

## USES OF PONDS IN NAWALPARASI WEST DISTRICT, LUMBINI PROVINCE OF NEPAL

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### Abstract

*This study analyzes the existing uses of ponds in the Nawalparasi West district of Lumbini Province of Nepal. Ponds are of great importance for various aspects of nature and human life. Its importance varies from nature wonder to religion, and culture to economic importance. There are various uses of ponds depending on their locality, topography, society, climate, and accessibility. Knowing the uses and the importance of the pond by local people for better development planning, for maximum benefits and sustainable management is a must. In this paper, data were collected from the Tarai plain areas using maps and through field study itself where several ponds are used by local people. The study revealed that the ponds have multiple uses. Most of the ponds are privately owned and mostly used for fishing, which is directly related to the income of the households. Many public ponds are also economically important for fishing at the community level. Additionally, many public ponds are historically tied to the religion and cultural practices of local indigenous people. Some ponds are ecologically important in the study site.*

**Keywords:** Culture, economics, religion, pond, tarai

### Introduction

A pond is defined as an inland basin filled with water and its dynamic process reflects its previous history (Podgórski & Szatten, 2020). Farm ponds help collect runoff from fields and barns, as well as for watering livestock (Das et al., 2013). Ponds also provide a location for wildlife habitat and a secure area for fire suppression. The water level of ponds varies with the availability of a source of water (Kubitza, 2016). Ponds have long been a component of the human landscape (Curado, Hartel, & Arntzen, 2011). In the late

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1800s, man-made spring-fed ponds for fish farming were developed. Many landowners have built new ponds recently, each with its distinctive features (Chen et al., 2019). Some of them are managed in a more particular way than other nearby ponds. Even adjacent ponds on the same property must be managed differently (Ochterski, 2007). Ponds have historically provided water for farmers and cattle. The ponds served some crucial uses, including providing water for common use and acting as water reserves for fighting fires (WHO, 2011). For many people living in rural areas, ponds offer a place to enjoy the beauty and learn about nature. The environment also depends heavily on ponds.

Nepal is the second-richest nation in terms of water resources after Brazil. There are 5,000 lakes, 1,380 reservoirs, and 5,183 village ponds that may be found in Nepal (Ismail, 2017). Ponds are excellent places to observe many of nature's beauties, including flowers, edible plants, splashing water, wind ripples, animal trails, bright sunshine, and seasonal sounds. Ponds are an excellent place for swimming, boating, fishing, and improving the landscape (Gurung, 2003). Create a stable walkway around your pond that offers access to the pond edge to provide an excellent opportunity for appreciating nature. This edge needs to be secure and well-drained. Using rot-proof boards made of cypress, larch, locust, or white cedar wood, some pond owners bolster their pond-side seating area (Ochterski, 2007).

In the south of Nepal, there is a flat, productive agricultural region known as Tarai. It is located at an elevation of 60 to 300 meters between the Indian border and the outer Siwalik Mountains, where more than 48.5% of Nepal's population resides (CBS, 2011). Ponds in the Tarai region are related to historical information, hydrology, and demographic history. Water can come from a variety of sources, including rain, streams, irrigation canals, domestic sewage, groundwater, etc. There are various property and management circumstances as well. The water level in ponds in the Tarai region is likely to be decreasing day by day due to anthropogenic activities, industrial operations, changing environments, extreme and unseasonal rainfall, growing habitation, etc. (Bastakoti, Prathapar, & Okwany, 2016). Pond levels will vary greatly in the lack of enough water. Nowadays, it has become a major problem in the world (UN, 2018). The preliminary survey of the study area revealed that ponds are used for a variety of purposes, including economic, sociocultural, livestock, ecological, etc. The usage of many public ponds for cattle is gradually giving way to commercial applications. Particularly for fish farming, the number of ponds is increasing more quickly in the Tarai region. Therefore, it is needless to say that the study of ponds is a crucial matter regarding the different applications, distribution, and management aspects of ponds.

In this context, this paper is seeking the distribution pattern, use, and management strategies of the pond in the Nawalparasi West district of Nepal.

