STATUS OF IMPROVED FISH PRODUCTION TECHNOLOGY ADOPTION IN DHANUSHA DISTRICT, NEPAL

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ABSTRACT

The study was conducted in Dhanusha district of Madhesh province of Nepal to find out the social and demographic characteristics of farmers, available technologies for fish production, identification and adoption of available technologies, and major problems faced by farmers in the adoption of improved fish production technologies. 64 respondents were selected by simple random sampling method. Collected data were analyzed using SPSS 25.0 and MS-Excel. Various factors affecting the adoption of improved fish production technology were assessed using the chi-square test. It was found that fish farming was male-dominated in the area, and the mean family size was 5.88. Additionally, the majority of respondents (60.9%) had a pond size greater than 1 ha with a mean pond size of 1.33 ha. Farmers' mean age was 45.67 years. The major sources of information on fish farming were fellow fish farmers and training. The chi-square test showed a significant association between adoption level with educational level, fish farming experience, pond size, and fish farming training received. Technologies like stocking of ponds (89.1%), fish harvesting (87.5%), fish feeding (79.7%), maintenance of ponds (78.1%), site selection for ponds (75%), and pond construction (64.1%) were highly adopted by farmers. However, they had low adoption in post-harvest preservation and storage (4.7%). High feed costs, inadequate capital, and lack of technical knowledge were major problems in adopting improved fish production technologies.

Keywords: *fish farming, adoption, socio-demographic, chi-square test, problems faced*

INTRODUCTION

Aquaculture is one of the fastest-growing industries in the world (Calixto et al., 2020) and also the fastest emerging food source that plays a vital role in the economy (Milon et al., 2020). The pre-sale value of all global sales is estimated to be US $406 billion, with the U.S. $141 billion for fisheries, including US $265 billion for aquaculture. More than 157 million tonnes (89%) of global fishery production is used for food. The remaining 20 million tonnes is used mainly for fish feed and fish oil production (16 million tonnes, 81% equivalent) (FAO, 2022).

In Nepal, the agricultural industry has the most significant contribution to the country's GDP, accounting for 23.95% (MoF, 2022) . At present, the fisheries sector contributes 0.44% to the GDP and 1.83% to AGDP in Nepal (CFPCC, 2021). In Nepal, commonly cultivated fish species are Rohu (*Labeo rohita*) , Common carp (*Cyprinus carpio*), Bhakur (*Catla catla*), Silver carp (*Hypophthalmychthis molitrix*), Tilapia(*Oreochromis niloticus*), Bighead carp (*Hypophthalmychthis nobilis*), Naini (*Cirrhinus mrigala*), Grass carp (*Ctenopharyngodon idella*), and Rainbow trout (*Oncorhynchus mykiss*).

Current total national fish production is 113,736 mt, of which 21,000 mt is contributed by capture fisheries while 92,736 mt is from aquaculture. In Dhanusha district alone, fish production is 7985 metric tons with a productivity of 6.1 metric tons per hectare with a water surface area of 1307 hectares (CFPCC, 2023). Dhanusha district presents a unique opportunity for the expansion of fish production due to its abundant water resources, suitable climate, and cultural inclination towards freshwater fish consumption. Despite Nepal's gross national fish production, the country still falls short of meeting the per capita demand for fish due to inefficient aquaculture practices, poor pond management, feeding, water quality, and disease/pest control in ponds (Dhakal et al., 2022).

Fish workers are usually among the poorest and manage small-scale fishing operations using traditional methods, although fish farming accounts for the majority of Nepal's yearly fish production (Neupane & Gharti, 2018). However, new regulations and technological advancements favor larger, capital-intensive businesses over small-scale, conventional commercial fishing (Delgado et al., 2003). Understanding the technology adoption dynamics within the local context is imperative for designing targeted interventions that facilitate the uptake of innovative practices, maximize their impact, and ensure long-term sustainability (Rizzo et al., 2023).

Hence, this research aims to identify the types of improved fish production technology adopted and the problems faced by farmers in the adoption of improved fish production technology. By evaluating factors influencing farmers' adoption decisions, identifying barriers and facilitators to technology uptake, and exploring opportunities for enhancing adoption rates, this research seeks to provide research-driven policy and actions that will support the region's aquaculture industry's sustainable development.

METHODOLOGY

Study site

The research was conducted in the Fish Super-zone domain of PMAMP Dhanusha. Dhanusha is recognized as the center point of the Madhesh Pradesh of Nepal. Janakpur, one of the religious cities of Nepal, is the headquarters of this district, as well as the simultaneous state capital of Madhesh Pradesh. Its area is 1,180 km^2 with a population of 838,084 (NSO, 2021).

