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Study of polyculture fish farming in Kanchanpur district of Nepal

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ABSTRACT

This research examines the study of polyculture fish farming in the Kanchanpur district of Nepal. Fish polyculture has been profitably adopted as a business enterprise in the western part of Nepal, particularly in the Kanchanpur district. Though the number of farmers actively involved in polyculture seems to be increasing, the production trend, productivity, and profitability are not satisfactory. Thus, polyculture study of fish farming was necessary. The research was conducted in various fish farm sites in Kanchanpur district of Nepal. 35 fish farms with a total of 103 ponds were selected for the research. Farm owners were interviewed with pre-tested, semi-structured questionnaires to assess production scale, cost, benefit, production-associated problems, and recommendations. Different fish species, particularly common carp, bighead carp, silver carp, grass carp, rohu, Nile tilapia, and bhakur, were present on the surveyed site. The average area for fish rearing ponds per household was 0.71 ha. The average number of fingerlings per hectare was 22,859. The cost of production includes feed, fertilizer, fingerlings, labor, liming, tools and machinery, investment, construction, and other costs contributing 36%, 3%, 3%, 6%, 0.4%, 2%, 39%, and 9%, respectively, of the total cost of production. The polyculture of carps, tilapia, and bhakur fish species in different polyculture systems was as profitable business enterprises with the productivity of 38.8 quintals/hectare and a benefit-cost ratio of 1.40. Polyculture fish farming was considered a profitable business enterprise in Kanchanpur district with highest B/C ratio, productivity, and benefit per person in carps (Indian and exotic), amongst others.

Contribution/Originality: The novelty of the study deals directly with farmers and the inputs they apply for the fish farming in the available or limited size of the ponds. The investigation is also concerned with the cost of each input and the preference of fish producers in rearing different species of fish. Productivity and B:C ratio that helped to determine benefit of farmers make this research much more attractive.

1. INTRODUCTION

1.1. Background

Polyculture is the practice of culturing more than one species of aquatic organism in the same pond. The motivating principle is that fish production in ponds may be maximized by raising a combination of species having different food habits (Hora & illay, 1962).

The combination of fish improves the utilization of the natural food available in a pond. Polyculture began in China more than 1000 years ago. The practice has spread throughout Southeast Asia and into other parts of the world. Chinese and Indian history provide the foundation for composite fish farming. Based on varied seed stocks that were gathered from natural sources, polyculture was used in the carp farming industries in both of these countries (Thu & Demaine, 1994).

Sorting out stocks of various species in their infancy was not feasible. Therefore, the farmers had no choice but to raise the various carp species in close proximity until they reached the fingerling stage. The farmers noticed that there were variations in feeding practices and preferences for natural food sources. This inspired the idea to modify stocking levels in accordance with the availability of natural food and the niches filled by each species in the ponds.

As a result, it can be advantageous in conventional production methods by cultivating the right species combinations. Such a practice could effectively lead to the utilization of a much larger quantity of food resources and developing a symbiotic relationship between the cultured species in the system. This would lead to higher production at a lower cost, and the farm environment can be maintained at required levels. Pond fish cultivation is primarily practiced in Nepal's southern subtropical region, where pond water temperatures range between 15 and 20 degrees Celsius throughout the winter months of December to February (Shrestha, 1999). In Nepal, herbivorous carp polyculture is a prevalent practice.

Fish feeds and chemical fertilizers are expensive and difficult to come by for small-scale resource-poor farmers, and animal dung is usually employed for land crops (Shrestha, 1999). Exploration of readily available or easily grown plant material that is not used in the production of human food is a critical component of solving these fish farmers' concerns. There are different types of carp polyculture, which is practiced to enhance productivity. The major and established system of Nepal is a semi-intensive carp polyculture. The main species under culture are rohu, naini (or mrigal), bhakur, silver carp, bighead carp, grass carp, and common carp (Swar & Gurung, 1988).

The motivating principle is that a combination of different species can maximize fish production. Different species combinations in a polyculture system effectively utilize available natural food produced in a pond and contribute to improving the pond environment. Polyculture management is based on the relationship between organisms at different levels of the food chain (Sharma et al., 2013).

Therefore, the selection of species plays a vital role in the polyculture system because all of the species should benefit from the available food without competing with one another (Shrestha & Pandit, 2012). Fertilization or supplemental feeding enriches food inches in this system, but only a proper combination and densities can efficiently utilize it. A suitable combination of species will maximize the synergistic and minimize antagonistic fish-fish and fish-environment relationships. Principal requirements of different species in combination (Shrestha & Pandit, 2012):

- They should have complementary feeding habits.
- They should occupy different ecological niches.
- They should attain marketable sizes at the same time.
- They should all be non-predatory and tolerate each other.

1.2. Statement of Problem

The agriculture sector in developing countries like ours faces issues linked to low productivity and profitability and is characterized by lower competitiveness, lower technology adoption, and a lack of technical knowledge among the producers. In order to stimulate economic growth, the primary focus should be on developing an efficient production system.