## **Methods and Materials**

This study is mainly based on primary data collected through observation, household surveys, and Key Informants' Interviews including informal discussions with local people. Different secondary information was also collected from various sources. Field observation was carried out for gathering information on the physical characteristics of the pond viz; shape, size, depth, and type of pond. All the events and objects related to ponds were also noted in the observation diary. The open-ended questions were prepared to understand the physical, socio-cultural, historical, ecological, and economic functions of ponds in this study (general to specific). One set of questionnaires was prepared for each pond. The finalized questionnaire was asked to the local person who has been using the public ponds of the village. Local people answered in their own words to the different open-ended questions. Household-level data of private pond owners were carried out using an already shortened questionnaire. Census survey method was carried out for household survey i.e. all 31 households of private pond owners were interviewed. One set of questionnaires was filled up for each household of pond owners. Key Informants Survey (KIS) was conducted to obtain information about the socio-cultural, historical, religious, and economic functions of ponds (Eyler et al., 1999). Ward leaders, members of the women's group, members of the community pond user group, etc. were included as key informants. KIS was carried out with three well-informed persons from each ward. The collected data has been analyzed at both aggregate and individual levels. Various tables, charts, and maps were created by using computer software programs and cartographic techniques to make them informatics and reliable. The spatial data were analyzed by using Arc GIS 9.3 software respectively. To see the spatial organization of ponds, a topographic maps and cadastral maps were used. Only water surface areas were digitized from Google Images of 2001 based on knowledge-based visual image interpretation.

## The Study Area

Palhinandan and Sarawak Rural Municipalities of Nawalparasi West district were selected for the study.

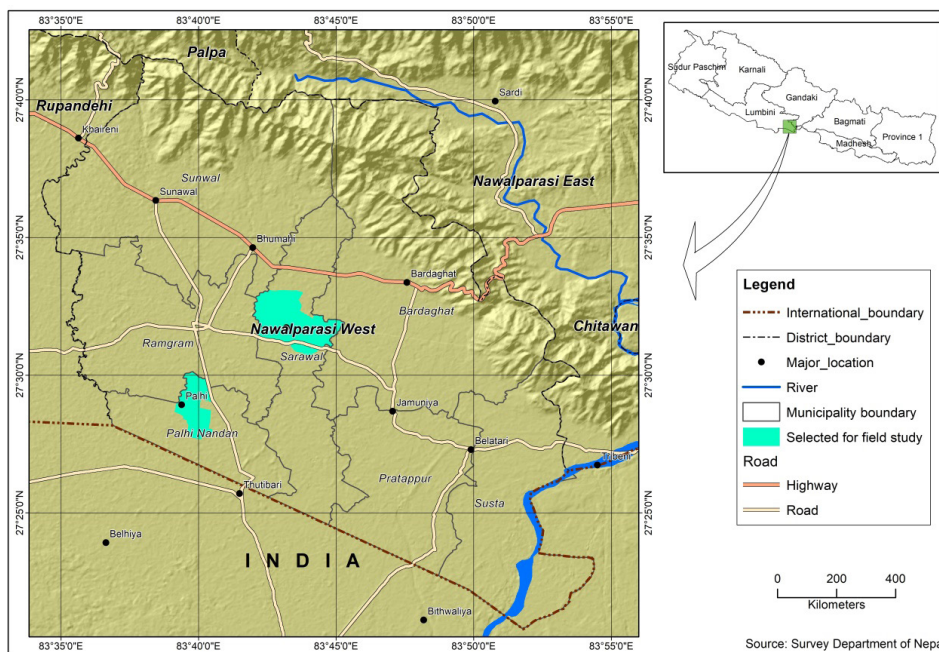


Figure 1: Location of the Study Area

The selected study sites of ward number 4 in Palhinandan Rural Municipality are situated between 27°27'38" to 27°30'7" in north latitude and 83°39'37" to 83°40'38" in east longitude. According to the population census of 2011, it has 5622 population and 939 households. The Palhi Bhagawati temple is a holy temple of Durga. Thousands of local and neighboring people come to worship in this temple during the festive season of Ram Navami (*dureshara*). The livelihood situation of the district is comparatively poor. The wards don't have links with major roads and services. Manari is a major settlement and an important place of wards number 2 and 3 of Sarawal Rural Municipality, which is located between 27° 30' 42" to 27° 33' 5" in north latitude and 83° 42' 10" to 83° 45' 30" in east longitude. According to the population census of 2011, it has a 5782 population and 1074 households. The majority of the households in Manari engage in agricultural cultivation. Manari is flatland and the main crops are rice and wheat. Tharu are the major population of this area and some other also exist. Tharus are famous for their custom and culture. A helpful and peaceful lifestyle is the general character of the