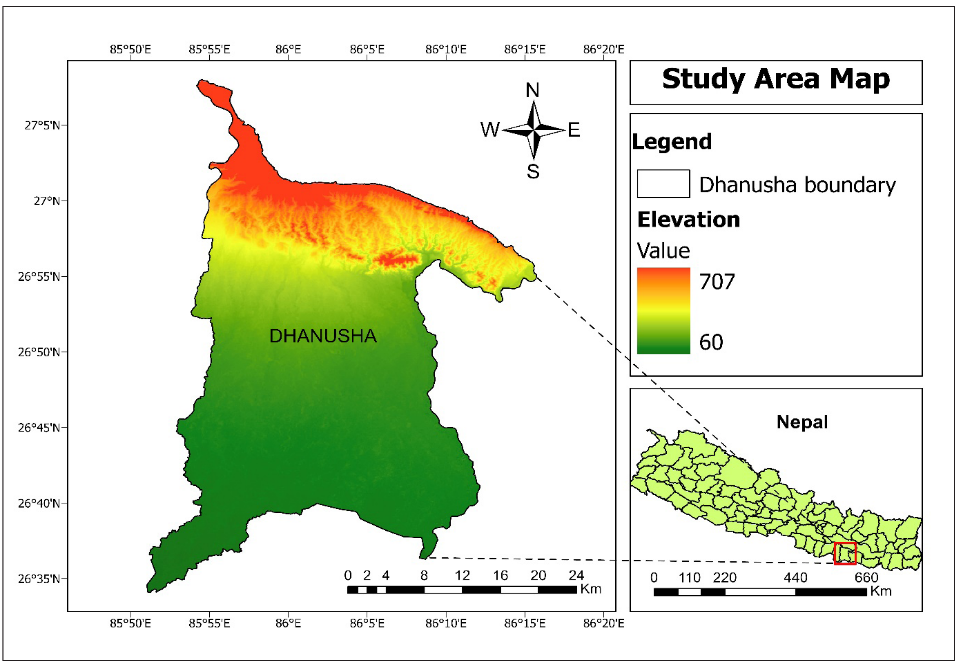

Figure 1. Study area map

Sampling; sampling frame and selection procedure

The study was focused on all the farmers who are practicing fish farming at a different level of intensification and commercialization. Among 176 farmers, farmers' groups, cooperatives, or firms registered in the Fish Super zone, Dhanusha, a sample of 64 respondents were selected via simple random technique using the Yamane's formula as below at 10% error margin;

Sample size = $N/(1+N*e^2)$,
where, N= size of population
e= error margin

Data collection

Primary data were collected using a semi-structured pre-tested interview schedule, Focus Group Discussion (FGD), and Key Informant Interview (KII). FGD was conducted in a group of 8 progressive farmers during the checklist preparation. KII was conducted with the representative of local stakeholders, lead farmers, extension workers, heads of community-based organizations, etc., to cross-verify the data. Similarly, secondary data were collected from documents and publications from PMAMP, Agriculture Knowledge Centre, Agriculture Census, NARC, FAO, CFPCC, journal articles, and other relevant reports and publications.

Data analysis techniques

SPSS (Version 25) and MS-Excel were used for the analysis of the collected data. The data have been represented in textual, tabular, and graphical for easy understanding. The percentage of people aware of the adoption of technologies as well as those who adopt the technology was calculated. The adoption level of specific technology was also be calculated as such individually.

Problem ranking

Scaling technique provides the direction and attitude of the respondents toward propositions. Major problems in adoption of improved fish production technologies in the area were identified and included in the interview schedule after discussions with PMAMP Dhanusha and focused group discussions. The most severe problem was assigned a value of 1, and the score for less severe difficulties was lowered by deducting 0.25 from the prior score using ranking scales.

Preferential ranking for constraints perceived by farmers in adoption was done by indexing

Indexing was calculated by following formula:

$I\ imp = \sum (Si * Fi / N)$

where, I imp = Index of importance

Si = Value at i^{th} priority,

Fi = i^{th} priority frequency,

N = Total number of respondents

Chi-square test for variables association analysis

Chi-square was used to examine if two variables were related to one another or independent of one another.

$\chi 2 = \sum(O_{mn} - Eij)^2 E_{mn}$

Where, $\chi 2$ =Chi-square

Oij = observed frequency of each mn^{th} term

Eij= indicates expected frequency of mn^{th} term

i= 1, 2, 3……….. e

j= 1, 2, 3…………f (This was examined for different degrees of freedom at the 0.05 level of probability)

Calculation of Adoption Index

Adoption index measures the extent to which improved technologies is adopted by farmers. Based on the adoption index value, farmers were categorized as either high or low adopters. Adoption index was calculated by adoption score. 0 and 1 scores were assigned for non-adoption and adoption of improved fish production technology respectively.

Adoption index was computed by using formula;

$$\text{Adoption score} = \frac{\text{Total score obtained}}{\text{Maximum attainable adoption score}}$$

Based on the adoption index, farmers were classified into low adopter or high adopter. From the adoption index, we can assess the level of adoption of each respondent.

Low Adopter: The Adoption Index is below the average level of total farmers.

High adopter: The Adoption Index is above the average of the total farmers.

RESULTS AND DISCUSSION

Socio-demographic characteristics of the sample household

Socio-economic and demographic characteristics that were important in assessing the study's objective are summarized in the section.

Gender of respondents

Out of the total sampled respondents, 87.5% were male and 12.5% were female. It depicts the dominance of males in fish farming in the district. The distribution of respondents based on gender is given in Figure 2.

