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Research Article

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Status of Fish Health Management Practices Adopted by Fish Growers In Badhaiyataal Rural Municipality, Bardiya, Nepal

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ABSTRACT
This study was conducted in Bardiya's PMAMP Fish Zone (Badhaiyataal rural municipality) to study the current fish health management practices adopted by fish growers. During the research period, 50 randomly selected fish farmer households were surveyed using structured questionnaires. The majority (80%) of the fish growers were male, averaging 45 years old with 13 years of farming experience. Most of them were literate (76%), practicing poly-culture fish farming focused on major carps with underground water as the main source of water. Training received respondents were dominated oversampled population. Argulosis, ulcer disease and asphyxiation were major diseases seen in the fish grower's farm at the study site. Most of the respondents used lime, maintained an optimum stocking rate, and selected healthy fingerlings, and pond drying as preventive measures. Most of the respondents followed biosecurity measures such as monitoring fish, avoiding contaminated feed, controlling of water source and sterilization of net by sun drying. The unavailability of diagnostic laboratories, lack of skilled technicians, advisory services from organizations and knowledge of disease and treatment were the major problems faced by farmers in curing the disease. Among these, the unavailability of a diagnostic laboratory was found to have caused severe impact. According to the research findings, the establishment of a training and diagnostic laboratory in the area will be essential for enhancing fish health and raising production as it would enable rapid disease identification and give local farmers the skills and information they need.
Keywords: Fish Health, Biosecurity, Fish diseases, Preventive measures, Aquaculture.

INTRODUCTION
Nepal is the second-richest country in terms of natural resources and has a lot of potential for water resources. Water resources account for approximately 2.6% of Nepal's total land area (MoALD, 2020), and its natural landscape is diverse. The fishes not only contribute to the local diet but are also good sources of animal protein, amino acids, folic acid, omega-3 fatty acids, and many more (Philibert et al., 2013). Besides the nutritional value, aquaculture has contributed 1.13% to the national gross domestic product, while 4.18% to the agricultural gross development product (AGDP) and per capita production of fish was found to be 3.11 kg (CFPCC, 2019). However, alongside these successes, challenges can be seen in fish health due to intensive fish farming practices. Studies showed that almost 50% of production loss is due to diseases that are more severe in developing countries (Leung & Bates, 2012) and 25 to 30% is estimated loss in Nepal due to diseases (MoALD, 2020). Fish diseases refer to any condition that adversely affects the health of fish, and can be caused by environmental stressors, genetic factors, or pathogens, which are broadly classified into infectious and non-infectious diseases, with gram-negative bacteria being a common cause of bacterial infections (Jeney, 2017). In Nepal, there are different parasitic, bacterial and fungal diseases found in fish, and EUS was identified as the prevailing bacterial-fungal ailment that greatly affected common carp fish in areas such as Trishuli, Begnas, and Mirmi. Meanwhile, the incidence of coccidiosis, attributed to *Eimeria spp*, has been observed to be on the rise in rainbow trout aquaculture (Shrestha et al., 2019). In Nepal, EUS is highly prevalent in fish ponds due to rapid fluctuation of temperature, limited or no exchange of water and poor application of liming material (Baidya & Prasad, 2013). During the winter season, there were increased reports of fin rot, which predominantly impacted common carp, silver carp, and bighead carp in Nepal (Shrestha et al., 2019).
Fish illnesses due to bacteria are common and among the toughest health problems to cure, and frequently seen in eggs, fry and fingerlings, and cause huge mortality in fish (Sandeep, 2016). Other bacterial diseases seen in

fish are Dropsy, Vibriosis, Columnaris, and Furunculosis. The most common reason for parasite infections in fish is protozoa, which are minute organisms that reside in aquatic environments that commonly affect the skin and gills of fish often leading discomfort, weight loss, and sometimes death, and chemicals like formalin, potassium permanganate, and copper sulfate are often utilized for therapeutics (Francis-Floyd, 2005). White Spot disease/Ich disease, Trichodinasis, Whirling disease, Gyrodactylosis and Dactylogyrosis are some examples of parasitic diseases found in fish. Fish aquaculture can be severely affected by non-infectious diseases, which are frequently due to environmental, genetic, or dietary causes. The primary causes are environmental problems such as high ammonia, low oxygen, and pollutants (Francis-Floyd, 2005).