Polyculture pond carp farming is the viable and common fishery in Nepal. More than 95% of total fish production is contributed by carp fish. With the huge availability of resources and opportunities, polyculture fish farming can be an important livelihood source as well as a poverty alleviation factor. In Kanchanpur, polyculture has not been as beneficial as intended.

Lack of timely supply, improper and unscientific techniques of feeding, fertilizing, and liming, the spread of illness, native methods of fish rearing, the impact of Indian fishes on the market, and the introduction of incompatible species have resulted in the fish enterprise slipping behind.

Veterinary Hospital and Livestock Service Expert Centre, Kanchanpur, is the major institution for promoting fish farming in the district. Due to the lack of proper implementation of the policies, the intended benefit is yet to be achieved by the farmers.

1.3. Rationale of the Study

In Kanchanpur district, polyculture fish farming has enormous potential. Its high demand among locals, easy access to markets, resources, and water, favorable seasonal temperatures, and a long history of native peoples' cultivation make it one of the region's most important occupations.

However, statistical analysis of the reviewed literature reveals that the overall production of fish raised under polyculture is very low and even not enough for the domestic market. This means that fish from India and other places outside the country has to be brought in (Swar & Gurung, 1988).

Enhancing the polyculture system, addressing and resolving production-related issues, lowering production costs, and strong coordination with government agencies can be very helpful in reducing poverty and ensuring food and nutritional sufficiency in the rural parts of Kanchanpur.

The study research is purely focused on studying and analyzing entire polyculture systems and primarily addresses problems that are existing in polyculture systems, their ranking, and the economic status of the farmer, which in turn will be instrumental to government bodies for preparing and executing policies intending to producers.

The study's results will also aid in the development of new guidelines and policies for the effective extension, promotion, and production of fish in the future.

1.4. Objective

1.4.1. Broad Objective

To study the polyculture fish farming system in the Kanchanpur district.

1.4.2. Specific Objectives

- To study the present status of polyculture fish farming.
- To find out the different polyculture systems in the Kanchanpur district.
- To access the socio-economic and financial positions of fish farmers and fish farms of the Kanchanpur district.
- To find out the fish production-associated problems and rank them based on respondent perception.
- To recommend the measures for the concerned stakeholders for the improvement of the economic status of fish farmers.

2. MATERIALS AND METHODS

2.1. Site Selection

As Kanchanpur district has a high potential for polyculture fish farming with the increasing participation of more new smallholding farmers, parts of Kanchanpur district, particularly Bheemdatta, Sukhlaphata, Bedkot, Krishnapur, and Belauri, were selected for the research since there are registered fish farms in these sites.

Figure 1. Map of Kanchanpur district.

2.2. Description of Site

2.2.1. Description of Site

Kanchanpur lies in the far western province of Nepal. The location of the Kanchanpur district on the globe can be found by its latitude and longitude range. Its latitude and longitude values in the world globe are 28.83720 N, 80.32130 E, respectively. This district lies in the Terai region of Nepal and has a Tropical climate with a maximum and minimum temperature of 41^{0}c during July and 50^{0}c during January, respectively.

2.2.2. Sampling Size and Procedure

Thirty-five fish farms and103 ponds were purposively sampled by using a pre-tested semi-structured questionnaire. The data collected through a survey was done in August of 2022.

2.3. Data Collection Methods

2.3.1. Primary Data

Data associated with socio-demographic, economic, production, productivity, problem ranking, etc., were collected with help of an in-person interview from each selected farm in August 2022, taking 45 days.

2.3.2. Secondary Data

Secondary data were collected from the research journals, articles, books, magazines, governmental reports, and internet sources.

2.4. Data Tabulation

Data was collected and tabulated using MS Excel 2019 for further analysis.

2.5. Methods of Data Analysis

Data collected from the survey were coded and directly entered in Statistical Package for Social Science (SPSS Version16). Detection and removal of errors and inconsistencies were done to improve the data quality. And then subsequent analysis was done by using different statistical tools like mean, frequency, and soon. Moreover, various graphs and charts were made by using the relevant tools of MS Excel 2019. While qualitative data were analyzed qualitatively and 7 expressed accordingly, both descriptive and analytical methods were used to analyze the quantitative data.

2.5.1. Quantitative Analysis

The quantitative data obtained from the household surveys were analyzed quantitatively by using both descriptive and analytical statistics.

2.5.2. Descriptive Analysis

Simple statistics like sum, mean, relative frequency, maxima & minima, and standard deviation were used for descriptive analysis of socioeconomic and farm characteristics of the respondents like family size, age, gender, caste, occupational pattern, landholding size, economically active population, production, price, cost, margin, etc.