Tharu community. There are two famous Shiva temples. They are located in Manari and Atrahati. A yearly cultural festival observed in January is called the *khichadi* festival organized by Tharus with some cultural shows. It is now becoming famous.

## Results and Discussions

### Distribution Pattern of Ponds

From the field study a total of 102 ponds were identified, among them 71 are private and the remaining 31 are public. There are a higher number of ponds in Palhinandan Rural Municipality compared to Sarawal Rural Municipality. The general distribution pattern of ponds is in the central and southern part of the study area of this Municipality while more ponds are in the north and northeast portion of the study sites of Sarawal Rural Municipality.

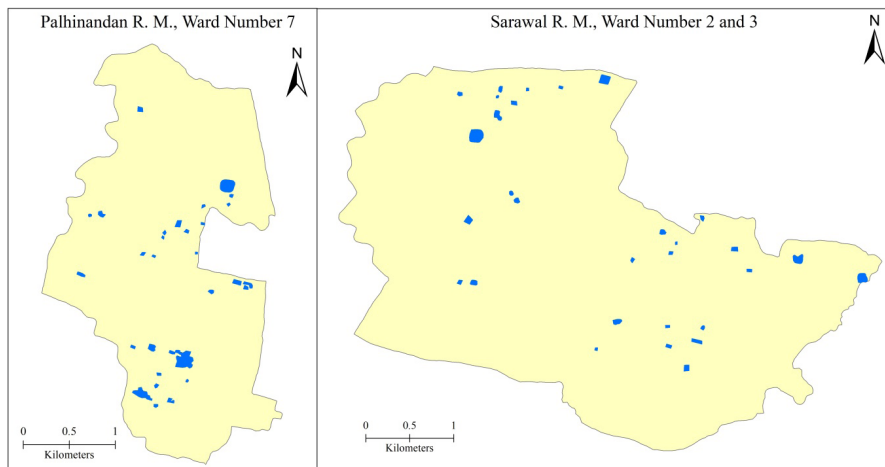


Figure 2: Distribution of fish ponds in the study area

There is a higher proportion of private ponds in Palhinandan compared to Sarawal. However, private ponds are higher in number compared to public ponds in both study sites (Table 1).

**Table 1: Number of ponds in the study sites**

Municipalities	Public		Private		Total
	Number	%	Number	%	
Palhimandan Rural Municipality	15	23.8	48	76.2	63
Sarawal Rural Municipality	16	41.0	23	59.0	39
Total	31	30.4	71	69.6	102

Source: Field Survey, 2021 (Figure 1)

There is a significant relationship between pond density with the richness of different taxa (Gledhill, James, & Davies, 2008). The density of ponds per sq. km is 10 in Palhinandan Rural Municipality, ward 4 and 3, whereas ponds are in ward number 2; and 3 in Sarawal Rural Municipality respectively.

### Physical Character

The shape of ponds has various implications (Worman & Kronnas, 2005). Mostly, the shape of private ponds is rectangular in Tarai Region. The rectangular shape of the pond is best for fish farming. So, the farmers have constructed the ponds in a rectangular shape. Likewise, public ponds are in irregular shape, some are circular while others are oval. The following table shows the shape of ponds in the study area.

**Table 2: Shape of Ponds in the Study Area**

Shape	Palhinandan R. M.		Manari R. M.		Total
	Public	Private	Public	Private	
Rectangle	1	46	5	22	74
Irregular	13	1	5	-	19
Circular	-	-	3	1	4
Oval	-	1	3	-	4

*Source: Field Survey, 2021*

Table 2 shows many private ponds are rectangular shapes while public ponds are of different shapes. They are rectangle, circular, irregular, and oval shapes.