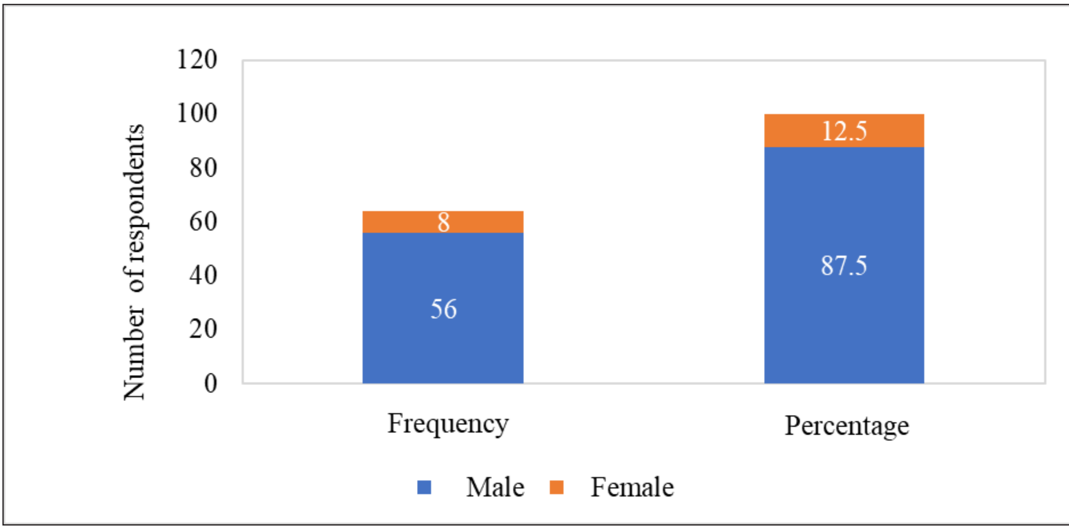

Figure 2. Classification of farmers by gender of respondents

Age of respondent

Among sampled population, 3.1% respondents are above 60 years, 3.1% have age below 30 years, 18.8% respondents are aged between 30 to 40 years, 53.1% are aged between 41 to 50 years and remaining 21.9% have age between 51 and 60 years.

The average age of the respondents was 45.61 years, suggesting that the fish farmers in the research area are likely to be relatively young, engaged in fish farming operations, and a potential source of labor for the local fisheries industry. The mean age of a fish farmer was found to be 40.2 years in the Dhanusha district (Yadav et al., 2023). The distribution of respondents based on age can be found in Figure 3.

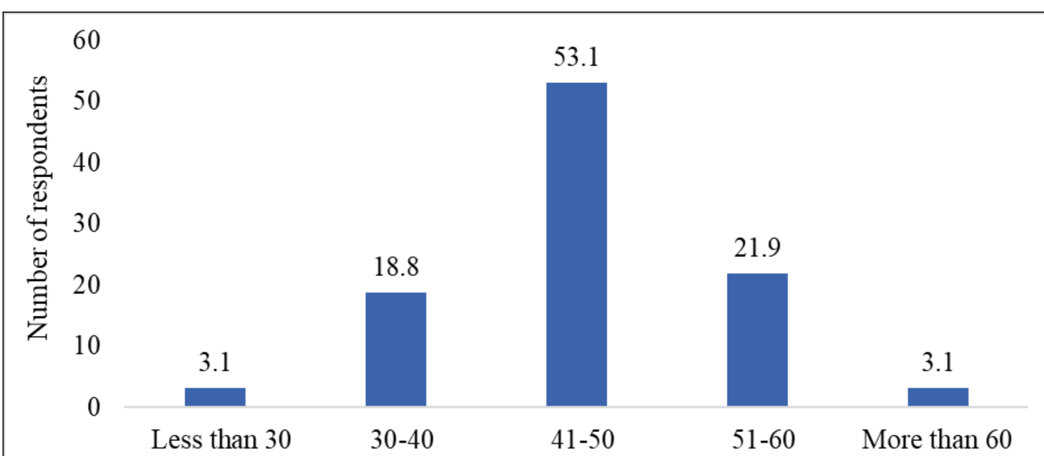

Figure 3. Classification of farmers based on age of respondent

Education level of respondents

The study shows that there are 9.4% illiterate, 40.6% had attained primary level education, 45.3% had attained secondary, 4.7% respondents attained university education respectively. The majority of responders had completed secondary education (45.3%). The results show farmers in the area are fairly educated. The distribution of education level of respondents is given in Figure 4.

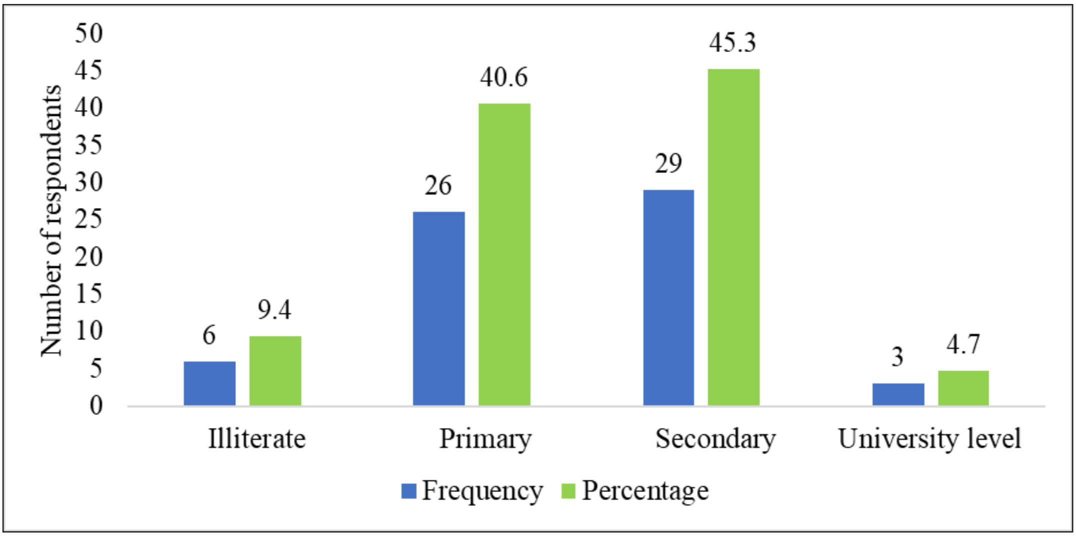

Figure 4. Classification of farmers on the basis of the education level of respondents

