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Research Article

Report on the Status of Ponds, It's Liming and Fertilization Practices for Fish Production in Fish Super Zone, Rupandehi, Nepal

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Abstract

This survey was conducted to analyze the status of pond fertilization and liming on the fish super zone of Rupandehi, Nepal in 2020. It was conducted in four rural municipalities of Rupandehi namely Siyari, Mayadevi, Gaidahawa, and Sudhhodhan. Altogether, 80 randomly selected households of fish farmers, 20 from each site in the study area were surveyed with the help of semi-structured questionnaires. The data collected was encoded and then tabulated and analyzed using MS- Excel 2013 and SPSS 25 software. To accomplish the study objectives, descriptive statistics, chi-square, and t-test were used. Respondent farmers were categorized into small (n = 47) and large farmers (n = 33) based on average pond size. The average pond size was 0.69 ha. About 31.25 percent of respondents were newly involved in fish farming occupation i.e. less than 5 years of experience. About 66.3 percent of the fish farmers had received training on pond fertilization, liming, and fish production. The majority of respondent fish farmers i.e. 95 percent used farm yard manure (FYM) as a major source of organic fertilizer for pond fertilization. The average amount of FYM use was 3928.81 kg per ha (1.56 times a year). Similarly, other organic fertilizers used were oil cake, poultry manure, and goat manure with average use of 92.08, 115.91, and 170.91 kg per ha with frequency use of 2.25, 0.26, and 0.71 times a year respectively. Similarly, the average amount of urea use was 47.19 kg per ha (7.95 times a year) and that of di ammonium phosphate (DAP) use was 47.12 kg per ha (8.66 times a year). The average amount of lime used was 564.62 kg per ha (1.43 times a year). The majority of households i.e. 88.8 percent believed that pond fertilization and liming is useful however only 22.5 percent of fish farmers knew about inorganic fertilizers and their constituents. The major problem faced by fish farmers during fish production was the timely unavailability of lime and fertilizers. Following unavailability of quality fish seeds and feed, water shortage, the incidence of diseases and pests and market problems were other primeones.

Keywords: Fertilizer; Lime; Co-operatives; Family

Introduction

Farming of aquatic organisms, like fish, mollusks, crustaceans, and aquatic plants can be known as aquaculture. It includes the rearing process which enhances production, rearing involves regular stocking, feeding, and protection from predators. The stocked cultivated may be either individual or corporate ownership. Contribution to aquaculture is by the harvesting of the aquatic organism which is cultivated by an individual or corporate body similarly aquatic organism harvested from natural water resources contributes the fisheries [1].

As fish is the cheapest source of animal protein providing many important nutritional and health benefits, it is acclaimed to be the principal source of animal protein for over a billion people globally [2]. Recently, it is estimated that the people involved in the primary sector of capture fisheries and aquaculture were 59.51 million in 2018 with 39.0 million people engaged in aquaculture and 20.5 million people engaged in fisheries [3]. The main fish producer is China with 64.5 million tons of fish production which contributes 57.9% of the world's total production, it is also the largest exporter since 2000. Following China, Norway, and Vietnam are the second and third largest exporter of fish and fish products respectively [3].

Despite the inability to generate its income from marine aquaculture, Nepal holds great potential for freshwater fisheries. Though currently, the aquaculture sector in Nepal is small it has great potential for growth [4]. The total fish production in 2018/19 was 91832 mt which is a 6.11% increase in the total production of the fish from 86544 mt in 2017/18. The aquaculture activity produced was 70832 mt in the same year 2018/19. Similarly, fish productivity is also increased by the rate of 0.2% which was 4.92 t/ha in 2018/19 and 4.91 t/ha in 2017/18. The gradual development in fish farming can be traced through the increase in water surface area for the production of the fish by 1.38% in 2018/19. Similarly AGDP, GDP contribution is also increased to 4.18% and 1.13% respectively the national fish consumption rate is also increased to 3.11 kg in 2018/19 [5]. The two main sources of fish production in Nepal are aquaculture and capture fisheries [6].

Chinese carp, Indian major carps, and common carp are major selected species are cultured which includes six to seven valuable species viz three indigenous species; rohu (*Labeo rohita*), Naini (*Cirrhinus mrigala*) and bhakur (*Labeo catla*) and four are exotic species; Common carp (*Cyprinus carpio*), Silver carp (*Hypophthalmichthys molitrix*), Bighead carp (*Hypophthalmichthys nobilis*) and Grass carp (*Ctenopharyngodon idella*). 25.2% of the population still lives below the poverty line according to the Nepal Living Standards Survey 2010/11 [7]. So, there is a potent scope for the Fisheries sub-sector to raise the living standard of people. Hundred thousands of people are directly or indirectly involved in this subsector among which male occupies 67% and female occupies only 33% [6].

The district has the tropical and subtropical type of climate which is mostly hot and humid. "Crop, fish, and livestock-based farming is the major means of rural livelihood in Rupandehi. Keeping cattle, buffalo, goats, pigs, poultry, and ducks are the major livestock integrated with crop production including fish farming as major in some communities of the western part of the district [8]. Rupandehi has one super zone for fish and four blocks for two commodities: 1 for rice and 3 for fish and 60 pockets of various commodities.

Fertilization and Liming play a crucial role in fish production. Fertilization helps to increase the availability of natural food in fish ponds eventually cuts off the feed requirement needed for fish production. Application of fertilizers containing nitrogen, phosphorus, and potassium (especially phosphorus) mainly provides inorganic nutrients for the rapid growth of phytoplankton (microscopic plants) which are the primary producers of the pond [9]. The heterotrophic organisms depend on primary producers, once the primary production is increased; series of the aquatic food chain is activated and finally resulting in the fish production economically [10,11]. Liming improves soil pH which makes the pond suitable for the stocking of fish and application of lime to the pond with soft water also increases bicarbonate, calcium concentration creating the best environment for the growth of the phytoplankton.

The lime reacts with bottom muds, neutralizing acidity, and increasing base saturation by the exchange of basic for acidic ions on the cation exchange site [12].

Objectives

General objectives

- To assess the status of pond fertilization and liming on the fish super zone of Rupandehi district, Nepal.

Specific objectives

- To analyze the amount and method of application of lime on the fish ponds
- To assess the amount and type of fertilizers used by the farmers
- To analyze the farmer's knowledge, attitude, and perception towards the fish farming.