2.6. Benefit-Cost Analysis

Benefit-cost analysis is the benefit of the farm business relative to its cost, expressed both in monetary value. The benefit-cost ratio is calculated by taking the ratio of total revenue and total cost. In this study, the total revenue denotes gross income, and total cost represents the summation of all the fixed costs and variable costs including the marketing costs as well. It was calculated by using equation.

$$B/C ratio = Grossincome/TotalCost$$

If the B/C ratio is greater than 1, the farm business is profitable. If the B/C ratio is less than 1, the farm business is unprofitable.

If the B/C ratio is equal to 1, the farm business can neither be considered profitable nor unprofitable.

2.7. Indexing

Indexing is a tool to analyze respondents' perceptions by using the scaling technique. Problem associated with polyculture fish farming was analyzed by using indexing technique.

The index of severity or importance can be computed by using equation.

$$I = (\sum Si * fi)/N$$

Where, I= Index of importance/Severity.

$\sum$ = Summation.

Si = Scale value at with importance/severity.

fi = Frequency of importance/severity given by the respondents N = Total number of respondents.

3. RESULTS

This section deals with the results of the research based on the primary and secondary data obtained by using various tools and processes described in the earlier section. The following sub-sections organize the results.

3.1. Socio-Demographic Aspect

Gender, ethnicity, household head, education level, and jobs were among the socioeconomic characteristics of respondents collected in this study. The following are some of these characteristics: Gender of the respondents:

3.1.1. Gender of Respondent

With concern to gender, the majority, 26 of respondents, were male, while the remaining 9 were female respondents. Figure 2 shows the respondents by gender.

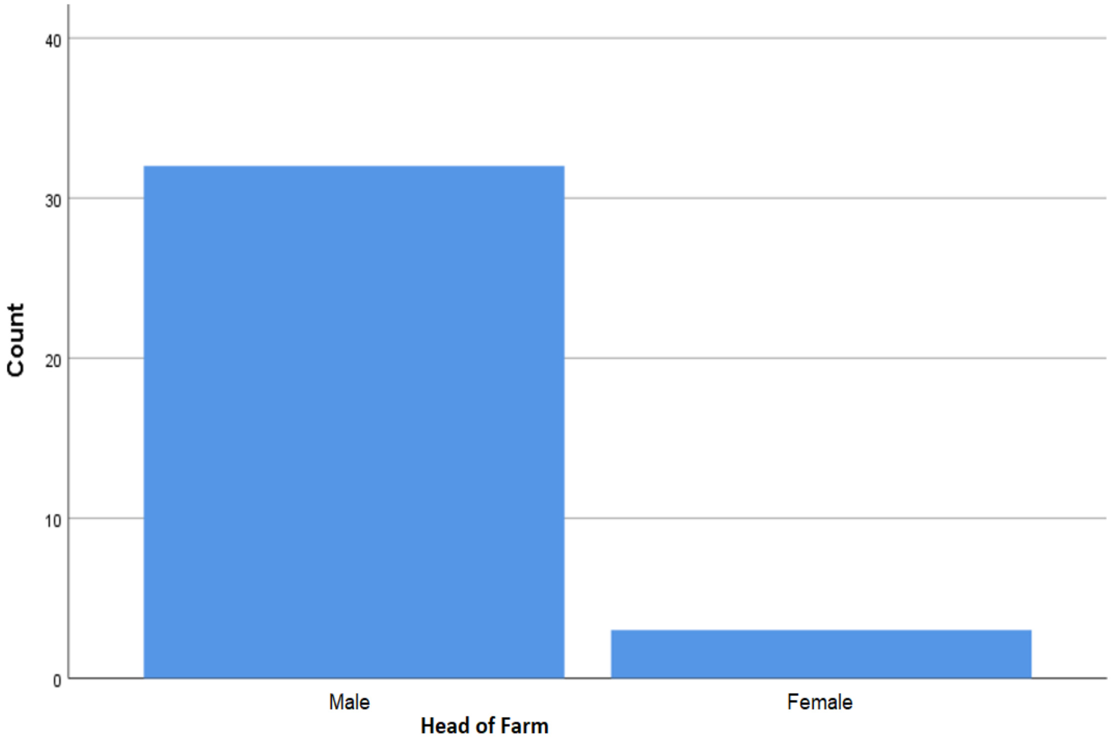

Figure 2. Respondents by gender.