Pond size can affect the macro-fauna community's structure and composition, but this effect can be influenced by other environmental factors like the trophic condition of the water, the habitat's structure, and the ecosystem's spatial connectedness (Tornero et al., 2016). A cadastral survey was done in 1967 A.D. by the Survey Office of Nawalparasi district. Survey Office, Nawalparasi provided a land ownership certificate for each landowner. The total area of the private pond is 4.76 hectares and the public pond is 6.9 hectares in Palhinandan Rural Municipality ward number 4. Similarly, the total area of the private pond is 2.07 hectares and the public pond is 6.78 hectares only in Sarawal Rural Municipality respectively. From Google image 2021 digitization, only the total water surface area is found at 6.95 hectares in Palhinandan Rural Municipality ward number 4 and 5.86 hectares in ward numbers 2 and 3 of Sarawal Rural Municipality.

Less sunlight will penetrate the pond's bottom as the water level rises. Pond weeds will grow significantly more slowly and occasionally not at all if they don't receive enough sunshine (Maiga, Wethe, Denyigba, & Ouattara, 2009). Thus, water depth is an important feature of any pond. The minimum water depth required for fish is 1.5 meters. The pond's size and depth depend on its primary purpose. Farm ponds used for agricultural irrigation tend to be large and wide, which is also suitable for boating and swimming. The pond should be a minimum of 8 feet deep to protect fish through periods of oxygen stress. For successful fish management, ponds should have a surface area of at least one acre with depths of 10 to 12 feet found in a quarter of the overall basin. Depths greater than twelve feet do not help enhance fish production and only lead to greater construction expenses. A steep pond shoreline slope can help prevent the growth of nuisance aquatic vegetation and make it easier for anglers to fish in deep water where fish are located. Private ponds are usually constructed with average depths ranging between six and eight feet, and with a maximum depth not greater than ten to twelve feet in the study area. Likewise, public ponds are in average depths ranging between seven to thirteen feet except for Atrahati-8 public ponds. The depth of the Atrahati-8 pond is 16 feet. Water depth is different during the rainy and winter season.

If ponds aren't kept clean, the algae will grow and drain plants' nutrients (Islam, Nakagawa, Abdullah-Al-Mamun, Siddique, & Berndtsson, 2022). Most of the private ponds are clean and public ponds seem dirty in the study area. Private ponds are constructed for fish farming in the Tarai area. Private pond owners clean their pond for economic development. However, most of the public ponds are also clean in Sarawal Rural Municipality. The local community of that ward cleans the pond after the the completion of catching fish . They extract soil from the pond and maintain a dam on the pond. Naturally grown vegetation and weeds are also cut during festive ceremonies time. But most of the public ponds of Palhinandan Rural Municipality are dirty except Shiva Temple's pond. Most of the public pond area is covered by *tinpatiya* and *jalkumbhi* weeds and other vegetations. Due to lack of budget, the ward office has been indifferent for cleaning and maintaining the public ponds. The local community only emphasized fish production resulting to economic growth. Pond water is used in everyday life by many people (Asare, Palamuleni, & Ruhiiga, 2018). Local People use soil of public land for different purposes. So, most of the public ponds are nearby settlements and earthen roads but one historical pond of Jawa village of Sarawal Rural Municipality is near cultivated land. It is nearly 1.5 km far from the historical pond. Landowners have constructed the private ponds for fish farming on the land that was formally used as cultivated land. So, most of private ponds are nearby cultivated land while some are by their own houses.

### Sources of Water

Ponds can get water through rain, drilling, canals, drainage, hand pumps, etc. Rain and a natural supply of fresh water provide the majority of natural ponds with their water (Hill et al., 2021). Fresh water for natural ponds can be obtained from a nearby spring or stream, which exchanges the water frequently and adds oxygen to the pond. In artificial ponds, the water typically comes from a hand pump or well in a home. The people claim that if a pond overflows during the rainy season, fish can escape from the pond. At that point, farmers use pumps installed in cultivated land or other areas to dispense overflow water. Water sources for a pond are shown in table 3.