Literature Review

Background of fish production in Nepal

Aquaculture is a relatively new activity in Nepal and was started in mid-1940's on a small scale in earthen ponds with indigenous Indian major carp seed from India. Introduction of exotic species Common carp (*Cyprinus carpio*) in 1956 and 1960 from India and Israel respectively paved the way for development of aquaculture in Nepal. German or scale carp (*Cyprinus carpio* var. communis) and Israeli or mirror carp (*Cyprinus carpio* var. specularis) are two popular varieties of Nepal. Monoculture practices followed after its breeding success in 1960 and considerable popularity was gained in private sector [13]. After the introduction and framing of three exotic Chinese carps: silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*) and grass carp (*Ctenopharyngodon idella*) further significant progress in aquaculture was seen. Silver carp was introduced from India and Japan in 1967 and 1968 respectively. Similarly, Grass carp also brought from India and Japan in 1967 and 1968 respectively. However, Big head carp was introduced from America and Hungary in 1969 and 1972 respectively. Major breakthrough in the development of aquaculture in Nepal was brought by their breeding success in captivity [14]. In the same way, induced breeding was successful in three commercially important indigenous major carps of our country i.e. rohu (*Labeo rohita*), naini (*Cirrhinus mrigala*) and catla (*Labeo catla*) [15].

Over the past 20-25 years there have been a significant increase in the production of fish and the annual per capita fish consumption have increased significantly from 0.330 kg per person per year in 1982 up to 1.753 kg per person per year in 2006 [16]. The Agriculture Perspective Plan (APP) has categorized fisheries and aquaculture in Nepal as a small but important and promising sub-sector of agriculture contributing about 4.25 percent of agricultural gross domestic product (AGDP) and 1.33 percent of the total Gross Domestic product (GDP) [16,17].

Nepal is rich in fish biodiversity with nearly 200 fish species available which around 190 are indigenous species and remaining are exotic species [18]. They inhabit altitudes ranging from a few hundred meters above sea level to as high as 4000 meters. Carp poly culture in ponds, poly culture of carps in lake enclosures, cage culture of herbivorous carps in lake and reservoirs, rice-fish culture with common carp and extensive method of carp poly culture in ghols are common aquaculture practices in Nepal [19].

Present Scenario of Aquaculture in Nepal

In terms of the fresh water resources, Nepal is second largest country in the world after Brazil and possesses about 2.27% of the world fresh water reserves [20]. 383000 ha of total land of the country occupied by water resource is one of the major factor for development of aquaculture sector [21]. 0.49% of the total GDP at current price (NRs 13438 million) is occupied by fish sector as shown in Table 1. The total fish production in the fiscal year 2018/19 through various types of aquaculture practices is 70,832 MT [22]. Among different aquaculture practices in Nepal, Pond fish culture contributed most in the national fish production contributing 62,725 MT (88.55%). Ghols being second largest contributor in fish production. There is 3,500 ha Ghols used in aquaculture with production of 6,390 MT in 2018/19. Beside fish production from aquaculture practices, Capture fisheries is also very important in Nepal since it not only produce fish but also generate employment opportunities. The total production from capture fisheries in Nepal is 21,000 MT. Contribution of irrigated paddy fields, rivers and ghols in fish production are significant whereas reservoirs and lakes have least contribution [22]. About hundred thousand people are directly or indirectly involved in aquaculture sector among which 67% is male while 33% is female whereas 4,62,070 people are engaged in capture fisheries among them 60% are female and 40% are male [23].

Year	2072/23		2073/74		2074/75	
	Amount	%	Amount	%	Amount	%
Amount in (Rs.1000000)	11082	0.53	12377	0.51	13438	0.49

Table 1: Contribution of fish sector in Gross Domestic Product at current prices.
Source: (CBS, 2019)

Fisheries production in Rupandehi district

PM-AMP recently has identified Rupandehi district as fish super zone upgraded from fish zone with view of making the country self-sufficient in fish production and exploring the potentialities of foreign exports over the next 10 years through commercialization, mechanization and diversification of fish sub-sector. Rupandehi has total watershed area of 2460 hectares, aquaculture pond occupies about 877 hectares in which 750 ha and ongoing 50ha of aquaculture pond falls under fish zone [24]. Number of fish farmers

Particulars	Pond (Nos.)	Total Area (ha.)	Production (MT.)	Yield (kg/ ha)
A. Fish Production from Aquaculture Practices			70,832	
A1 Pond Fish Culture	45,936	12,749	62,725	4,920
Mountain	156	11.1	28	2,536
Hill	4,278	445.95	1,272	2,852
Terai	41,502	12,291.95	41,425	3,370
A2 Other Area (Ghols)		3,500	6,390	1,826
A3 Paddycum Fish Culture (ha)		72	9	125
A4 Cage Fish Culture (m3)		71,800	302.28	
A5 Enclosure Fish Culture (ha)	50	65	1,300	
A6 Trout Fish Culture in Raceway (ha)	3.2	420	131,250	
A7 Fish Production in Public Sector (MT)		18.8		
B. Fish Production from Capture Fisheries		21,000		
B1 Rivers	395,000	7,110	18	
B2 Lakes	5,000	1,000	200	
B3 Reservoirs	1,500	525	350	
B4 Marginal/ Swamps/Ghols etc.	9,000	5,200	578	
B5 Low Land Irrigated Paddy Fields	398,000	7,165	18	
Total Fish Production (MT)		91,832		

Table 2: Fishery Production by different types of sources in 2018/19.
Source: (MoALD, 2019)

in this district is about 2140 with pond number of 3910 [8] out of which 1517 farmers are under fish super zone, Rupandehi PIU farming in 3046 ponds [24]. Fish production of Rupandehi fish super zone in the fiscal year 2074/75 was 4132.5MT with productivity of 5.51MT/ha [24]. Various aquaculture methods are practiced like extensive, semi intensive and intensive aquaculture with pond areas of 206 ha, 221 ha and 450 ha respectively [8]. Fish farming has played vital role to uplift the economic development of rural VDC members in Rupandehi district [25].