Family size of the respondents

The average family size in the study area was 5.58, with a maximum family size of 13 members and a minimum of 3 members in the family. The standard deviation was found to be 1.704.

Ethnicity of the respondents

Fish farming was practiced by respondents from a variety of ethnic groups in this survey, including Yadav (26.57%), Sah/Teli (17.18%), Mukhiya (9.39%), Chaudhary (4.7%), Brahmin (4.7%), Mandal (3.7%), Sahani (1.6%), and others (17.18%). Even though Mallah and Mukhiya pioneered the fishery sector, other caste involvement appears to be dominating in this sector. Due to their increased influence over the district's overall population, ethnic groups like the Yadav and Teli/Sah are becoming more and more involved. The distribution of respondents based on ethnicity can be found in Figure 5.

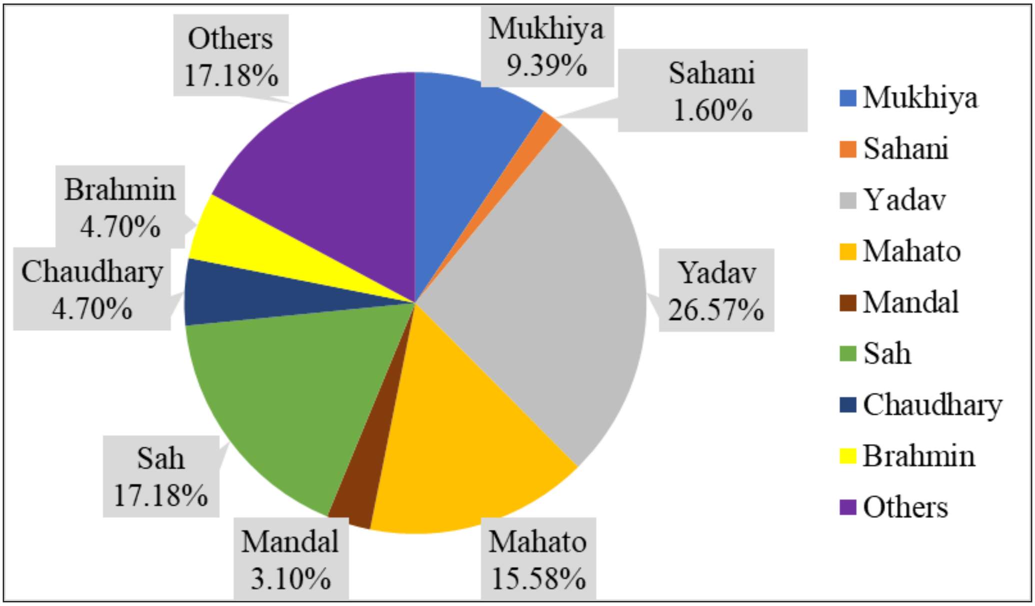

Figure 5. Pie chart showing ethnicity of respondents

Fish Farming experience of respondents

Although the majority of the respondents in this study have relatively little experience, it was found that they are quite experienced in fish farming. This suggests that fish farming in this district is attracting a lot of young entrepreneurs. The average farming experience was found to be 10.33 years. The distribution of respondents based on fish farming experience can be found in Figure 6.