Fish disease incidence in Nepal was first reported in 1965, with overcrowded ponds leading to up to 65% fry mortality (Jha & Bhujel, 2012). Environmental factors, parasites, and poor management contribute to high mortality rates (Bista et al., 2001). In central Terai, high disease prevalence is due to overcrowding and poor management, while the western Terai has fewer issues due to better pond systems, farmer education, and effective practices (Jha & Wagle, 2016).

Fish health management in aquaculture refers to the set of practices aimed at averting fish diseases (Kyule-Muendo et al., 2022). Once fish become diseased, it can be challenging to rescue them. Therefore, effective fish health management entails preventing diseases instead of treating them (Francis-Floyd, 2005). The study conducted by Mandal & Paudel (2019) found that dipping fish in 2-3% salt solution for 5-10 minutes and dipping in a solution containing 500 parts per million of copper sulfate for one minute daily was found to be an effective method for curing Argulosis and fungal infection, respectively in fish cultured in the ponds of Begnas. A combination of lime and potassium permanganate was commonly used for disease treatment, although some farmers used only lime or a mixture of lime and salt (Faruk et al., 2004). To effectively prevent diseases and early diagnosis of health issues, routine health monitoring of farmed fish is essential. Apply Salt @ 200 - 300 Kg/ 0.16 ha when water becomes heavily polluted and a mixture of 500g KMn04 with 60 - 80 Kg lime spray all over the water surface of 0.16 ha for controlling EUS (Das & Das, 2015). To eliminate *Ichthyophthirius multifiliis* (Ich) in catfish fingerlings, Formalin (25mg/L) and Malachite green is found to be effective chemicals (Tieman & Goodwin, 2001).

Fish farming in Bardiya district is now a popular business, as a result, the proximity of ponds can be seen so that various pathogens could be transmitted to the healthy pond through multiple means such as birds, and different utensils. Trained and skilled manpower is lacking in the research site and those who are available are required to perform a wide range of duties that increase workloads and lower quality work, potentially increasing risks to fish health. This might have negative consequences, including an increased risk of disease outbreaks that could have a significant impact on the health of fish populations and the livelihoods of those who depend on them. The research site is deprived of adequate quarantine services, information regarding fish disease and management practices, and diagnostic laboratories. This research will look closely at how the farmers take care of their fish ponds and give them better advice to keep their fish healthy. The objectives of this research is to investigate fish health management practices adopted by fish growers and the problems in health management practices.

MATERIALS AND METHODS

Research Site

The research was conducted in Badhaiyataal Rural Municipality of Bardiya district, Nepal. This municipality was selected due to the large number of fish farmers reside in this area. It ranges in altitude from 143 to 157 meters above sea level and has an area of 115.19 square kilometers.

Figure 1. Map of Nepal showing research Site

Two types of data were collected for this research, primary and secondary data. Primary data was collected through the help of face-to-face interviews with the individual respondents. A structured questionnaire was made for collecting data, and recorded in Excel. Secondary data was retrieved through publication from various reputable institutions such as the Agriculture Knowledge Center (AKC) Bardiya, Agriculture Information and Communication Centre (AICC), Central Bureau of Statistics (CBS), Nepal Agriculture Research Council (NARC), and the Prime Minister Agriculture Modernization Project (PMAMP).

Sampling

The total number of fish farmers in the Badhaiyataal rural municipality was computed, resulting in a count of 55 farms and calculated sampling size with the help of the Taro Yamen formula with a 95% confidence level.

$$n = \frac{N}{1+Ne^2}$$

Where,

n = number of samples,

N = number of population

e = allowable error

Having calculated the sample size with the help of the above-mentioned formula, 50 farmers were selected using a simple random sampling method. Before being interviewed, a preliminary questionnaire was prepared to identify questions that may pose difficulties for the respondents, evaluate the questionnaire's applicability and clarity, and adjust it to the conditions on-site. After that survey was conducted from April to May 2023 through face-to-face interviews with farmers.

Data Analysis

After the collected data was entered and cleaned through MS Excel, it was analyzed in Statistical Package for Social Sciences. Descriptive analysis was done for socio-demographics and farming systems such as age, gender, level of schooling, occupation, farming experiences, source of fingerlings and water, Training and so on, whereas forced ranking technique was used for ranking problems and reason for fish mortality using formula:

$$I = \sum \frac{S1F1}{N} \qquad (Miah, 1993)$$

Where,

I = Index value

∑ = Summation

Si = I^{th} scale value

Fi = Frequency of i^{th} importance given by the respondents

N = Total number of the respondents

RESULTS AND DISCUSSIONS

Age, Area of pond and Farming Experiences

The age range of the 50 respondents was ranges from 28 to 65 years, with an average age of 45 years. The respondents had varying degrees of farming experience, ranging from 1 to 23 years with an average of 13 years, and the area of the pond varies from 0.07 to 7.34 ha, with an average area of 1.2380 ha. This data is illustrated in Table 1.