**Table 3: Sources of water for ponds**

Sources of water	Sarawal R. M.		Palhinandan R. M.		Total
	Public	Private	Public	Private	
Rainfall only	11	-	12	-	23
Rainfall & Tube well	-	2	-	-	2
Rainfall & Hand pump	-	5	-	5	10
Rainfall & Boring	2	12	2	38	54
Rainfall & Canal using pumpset	2	4	-	5	11

*Source: Field survey, 2021*

Table 3 presents sources of water for the pond. It shows private ponds are not dependent only on rainfall for fish farming. Farmers use alternative sources of water for this purpose. According to the local people of the study area, public ponds are there since long. Water remains on the pond all over the year but its level fluctuates. So, fish farming depends on rainfall on the public pond since local people do not use an alternative source of water for this task.

### Types and Uses

Natural ponds form in depressions that are enough to support rooted vegetation across most or all of their areas. In other words, the pond may arise naturally in floodplains as part of a river system or they may be somewhat isolated depression. Man-made ponds are bodies of water that were built and/or maintained by humans. Within this broad category are several pond sub-categories such as water gardens where the main purpose is the ornamental display, fish ponds where the main purpose is housing or breeding fish, or industrial ponds where the purpose is to store water as part of some industrial process. The biggest difference between a man-made pond and a natural pond is how they are constructed. Natural ponds develop in the ground over long periods and become natural



parts of the landscape. On the other hand, man-made ponds are built into the ground with human labor and lots of digging. Natural ponds are not constructed but they have formed automatically in nature at different times. At the time of the interview, Local people couldn't give the exact date/time at what time the natural ponds formed. Most of the natural ponds were in existence in nature many years ago in the study area. There are nine natural ponds and twenty-two man-made ponds in Sarwal Rural Municipality. Likewise, there are eleven natural ponds and fifty-one man-made ponds in Palhinandan Rural Municipality. In recent decades, many landowners have constructed each new pond with unique characteristics. They construct new private ponds, especially for fish farming, and sometimes it is for irrigation also (Abdelraouf, 2019). Likewise, public ponds were made at the time of the extraction of clay from public land. The public ponds serve the local community for irrigation, water for livestock, bathing, watering and house construction, extraction of clay, safety from fire suppression, aesthetic value, religious value, etc. Thus ponds in the study are categorized into two categories such as private and public ponds. Private ponds are mostly made for economic purposes and public ponds are for public uses like spiritual, religious, economic, etc.

### ***Use of Private Ponds***

Generally, private ponds are used for fish farming in the Tarai area (Bastakoti et al., 2016). Fish farming is done by local people for their livelihood and economic purposes. Nowadays, the majority of landowners have been involving commercial fish farming in private ponds. The respondent reported that they celebrate *bhoj bhater* in many festivals like *khichadi*, *holi*, new year, etc. Fishes are deliciously consumed on the occasion of feasts. Private ponds are generally used for economic purposes in the study area.

Farmers are also growing fisheries along with crops in the Tarai. The fishery business is becoming popular in almost every village in the Tarai region due to the rapid growth of demand. Nodnath Lamichhane, a technician at the District Agriculture Development Office, Chitwan said "fish farming doesn't need a big investment and it can be done with few people." Landowners have not done fish farming with big investments and people involved only their own families in fish farming in the study area. But, two hatchery farms are running with big investments and involving other people in Palhinandan Rural municipality. A general description of fish farming is described below.

### ***Use of Public Ponds***

Many public ponds were formed automatically in nature at different times and some were constructed by local people on public land. Now, public ponds are managed mainly for fish farming, in addition to providing water for livestock and irrigation for vegetables in the study area. Fish farming is adopted by the local people for economic growth. So, public ponds play a great role for this purpose. There are 14 public ponds in

Palhinandan Rural Municipality. Out of them, 11 ponds have economic use and 3 ponds have neither economic nor socio-cultural use.

Some ponds are not simply managed for economic use but they have also great religious and cultural values. Some ponds are still regarded as a place to visit at least once a year. For example Atrahati Pond during Shiva Ratri, Palhi Pond during Dashain, etc. Out of 14 public ponds in Palhinandan Rural Municipality, 4 ponds have socio-cultural and livestock use. Similarly, there are 15 public ponds in Sarawal Rural Municipality. Different uses of public ponds are found in this municipality. Some ponds have economic use, some have socio-cultural and some livestock.