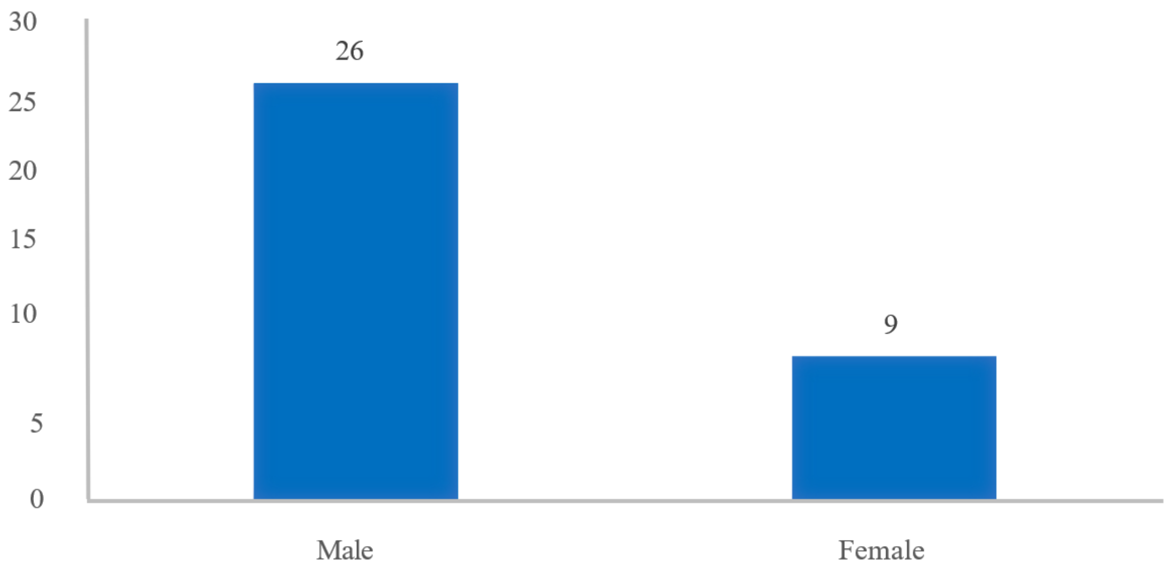

Figure 3. Illustration of the respondents by the head of the household head.

3.1.2. Analysis of Household Head

With concern for the household head majority, 32 of the respondents revealed male as the head of the family, whereas the remaining 3 of the respondents revealed female as the head of the household. Figure 3 illustrates the analysis for the household.

3.1.3. Ethnicity of Respondents

With concern to the ethnicity, most of the respondents were found to be Chhetri, 15, and Tharu, 9. It was followed by Brahmin 8, Thakuri 2, and Dalit 1. Figure 4 presents the ethnic composition of HH (household) at the sample.

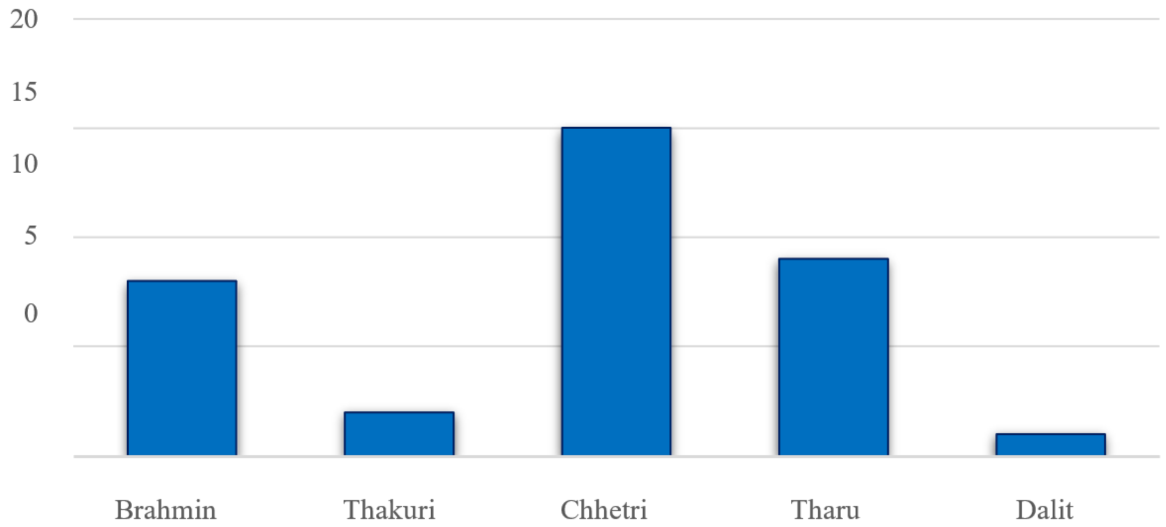

Figure 4. Ethnical composition of respondents.

3.1.4. Education Level

Concerned with the education status of the respondents, the no. of years of schooling as a parameter was selected, and most of the respondents, 52%, were found to have a higher level of education, followed by 31% of the respondents with primary-level education and 11% with secondary. The remaining 6% were found to be poorly educated; however, they can read and write to some extent. Figure 5 illustrates the education status of the respondents. Figure 6 illustrates the maximum education in the family, the majority, 86%, were having a higher level of education, and 8% of the respondents had primary and 6% secondary levels of education.