Trend analysis

The total number of fish ponds in Nepal was 23,884 which was in 10,362 ha area in 2007/08 which increase in number and area with year to 45,936 and 19,614 ha area in 2018/19. The fish production of Nepal from pond fish culture was 24,295 MT with the productivity of 3.607 MT/ha during 2007/08 which has increased up to 62,725 MT with the productivity of 4.92 MT/ha in 2018/19 [22,26,27]. Although the annual fish production is increasing with the year but this increasing rate is not capable to meet the ever rising population of the country. Because of this reason, there has always been trade deficit in trade of fish which was about 519 million in the year 2011/12 and raised up to 1 billion during 2016/17. India is major source for importing fish and other aquatic organism. In the year 2069/70, the fish import in Nepal was 9,963 MT which raised to highest fish import in 2070/71 which was 12,869 MT. The total fish import in Nepal was 10,757.02 MT during 2074/75, which showed irregular trends of fish import in Nepal.

Year	Pond's No	Pond's Area	Water Surface Area (ha)	Total Fish Production (MT)	Yield (kg/ha)
2007/08	23,884	10,362	6,735	24,295	3,607
2008/09	23,790	10,308	6,700	23,780	3,549
2009/10	24,418	10,615	6,900	24,869	3,604
2010/11	26,036	11,195	7,277	26,941	3,702
2011/12	29,270	10,718	7,939	29,999	3,779
2012/13	32,020	12,338	8,020	31,221	3,893
2013/14	34,400	13,231	8,600	37,427	4,352
2014/15	36,666	14,154	9,200	41,481	4,509
2015/16	39,308	15,283	9,934	48,543	4,887
2016/17	44,725	17,532	11,396	55,842	4,900
2017/18	45,437	18,286	11,889	58,433	4,915
2018/19	45,936	19,614	12,749	62,725	4,920

Table 3: Yearly Summary Statistics on Pond Fish of Nepal.
Source: (MoAD, 2017; MoALD, 2018; MoALD, 2019).

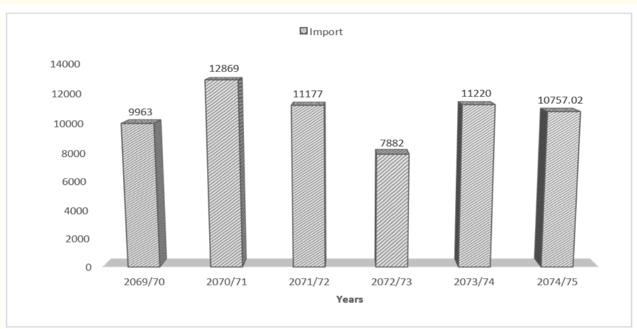

Figure 1: Fish import trend in Nepal.
Source: (MoAD, 2017; CFPCC, 2019).

Conceptual and theoretical review

Pond fertilization

For improving the growth of natural food i.e. phytoplankton and zooplankton which is vital for efficient fish production, pond fertilization is important. Broadly there are two sources of fertilizers in practice i.e. organic and inorganic fertilizers.

Organic fertilizers

Planktons can be multiplied rapidly by using organic manures which are decomposed by bacteria which results in release of nutrients which are leached to pond water [11]. Fish-livestock system i.e. raising of pigs and poultry on the banks of a pond provide a regular supply of organicmanure [28]. 1000 ducks/ha recommended by [29] and pigs (1 male and 3 females) recommended by [30] per 100 square meter pond area. In case of sterile newly built ponds application of organic fertilizers is highly recommended since it enhances the quantity of organic matter and speed up the conditioning of pond soil [28]. Not only organic fertilizers serve as food for zooplankton but in some type of aquaculture, use of organic fertilizers in pond preparation encourage the rapid multiplication of zooplankton blooms to serve food for young fishes and crustaceans [12].

With increasing manure loading, Net Fish Yield (NFY) generally found to be decreasing. This is mostly due to limited availability of phosphorous from chicken manure rather than due to environmental degradation from organic inputs [31]. High densities of livestock or poultry can severely reduce oxygen content of pond since, water quality is not only degraded by inputs of nutrients but also from ammonia and organic matter which is decomposed by microbes increasing Bio-chemical Oxygen Demand (BOD) [32].

In the ponds receiving inorganic fertilizer, application of organic manure results in increased fish production as carbon dioxide is slowly accumulated in fertilized ponds from air resulting in better phytoplankton growth and higher fish production after first year [33]. Applications of plant meal for example- alfa alfa leaf meal, cotton seed meal, rice barn, etc. or fish meal @ 25 to 50 kg/ha at interval of 4 to 5 days can quickly establish a zooplankton bloom and are applied in conjunction with chemical fertilizers. The pond should be fertilized with organic fertilizer (cattle manure) @3000 kg/ha after 5 to 7 days of lime application [34]. As pond water becomes warmer, the response to a fertilizer application will be stronger and more rapid [35].

Inorganic fertilizers

Inorganic fertilizers are rich in nutrient content. Prior to spraying all over the pond, it should be dissolve in water. The time of application of fertilizers should be in the early hours of the day; about 2 to 3 hours after sunrise and fertilization should always be adjusted and maintained based on water quality of pond and fish behavior [11].

The single most limiting fertilizer component maintaining the fertility of pond in fish production has been found to be phosphorus [28,36]. Forms of nitrogen is the major factor that determine the efficiency of nitrogen fertilizers in increasing ponds productivity. The commonly used nitrogen fertilizers are urea, ammonium sulfate and calcium ammonium nitrate. Depending on the available nitrogen content of the pond soil, application of 50-70 kg nitrogen/ha (i.e. 108-152 kg urea/ha; 200-280 kg calcium ammonium nitrate/ ha; 250-350 kg ammonium sulfate/ha in rearing ponds and 75-150 kg/ha/year (i.e. 163-326 kg urea/ha/year; 300-600 kg calcium ammonium nitrate/ha/year; 375-750 kg ammonium sulfate/ha/year) in stocking ponds give good results [37]. Single Super Phosphate (SSP) is most commonly used as phosphate fertilizer in fish ponds. Depending on the available phosphate content of pond soil, application of 25-50 kg phosphate ($P2O5$)/ha (i.e. 156-312 kg SSP/ha) and 40-75 kg phosphate/ha/year (i.e. 250-468 kg SSP/ha) in rearing and stocking ponds, respectively give good results [37]. Muriate of Potash (potassium chloride, KCl) and sulfate of potash (potassium sulfate, K_2SO_4) are commonly used as potassium fertilizers in fish ponds. Application of 10-20 kg potash/ha (16-32 kg KCl/ha or 20-40 kg K_2SO_4/ha/year) and 25-50 kg potash/ha/year (41-66 kg KCl/ha or 52-83 K_2SO_4/ha/year) in rearing and stocking ponds, respectively gibe good results [37].