With the enactment of the Local Self Government Act, the ownership, control, and decision-making rights on the use of wetlands have been vested in municipalities. The municipality has taken over the active administration of ponds since 1999, contracting them out through public tender to the highest bidder, generally to individuals for periods of two to five years. Local communities claim that their customary rights have been curtailed by the municipality's control of the ponds. Men used to fish, while women and children collected mud, as well as roots, leaves (*semuwa*), and flowers. Further, the wetland resource is deteriorating due to siltation, overgrazing, and vegetation succession. Generally, fish farming is done in public ponds with the agreement of ward offices in the study area. But It is found that there is a different farming system in different municipalities.

Palhinandan Rural Municipality office has contracted out for fish farming on a tender basis. Using a system of open auctions, the ward office has contracted out the rights to fish farming in public ponds for 5 year period. The notice is published in April-May month of every five years and spread through public distribution, notices in government and ward-buildings, etc. At that time, public people gather in a public place and fish farming is contracted on a *daak* basis to the highest bidder. The highest bidder has to pay revenue in annual installments for five year period. If the contractor does not pay tax annually to the ward office, then the ward office looks for another contractor. It also mirrors the different risk profiles of the investments. Two ponds in Ward 8 and 9, at Bairawa and Bhrampurwa, have been contracted out to a youth club and women's group. One pond in ward no 6, at Loharauli, ward office was handed over to Primary Health Center (PHC) in 2067 B.S. to bury and make the building of PHC. There is no provision of agreement with the highest bidder of fish farming about the conservation and management of public ponds. During the period of field observation, it was found that fish farmers were oriented to do more production of fish only. They have not done any conservation and management of the ponds. Local people have been encroaching on ponds for different purposes. Some ponds are used as dumping sites in the village. So, the pond area is decreasing day by day. According to the ward secretary, the ward

office has not managed ponds due to a lack of budget. There is a conflict between the local community and the local governing body concerning the ownership of public ponds. The local community wants to control the pond as they are doing so in the past but the ward committee wants to control public ponds. Thus, the local community has control over a partial part of the public ponds

In Sarawal Rural Municipality, a fish farming system in the public pond is quite different. The ward has contracted out the rights of fish farming in public ponds to the local community for 5 years. Ward office decided revenue of fish farming pond through observation of the ponds area. The community has to pay the revenue in annual installments over five years. Although the ward office wants to control the public pond, the local community still has control over this. Local people of the village have done fish farming in public ponds altogether. One person in each house is involved at the time in stocking fingerlings, cleaning and maintaining a bank of ponds and harvesting fish, etc. Each house collects the necessary money to buy fingerlings, pond maintenance material, fish food, etc. They harvest fish at *Khichadee*, *holi*, and the new year, etc. Member of the community announces the fixed time of one or two days of *khichadee*, *holi*, and New Year to harvest fish from the public pond.

Ponds represent a cultural heritage in the Tarai area with social, religious, historical, ecological as well as economic functions, especially for Tharu and Madeshi people who have been living in this plain area for generations. Nepal is rich in cultural heritage and water use has influenced Nepali culture with spiritual inputs and entertainment. Pond cultural heritage has been overlooked by scientists. Ponds are of interest to the Agriculture Department of Nepal at different levels of the period. Ten ponds have become an inspiration to our festival, religious function, and culture and tradition in the study area. Different religious functions and festivals are found in these ponds. Four ponds are located in Palhinandan Rural Municipality and six ponds are located in Sarawal Rural Municipality. One pond has historical importance with religious function in Jawa.

Several public ponds have religious importance. They worship several gods and goddesses in and around the pond. They celebrate festivals on different occasions and perform cultural practices during these celebrations. The major days of religious celebrations are *jiuti*, *krishna janmastami*, and *nag panchami*. Additionally, these ponds are highly important during death, birth, and marriage ceremony.

