle including cows, buffaloes, horses, sheep, goat etc. and about 6000 of nomad's graze in the wetland area after March in the drawdown area. It is estimated that the quantity of grass consumed through cattle grazing per farm from the wetland area in summer and winter was 312 kg and 274 kg respectively (Pathania and Kumar 2017).

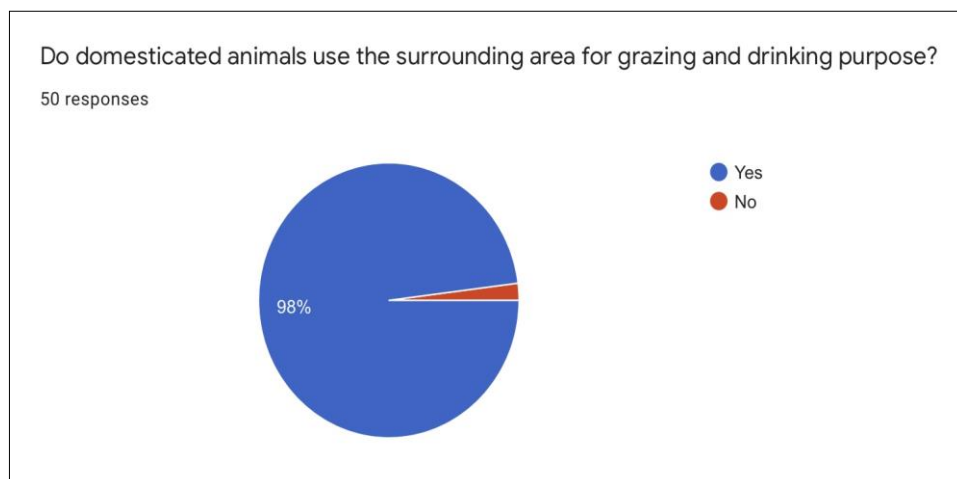


Figure 5: % of respondents who agree that communities living close to Pong dam reservoir are allowed to graze their domesticated animals around Pong

Fish

Commercial fishing and breeding

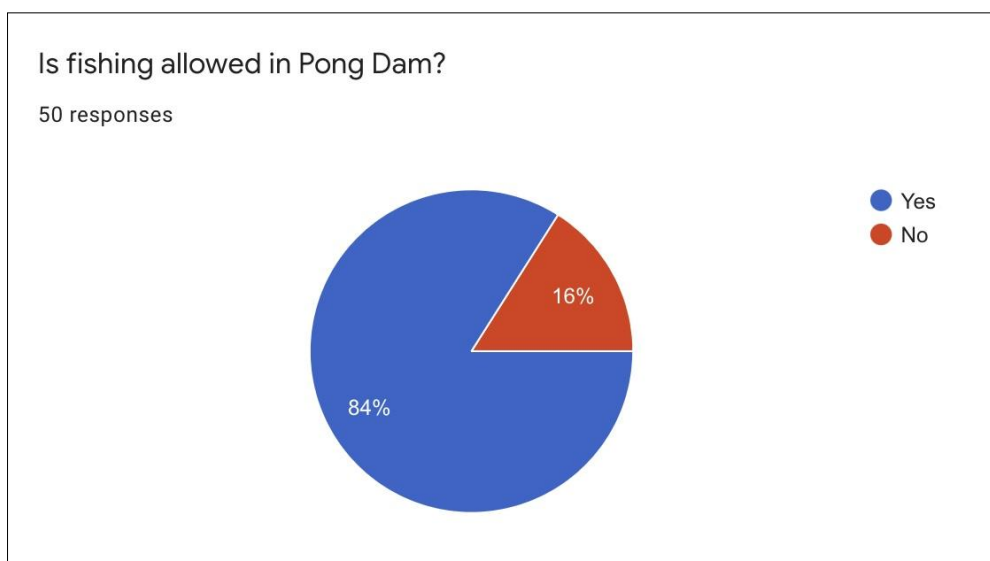


Figure 6: % of people who agree that fishing is allowed in Pong and operates with 15 fishing cooperative societies

CIFRI has conducted a detailed assessment on fisheries resources of Pong. Fishing which is done commercially in 15 landing centers by the cooperative societies covering all the course of the reservoir. The fish landing was comparatively higher in Dehra, Nagrota Suriyan, Katihar, Haripur, and Barnali landing centers among the 15 landing centers. The majority of the fish catch was contributed by the catfish *Sperata seenghala* in all the landing centers except in Sathana landing center. In Sathana landing center *Cyprinus carpio* was the major fish catch.

As per the fisheries officials' and fishermen's perspective, 6 actual breeding grounds of IMC, *Sperata seenghala*, *Tor putitora* etc. were identified. The breeding grounds are located near the sites where the streams and small rivers flow into the reservoir (locally known as Khuds). These sites are having moderate water flow during the monsoon which is the critical habitat parameter for the breeding of fish. Apart from the actual breeding grounds, 6 sites were identified as the probable fish breeding places where streams are flowing into the reservoir.

The seasonal fish catch pattern was assessed to find out the pattern of the fish abundance variation in the reservoir. The fish abundance pattern indicated that *Sperata seenghala* was the species contributing the majority of the fish caught in all the seasons. The abundance of *Sperata seenghala* was comparatively higher in most of the zones of the reservoir. IMC also contributed the majority of the fish catch next to *Sperata seenghala*. The

IMC fish catch was observed in all the landing centers as well as in all the seasons. *Tor putitora* (*Mahaseer*) is among the single species contributing the majority of the fish catch in the reservoir. *Mahaseer* was observed in all the seasons in each fish landing centers. The other important fish species contributing to the fish catch were *Cyprinus carpio*, *Wallago attu* and *Labeo calbasu*. Among the 15 landing centers Dehra Haripur, Nagrota Suriyan, Kathihar, and Barnali were having higher fish landing as compared to other fish landing centers. The average size of fish catch ranged from 1 to 11.5 kg. *Seenghala* and *common carp* were having the least average size of fish catch but *catla* and *silver carp* were having a higher average size of fish catch.

Fish production estimation

Various models have been tried to derive the fish production potential of this ecotope but mostly do not conform to any conclusion barring the algal biomass model (Waldichuk, 1958; Rodhe, 1958). The estimated potential fish yield is of the order of 132-156 kg/ha/y (Av. 140 kg/ha/y) on the basis of the algal biomass model which is very modest for this ecosystem.

Though the reservoir is a catfish reservoir, stock build-up of Indian major carp is also necessary to utilize the un-utilized ecological niches so as to enhance fisheries in a modest way. Present fish yield is hovering around 20-24 kg/ha/y which could be enhanced to at least 50 kg/ha/y following sound and sustained stocking program coupled with other management protocols. Stocking size of Indian major carp fingerlings should not be below 100 mm with 300 numbers/ha to be stocked every year for stock build-up with Catla: Rohu: Mrigal ratio would be 30:50:20 to have adhered strictly would be reflected in future in fisheries enhancement in this reservoir.