The fertilizer should be applied in equal monthly splits alternately with organic manure with a gap of about a fortnight [37]. If there appearance of thick green or blue green blooms of algae in the pond, we should stop the application of any type of fertilizers i.e. both organic and inorganic otherwise it will cause depletion of oxygen in pond. Pre-decomposed organic manure should be used to prevent un-hygienic conditions in pond. Regular monitoring helps to understand chemical and biological conditions of pond soil and water which along with efficient management practices enhances production of fish food organisms thus, increase the growth and survival of fish [37].

Liming

Fish culturists has adopted liming as agricultural practice and liming materials used in ponds and agricultural soils are same ones [11]. Pond may benefitted by lime, if the total alkalinity of the water sample fall below 20 mg/L. The chemical characteristics of the bottom sediment acts as determinant of amount of lime needed. Use of quick lime (CaO) or slaked lime ($Ca(OH)_2$) is not advisable because of being more expensive and can cause pH to rise rapidly to levels that can harm aquatic life [37].

Finely crushed agricultural limestone react faster and dissolve more rapidly and completely than large particles hence it is usually considered the best material for liming purpose. It is also cost- effective and readily available. By application of either calcite ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$) limestone, pond alkalinity and hardness can be increased. However, agricultural lime will sink to the bottom since it does not dissolve quickly in water [37]. Liming have several benefits in pond such stimulation of microbes for decomposition of organic matter, source of calcium in pond, enhances the content of nitrate in pond and lastly improve sanitation of pond environment. Liming improves the effectiveness of fertilization by creating a strong buffer system in the aquatic environment. However, liming should be avoided shortly after fertilizing since it remove phosphorus from the water, which could prevent a phytoplankton bloom from developing [37]. The most desirable pH for fish production is 6.5-9.0 whereas alkaline and acidic death is caused if pH reaches greater than 11 and less than 4 respectively [38].

Common name	Chemical name	NV (%)
Basic slag		55-79
Calcite limestone	Calcium carbonate, $CaCO_3$	85-100
Dolomitic limestone	Calcium magnesium carbonate, $CaMg(CO_3)_2$	95-109
Slaked or hydrated lime*	Calcium hydroxide, CaOH	136
Quick or burnt lime*	Calcium oxide, CaO	179

Table 4: Common names, chemical names, neutralizing values percentage (NV %) of various liming materials

*Use of these materials is not recommended because their effects on pH can be harmful to aquatic life.

Source: (Wurts and Masser, 2004).

Conceptual framework

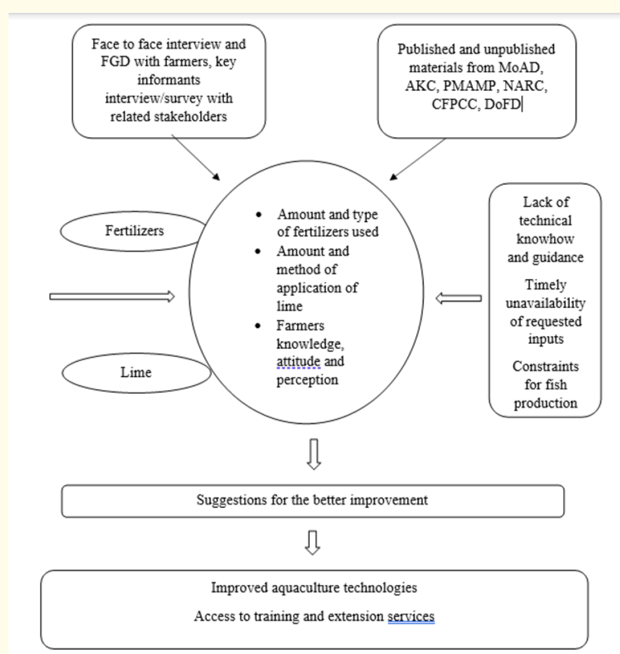

Figure 2: Conceptual framework of the study [39].

Materials and Methods

Study area

The survey was carried out in the fish super zone, Rupandehi which is Terai district located in Province no. 05. PM-AMP has recently identified the Rupandehi district as a fish super zone upgraded from the fish zone. Its neighbor districts are Kapilvastu in the west, India in the south, Nawalparasi to the east, and Palpa in the northern part. Administratively, the district has 7 rural- municipalities and 6 Municipalities. The district has 241587 hectare land of which 100,149 hectare is cultivable and the remaining is covered by forest, watersheds, and grazing land [8]. It covers an area of 1350 sq. km and has a population of 8, 80,196 with an average population density of 647 people/km^2 [40]. Rupandehi was the fourth-highest fish producer in terms of total fish production as well as production area in the year 2016/2017 [26]. The study was carried out in four rural municipalities of Rupandehi district namely Siyari, Mayadevi, Gaidahawa, and Sudhhodhan. These areas were purposively selected because a majority of fish farmers i.e. about 80% are from these areas and contribute about 800 hectares of pond area about 75% of the total fish production of the whole district.

Figure 3: Location map of the study site (shaded region depicts the study area).
Source: content.sciendo.com.

Sample and sampling technique

The sampling population for the present study included all the fish growers of the fish zone who owned at least one pond. Out of all fish farmers included in the fish super zone, 80 randomly selected households of fish farmers were randomly selected, 20 from each site. Simple Random Sampling technique was followed.

Research design

Duration of research: The total period of research starting from general interview scheduling till final report preparation was a total of seven months (Magh-Shrawan).

Stages of the survey: The proposed research was carried out in the following stages:

- Interview scheduling and questionnaire preparation.
- Pre-testing of the questionnaire with fish farmers to ensure reliable information gain from respondents.
- Focus Group Discussions: It was conducted in Siyari and Gaidahawa rural municipality to triangulate and supplement information gathered from the household interview and other sources especially with the subsistence rural farmers.
- Field survey and data collection from selected sites: From fish farmers (80 sample size).
- Data tabulation and data analysis using MS-Excel and SPSS software. Both qualitative and quantitative methods were followed.