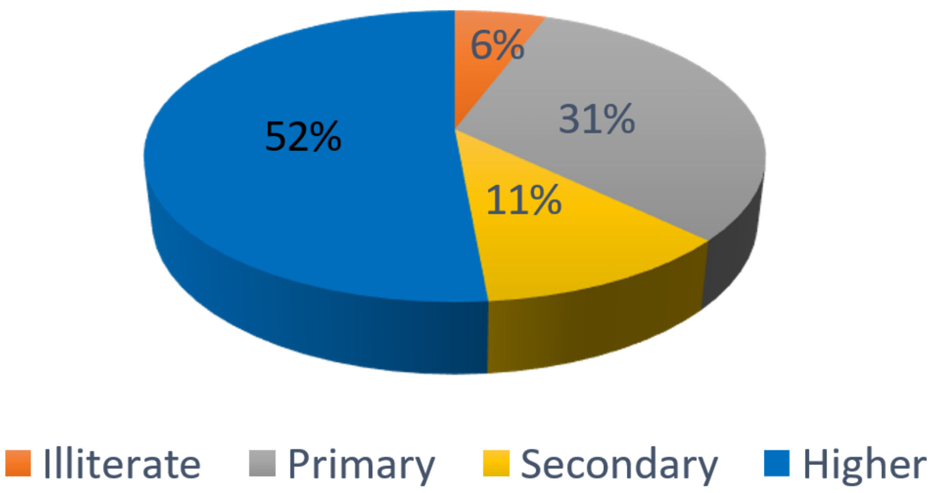

Figure 5. Illustration of the education level of the respondents.

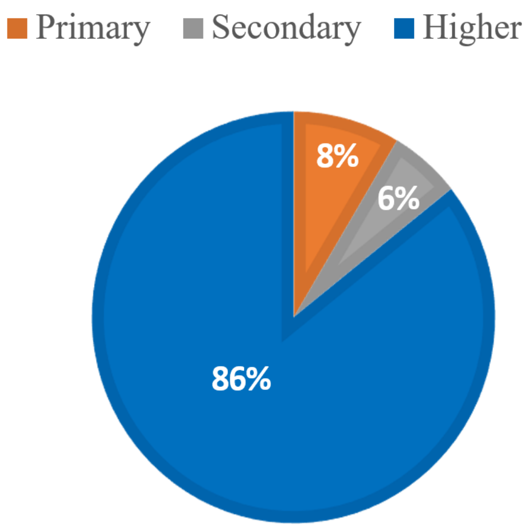

Figure 6. Illustration of maximum education of the respondent's family.

3.1.5. Occupation of Respondent

The majority of the respondent's household profession was agriculture (20), growing other field crops besides polyculture fish farming. 8 of the respondents were found involved in agriculture and business, and 4 of the respondents was found involved in the service sector, which has been illustrated in Figure 7.

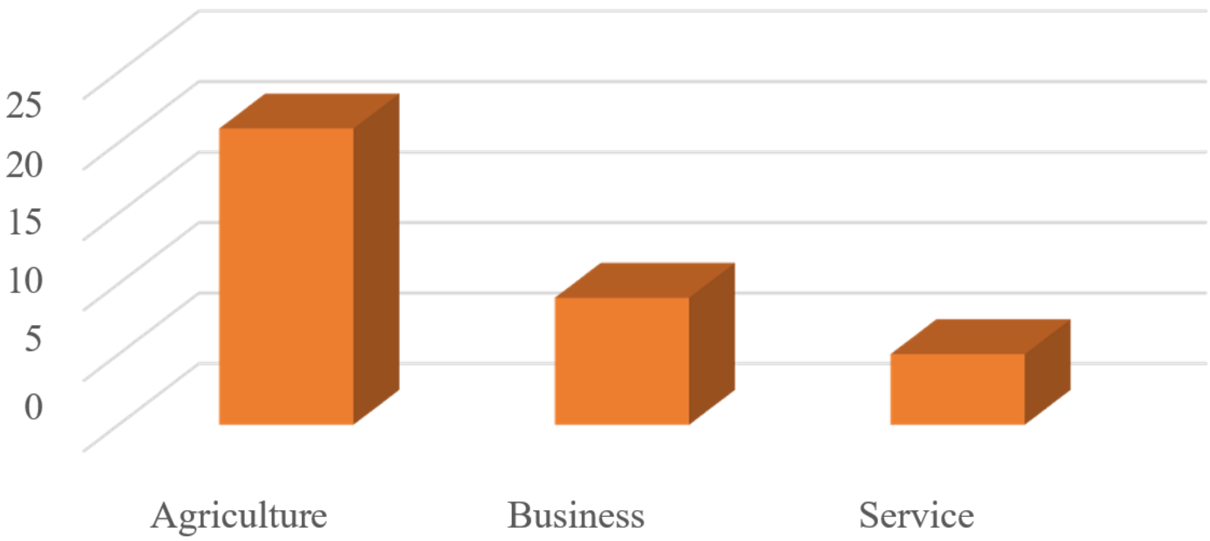

Figure 7. Illustration of the occupation of the respondents beside fish farming.