Maximum sustainable yield

The maximum sustainable fish yield was assessed using the time series data of fish yield and fishing effort data. The fishing effort was calculated based on the number of fishers given for license to have fishing right in the reservoir each year. Each license persons were allowed to operate two gill net in the reservoir in a day except during ban season (15 June to 15 August). Schaefer and Fox model of Surplus Production model was used for the estimation of MSY in the reservoir. The estimated value of MSY according to Schaefer model was 29 kg/ha/yr and the optimum fishing effort (fMSY) was 67 gill net per hectare per year. According

to Fox model the MSY was 26 kg/ha/yr and the optimum fishing effort (fMSY) was 60 gill net per hectare per year.

Current modes of fishing

The fisheries in Pong reservoir are under the control of the Department of Fisheries, HP. Licenses were given to the fishermen in each landing centers for fishing in a particular area of the reservoirs. Each license holder has the right to operate two gill nets of 80 m in length every day. Gill net is the only fishing gear operated for the commercial fish catch in Pong reservoir. Gill net is operated throughout the reservoir by the fishermen except during the fishing ban season (15 June to 15 August). The reservoir is divided into different fishing zones and 15 Cooperative societies were in function to perform fishing using gill net. Apart from gill net and rod and line (angling) are operated as a sport fishery in six different areas of the reservoirs.

Fish yield trend

The decadal pattern of fish yield showed a decreasing trend of fish yield. During the year 1976-1987 and 1987-1998 the fish yield was almost similar with 30 kg/ha/yr. But the fish yield decreased to 24.5 kg/ha/yr during 1998-2009 and further decreased to 23.19 kg/ha/yr during 2009-2020.

5.1.2 Regulatory services

With a storage area of and volume of the reservoir serves as a vital flood buffer during extreme rainfall runoff from the catchment areas. The regulated system of water dissemination caters to water demands several States downstream. This large wetland is also responsible for creating and regulating the micro-climate of the adjoining villages.

5.1.3 Cultural Services

Recreation and Tourism

The Pong reservoir has immense untapped potential for various activities such as bird watching, camping sites, water sports, trekking trails, thick forests, religious places, heritage villages and sites, conservation of rare and endangered species and mainly the tourism. This wetland possesses all the merits which the children, students, authors, poets, saints, environmentalists, anglers, tourists, adventurers and sportsmen require. This lake alone can be

the best Birds Paradise in the world and can yield the high amount of revenue to the Government of Himachal Pradesh.

The Pong Dam Lake bird sanctuary is nature's wonderful creation being the largest man-made reservoir of northern India. This lake looks like sea splendid with the variety of chirping birds. The Dhauladhar range on its north providing beautiful snow-covered mountains makes the area excellent. The Pong Lake provides vast opportunities for the promotion of adventurous tourism such as water sports namely yachting, canoeing, surfing, water skiing, boat racing, swimming etc. Four islands i.e., Rancer, Karu, Rajeli and Jatan-da-kawal have good potential of tourism. The wide variety of the birds attracts the bird lovers and environmentalists. The eco-tourism will provide alternate sources of their income generation.



Figure 7: Boating a major tourist attraction in Pong

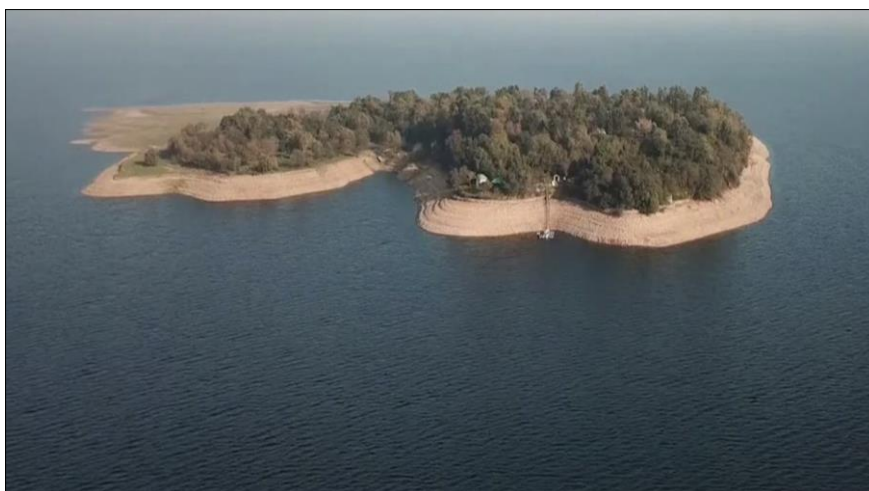


Figure 8: Rancer Island in Pong

Due to lack of proper transportation by road and water, proper stay, food, infrastructure facilities hinder the promotion of eco-tourism. Pong catchment also harbors places of significance tourism and cultural values.

There is a Vulture café in Pong wherein cattle carcass is dumped inviting the Vultures to scavenge upon them.



Figure 9: Vulture sighting area in Pong Wildlife Sanctuary

Education and research

As Pong falls into the Central Asian Flyway (CAF) and is known to be the favorite pit stop for the Bar-headed Goose, there are several research questions that are untapped. Studies are continuously carried out by eminent universities and institutions to supplement the discovered ecology of this site. This wetland also serves as a very good place for students and other enthusiasts to know more about migratory birds, since they arrive in large numbers and variety.

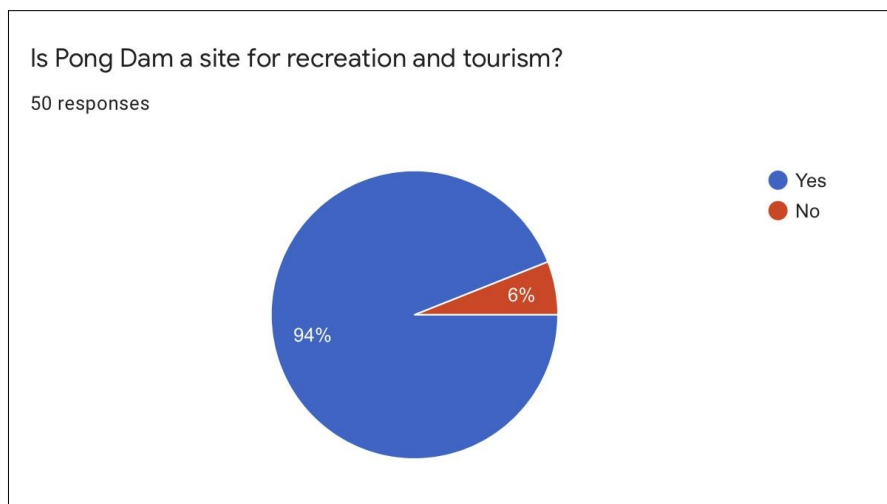


Figure 10: Tourists visit pong for its natural beauty, bird watching, boating and etc