Data and data types

Both primary and secondary information was collected during the research study. The primary sources of information were the fish farming household of four rural municipalities of Rupandehi district namely Siyari, Mayadevi, Gaidahawa and Sudhhodhan, FGDs, key informants of related sectors. And Secondary data was collected from the publications of related organizations, both governmental and non-governmental such as NARC, DOFD, PMAMP, CBS, DOA, KGK, MOALD, AFU, FNCCI, etc., and journal articles, newsletters.

Data analysis technique

The collected data and information was tabulated and analyzed using the various statistical tools like MS-Excel 2013, SPSS (version 25.0) software, and descriptive analysis of the data for the variables like family size, educational status, size of landholding, different management practices like liming and fertilization, etc. The obtained information was presented in the form of graphs, charts, tables, and bar diagrams.

Socio-economic and farm characteristics

The socio-economic and farm characteristics of the respondents such as family size, gender, age, economically active population, dependency ratio, occupational pattern, landholding size, pond size, source of fish seeds and water, supporting organizations, etc. were analyzed by using simple descriptive statistics such as mean, frequency, and percentage. Comparisons between the types of farmers with these characteristics were analyzed by chi-square test and independent-sample t- test.

Fertilizers and lime

The amount, type, frequency, and method of application of different organic fertilizers used such as FYM, Oil cake, Poultry manure, and Goat manure were analyzed. Similarly, in the case of inorganic fertilizers (i.e. Urea and DAP) and lime also. Comparisons between the types of farmers about the use of fertilizers and lime were analyzed by chi-square test and independent- sample t-test.

Scaling and indexing

The index was used to rank various problems and reasons. Scaling techniques, which provide the direction and extremity attitude of the respondent towards any proposition was used to construct the index.

The intensity of production problems being encountered by the fish farmers was identified by using a five-point scaling technique using scores of 1, 0.8, 0.6, 0.4, and 0.2. The formula given below is used to find the index for the intensity of various problems [41].

$I_{prob} = \sum (S_iF_i)/N$ Where,

I_{prob}= Index value for intensity S_i= Scale value of i^{th} intensity F_i= Frequency of i^{th} response N = Total number of respondents.

Results and Discussions

Socio-economic and demographic characteristics (Categorical variables) of respondents

Regarding the gender of respondents in the study area, the majority were males (86.25%) compared to females (13.75%) which was true for both small as well as large farmers. In the case of marital status, most of the respondents were married (92.5%) whereas few of the respondents were unmarried (6.25%) and 1.25% widowed in the study area.

Considering the type of family in the study area, the joint family (65%) was dominant over the nuclear family (35%). The chi-square values were found to be 1.028, 1.755, and 0.069 for the gender of respondents, marital status, and type of family respectively which were not statistically different among small and large farmers (Table 5).

In the study area, the most prominent ethnic groups were Brahmin (46.25%) followed by Janajati (26.25% and other groups as shown in table 5. Hinduism (88.75%) was followed as the major religion by the majority of respondents in the study area after that Buddhism (6.25%), Islam (3.75%), and Christianity (1.25%). The chi-square values for ethnicity and religion were 8.357 and 5.183 respectively which wasn't statistically significant between types of farmers (Table 5). Since the land around the buffer zone wasn't suited for growing other crops, fish farming (62.5%) having great potential in the study area ranked first among different categories of major sources of income followed by crop raising and livestock rearing with 28.75% of respondents engaged in it. Other sources of income were services (5%), remittance (2.5%), and business (1.25%). The chi-square value was 19.719 which showed that there was a significant difference among the types of farmers with the major source of income at 1% level.

The level of education of respondents was divided into four different groups. Illiterate are those who have never attended any formal classes in their life. They are usually unable to read and write. Similarly, those who have attended school up to grade 8, 12, and up to bachelor degree and above were grouped into the primary level, secondary level, and higher education respectively. Table 5 depicted that about 15% of respondents were illiterate and the remaining 85% were literate. Among literate, 27.5%, 41.25%, and 16.25% of respondents attended school up to primary level, secondary level, and higher education respectively. The chi-square value was found to be 4.617 which wasn't statistically significant between the types of farmers (Table 5).

The experience was pivotal in increasing the knowledge of farmers about farming techniques, adoption, and transfer of advanced

Variables	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square
Gender of respondent				
Male	39(83.0)	30(90.9)	69(86.25)	1.028
Female	8(17.0)	3(9.1)	11(13.75)	
Marital status				
Married	42(89.4)	32(97)	74(92.5)	
Unmarried	4(8.5)	1(3.0)	5(6.25)	1.755
Widowed	1(2.1)	0(0.0)	1(1.25)	
Family type				
Joint	30(63.8)	22(66.7)	52(65.0)	0.069
Nuclear	17(36.2)	11(33.3)	28(35.0)	
Ethnicity				
Brahmin	19(40.4)	18(54.5)	37(46.25)	
Chhetri	5(10.6)	1(3.0)	6(7.5)	
Janajati	15(31.9)	6(18.2)	21(26.25)	8.357
Dalit	3(6.4)	0(0.0)	3(3.75)	
Madhesi	3(6.4)	6(18.2)	9(11.25)	
Others	2(4.3)	2(6.1)	4(5.0)	
Religion				
Hindu	40(85.1)	31(93.9)	71(88.75)	
Buddhist	5(10.6)	0(0.0)	5(6.25)	5.183
Islam	1(2.1)	2(6.1)	3(3.75)	
Christianity	1(2.1)	0(0.0)	1(1.25)	
Occupation				
Fish farming	20(42.6)	30(90.9)	50(62.5)	
Crop farming and livestock rearing	20(42.6)	3(9.1)	23(28.75)	
Business	2(4.3)	0(0.0)	2(2.5)	19.719***
Services	4(8.5)	0(0.0)	4(5)	
Remittance	1(2.1)	0(0.0)	1(1.25)	
Level of education				
Illiterate	9(19.1)	3(9.1)	12(15)	
Primary level	10(21.3)	12(36.4)	22(27.5)	4.617
Secondary level	22(46.8)	11(33.3)	33(41.25)	
Higher education	6(12.8)	7(21.2)	13(16.25)	
Experience (in years)				
1-5 years	18(38.3)	7(21.21)	25(31.25)	
6-10 years	16(34.0)	8(24.24)	24(30.0)	6.213
11-15 years	7(14.9)	11(33.33)	18(22.5)	
>15 years	6(12.8)	7(21.21)	13(16.25)	
Land leased in/out	5(10.6)	7(21.2)	12(15.0)	1.7

Table 5: Socio-economic and demographic characteristics (categorical variables) of respondents.