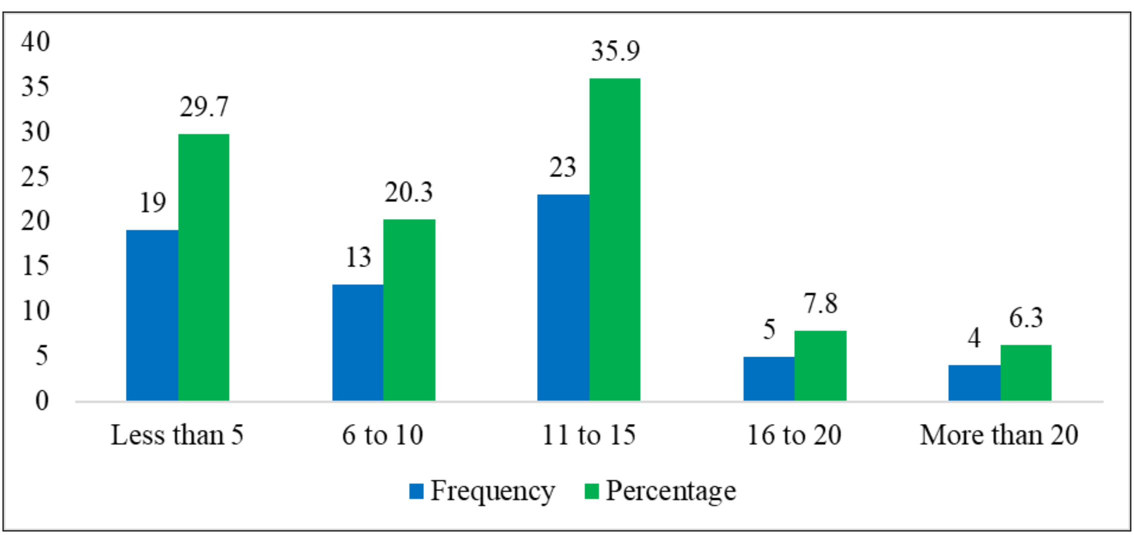

Figure 6. Bar diagram showing the fish farming experience of respondents

Source of capital

Among the total respondents, 59% used bank loans as source of capital for fish farming followed by personal saving 28%, co-operative loans 11% and government grants 2%. Majority of respondents used bank loan as source of capital due to large availability of funds and easy availability of banking services and availability of subsidized interest rate in agriculture loans. The distribution of respondents on the basis of sources of capital for fish farming is given in Figure 7.

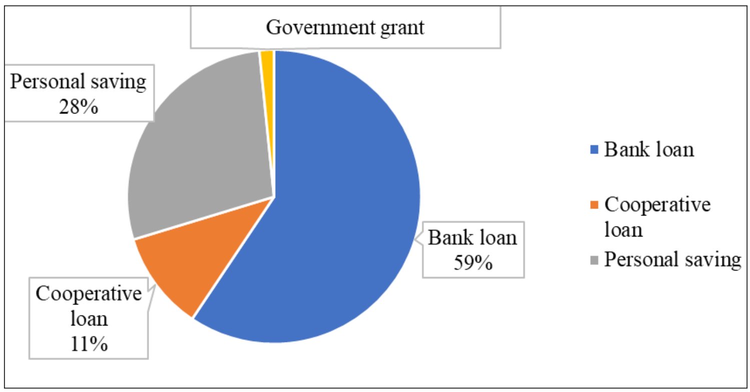

Figure 7. Pie chart showing different sources of capital

Number of Fish farming training attended

The majority (60.9%) of respondents, had not attended any kind of training. 12.5% of respondents had attended training more than 4 times as well as between one to two times. 14.1% of respondents had attended training three to four times. The mean number of fish training attended by respondents was 2.02±0.461. It indicates that the large number of fish farming training is needed at an intensive scale in the district. The distribution of respondents based on number of trainings attended is given in Figure 8.

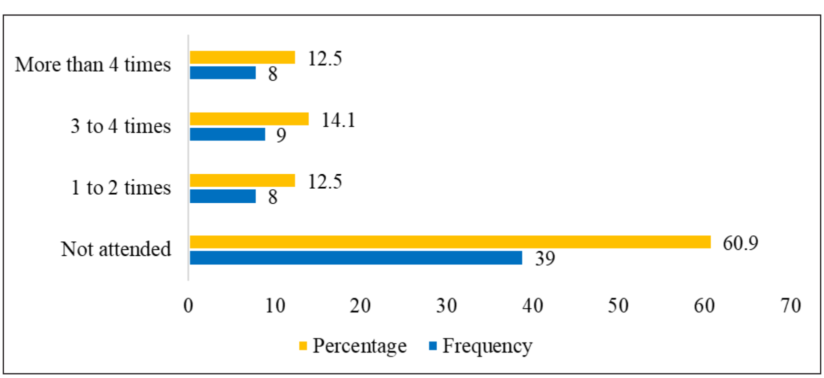

Figure 8. Clustered bar diagram showing the number of farming trainings attended

Source of information about fish farming

Majority of respondents (67.2%) depended upon fellow fish farmers for information regarding fish farming. 20.3 % of respondents depend upon training for information regarding fish farming followed by government offices which accounts for 12.5%. None of the respondents depended upon ICT for fish farming information. It depicts the lack of proper extension services by the government and related institutions in the area. The distribution of respondents according to the source of information on fish farming is given in Figure 9.

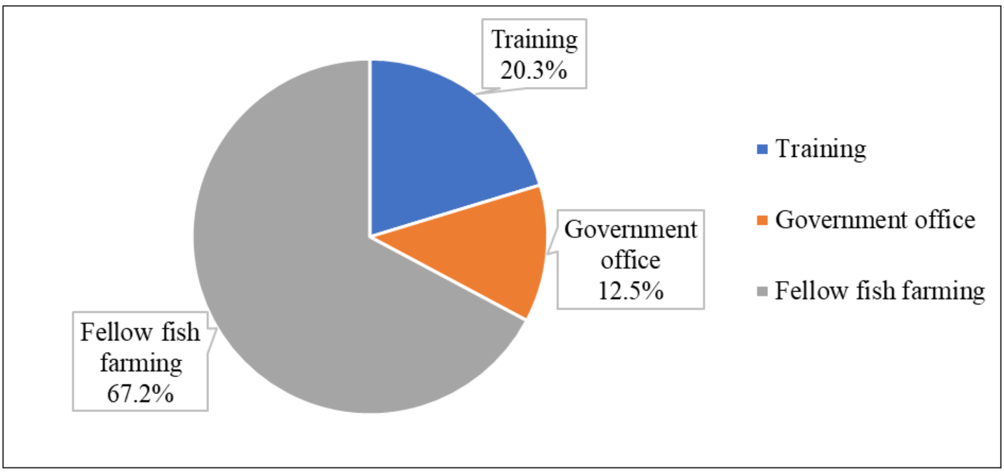

Figure 9. Pie chart showing different sources of information about fish farming

Fish Pond size

Majority of respondents (60.9%) had a pond size greater than 1 ha. 21.9% of the respondent had a pond size between 0.6 and 1 ha. The remaining 17.2% of respondents had pond size less than 0.6 ha. The mean pond size was 1.33 ha in the area. Majority of pond area were greater than 1 ha due to sufficient availability of plain land in the region. The distribution of respondents based on pond size is given in Figure 10.