Spiritual value

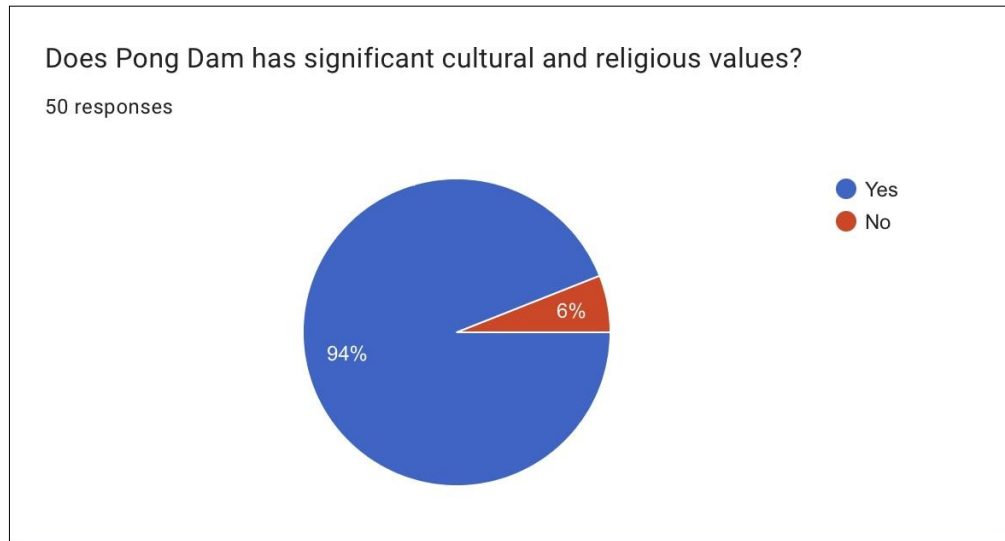


Figure 11: Pilgrims visit Pong in summer for cultural and religious values

Bathu temples, known locally as Bathu ki ladi , is a cluster of temples in the Kangra district of Indian state of Himachal Pradesh, with the main temple dedicated to goddess Parvati and Lord Shiva. These temples were submerged in Maharana Pratap Sagar, a reservoir created by Pong dam in the early 1970s. Since then, these temples are only accessible from May to June when the water level decreases. The temples are accessible by boat from Dhameta and Nagrota Surian and accessible by road from Jawali. There are several small villages near the temple site, which includes Guglara, Sugnara, Harsar, Jarot, Bajera, Katnor, Khabal, Ludret, and Bhial.

According to common local belief, it was built by local king who ruled the region. Many stories about the origin of the temples are famous among the folklore. Other beliefs say that temple was built by Pandavas. The folklore tells a story dating back to Mahabharata when Pandavas attempted to build a staircase to ascend to Heaven at monolithic Masrur Rock Temples located at the opposite of the lake but Indira intervened. But, successfully built the 'Stairway to Heaven' at 'Bathu ki Ladi' temples where that staircase still exists even today and one can climb to the top most part to have a feel. The central temple is dedicated to Lord Shiva. Submerged 'Bathu ki Ladi' temples can be visited in winters when water recedes.



Figure 12: Partially submerged Bathu ki ladi temple in Pong Dam (Wikimedia

5.2 Identification of Threats in Pong Dam

Table 3 describes the impact of change on the particular wetland features which can prove to be a threat to the wetland.

Table 3: Threats & impact on Wetland due to adverse changes

Feature component	Priority wetland Feature	Trend summary	Likely impact on wetland	Strategies
Extent	Area under protection	Decline from 2002-2020	Encroachment and human-wildlife conflict	<ul style="list-style-type: none"> • Restrict change in land use and land cover within the wildlife sanctuary
Catchment and Hydrology	Flow regime	Inflow and outflow due to monsoon runoff has increased by 3683 Million Cubic Meter (MCM) and 2519 MCM respectively from 2002-2018	<ol style="list-style-type: none"> 1. Flash floods, 2. Habitat destruction, 3. Decrease in fish diversity, 4. Decrease in migratory birds, 5. Water quality fluctuation 	<ul style="list-style-type: none"> • Ensure inflowing streams are not choked • Construct nature-based check dams to ensure sediment inflow • Ensure adaptive management to climate risk
	Water quality	Temperature and electrical conductivity have increased, pH is sliding towards alkaline levels	<ol style="list-style-type: none"> 1. Decline in aquatic species, 2. Decline in water quality, 3. Increase in invasive species, 	<ul style="list-style-type: none"> • Control water quality of the wetland from degrading
Biodiversity	Migratory birds	Numbers of species has decreased	<ol style="list-style-type: none"> 1. Decline in tourism 2. Decline in habitat health, 	<ul style="list-style-type: none"> • Maintain habitat of migratory birds • Protect breeding sites of wetland dependent birds
	Golden Mahseer	Numbers have decreased by 50%	<ol style="list-style-type: none"> 1. Lesser spawning and breeding of Golden Mahaseer, 2. Increase in competing species, 	<ul style="list-style-type: none"> • Maintain fish diversity and check invasives fish • Introduce native fishing

Ecosystem Services	Grazing	Nomadic grazers and gujjars, Migrant grazers, stray cattle etc graze over 12000 no. of cows, buffaloes, horses, sheep, goat etc. in the sanctuary	High intensity of illegal grazing incidents poses a threat to this bird sanctuary, biodiversity besides fear of spread of contagious diseases, contamination of lake water, deterioration of aquatic ecosystem, fish culture will also be affected.	<ul style="list-style-type: none"> • Ensure grazing to be done by licensed grazers • Promote alternative livelihood for agriculturalist and grazers • Impose fine on illegal grazers
	Tourism	Tourists are known to visit the wetland for birding and recreational activities like boating and leisure stay	<ol style="list-style-type: none"> 1. Sustainable and sensible tourism might be beneficial for income generation for conservation and management of the wetland, 2. Rampant tourism might create disturbances in bird and fish habitat lead to reduction in count, 	<ul style="list-style-type: none"> • Promote eco-tourism
Institutions and Governance	Stakeholder coordination	Owned by Bhakra Beas Management Board, Managed by Himachal Pradesh forest department -Pong Wildlife Sanctuary	<ol style="list-style-type: none"> 1. Overlapping rules of Wildlife protection act, BBMB, Wetland rules etc. 2. If wise use is not followed then it can impact the ecology / habitats of wetland. 	<ul style="list-style-type: none"> • Incorporate wetlands wise use in wildlife act • Encourage all stakeholders and their ownership for the sustainability of the site • Regular stakeholder meetings • Training and capacity development of staff and stakeholders • participation and consideration of local communities, including women and marginalized groups and panchayats in decision making

In survey 50 respondents were asked to rate the mentioned threats for present state of pong