Table 1. Age, Area of Pond, Farming Experience

Items	Mean	Minimum	Maximum	Std. Deviation
Age (Year)	45.84	28	65	10.249
Area of Pond (ha)	1.2380	0.07	7.34	1.34421
Farming Experience (year)	13.70	1	23	6.944

Gender, Religion and Education

Out of the sampled population, the majority of the respondents were male, accounting for 80% (n=40), whereas only 20% (n=10) were females, illustrated in Figure 2. Most of the fish farmers were Hindus, which comprise 92%, followed by Muslims 6%, and Buddhists only 2%, the data is illustrated in Figure 3. The majority of the farmers were educated where 32% had been educated up to at least Higher Secondary school which was followed by 30% having School Education Examination (SEE) and 10% being below SEE. Only 4% were educated up to graduation level and 24 % were illiterate. The data on education is depicted in Figure 4.

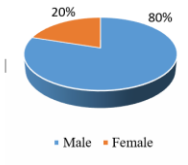

Figure 2: Gender of Respondent

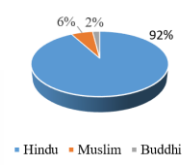

Figure 3: Religion of Respondent

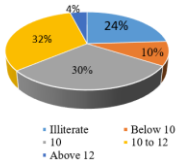

Figure 4: Education of Respondent

Farming System, Procurement of fingerlings, and Training

Out of the total respondents, only one individual practised monoculture of Pangas species as their farming system whereas the majority followed polyculture of Carp species such as Rohu, Naini, Common Carp, Silver Carp, Grass Carp, Bighead Carp, and Bhakur. This suggests that the majority of respondents have good knowledge about the proper use of various levels of water. Similarly, 74% (n=37) said that they had acquired fingerlings from government farms whereas 24% (n=12) used both government farms and private nurseries/hatcheries as their sources of fingerlings. However, only 2% relied solely on private nurseries or hatcheries. Likewise, 66% (n=33) had attended fish farming training, while 34% (n=17) had not received such training. The data about the Farming system, procurement of fingerlings and training are illustrated in Figure 5, 6, and 7 respectively.

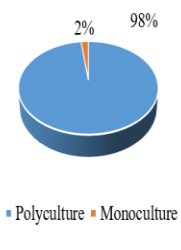

Figure 5: Farming System

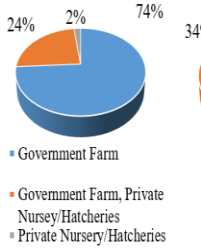

Figure 6: Procurement of fingerlings

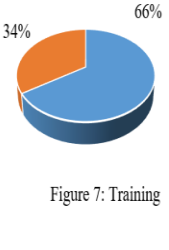

Figure 7: Training

Mode of Fishing and Main Source of Water

Figure 8 shows the result of the mode of fishing in which a significant proportion of participants, comprising 86% (n=43), reported that they were full-time fishing. This indicates fishing is the main source of income for a significant portion of the community. Nevertheless, 14% of respondents (n=7) stated that they fished as a hobby on the side. On the other hand, the distribution of main source of water to the pond is described in Figure 9, where most of the respondents used underground water to their ponds using boring, which accounts for 67%, followed by monsoon water (16%) and submersible pump water (12%). However, only a small percentage of respondents (4%) reported using lake water in their pond. Same result was found in the research conducted by Yadav et al. (2023) reveled that fish farms were found to use water from various sources, such as deep boring, shallow tube wells, and rivers/canals.

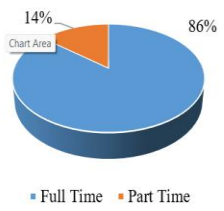

Figure 8: Main Source of Water

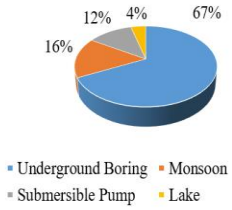

Figure 9: Mode of Fishing

Information about fish disease

The variables of fish disease information is illustrated in Table 2 along with frequency and percentage.