Notes: Figures inside the parentheses denote percentage.

*** indicate significant difference at 1% level respectively.

technology for increasing fish production. The result showed that 31.25% of the farmers have less than 5 years of experience, 30% have 6 to 10 years of experience, 22.5% have 11 to 15 years of experience and 16.5% have more than 15 years of experience. The chi-square value is 1.7 which wasn't statistically significant between the types of farmers (Table 5).

Socio-economic and demographic characteristics (continuous variables) of respondents

The average age of respondents was found 49.55 years. The average size of respondent household was 7.13 members per household which were quite more than that of the national average household size i.e. 4.88 [7]. In the study area, there were more economically active members (4.66) in a household of respondents than dependent members (2.57) as mentioned in table 7. The average of the economically active population was higher in large farmers (4.7) than in small farmers (4.64). The dependency ratio was found at 0.64. The total own landholding size of the sampled household ranged from 0.03 to 5.33 ha with an average being 1.04 ha and that of small and large farmers were 0.64 ha and 1.61 ha respectively. The t-value shows there was a significant difference at the 1% level (Table 2) between the types of farmers. The average total cultivated land including leased is found to be 1.13 ha whereas that of small and large farmers were 0.69 ha and 1.77 ha respectively. Their t-values showed there was a significant difference among types of farmers at the 1% level.

Variables	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Mean difference	t-value
Age of respondents	49.85(13.43)	49.12(12.07)	49.55(12.81)	0.73	0.249
Size of household	6.85(3.07)	7.52(3.67)	7.13(3.32)	-0.664	-0.878
Annual gross income	367319.15(25	1259393.94(11	735300(8588	-892074.79	-4.512***
	8208.64)	14873.70)	30.591)		
Economically active Population	4.64(2.57)	4.7(2.48)	4.66(2.52)	-0.059	-1.02
Dependent population	2.26(1.81)	3.03(2.08)	2.57(1.95)	-0.774	-1.770*
Landholding (ha)					
Total own land	0.64(0.45)	1.61(0.93)	1.04(0.84)	-0.973	-5.57***
Total cultivated land	0.69(0.47)	1.77(1.11)	1.13(0.96)	-1.087	-5.314***

Table 6: Socio-economic and demographic characteristics (continuous variables) of respondents.
Notes: Figures inside the parentheses denote standard deviation. *** And * indicates a significant difference at 1% and 10% level respectively.

Type of farmer and pond size

According to farmers' pond size, fish farmers were divided into two category small and large farmers based on mean and standard deviation. The average pond size was found to be 0.69 ha. Farmers having less than or greater than average pond size were grouped into small farmers and large farmers respectively. In the case of small and large farmers average pond size was 0.37 ha and 1.18 ha respectively whose t-value shows a significant difference at the 1% level (Table 7).

Pond description (ha)	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Mean difference	t-value
Total pond area	0.37(0.12)	1.18(0.52)	0.69(0.53)	-0.810	-8.844***
Total pond water area	0.25(0.09)	0.92(0.43)	0.53(0.44)	-0.663	-8.534***

Table 7: Pond size of the respondents.
Notes: Figures inside the parentheses denote standard deviation. *** indicates a significant difference at the 1% level.

Type of fish culture and nursery pond

97.5% of respondents practiced polyculture while only 2.5% practiced monoculture which showed nearly all the fish farmers in the study area practiced Polycarp culture. According to the fish farmers, polyculture was more profitable. A similar result was found by Singh (2007) i.e. 98% of sampled fish farmers followed Polycarp culture in West Tripura district of Tripura, India. In polyculture, three indigenous species of carp i.e. Rohu, Naini, and Bhakur, and four exotic species of carp i.e. Common carp, Grass carp, Silver carp, and Bighead carp were cultured in the same pond. The chi-square value was 1.44 which wasn't statistically significant between the types of farmers (Table 8). Majority of the fish farmers (73.8%) constructed nursery ponds in the study area. In comparison between types of farmers, a greater percentage of large farmers (87.9) constructed nursery ponds than small farmers (63.8). Its chi-square value i.e. 5.792 shows a significant difference at a 5% level (Table 8).

Sources of fish seeds and water for fish farming

Most of the people in the study area relied on private nurseries/hatcheries (78.8%) as the major source of fish seeds since private nurseries/hatcheries were relatively nearby compared to government farms. The majority of such private nurseries/hatcheries bre-

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Type of fish culture				
Monoculture	2(4.3)	0(0.0)	2(2.5)	1.44
Poly culture	45(95.7)	33(100)	8(97.5)	
Nursery	30(63.8)	29(87.9)	59(73.8)	5.792**

Table 8: Type of fish culture and nursery ponds.
Notes: Figures inside the parentheses denote percentage.
** indicate significant difference at 5% level respectively.

ed fishes in their mother pond and produce fish seeds themselves. 18.8% of the respondents purchased fish seeds from government farms. Some respondents (2.5%) imported fish seeds from India (Table 9).

Motor pump (92.5%) was a major source of water for fish farming in the study area for fish farmers followed by water canal (5%) and seepage water (2.5%) (Table 9).

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Source of fish seeds				
Government farms	7(14.9)	8(24.2)	15(18.8)	
Private nurseries/ hatcheries	38(80.9)	25(75.8)	63(78.8)	2.372
Import from India	2(4.3)	0(0.0)	2(2.5)	
Source of water for fish culture				
Motor pump	41(87.2)	33(100)	74(92.5)	
Water canal	4(8.5)	0(0.0)	4(5.0)	4.554
Seepage water	2(4.3)	0(0.0)	2(2.5)	

Table 9: Sources of fish seeds and water for fish farming.
Notes: Figures inside the parentheses denote the percentage.

Months of stocking

Most of the sampled farmers stocked fish seeds during Feb/March (46.30%) month followed by April/May (31.20%), Jan/Feb (13.70%), and May/June (8.80%) in the study area (Figure 4).

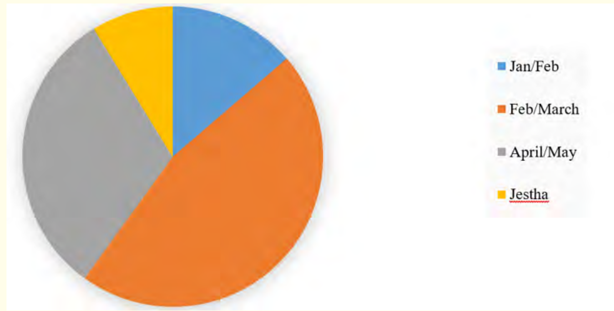

Figure 4: Months of stocking fish seeds.