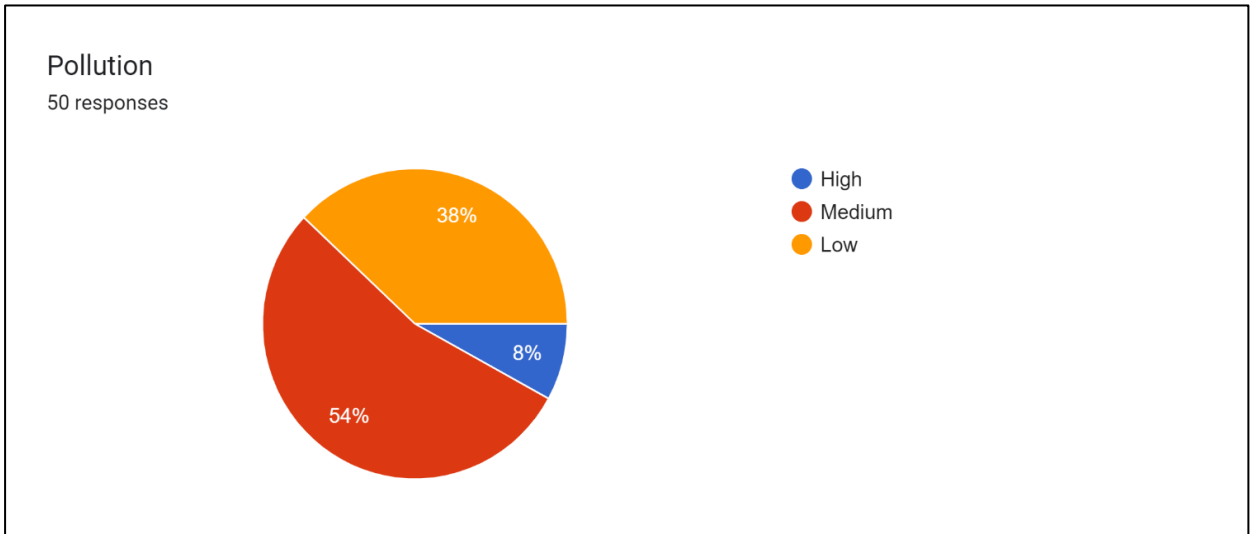


Figure 13: 54% respondent believe pollution is a medium level threat

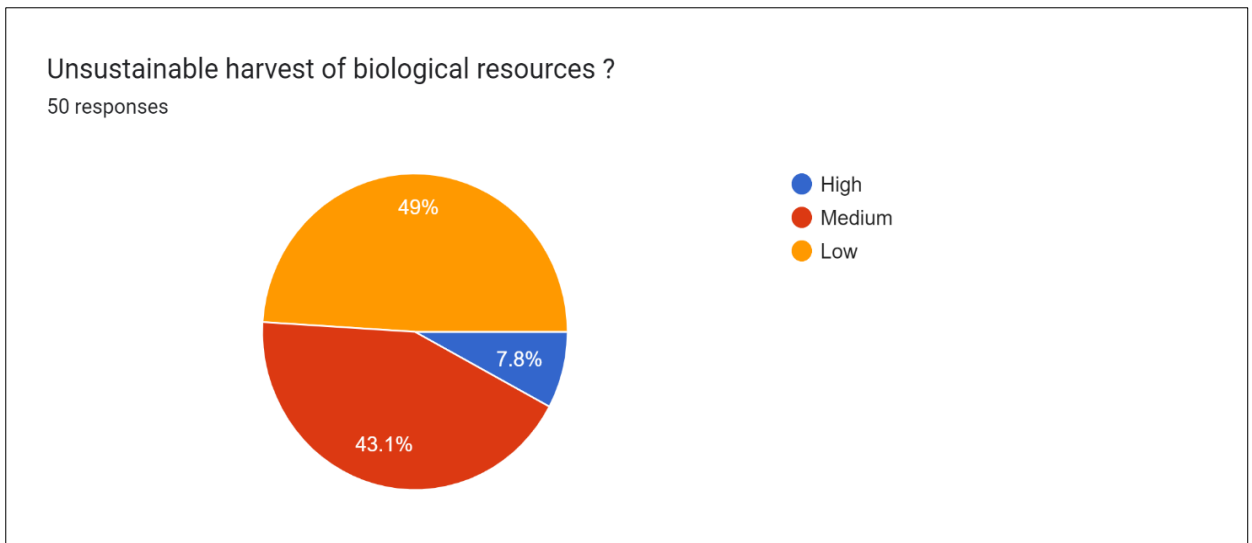


Figure 14: 49% of Respondents believe Unsustainable harvest is low-level threat at present

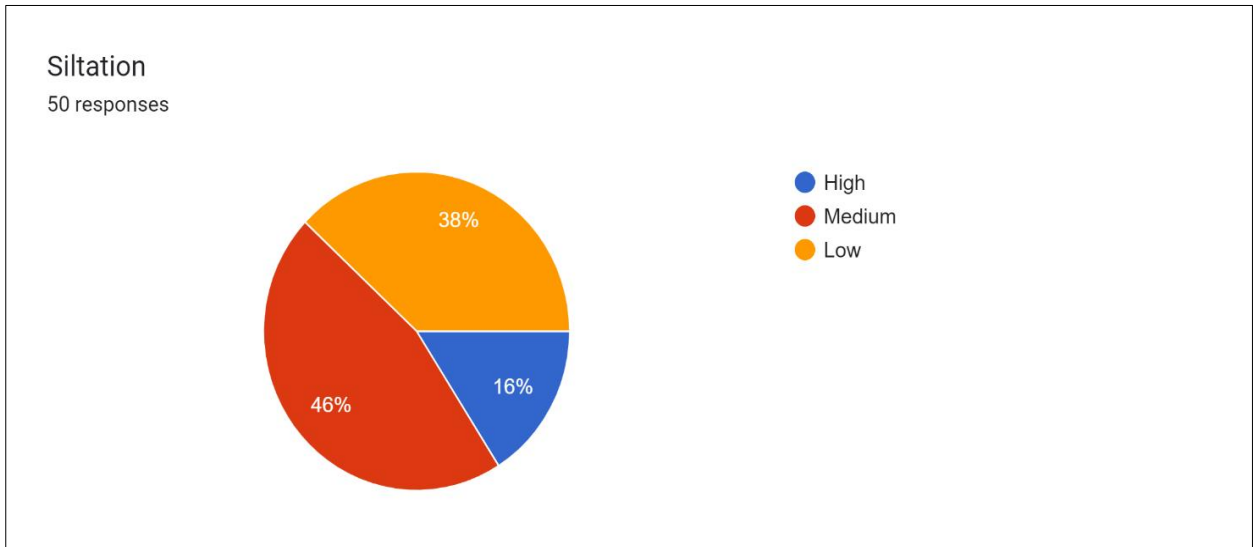


Figure 15: 46% respondents believe siltation is a medium level threat at present and can be dangerous to biological characteristics of Pong