1. Fish Disease

The majority of the respondents revealed that their ponds were affected by Asphyxiation, a non-infectious disease due to lack of oxygen in the ponds that results devastating fish death in their pond. Similarly, Argulosis was another important infectious disease seen in the pond followed by ulcer. Shrestha et al. (2019) also found that Argulosis, caused by the parasite Argulus, was a common disease in Indian major carp, particularly among brood fish which was problematic in locations such as Mirmi and Syangja. Likewise, Yadav et al. (2023) reported that Argulosis was the most prevalent disease in the Dhanusha district whereas asphyxiation caused the highest mortality.

2. Disease Reported in Farm

When respondents were asked whether they had a disease problem in their pond, 64% of the respondents (n=32) said that they had a disease problem during the last year, while only 6 farmers said that they didn't have a disease problem in their pond to date. Interestingly, 10% of the farmers were recently observed the diseased, which suggests that there may still be ongoing health issues on the farm. This result is supported by Frauk's (2008) study in which the majority of farmers said that they had fish health problems during the previous year and few farmers said that they did not find any disease in their pond.

3. Importance of disease to the respondents

The most commonly reported perception was a moderate problem, accounting for 42% of the responses (n=21). Following that, a minor problem was reported by 26% of the farmers (n=13). On the other hand, 18% of the respondents (n=9) considered fish diseases to be a major problem. Lastly, 14% of the farmers (n=7) reported that fish diseases were not a problem for them. The same result was found in the study of Frauk et al. (2004) in which the majority of fish growers considered fish disease as a moderate problem in Bangladesh.

4. Recognition and knowledge about the cause of disease

Farmers were asked about their ability to identify diseases. A few respondents (26%) reported that they were unable to recognize most of the diseases, while the majority (74%) mentioned being capable of recognizing certain diseases based on specific clinical signs. Similarly, just a small portion of the participants (18%) demonstrated knowledge about the causes of different diseases, whereas the majority (82%) lacked understanding regarding the causes. These results are in line with the study conducted by Aftabuddin et al. (2016) in Bangladesh in which the majority of respondents recognized some diseases whereas few of them were unable to recognize any fish diseases. Similarly, the study conducted by Hasan et al. (2019) also reported that a number of diseases and conditions were recognized clinically by most of the farmers.

5. Fish mortality, and reporting to government office

Most of the respondents (64%) said that they had fish mortality in their farm. Only 36% of the participants' farms reported an absence of disease or mortality. These findings align with Mulei et al. (2021), who also found that most farmers observed fish mortalities on their farms. On the other hand, only 12% of farmer said that they sometimes report to the government office about the outbreak of the disease in their pond and seek advice. While other respondents received advice from fellow fish farmers and agro-vet technicians. Similarly, Jha & Wagle (2016) noted that the level of assistance and reporting of fish diseases to government offices was quite low.

Table 2. Information about Fish Diseases

Variables	Frequency	Percentage
Degree of the importance of disease to the farmer	6	12.0
Not seen		
Recently	5	10.0
6 month ago	6	12.0
1 year ago	32	64.0
Degree of the importance of disease to farmer	9	18.0
Major problem	21	42.0
Moderate problem		
Minor problem	13	26.0
Not a problem	7	14.0
Recognition of disease by farmer	37	74.0
Yes	13	26.0
No		
Knowledge about the cause of disease	9	18.0
Yes	41	82.0
No	32	64.0
Fish Mortality	18	36.0
Yes		
No	6	12.0
Report to government offices	44	88.0
Yes		
No	46	92.0
Disposal of dead fish	1	2.0
Buried in the soil	0	0
Sell them at low price	3	6.0
Consume it		
Don't do anything		

6. Disposal of dead fish

Only 2% of those surveyed sold their unhealthy fish to other people, according to the study, which found that 92% of farmers buried their sick fish in the earth. Remarkably, not a single respondent ate the contaminated fish, and six percent of them did nothing except throw the infected fish into an adjacent canal. Similar findings were reported by Aftabuddin et al. (2016), indicating that sellers were unable to sell diseased fish due to consumer resistance, and the majority of farmers buried their sick fish.