Sources of information about fish farming

The majority of fish farmers in the study area initiated fish farming after they got information about fish farming from fellow neighbor farmers (86.3%) followed by extension agents (7.5%) and training(6.3%) (Figure 5).

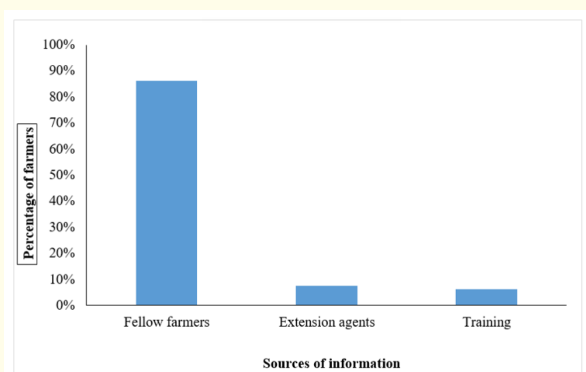

Figure 5: Distribution of respondents by sources of information about fish farming.

Involvement in fish farmers groups/cooperatives and access to credit, training, and extension services

Farmer groups or cooperatives help to change the attitude and perception of farmers towards fish farming and also provide easy access to a loan. Its chi-square value was 0.215 which wasn't statistically different among the types of farmers (Table 10). The majority of respondents (82.5%) were involved in farmer groups or cooperatives while that of small and large farmers were 80.9% and 84.8% respectively.

There were 48.8% respondents in the study area who had taken loans for agricultural purposes. The majority of respondents took a loan from the bank (71.8%) followed by cooperatives (28.2%). In comparison to small farmers (54.5%), large farmers (94.1%) were more acquainted with banks for loan purposes. This was significant at the 1% level (Table 10). Most of the respondents (66.3%) received training regarding fish farming. 87.5% of sampled fish farmers had access to extension services. Sources of extension services were government extension (51.4%) and cooperatives (48.6%). Most of the respondents (72.5%) were in contact with extension service agents. Its chi-square value shows a significant difference at the 5% level between small farmers (63.8%) and large farmers (84.8%). 29.3% of respondents were in contact with extension service agents very regularly, 56.9% regularly and 13.8% rarely have contact.

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Involvement	38(80.9)	28(84.8)	66(82.5)	0.215
Taken agriculture loan	22(46.8)	17(51.5)	39(48.8)	0.172
Sources of loan				
Bank	12(54.5)	16(94.1)	28(71.8)	7.416***
Cooperatives	10(45.5)	1(5.9)	11(28.2)	
Total	22(100.0)	17(100.0)	39(100.0)	
Training	28(59.6)	25(75.8)	53(66.3)	2.271
Access to extension service	39(83.0)	31(93.9)	70(87.5)	2.13
Sources of extension services				
Government extension	17(43.6)	19(61.3)	36(51.4)	2.166
Cooperatives	22(56.4)	12(38.7)	34(48.6)	
Total	39(100.0)	31(100.0)	70(100.0)	
Contact with extension service agents	30(63.8)	28(84.8)	58(72.5)	4.296**
Very regularly	9(30)	8(28.6)	17(29.3)	
Regularly	17(56.7)	16(57.1)	33(56.9)	0.02
Not regularly	4(8.5)	4(14.3)	8(13.8)	
Total	30(100)	28(100.0)	58(100.0)	

Table 10: Involvement of respondents in fish farmer groups/ cooperatives and access to credit, training, and extension services. Notes: Figures inside the parentheses denote percentage. *** And ** indicates a significant difference at 1% and 5% level respectively.

Insurance of pond, subsidy taken, a test of pond soil and water quality

Only 6.3% of respondents made insurance of their pond, in case of small and large farmers 2.1% and 12.1% respectively. This was significant at the 10% level (Table 11). The majority of respondents (83.8%) got a subsidy for fish production in the study area. Only 12.5% of the respondents tested soil before pond construction in the study area while that of small and large farmers were 4.3% and 24.2% respectively which was significant at the 1% level. However in the case of water tests, 55% of the fish farmers have checked their pond's water quality parameters.

Farmers' perception, attitude, and knowledge towards pond fertilization, liming and fish production

Most of the fish farmers (85%) were aware of an integrated fish farming system through training or contact with extension agents. In the case of small and large farmers, 76.6% and 97% respectively were aware. This was a significant difference at the 5% level (Table 12). In the same way, 91.3% of fish farmers knew pond fertilization and liming. Similarly, pond fertilization being useful was accepted by 88.8% of respondents. About 70% of fish farmers perceived that pond fertilization and liming increase fish production. Only 22.5% of respondent farmers knew about inorganic fertilizers and their constituents. All most of all respondents (97.5%) believed that fertilizers and lime don't have any undesirable effects on the pond if used at the right amount and time.

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Insurance	1(2.1)	4(12.1)	5(6.3)	3.305*
Subsidy taken	39(83.0)	28(84.8)	67(83.8)	0.05
Pond soil Tested	2(4.3)	8(24.2)	10(12.5)	7.081***
Water quality checked	23(48.9)	21(63.6)	44(55.0)	1.693

Table 11: Distribution of respondents by insurance of pond, subsidy taken, the test of pond soil and water quality.

Notes: Figures inside the parentheses denote percentage. *** And * indicates a significant difference at 1% and 10% level respectively.

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Integrated fish farming system	36(76.6)	32(97.0)	68(85.0)	6.312**
Pond fertilization and liming	41(87.2)	32(97.0)	73(91.3)	2.302
Pond fertilization and liming is useful	40(85.1)	31(93.9)	71(88.8)	1.515
Pond fertilization and liming increase in fish production	39(83.0)	31(93.9)	70(87.5)	2.13
Knowledge about liming materials	40(85.1)	32(97)	72(90.0)	3.032*
Inorganic fertilizers and their constituents	7(14.9)	11(33.3)	18(22.5)	3.78*
Fertilizers and liming don't have any undesirable effects on the pond	45(95.7)	33(100.0)	78(97.5)	1.44

Table 12: Farmers' perception, attitude, and knowledge towards pond fertilization, liming and fish production.