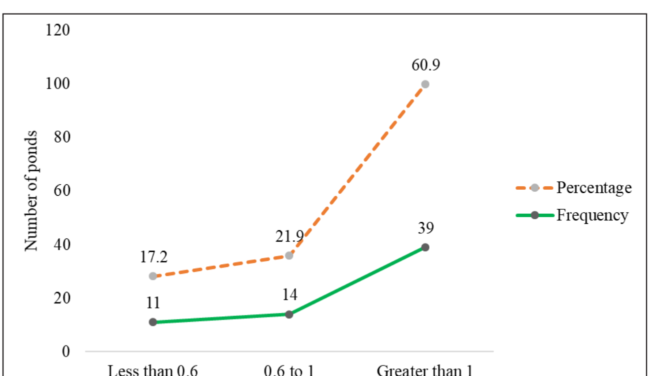

Figure 10. Line graph showing categories of pond size

Improved Fish Production Technology Used

The findings showed that farmers liming and fertilizing the pond was 100%; followed by improved breeds of fingerlings (96.9%) provision of inlet and outlet in the pond (93.8%), regular sampling/sorting of fish (92.2), improved techniques in pond construction and maintenance (90.6%), floating feeds (87.5%), prevention and control of diseases (85.9%), daily sanitation and record-keeping (79.7%), optimum stocking rate (75%), aerated containers for fingerlings transportation (73.4%). The lowest ranks were fish preservation and storage techniques (3.1%) followed by aerators (7.8%), water testing kits (9.4%), and techniques of hatchery and fingerling production (9.4%). Improved fish production technology used by respondents is given in Table 1.

Table 1. Improved fish production technology used by respondent farmers

Improved Fish Technology used	Frequency	Percentage	Percentage Rank
1. Fertilization and liming in pond	64	100	I
2. Improved breeds of fingerlings	62	96.9	II
3. Provision of inlet and outlet in pond	60	93.8	III
4. Regular sampling/sorting of fish	59	92.2	IV
5. Improved techniques in pond construction & maintenance	58	90.6	V
6. Floating feeds	56	87.5	VI
7. Prevention and control of fish diseases	55	85.9	VII
8. Daily record-keeping practices	51	79.7	VIII
9. Optimum stocking rate	48	75	IX
10. Aerated containers for fingerlings transportation	47	73.4	X
11. Frequent change of water	39	60.9	XI
12. Feed fortification	35	54.7	XII
13. Soil testing before site selection	30	46.9	XIII
14. Pellet feed	22	34.4	XIV
15. Integrated fish farming	13	20.3	XV
16. Techniques of hatchery and fingerling production	9	14.1	XVI
17. Water testing kit	6	9.4	XVII
18. Aerators	5	7.8	XVIII
19. Fish preservation	2	3.1	XIX

Awareness and adoption of improved fish production technology

Respondents were highly aware of technologies such as Pond selection (84.4%), pond construction (71.9%), stocking of fish (92.2%), feeding (90.6%), pond maintenance (84.4%), harvesting of fish (93.8%), and post-harvest fish preservation (73.4%).

Respondents highly adopted technologies such as pond site selection (75%), pond construction (64.1%) and stocking of ponds (89.1%), feeding (79.7%), pond maintenance (78.1%), harvesting of fish (87.5%). But respondents have low adoption in post-harvest preservation and storage(4.7%). Awareness and adoption of improved fish production technology by respondent farmers is given in Table 2.

Table 2. Awareness and adoption of improved fish production technology by respondent farmers of the study area

Improved Technology Assessed	Technology awareness		Technology adoption	
	Aware(%)	Not Aware(%)	Adopted(%)	Not Adopted(%)
Pond site selection	84.4	15.6	75	25
Pond construction	71.9	28.1	64.1	35.9
Stocking	92.2	9.4	89.1	10.9
Feeding	90.6	9.4	79.7	20.3
Pond maintenance	84.4	15.6	78.1	21.9
Harvesting	93.8	6.3	87.5	12.5
Post-harvest preservation	73.4	26.6	4.7	95.3

Problem ranking of respondents farmers in using improved fish production technology

Various problems were identified on the farm during discussions with PMAMP Dhanusha as well as focused group discussions, which have the potential to hinder the adoption of advanced fish production technology. These problems were assessed and prioritized according to the feedback provided by the farmers. An index value was calculated, and finally, the ranking was determined. The problem ranking of respondent farmers in using improved fish production technology is given in Table 3.