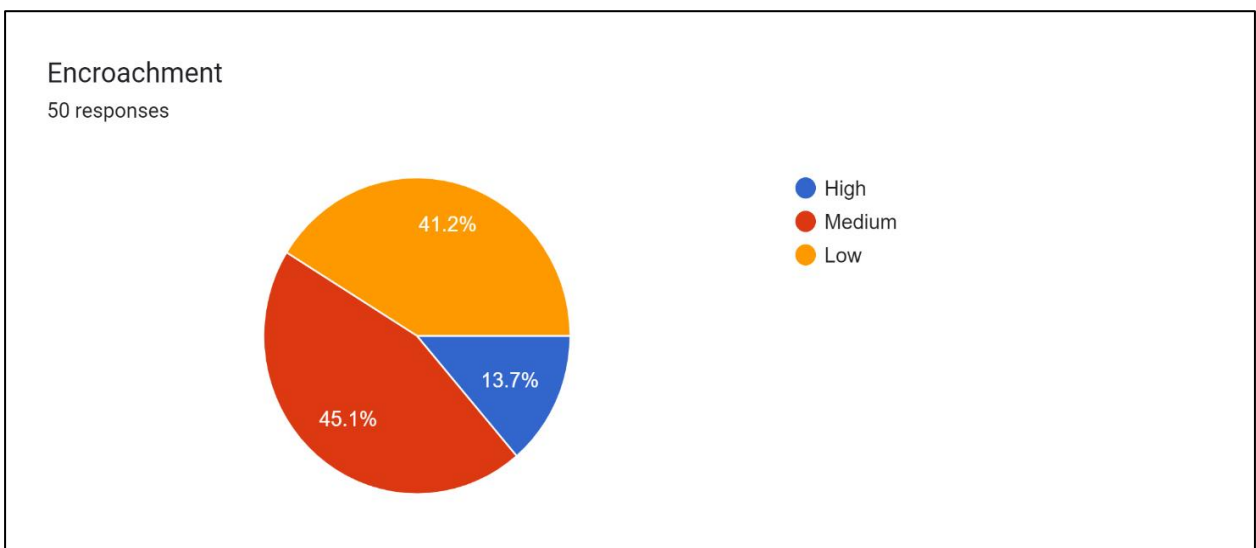


Figure 16: 45.1% of respondents believe encroachment is medium-level threat in present and guarding reservoir needs more efforts

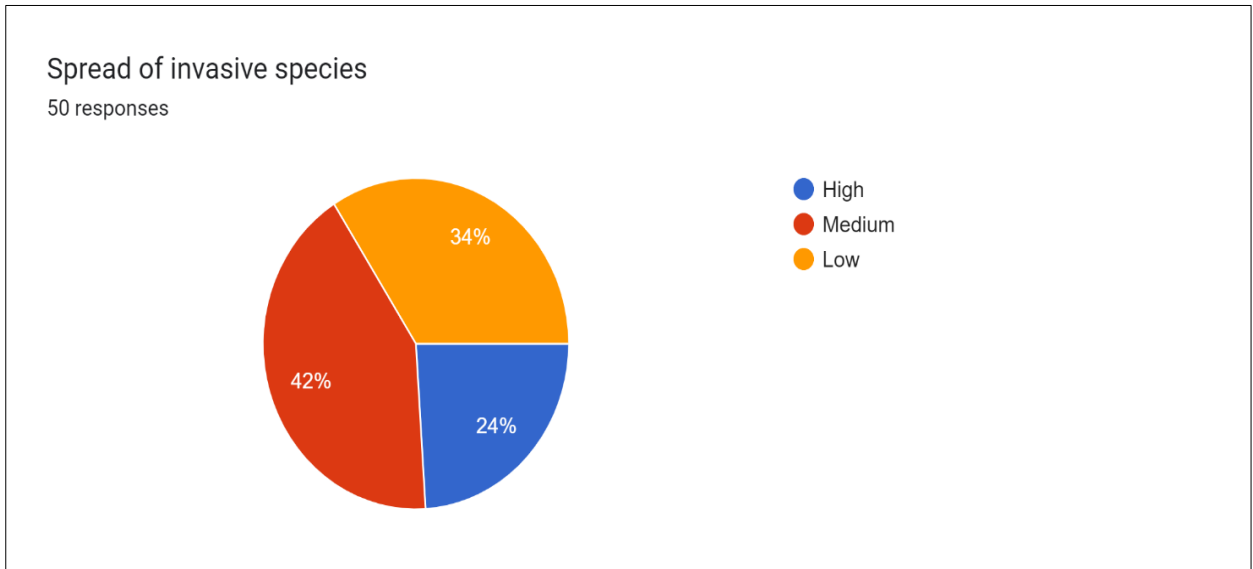


Figure 17: 42% respondents believe spread of invasive species is a medium level threat and can be lethal for endemic species

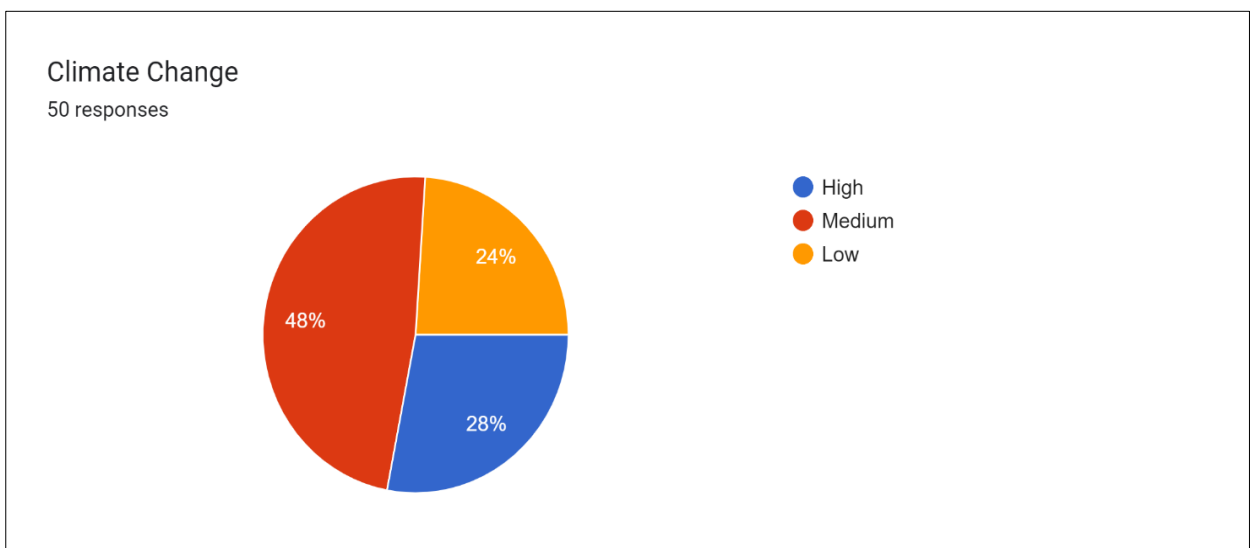


Figure 18: 48% respondents believe climate change is a medium level threat and can be harmful to all the living beings around Pong