3.2. Source of Input

Under the sources of input, a source associated with water, fingerlings, and labor was studied.

3.2.1. Source of Water

The majority of the farmers, 22 farmers, were found to use Boring as a source of water for fish rearing, followed by irrigation canals used by 7 farmers, and 6 farmers used motor pumps, which are illustrated in Figure 8.

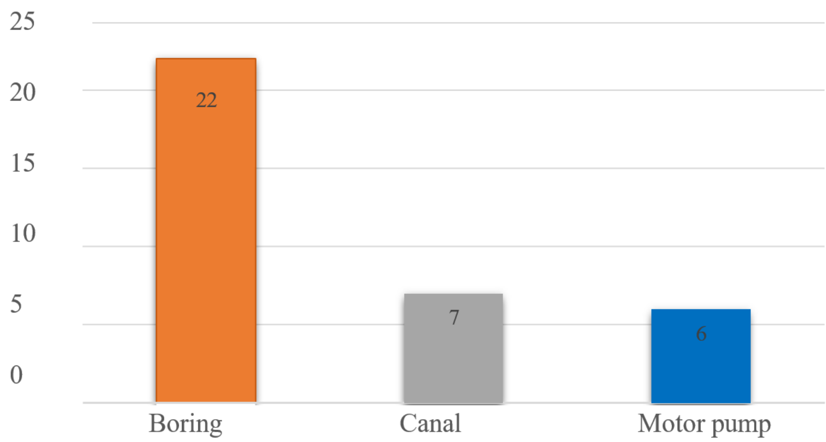

Figure 8. Illustration of different sources of water used for fish rearing.

3.2.2. Source of Labor

While finding the source of labor for the management of the farm, the majority, 74% of the respondents, stated family members as their labor source, while 26% of the respondents revealed hired labor as the source of the labor for the farm, as shown in Figure 9.

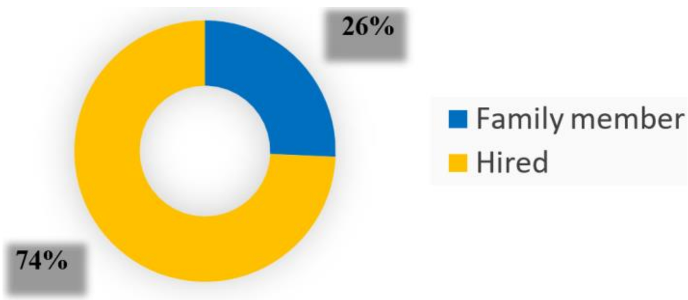

Figure 9. Illustration of the source of labor.

3.2.3. Source of Feeds

Talking about the type of feed provided by the respondents, the majority of the respondents 16 revealed bran, Mustard oil cake, and pellets as feed sources. 6 of the respondents reveal bran, flour, mustard oil cake, and pellets as feed sources. 4 each of the respondents revealed pellet and fodder, also bran and oilcake, as a feed source, respectively. While 3 of the respondents revealed bran, flour, oilcake, and grass as their feed and 2 revealed flour, oilcake, and bran as their feed. The type of feed used for fish rearing on farms is illustrated in Figure 10.

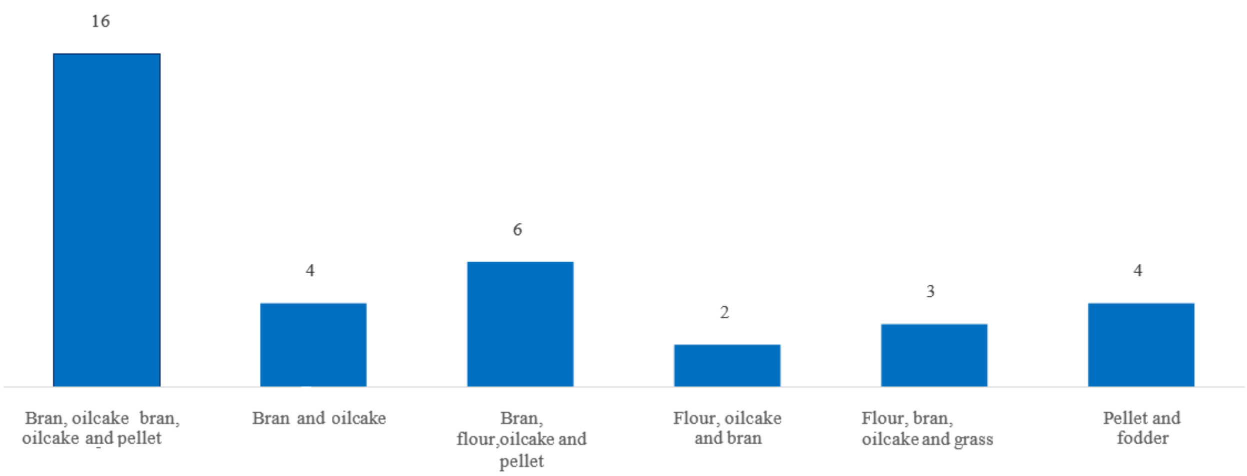

Figure 10. Sources of feed for fish rearing by respondents.