Ponds are very important to us as an individual and as a nation also (Cereghino, Cauchie, Martens, & Oertli, 2014). The pond is beneficial to allow water levels to fall each year during drier periods. Artificially constructed ponds also provide wildlife

viewing opportunities. Many people visit the public pond of Jawa and Atrahati villages due to its historical importance as well as its scenic beauty enhanced by bloomed lotus in Sarawal Rural Municipality. Almost other public ponds are near the settlement. So, these ponds help to control the logging water from the village hand pump. It helps to control floods (*bhall*) in the rainy season of the village. Some public ponds still support significant wetland birds in the study area. According to the respondent, seasonal birds like *tel hash*, *langodi*, kingfisher, crane (*bakulla*), *machhar khauwa*, etc. stay in public ponds water. Local people come to stay on *chautara* surrounded by the pond in Chait and Baisakh month. They feel cool in the summer season. Ponds serve as a source of water for farms, and livestock and perform beauty. It plays a vital role in the ecosystem also. These ponds help to collect runoff water which helps in water conservation. Water conservation ponds are storing water and replenish groundwater reserves. In this way, they are ecologically important areas that harbor important wildlife, meet their daily needs, recharge groundwater, cycle important nutrients, and have recreational and cultural values. These ponds are found in the study area. However, encroachments of some of these important ponds are major problems in the study area. However, over the years, due to the hard work of scientists, it is today known that ponds provide multiple functions and services to ecosystems. These are ecologically important for the survival of living beings on earth.

## **Conclusion**

Local people have religious and cultural values about these ponds, and water resources play important role in the study area. Public ponds have been given less priority and coverage area at present and the importance of ponds has been ignored. So, it lacks the effort to conserve them. Water hyacinth has imposed threats to many of these ponds. If a timely effort is not paid then it is no doubt the municipality will lose the glory. However, Ponds have ecological, economic, cultural, historical, and recreational values in the study area. The present trend of the use of ponds in the studied areas indicates that the use of ponds and traditional practices will continue to play a significant role in the socio-cultural life of these village communities. Even fish farmers may lack the skills and technical knowledge of how to effectively manage fish farming in the study area. The total area and water of the pond are getting lesser and too polluted due to the establishment of buildings, encroachment, increase of unsustainable anthropogenic practices, and lack of awareness and education for local people in the study area. Ponds are getting buried due to the growth of water weeds like *tinpatiya* and *jalkumbhi* and other plants, not preserved by people, etc. These activities show that action is urgently needed to conserve and manage the ponds. Therefore, priority should be given to implementing management and conservation practices with an integrated approach for sustainable development. Government should run education and further awareness program about the importance of pond conservation and the wise use of ponds as well.

## References

- Abdelraouf, R. E. (2019). Reuse of fish farm drainage water in irrigation. In A. M. Negm (Ed.), *Unconventional Water Resources and Agriculture in Egypt*, pp. 393-410. Cham: Springer International Publishing.
- Asare, F., Palamuleni, L. G., & Ruhiiga, T. (2018). Land use change assessment and water quality of ephemeral ponds for irrigation in the north west province, South Africa. *Int J Environ Res Public Health*, *15* (6). doi:10.3390/ijerph15061175
- Bastakoti, R. C., Prathapar, S. A., & Okwany, R. O. (2016). Community pond rehabilitation to deal with climate variability: A case study in Nepal Tarai. *Water Resources and Rural Development*, *7*, 20-35. doi:https://doi.org/10.1016/j.wrr.2016.01.001
- Braun, V., Clarke, V. E., B., Davey, L., & McEvoy, C. (2020). The online survey as a qualitative research tool. *International Journal of Social Research Methodology (1):1-14*, *24*(1), 1-14. doi:10.1080/13645579.2020.1805550
- CBS. (2011). *National Population and Housing Census 2011 (National Report)*. Retrieved from Kathmandu:
- Cereghino, R., Cauchie, H., Martens, K., & Oertli, B. (2014). The ecological role of ponds in a changing world. *Hydrobiologia*, *723*(1), 1-6. doi:10.1007/s10750-013-1719-y
- Chen, W., He, B., Nover, D., Lu, H., Liu, J., Sun, W., & Chen, W. (2019). Farm ponds in southern China: Challenges and solutions for conserving a neglected wetland ecosystem. *Science of The Total Environment*, *659*, 1322-1334. doi:https://doi.org/10.1016/j.scitotenv.2018.12.394
- Clifford, N., & Valentine, G. (2003). *Key methods in geography*. Thousand Oaks, CA: Sage.
- Curado, N., Hartel, T., & Arntzen, J. W. (2011). Amphibian pond loss as a function of landscape change – A case study over three decades in an agricultural area of northern France. *Biological Conservation*, *144* (5), 1610-1618. doi:https://doi.org/10.1016/j.biocon.2011.02.011
- Das, A., Choudhury, B. U., Ramkrushna, G. I., Tripathi, A. K., Singh, R. K., Ngachan, S. V., . . . Munda, G. C. (2013). Multiple uses of pond water for enhancing water productivity and livelihood of small and marginal farmers. *Indian Journal of Hill Farming*, *26* (1), 29-36.
- Eyler, A. A., Mayer, J., Rafii, R., Housemann, R., Brownson, R. C., & King, A. C. (1999). Key informant surveys as a tool to implement and evaluate physical activity interventions in the community *Health Education Research*, *14* (2), 289–298. doi:https://doi.org/10.1093/her/14.2.289