Table 3. Problem ranking of respondent farmers in using improved fish production technology

Problems	Least	Moderate	Serious	Extreme	Weightage	Index	Rank
High cost of feed	0	2	1	61	62.75	0.980	1
Inadequate capital	1	6	23	34	54.5	0.851	2
Lack of technical knowledge	13	22	12	17	40.25	0.628	3
Disease outbreak	13	33	15	3	34	0.531	4
Theft	27	20	9	8	31.5	0.492	5
High cost of Fingerlings	29	32	1	2	26	0.406	6
Water quality Problem	33	24	7	0	25.5	0.398	7
Poor marketing	37	23	1	3	24.5	0.382	8
Water scarcity	40	16	7	1	24.25	0.378	9
Scarcity of labor	38	22	2	2	24	0.375	10

Association of socio-economic variables with adoption level of improved fish production technology.

The chi-square test was used to assess the relationship between the socio-economic variables and the adoption of improved fish production technology.

Based on adoption index value, the respondents were categorized into low adopters (less than 0.61) and high adopters (greater than 0.61). Value of adopter's category is given in Table 4.

Table 4. Value of adopter's category

Adoption level	Frequency	Percentage	Mean
Low(<0.61)	34	53.1	0.61(0.12)
High(>0.61)	30	46.9	
Total	64	100.0	

Note: Figures in parentheses indicates the standard deviation

Association between farmers' age and adoption of improved fish production technology

The study revealed that farmers of the age group 41-50 years are high adopters compared to other ages. Association between farmers' age and adoption of improved fish production technology is given in Table 5.

Table 5. Association between farmers' age and adoption of improved fish production technology

Variable	Adoption level of Technology		Overall	Chi-square	p-value
Age	Low adopters	High adopters			
Less than 30	2(3.1)	0	2(3.1)	7.536	0.110
30-40	9(14.1)	3(4.7)	12(18.8)		
41-50	15(23.4)	19(29.7)	34(53.1)		
51-60	6(9.4)	8(12.5)	14(21.9)		
60 above	2(3.1)	0	2(3.1)		

Note: Figures in parenthesis indicates the percentage

The result shows a non-significant association between the age of the farmer and the adoption of improved fish technology. Farmers above 60 years and below 30 years are low adopters of improved fish production technology. Since older farmers have nearly fixed mentalities and behavioral patterns, training in production technologies should be directed toward middle-aged and younger farmers in particular (Meena et al., 2017).

Association between gender and adoption of improved fish production technology

The table below shows the association between respondents based on gender and the adoption of improved fish production technology. The association between gender and the adoption of improved fish production technology is given in Table 6.

Table 6. Association between gender and adoption of improved fish production technology

Variable	Adoption level of Technology		Overall	Chi-square	p-value
Gender	Low adopters	High adopters			
Male	28(43.8)	28(43.8)	56(87.5)	1.757	0.185
Female	6(3.1)	2(2.1)	8(12.5)		

Note: Figures in parenthesis indicate the percentage

The result indicated that there was no significant association between gender and adoption level of improved fish production technology. It may be due to the fact that adoption of the technology does not depend on whether the farming is carried out by a male or a female.

Association between education level and adoption of improved fish production technology

The association between education level and the adoption of improved fish production technology is given in Table 7.

Table 7. Association between education level and adoption of improved fish production technology

Variable	Adoption level of technology		Overall	Chi-square	p-value
Educational level	**Low adopters**	**High adopters**			
Illiterate	3(4.7%)	3(4.7%)	6(9.4%)	7.340*	0.04
Primary	19(29.7%)	7(10.9%)	26(40.6%)		
Secondary	11(17.2%)	18(28.1%)	29(45.3%)		
University level	1(1.6%)	3(4.7%)	3(4.7%)		

*Note: * indicates significance at 5% level. Figures in parenthesis indicate percentage.*
Source: Field survey (2023)

The result shows significant association between education level and adoption of improved fish production technology**.** This demonstrated that the degree of adoption increased with education level. This was per the findings by (Pokar et al., 2014). According to his report, there was a positive relation between respondents' level of knowledge and education.

Association between farming experience and adoption of improved fish production technology

Table 8 shows the association between the distribution of respondents based on farming experience to the adoption level of improved fish production technology

Table 8. Association between farming experience and adoption of improved fish production technology

Variable	Adoption level of technology		Overall	Chi-square	p-value
Farming experience	**Low adopters**	**High adopters**			
Less than 5	13(20.3)	6(9.4)	19(29.7)	9.329*	0.043
6 to 10	6(9.4)	7(10.9)	13(20.3)		
11 to 15	14(21.9)	9(14.1)	23(35.9)		
16 to 20	1(1.6)	4(6.3)	5(7.8)		
More than 20	0(0)	4(6.3)	4(6.3)		

*Note: * indicates significance at 5% level of significance. Figures in parenthesis indicate percentage.*
Source: Field survey (2023)

This result shows significant association between farming experience and adoption of improved fish production technology. Farmers having higher experience were high adopters compared with farmers having low experience.

Association between pond size and adoption of improved fish production technology

The association between pond size and the adoption of improved fish production technology is given in Table 9. The results show that farmers with large pond size were likely to be high adopters of improved fish production technologies**.**

Table 9. Association between pond size and adoption of improved fish production technology

Variable	Adoption level of technology		Overall	Chi-square	p-value
Pond size	**Low adopters**	**High adopters**			
Less than 0.6 ha	8(12.5)	3(4.7)	11(17.2)	12.386*	0.002
0.6 to 1 ha	12(18.8)	2(3.1)	14(21.9)		
Greater than 1 ha	14(21.9)	25(39.1)	39(60.9)		

***Note:** * indicates significance at 5% level. Figures in parenthesis indicate percentage.*
Source: Field survey (2023)

This finding indicates that there is a statistically significant relation between the size of fish ponds and improved fish production techniques. This indicates that fish producers with bigger pond areas had greater adoption rates.