3.2.4. Types of Fertilizer

While asking the respondent which type of fertilizer they used, it was found that 91% of the farmers used both organic and inorganic fertilizers, 6% used organic fertilizers only, and 3% used inorganic fertilizers only, as illustrated in Figure 11.

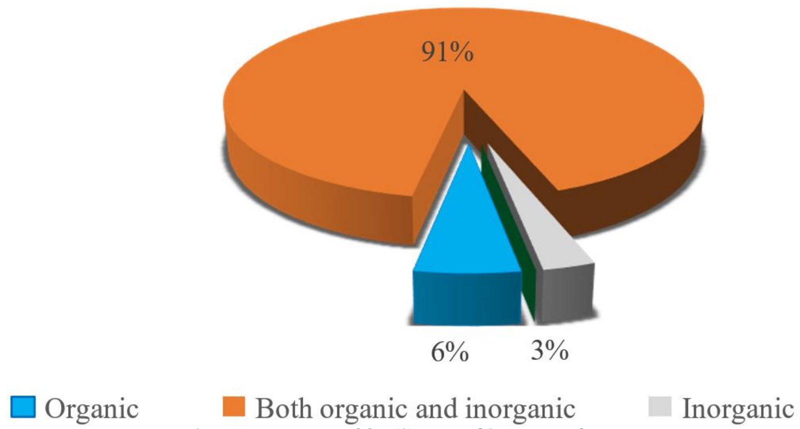

Figure 11. Types of fertilizer used by respondents.

3.3. Cost of Production

Both the variable and fixed costs were included, mainly cost of fingerlings, feeds, fertilizers, labor cost, liming cost, tool and equipment cost, and other costs, were included in the variable cost and initial investment was only included as the fixed cost amount. All the tools and types of equipment were found new and recently bought. Therefore, the depreciation for tools and equipment was not considered in the study. Different costs, along with the total cost of production, are illustrated in Table 3. From the table, it can be found out that feed shares the highest percentage of TVC (Total Variable Cost) (36%), followed by other costs (9%), labor costs (6%), fertilizer costs (3%), fingerling costs (3%), tools and equipment costs (2%), and liming cost (1%), which total variable cost as 61% of the total cost, and remaining 39% is total fixed cost, as the initial investment is 39%, illustrated in Table 1.

Table 1. Cost of production of all the fish farm.

Category	Amount (in Rs)	Percentage
Fingerlings cost	817100	3%
Tools and equipment cost	500000	2%
Fertilizer cost	691970	3%
Feed cost	9027850	36%
Liming cost	106105	1%
Labor cost	1602000	6%
Other cost	2286500	9%
Total variable cost	15031525	61%
Initial investment	9701000	39%
Total fixed cost	9701000	39%
Total	24732525	100%

3.4. Descriptive Analysis

The average area of fishpond was found to be 2 and 200 katha as minimum and maximum size with mean and S.D. 20.97 and 34.918, respectively. Average minimum and maximum cost (in NPR.) of fingerlings per year was found to be 750 and 40,000, whose mean was 23345.71 with S.D. 68193.671, respectively. Average minimum and maximum cost (in NPR.) of feed per year was found to be 32850 and 2000000, with mean and S.D. as 257938.57 and 391327.129, respectively. Similarly, average minimum and maximum costs (in NPR.) of fertilizer per year were found to be 1200 and 180000, with means and S.D.s of 19770.57 and 38374.038, respectively. The Average minimum and maximum cost (in NPR.) of lime per year was calculated as 200 and 30000, with mean and S.D. of 3031.57 and

5642.261. Total cost was analyzed as NRS. 24732525 with a B:C ratio of 1.40 in total, with 35 beneficiaries illustrated in Table 2.

Table 2. Descriptive analysis of polyculture system.

Particulars	N	Minimum	Maximum	Mean	S.D.
Area in katha	35	2	200	20.97	34.918
Cost of fingerling/yr	35	750	40000	23345.71	68193.671
Cost offered/yr	35	32850	2000000	257938.57	391327.129
Cost of fertilizer/yr	35	1200	180000	19770.57	38374.038
Cost of lime/yr	35	200	30000	3031.57	5642.261
Valid N (Listwise)	35				
Total cost	24732525				
B/C ratio	1.40				

3.5. Productivity Analysis

While finding the productivity among the different polyculture systems, productivity was found highest in exotic carps polyculture with the productivity of 4172.41 kg/ha and the least was found in exotic carp polyculture with the productivity of 3099.19 kg/ha, which is illustrated in Table 3.