- Gledhill, D. G., James, P., & Davies, D. H. (2008). Pond density as a determinant of aquatic species richness in an urban landscape. *Landscape Ecology*, 23(10), 1219-1230. doi:10.1007/s10980-008-9292-x
- Gurung, T. B. (2003). Fisheries and aquaculture activities in Nepal. In S. Wilkinson (Ed.), *Aquaculture Magazine, published by Network of Aqua* (Vol. VIII, pp. 14-19). Thailand: Network of Aquaculture Centers in Asia-Pacific.
- Hill, M. J., Greaves, H. M., Sayer, C. D., Hassall, C., Milin, M., Milner, V. S., . . . Wood, P. J. (2021). Pond ecology and conservation: research priorities and knowledge gaps. *Ecosphere*, 12(12), e03853. doi:https://doi.org/10.1002/ecs2.3853
- Islam, M. S., Nakagawa, K., Abdullah-Al-Mamun, M., Siddique, M. A. B., & Berndtsson, R. (2022). Is road-side fishpond water in Bangladesh safe for human use? An assessment using water quality indices. *Environmental Challenges*, 6, 100434. doi:https://doi.org/10.1016/j.envc.2021.100434
- Ismail, B. I. E. ed. (2017). *Renewable Hydropower Technologies*. Croatia: Janeza Trdine.
- Kabir, S. M. S. (2016). *Methods of data collection*. Chittagong-4203. Bangladesh: Book Zone Publication.
- Kubitza, F. (2016). Proper water circulation in aquaculture ponds is critical. *Global Aquaculture Advocate*, 1-6.
- Maiga, Y., Wethe, J., Denyigba, K. & Ouattara, A. S. (2009). The impact of pond depth and environmental conditions on sunlight inactivation of *Escherichia coli* and enterococci in wastewater in a warm climate. *Canadian Journal of Microbiology*, 55 (12), 1364-1374. doi:10.1139/W09-104
- Ochterski, J. (2007). *The pond guidebook*. Ithaca, N.Y.: Natural Resource, Agriculture, and Engineering Service, Cooperative Extension.
- Podgórski, Z. & Szatten, D. (2020). Changes in the Dynamics and Nature of Sedimentation in Mill Ponds as an Indicator of Environmental Changes in a Selected Lake Catchment (Chełmińskie Lake District, Poland). *Water*, 12(1). doi:10.3390/w12010268
- Tornero, I., Sala, J., Gascón, S., Avila, N., Quintana, X. D. & Boix, D. (2016). Pond size effect on macrofauna community structure in a highly connected pond network. *Limnetic*, 35(2), 337-354. doi:10.23818/limn.35.27
- United Natopns [UN]. (2018). *Clean water and sanitation*. Retrieved from New York: World Health Organization [WHO], (2011). *Guidelines on Water Supply and Sanitation at Extreme Water Events*. Copenhagen: Author.
- Worman, A., & Kronnas, V. (2005). Effect of pond shape and vegetation heterogeneity on flow and treatment performance of constructed wetlands. *Journal of Hydrology*, 301(1), 123-138. doi:https://doi.org/10.1016/j.jhydrol.2004.06.038