Association between training received and adoption of improved fish production technology

The association between training received and the adoption of improved fish production technology is given in Table 10. The research showed that fish farmers who were trained were likely to be high adopter of improved fish production technologies.

Table 10. Association between training received and adoption of improved fish production technology

Variable	Adoption level of Technology		Overall	Chi-square	p-value
Trainings received	**Low adopters**	**High adopters**			
Yes	13(20.3%)	23(35.9%)	36(56.3%)	9.565*	0.002
No	21(32.8%)	7(10.9%)	28(43.8%)		

*Note: * indicates significance at 5% level. Figures in parentheses indicate percentage.*
Source: Field survey (2023)

This finding indicates that there is a statistically significant relation between farmers' adoption of improved fish production technology and their training attendance. This shows that fish farmers with access to training had a greater degree of adoption. Mathur (1996) provided support for this conclusion. According to his research, training plays a significant role in the extension approach that all agricultural development programs adhere to. This was also supported by Joshi et al. (2019). According to his research, if the participation in training increases by one unit, then the probability of being aware of Good Agricultural Practices increases by 20.1%.

CONCLUSION

The study provides a valuable insights into the adoption of improved fish production technology in the Dhanusha district, highlighting both successful areas and challenges faced by farmers. If fish farming is practiced by adopting essential technologies, then it can turn out to be a viable alternative for increasing income and sustaining livelihoods. Addressing challenges and enhancing technology adoption, such as targeted training programs and financial support, could contribute to sustainable fish farming practices in the region.

REFERENCES

Ahasan, H., Jiaur, R. M., Milon, S. M., Najiah, M., Belal, H. M., Abdullah, S., & Abdullah, M. A. (2020). Breeding performance of riverine Rohu (*Labeo rohita*) and growth performance of F1 progenies reared in hapas. *Journal of Sustainability Science and Management, 15*(2), 24-32.

Calixto, E. S., Santos, D. F. B., Lange, D., Galdiano, M. S., & Rahman, I. U. (2020). Aquaculture in Brazil and worldwide: Overview and perspectives. *Journal of Environmental Analysis and Progress*, *5*(1), 98-107. https://doi.org/10.24221/jeap.5.1.2020.2753.098-107

CFPCC. (2021). *Annual progress report*. Central Fisheries Promotion and Conservation Centre, Balaju, Kathmandu.

CFPCC. (2023). *Annual progress report*. Central Fisheries Promotion and Conservation Centre, Balaju, Kathmandu.

Delgado, L. C., Wada, N., Rosegrant, M. W., Meijer, S., & Ahmed, M. (2003). *The future of fish: Issues and trends to 2020*. https://cgspace.cgiar.org/handle/10568/2039

Dhakal, A., Pandey, M., Kayastha, P., Suwal, G., & Suwal, B. (2022). An overview of status and development trend of aquaculture and fisheries in Nepal. *Advances in Agriculture*, 1-16. https://doi.org/10.1155/2022/4206401

FAO. (2022). *The state of world fisheries and aquaculture. Towards Blue Transformation*. FAO. https://doi.org/10.4060/cc0461en

Joshi, A., Kalauni, D., & Tiwari, U. (2019). Determinants of awareness of good agricultural practices (GAP) among banana growers in Chitwan, Nepal. *Journal of Agriculture and Food Research, 1*. https://doi.org/10.1016/j.jafr.2019.100010

Mathur, P. (1996). *Experimental Learning Cycle*. Jain brothers.

Meena, R., Geanger, K., Meena, B., Bhatnagar, P., & Meena, P. L. (2017). Analysis of adoption and constraint perceived by mandarin growers in jhalawar district of Rajasthan state, India. *International Journal of Current Microbiology and Applied Sciences*, *6*(4), 1465-1470. https://doi.org/10.20546/ijcmas.2017.604.178

MoF. (2022). *Economic Survey*. Ministry of Finance, Government of Nepal.

Neupane, S., & Gharti, K. (2018). Status of adoption of improved fish production technology in Rupandehi, Nepal. *International Journal of Applied Sciences and Biotechnology*, *6*(4), 302-307. https://doi.org/10.3126/ijasbt.v6i4.21226

NSO. (2021). *National Accounts Statistics of Nepal*. National Statistics Office, Thapathali, Kathmandu.

Pokar, M. V., Javia, R. M., & Sapara, G. K. (2014). Knowledge level of beneficiary and non- beneficiary farmers about improved groundnut production technology. *AGRICULTURE UPDATE*, *9*(3), 306-310. https://doi.org/10.15740/HAS/AU/9.3/306-310

Rizzo, G., Migliore, G., Schifani, G., & Vecchio, R. (2023). Key factors influencing farmers' adoption of sustainable innovations: A systematic literature review and research agenda. *Organic Agriculture, 14*(1), 57-84. https://doi.org/10.1007/s13165-023-00440-7

Yadav, M., Ranjan, R., & Shah, T. (2023). Fish farming practices and disease occurrence in the fish farms of Dhanusha district, Nepal. *Malaysian Animal Husbandry Journal*, *3*(1), 15-27. https://doi.org/10.26480/mahj.01.2023.15.27