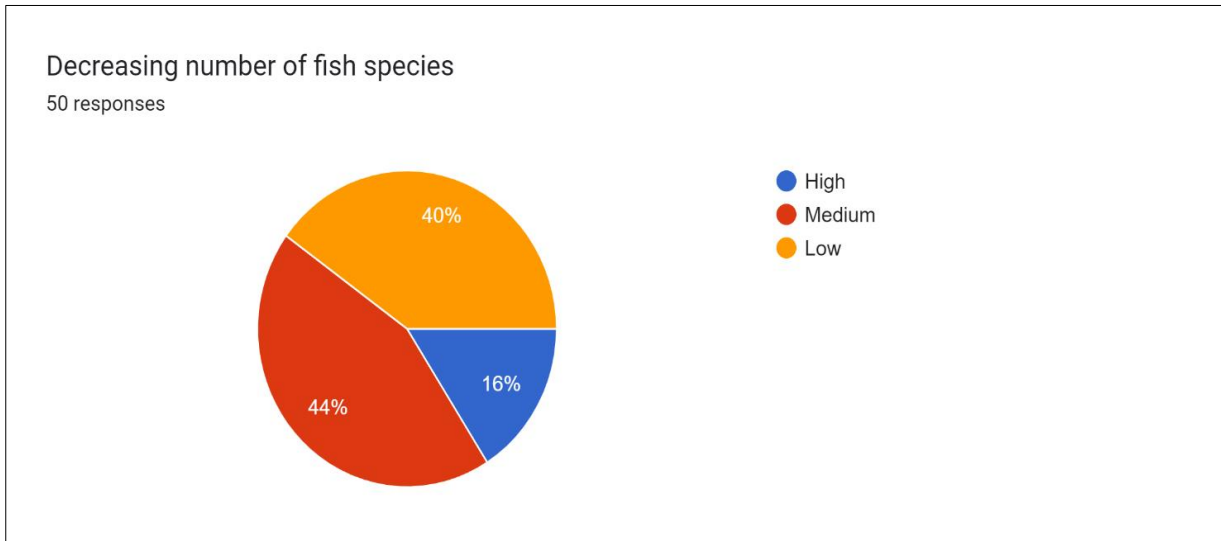


Figure 19: 44% of respondents believe decreasing number of fish species is a medium level threat in present and to maintain international importance species should be conserved

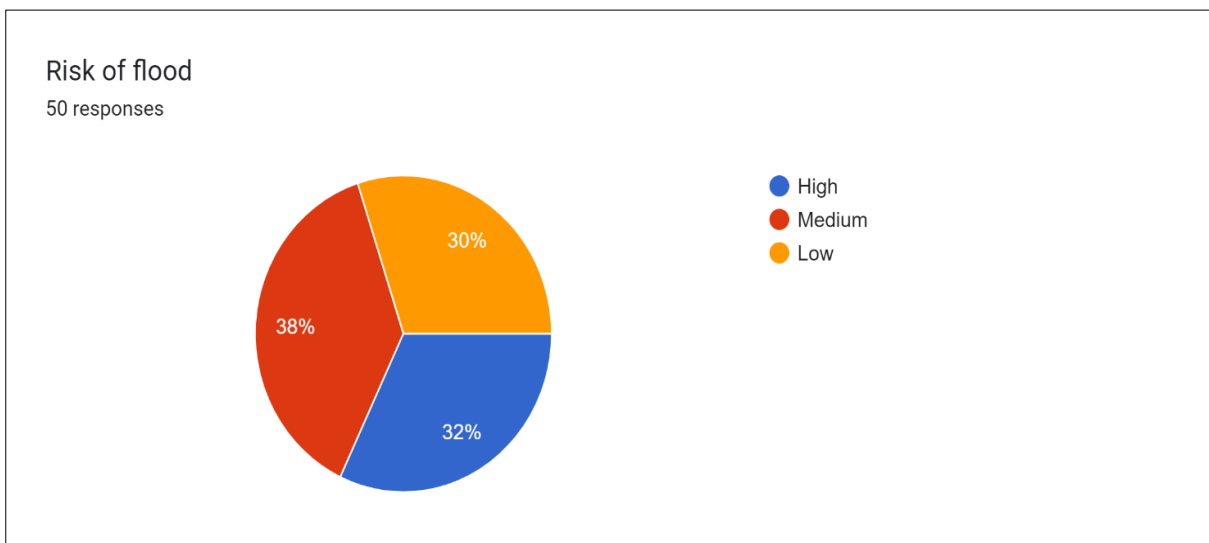


Figure 20: 38% respondents believe floods are a medium level threat in present for Pong and its surrounding

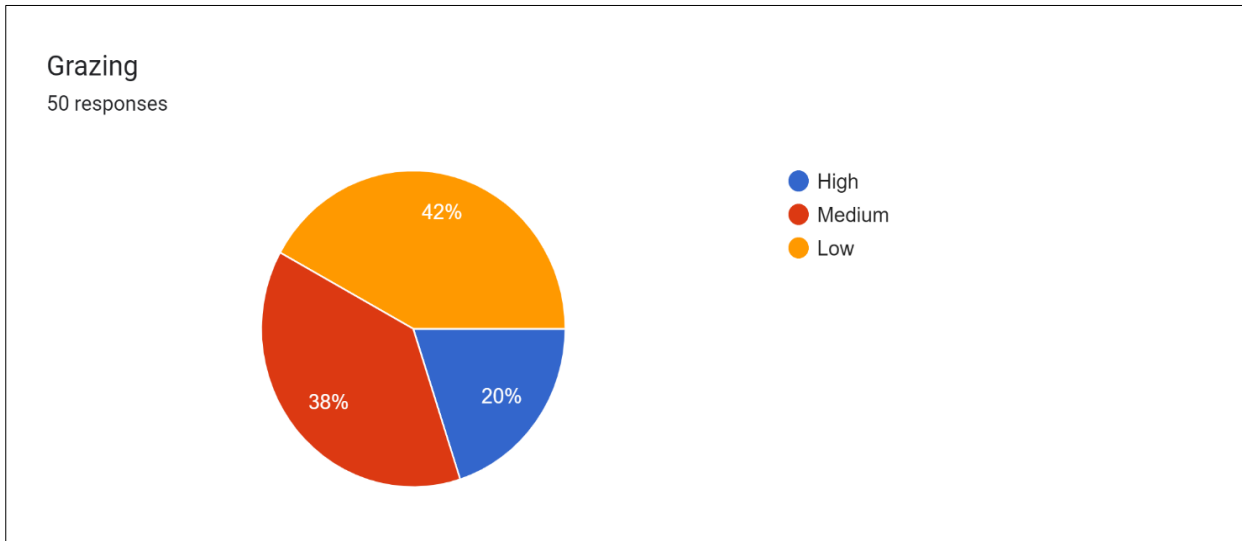


Figure 21: 42% respondents believe over grazing by community can be dangerous for wildlife that relies on grazing