Fish Health Management Practices

1. Preventive Measures

Figure 10 describes about the preventive measures used by the respondents, where almost all respondents apply lime in their ponds, and about 42 of them also dry their ponds as part of their preventive measures. This result is in line with the study conducted by Jha & Wagle (2016) reported that most of the respondents took preventive measures to prevent the outbreak of disease in their pond such as use of lime before disease outbreak, pond drying, and disinfection of equipment. Selection of healthy fingerlings is the second most common preventive measure as they procure fingerlings from government farms and renowned hatcheries, accounts for 44 respondents; however, only 6 farmers did not procure from there, which is quite similar to the findings of the study conducted by Rahman et al. (2022) which showed that 87.5% farmers collected fingerlings from renowned hatcheries. Similarly, 41 respondents maintained the optimum stocking rate for their ponds; in contrast, a similar number of respondents did not only check water before applying in the pond but also test water quality. The number of farmers who have disinfected their equipment and those who haven't accounted for 29 and 21, respectively. Disinfection of farm equipment and culture facilities is routinely included in fish health management schemes in hatcheries (Opiyo et al., 2018).

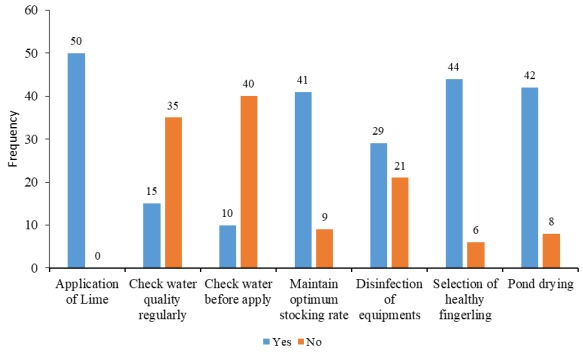

Figure 10: Preventive Measures for Fish Diseases

2. Biosecurity Measures

From figure 11, it was clear that monitoring of fish diseases and avoiding feeding contaminated feed were the most commonly followed biosecurity measures by the same number of respondents (n=48). Disease monitoring is an essential part of any biosecurity program. This consists of regular health evaluations of all stock in a fish nursery. The result from the study conducted by Deb et al. (2021) observed a similar emphasis on monthly fish health monitoring by farmers. Similarly, most of the respondents (n=41) followed proper disposal of diseased fish by burying them in the soil, and sterilization of net before and after use to harvest fish. This prevents the further spread of diseases in the pond. Rahman et al. (2022) also identified monitoring as the most common practice followed by farmers in Mymensingh District, Bangladesh, which also identified most of the farm's proper disposal of dead fish and limited farm access were observed. The practice of sterilizing nets through sun drying, as observed in the study by Yadav et al. (2023), further strengthens the collective understanding of effective biosecurity measures. Water source is one of the most important biosecurity measures as good quality of water is required for the proper growth and development of fish. Most of the respondents (n=45) control the water source by applying underground water using a motor and few use lake water with a net in the inlet pipe. The least practiced measure, quarantine of fish, was also aligned with the findings of Opiyo et al. (2018) in Kenya, where the absence of quarantine facilities hindered disease monitoring for new fish introductions. This shows that most of the respondents were aware and had good knowledge about biosecurity measures.

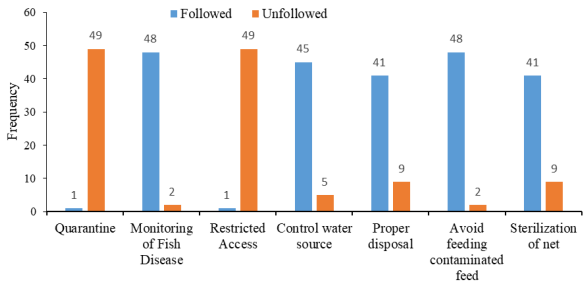

Figure 11: Biosecurity Measures Implemented by the Farmers

3. Chemicals Used in Fish Health Management Practices

Figure 12 displays the results of the research, which are intended to evaluate both the usage of chemicals in aquaculture as well as the level of awareness surrounding them. According to 30 responders, Toximar was the chemical most commonly employed for disease control during the survey. This was followed by Clinar and Potassium Permanganate, used by 28 and 27 respondents, respectively. A similar proportion of responders, comprising 21 to 23 farmers, also used salt, Kohrsolin, and Sokrena. The two chemicals that are least frequently used to prevent fish disease are NOVIBI and Malachite Green. Farmers reported using these chemicals in their ponds after receiving advice from local market sellers. This reliance on suppliers may introduce bias, as suppliers might promote their products to increase sales, potentially leading to higher prices. Farmers relied solely on supplier instructions and were unaware of the proper dosages, which might be

hazardous for fish farming operations. It is suggested that the government should take action to address the problem by providing sufficient technicians to these regions and educating farmers about the proper use of pesticides in aquaculture. Similar findings regarding the use of chemicals in Bangladesh's aquaculture industry have also been observed in previous research (Frauk et al., 2004). Although they have knowledge of preventive and biosecurity measures, they lack proper knowledge of the appropriate dosage of chemicals needed for controlling diseases in the ponds.