Table 3. Productivity analysis of different polyculture system.

Polyculture system	Area (ha)	Production (kg)	Productivity (kg/ha)
Carps (Indian major and exotic)	18.3	76355.24	4172.41
Exotic carps	2.5	7747.98	3099.19
Carp and Tilapia	4	12596.77	3149.19

3.6. Profitability Analysis

While the B:C ratio is taken as the basis of analysis for different polyculture techniques, the carp polyculture system was found most profitable with a B:C ratio of 1.72, and the least profitable is the exotic carps polyculture with a B:C ratio of 1.27 as per Table 4.

Table 4. Profitability analysis of different polyculture system.

Polyculture system	B:C ratio	Remarks
Carps (Indian major and exotic)	1.72	Most profitable
Exotic carps	1.27	Intermediate profitable
Carp and Tilapia	1.29	Least profitable

3.7. Problem Ranking

Problem ranking was done by using, Likert scale.

Table 5. Problem ranking using indexing technique.

List of problems	Severe problem	Moderate problem	Slight problem	No problem	Indexing	Ranks
Cost of input	4	3	2	1	2.91	1
Infectious disease, pest, and mortality	3	2	2	2	2.85	2
No of fingerlings in time	12	7	7	9	2.62	3
Oxygen deficiency	9	7	7	12	2.37	4
Lack of quality fingerlings	7	8	6	14	2.17	5
Seep age of pond	5	5	10	15	2	6
Lack of quality water	1	8	10	16	1.82	7
Inadequate market efficiency	3	4	7	21	1.68	8
High labor wage	2	4	4	25	1.51	9
Electricity problem	1	1	8	25	1.37	10

The major problem identified in the surveyed site was high cost of input, with an index of 2.91, followed by infectious disease, pest, and mortality with an index value of 2.85, no fingerlings in time with an index score of 2.62, oxygen deficiency with an index score of 2.37, lack of quality fingerlings with an index score of 2.17, and other production problems, as shown in Table 5.

4. DISCUSSION

Participants prioritize their occupation in agriculture, followed by business, reflecting their socio-economic condition. Similar result was revealed in the study of Thomas (1994).

Instead of irrigation channels and other sources, highest number of people preferred irrigation through underground (boring) water for fish rearing. The result was supported by Alikunhi (1957) according to whom underground water was mostly used for rearing fish in rural communities.

In most cases of rural sites, family members engage in farm work, especially in fish farming (Jhingran, 1991). Fish producers generally produce and make fish consume pellet and bran, including high amount of oilcake (NACA, 1989). The study aligns with the current research, indicating that farmers prioritize pellet, bran, and oilcake over other feed sources. Combined or integrated types of fertilizer application were revealed to be used by most producers (Stickney, 2013). Farmers commercially use mixed types of fertilizer instead of standalone fertilizer input. Farmers invest huge amounts of money and effort in feed in comparison with other such as labor, fertilizer, etc. (Wang, 1994). The finding was also supported by some previous studies, such as those of FAO (2005).

It was observed that potential exotic breeds with higher productivity as per the study of Rajbanshi (2002) as well. Sharma et al. (2013) also confirm the similar study in previous research. The B:C ratio was found significant while studying various polycultures (Thilsted, Roos, & Hassan, 1997). The study of problem ranking was supported by Zimmermann, Nair, and New (2009) and Ministry of Agriculture and Cooperatives (MOAC) (2004).

5. CONCLUSIONS

Presence of different fish species was found, particularly common carp, bighead carp, silver carp, grass carp, rohu, Nile tilapia, and bhakur, on the surveyed site. The average area for a fish-rearing pond per household was found to be 0.71 ha. The polyculture of carps, tilapia, and bhakur fish species in different polyculture systems was found to be profitable business enterprises with the productivity of 38.8 quintals/hectare and a benefit-cost ratio of 1.40.

The polyculture fish farming was a profitable business enterprise in Kanchanpur district with an average B/C ratio of 1.40, an average productivity of 38.8 quintals/ha, and an average benefit per ha of Rs 398892.04. While comparing the profitability, it was found that B/C: Benefit Cost ratio was highest among carps (Indian and exotic) polyculture fish farming. Most severe problem in the site was found to be the high cost of input. Thus, it is recommended to concerned stakeholders to reduce the price of input and provide necessary incentives for input. The study of such subjects in future could also be possible and imperative.

Abbreviation:

AGDP : Agriculture Gross Domestic.
CBS : Central Bureau of Statistics.
DADO : District Agriculture.
FAO : Food and Agricultural Organization.
FYM : Farmyard Manure.
GDP : Gross domestic product.
NARC : Nepal Agricultural Research.

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Institutional Review Board Statement: The Ethical Committee of the Institute of Agriculture and Animal Science, Lamjung Campus, Nepal has granted approval for this study on 19 December 2022 (Ref. No. 1-2-44-76-2017).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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