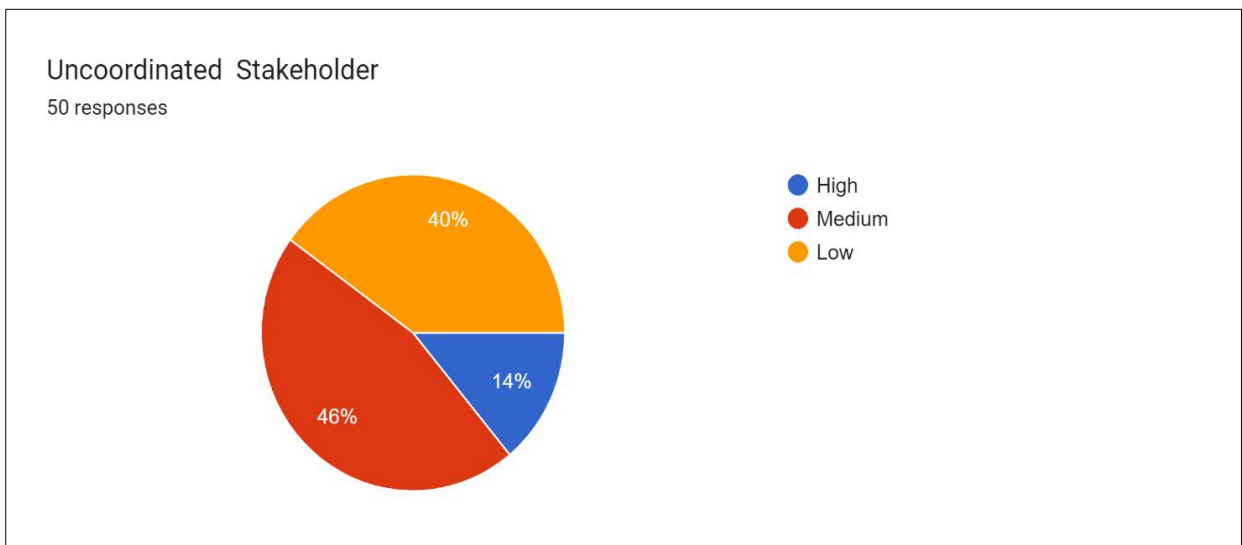


Figure 22: 46% respondents believe lack of coordination between stakeholders can be lethal for Pong

5.3 Identification of Institutes/ stakeholders and management strategies for pong Dam

Through the regulatory framework, different structures have been constituted with specific roles and responsibilities. These include the national wetland committee, state wetland authority, district wetland committee and site management body.

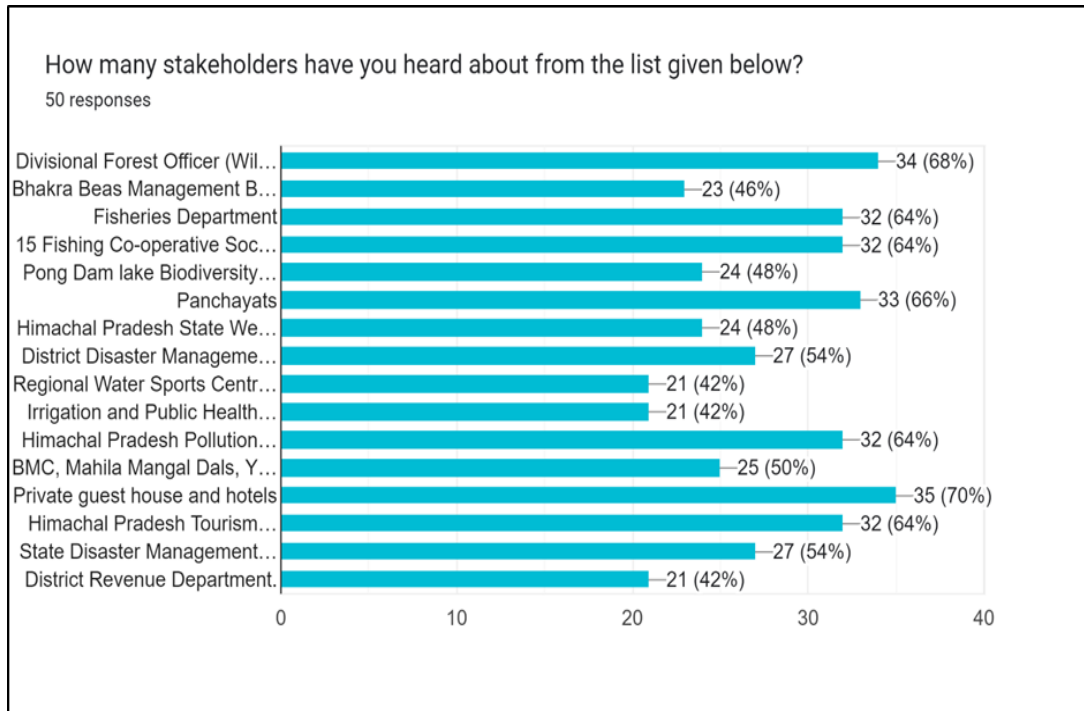


Figure 23: Communities and their familiarities with stakeholders

Current Management plan

Pong Dam Lake Wild Life Sanctuary Management Plan (2014-15 TO 2023-24) exists to manage the wildlife sanctuary, the current sanctuary management plan there are 32 permanent staff and 4 temporary staff in Himachal Pradesh Forest Department.

<ul style="list-style-type: none"> Divisional Forest Officer (Wildlife) and Site Manager 	<ul style="list-style-type: none"> Himachal Pradesh State Wetland Authority and Forest Department
<ul style="list-style-type: none"> Bhakra Beas Management Board (BBMB) 	<ul style="list-style-type: none"> District Disaster Management Authority
<ul style="list-style-type: none"> Fisheries Department 	<ul style="list-style-type: none"> Regional Water Sports Centre Pong Dam
<ul style="list-style-type: none"> 15 Fishing Co-operative Societies 	<ul style="list-style-type: none"> Irrigation and Public Health Department
<ul style="list-style-type: none"> Pong Dam lake Biodiversity Conservation Society & EDC's 	<ul style="list-style-type: none"> Himachal Pradesh Pollution Control Board
<ul style="list-style-type: none"> Panchayats 	<ul style="list-style-type: none"> BMC, Mahila Mangal Dals, Youth Clubs
<ul style="list-style-type: none"> Private guest house and hotels 	<ul style="list-style-type: none"> Himachal Pradesh Tourism Co-operation
<ul style="list-style-type: none"> State Disaster Management Authority 	<ul style="list-style-type: none"> District Revenue Department

Figure 24: Stakeholder's list

5.3.1 Stakeholders and Institutions at Pong

A 'stakeholder' is taken to mean any individual, group or community living within the influence of the site, and any individual, group or community likely to influence the management of the site.

Stakeholder interests can have considerable implications for site management, and will place significant obligations on managers. Public interest, at all levels, must be taken into account. Wetland managers must recognize that other people may have different, and sometimes opposing, interests in the site. It is essential that these interests be safeguarded wherever possible, but this must not be to the detriment of the features of the ecological character of the site. Any use of the site must ultimately meet the test of compatibility with the wise use and conservation purpose and objectives, and this is of added significance where the site has been designated as a Wetland of International Importance. The involvement and understanding of local communities and indigenous peoples in the management of wetlands is of particular importance where the wetland is under private ownership or in customary tenure, since then the local communities are themselves the custodians and managers of the site, and in these circumstances, it is vital that the management planning process is not seen as one imposed from outside upon those who depend on the wetland for their livelihoods. As the site is directly (positively and negatively) influenced by the stakeholder through their interactions, it is important to assess engagement of stakeholders with the site and its management. Such an assessment is also useful in identifying present and potential conflicts enabling the management to take corrective action well in time. Around Pong Dam there are many stakeholders that affect the ecology of the wetland. These are fishermen, farmers, BBMB, Tourism department, fisheries dept. Pong 'Out-sees' committee, residents of the watershed, water sports complex, VDC's Some of the key stakeholder functions are listed below.