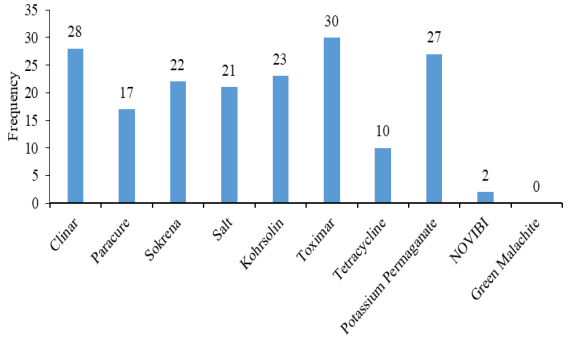

Figure 12: Chemicals Used in Managing Fish Disease

Problems in health management practices

The problems that farmers experience when implementing fish health management techniques into reality are listed in Table 3. The forced ranking method was used to evaluate these challenges according to rank and their index value. The ranked list reveals that the most major problems were the unavailability of a diagnostic laboratory (0.99), lack of skilled technicians (0.98), lack of advisory services from the organization (0.96), Lack of training on fish disease (0.95), Lack of knowledge of the disease, and treatment (0.94). These problems were all considered major issues, with index values greater than a weighted average of index value i.e., 0.93, signifying their significant impact on farmers' health management practices. While, lack of capital, the high price of medicine, limited access to feed and nutrition, and unavailability of medicine were fewer constraints in implementing health management practices. The study conducted by Shrestha et al. (2019), and Halim et al. (2020) in Nepal identified similar constraints such as lack of assistance, poor technical knowledge, and lack of suitable diagnostic laboratory and their proper use as a major problem in fish health management.

Causes of Fish Mortality

To know the causes of mortality in fish, the problem ranking method was used, and illustrated in Table 4. Out of the 50 sampled fish farms, the low amount of water was a major reason for fish mortality, which is followed by poor water quality, disease, flood, and predator attacks. The research site is a potential area for fish farming, with many farms relying on groundwater. However, simultaneous use of pumps by multiple farms could lead to a decrease in groundwater levels, resulting in reduced water availability for ponds.

Table 3. Problems Encountered in Managing Fish Health

Problems	Mean	Std. Deviation	Index Value	Rank
Unavailability of diagnostic laboratory	1.1	0.36	0.99	I
Lack of skilled technician	1.2	0.45	0.98	II
Lack of advisory services from the organization	1.38	0.56	0.96	III
Lack of training facilities about fish disease treatment	1.44	0.64	0.95	IV
Lack of knowledge of disease	1.56	0.73	0.94	V
Lack of knowledge of treatment	1.56	0.73	0.94	V
Limited access to feed and nutrition	2.22	0.61	0.92	VI
The high price of medicine	1.72	0.64	0.91	VII
Unavailability of medicine	1.88	0.59	0.88	VIII
Lack of capital	2.12	0.74	0.87	IX

Table 4. Causes of Fish Mortality

Causes of fish mortality	Index Value	Rank
Low Amount of Water	0.86	I
Poor Water Quality	0.83	II
Disease	0.59	III
Flood	0.52	IV
Predator Attack	0.48	V

CONCLUSION

This study demonstrated that the status of fish health management practices in Bardiya district is moderately good, and the prevalence of fish disease is also moderate. However, it should not be neglected, as there are some major problems in managing health issue in fish by the farmers such as absence of diagnostic laboratory to the area, inadequate skilled technician, and insufficient training programs related to fish disease and their management practices. Based on this research, Bardiya has not been proned to disease in fish till now, but it would be a major problem if the government does not take responsibility for addressing it. A diagnostic lab along with the skilled and experienced technician, is needed at the research site because there is no any reporting office about the disease and other pathogens except for private suppliers and experienced farmers in that area. Additionally, farmers need training programs on fish diseases and their management practices so that they can more effectively maintain their fish healthy and free from pathogens. Also, both government and non-government organizations should provide regular advisory services to farmers, offering guidance on disease prevention, management, and health improvement.

CONFLICT OF INTEREST

The author here declares that there is no conflict of interest in the publication of this article.

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