BBMB-It is the primary owner of Pong Dam and its reservoir. It regulates hydrology of the reservoir as well as catchment. Since its historical presence it carries out developmental and eco- developmental activities through village level societies and thus are not only a stakeholder but also key player in management of the area.

HPFD- It is responsible to manage the wetland as Pong Dam Lake is a notified wildlife sanctuary under the Wildlife Protection Act 1972.

Fisheries Department-The H.P. Fisheries Act, 1976, empowers the Fishery Department to regulate and enforce rules related to fishing and development of fisheries as per the mandate. Their economic dependency is high through issue of contracts. The act however, is divergence with the Wildlife Protection Act.

Small Hydropower companies- There has been a spurt in hydropower development in the state- both small and large projects have been undertaken. Micro and mini- hydel projects directly affect the hydrology and therefore the ecology of small streams that in turn effect the larger streams/ khuds. The khuds draining into the Pong reservoir are directly affected due to this. Although a detailed study/ or data regarding small hydro energy is not available, the effects are well known.

Fisher-There are nearly 3000 fisher who depend on the lake for their livelihood. Pong lake accounts for a large fish catch annually which is largely supplied to Punjab. There are organized fishermen cooperative societies regulated by the state fisheries department.

Farmer- Large tracts along the shoreline are farmed for food grains during the draw down phase of the reservoir. Even though illegal, farmers consider it their right to farm these. This section is politically organized and some of the farmers are outsees of the dam. Wildlife wing has no control over the illegal sowing and cropping of the crops, the land being under the ownership of the BBMB.

Villagers unsettled since 1974-75 -This group of villagers from surrounding areas is extensively dependent on the Sanctuary land for livelihoods. They cultivate crops in drawdown areas, fish in the reservoir, extract NTFP etc.. The settlement of their land/compensation since construction of Dam is pending. They are organized, politically influential, act as pressure group against musclemen and other farmers with large landholding in the encroached areas.

Pong Water Sports Complex- The water sports complex organizes training programme in water sports regularly. These activities cause significant disturbance to the wetland.

Wetland management, and particularly the planning process, should be as inclusive as possible. Legitimate stakeholders, particularly local communities and indigenous people, should be strongly encouraged to take an active role in planning and in the joint management of sites. For effective management it is imperative that certain activities be coordinated with the BBMB and state fisheries department and that these activities should be closely monitored. It is important that land ownership/settlement-related issues be resolved in partnership with BBMB and the issues related to the conservation of fish fauna with the fisheries department. Programs and projects should be jointly planned with these departments. It is highly desirable that positive steps be taken to ensure that gender issues, including women and their interests, are fully taken into account at all stages in the process. If necessary, appropriate incentives to ensure full stakeholder participation should be identified and applied (Pong Dam Lake Wildlife Sanctuary Management plan).

CHAPTER 6: CONCLUSION

Pong Dam is unique in ways that as it is both a high-altitude wetland and a wildlife sanctuary, making it unlike any other wetland in India. The site is rich with ecosystem services and the community around Pong gains good benefits of that. Continuous and rapid urban expansions, as well as the conversion of forest cover into barren land have posed few challenges to the ecological landscape and ecosystem functions. In a wetland setting like the Pong Dam, it's important to categorize these changes qualitatively because the region is undergoing rapid changes since its designation as a Ramsar site. In this study, efforts were made to identify all the ecosystem services provided by the site along with the threats to the reservoir and strategies that can be implemented to control the threat. Stakeholders/institutes around Pong have been identified who are responsible for activities in and around and to help comprehend the management practices undertaken and attempt to come up with conservational strategies together that will provide concrete means to manage the future sustainably.

However, to satisfy the above-mentioned objectives, a survey was conducted and reference was taken from remarkable research papers, articles, and reports. The findings show that the pong wetland offers a number of ecosystem services mainly provisioning services as it acts as a source of water for hydropower generation, downstream irrigation, drawdown area for agriculture and grazing, and fishing. Regulatory services (flood buffer, climate regulation), cultural services (tourism, spiritual significance, education, and research) and supporting services (habitat for myriad species) are a few of the other ecosystem services offered by Pong dam. This high number of ecosystem services is attributed to the high diversity of biota, and to the cultural and ethnic diversity in the study area.

Though all the aspects are different yet are interconnected, provisional services, regulatory services, supporting services and cultural services, aid in keeping the site balanced, beautiful and safe for all and surrounding. As per the study the over exploitation of ecosystem services has shown dominant relation with most of the threats in Pong Dam. Hence, this report provided an assessment of these vulnerabilities (threats) of the Pong Dam Ramsar site and its key impact on the ecological features pertaining to the area. It is apparent from the study and analysis presented that pollution, unsustainable harvest of biological services, siltation, encroachment, spread of invasive species, climate change are some of the medium-level threats existing in the area as of now but has the potential to increase to a high level and damage the site in future.

The study showcased how the community takes advantage of diverse ecosystem services and different individuals have different priorities yet the daily essentials like food and water is common need for all and 82% of families are directly/indirectly reliant on fishing in Pong Dam. That is one of the reasons behind decline in fish species. To mitigate this threat, new policies have been applied like fishing ban in breeding season and promotion of ecotourism which will help the community to diversify and will reduce the reliance on fishing as the sole livelihood occupation.

Similarly, strategies have been put forward to mitigate other mentioned threats which include actions such as restricting change in land use and land cover within the wildlife sanctuary, controlling water quality of the wetland from degrading, ensuring adaptive management to climate risk, maintaining habitat of migratory birds, protecting breeding sites of wetland-dependent birds, promoting sustainable fishing activities, ensuring that grazing to be done by licensed grazers and promoting alternative livelihood for agriculturalist and grazers, enhancing ecotourism, regulating stakeholder meetings, training and capacity development of staff and stakeholders, engaging research and academic institutions to conduct research on priority areas identified by the State Wetland Authority and Forest Department, etc.

Further in the thesis, stakeholders of Pong have been identified which include people from the Forest department, Fisheries department, Fishing co-operative societies, State disaster management authority, BBMB, Panchayats, wetland authorities, public health departments, the tourism department ,and the local sectors such as owners of guest houses and hotels, Mahila mangal Dal, Youth clubs, etc, Roles and responsibilities of some stakeholders are mentioned as they can act as a crucial knowledge providers to form management strategies and policies for the conservation & sustainability of Pong Dam and also ensure effective risk reduction of threats and efficient management of its resources.

The outcome of this study can be a reference for decision-makers, planners, and administrators in formulating a suitable action plan and adopting relevant management and conservation practices to improve the overall status of the region.

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