Notes: Figures inside the parentheses denote percentage. ** And * indicates a significant difference at 5% and 10% level respectively.

Fertilizers organic fertilizers

Farmyard manure (FYM)

Almost all respondents (95%) used FYM for purpose of pond fertilization. It may be because of the majority of the respondents reared livestock and had easy access to FYM. The chi-square value shows there was a significant difference at the 10% level between small and large farmers. 82% of the households used cow dung, according to Singh (2007). The average amount of FYM use was found to be 3928.81kg per ha which was significant at a 1% level among types of the farmer. The majority of farmers (90.8%) heaped the FYM at a corner, only a few (9.2%) broadcasted FYM at the time of field preparation. The average frequency of FYM use was 1.56 times in a year. The average cost of FYM was NRs 13095.91 per ha which was significant at a 1% level among types of the farmer.

Oil cake

Only 15% of the total respondents used oil cake as manure. The average amount of oil cake used was 92.08 kg per ha which was significant at a 5% level between types of farmers. Most of the farmers (66.67%) used oil cake mixed with rice barn followed by broadcasting (33.33%). The average frequency of oil cake use was found to be 2.25 times in a year which was significant at a 5% level between types of the farmer. The average cost of oil cake was NRs 3071.9 per ha.

Poultry manure

Few respondents (13.8%) used poultry manure in the pond as manure. The average amount of poultry manure used was 115.91 kg per ha which was found significant at a 1% level between types of farmers. The majority of farmers (72.7%) heaped poultry manure at a corner followed by broadcasting (27.3%). The average frequency of using poultry manure was 0.26 times in a year. The average cost of poultry manure was NRs 446.55 per ha which was found significant at a 1% level between types of farmers.

Goat manure

Only 13.8% of respondents used goat manure for pond fertilization. The average amount of goat manure used was 170.91 kg per ha which was significant at a 1% level among types of farmers. Most farmers (81.8%) used goat manure heaped at a corner followed by broadcasting (18.2%). The average frequency of using goat manure was 0.71 times a year which was significant at a 1% level among types of farmers. The average cost of goat manure was NRs 692.22 per ha which was significant at a 1% level among types of farmers.

Organic manure	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
FYM	43(91.5)	33(100)	76(95.0)	2.956*
Oil cake	7(14.9)	5(15.2)	12(15.0)	0.01
Poultry manure	5(10.6)	6(18.2)	11(13.8)	0.930
Goat manure	6(12.8)	5(15.2)	11(13.8)	0.093

Table 13: Distribution of respondents by type of organic fertilizers used.

Notes: Figures inside the parentheses denote percentage.

* indicates a significant difference at the 10% level.

Inorganic fertilizers Urea

The majority of respondents (90%) used urea in the pond for fertilization purposes which was found significant difference at the 10% level among small (85.1%) and large farmers (97%). The use of urea could be due to low cost and easy access as proximity to the Indian border. The average amount of urea used was found to be 47.19 kg per ha and that of small and large farmers used 44.34 and 50.77 kg per ha. The most widely practiced method of application of urea in the study area was floating in a perforated container (76.4%) followed by broadcasting (23.6%). The average frequency of use of urea was 7.95 times in a year which was mostly based on observation of greenery of pond water. It was found significant at 10% level among different types of farmers. The average cost of urea was NRs 759.14 per ha.

Method of application	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
FYM				
Heaping at a corner	38(88.4)	31(93.9)	69(90.8)	0.692
Broadcasting	5(11.6)	2(6.1)	7(9.2)	
Total	43(100.0)	33(100.0)	76(100.0)	
Oil cake				
Broadcasting	3(42.9)	1(20.0)	4(33.33)	0.686
Mixed with rice barn	4(57.1)	4(80.8)	8(66.67)	
Total	7(100.0)	5(100.0)	12(100.0)	
Poultry manure				
Heaping at a corner	3(60.0)	5(83.3)	8(72.7)	0.749
Broadcasting	2(40.0)	1(16.7)	3(27.3)	
Total	5(100.0)	6(100.0)	11(100.0)	
Goat manure				
Heaping at a corner	5(83.3)	4(80.0)	9(81.8)	0.02
Broadcasting	1(16.7)	1(20.0)	1(18.2)	
Total	6(100.0)	5(100.0)	11(100.0)	

Table 14: Method of application of organic fertilizers.

Notes: Figures inside the parentheses denote percentage.

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Mean difference	t-value
FYM					
Amount	3097.21(1264.	4960.32(1556.	3928.81(1729.	-1863.11	-5.602***
	53)	39)	85)		
Frequency	1.49(0.67)	1.67(0.59)	1.56(0.64)	-0.17	-1.208
Cost	10323(4215.07)	16534.25(5187.93)	13095.91(5766.12	-6210.32	-5.758***
Oil cake					
Amount	66(24.78)	128(44.38)	92.08(45.35)	-61.57	-3.092**
Frequency	1.64(0.74)	3.1(0.89)	2.25(1.07)	-1.45	-3.073**
Cost	2568.11(967.9 2)	3777.21(1318. 9)	3071.9(1237.4 2)	-1209.09	-1.841
Poultry manure					
Amount	156(36.47)	82.5(24.44)	115.91(48.00)	31.88	3.995***

Frequency	0.18(0.1)	0.32(0.15)	0.26(0.14)	-0.14	-1.728
Cost	604.99(134.93)	314.52(82.97)	446.55(183.67)	290.46	4.394***
Goat manure					
Amount	80.83(43.40)	279(54.35)	170.91(113.29)	-264.71	-6.736***
Frequency	0.25(0.14)	1.25(0.5)	0.71(0.62)	-0.99	-4.692***
Cost	306.02(171.78)	1155.67(240.82)	692.22(484.59)	-849.64	-6.833***

Table 15: Amount (per ha), frequency (per year) and cost (per ha) of organic fertilizers.

Notes: Figures inside the parentheses denote percentage. *** And ** indicates a significant difference at 1% and 5% level respectively.

Inorganic fertilizers	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Urea	40(85.1)	32(97.0)	72(90.0)	3.032*
DAP	40(85.1)	32(97.0)	72(90.0)	3.032*

Table 16: Distribution of respondents by inorganic fertilizers use.

Notes: Figures inside the parentheses denote percentage.

* indicates a significant difference at the 10% level.

Method of application	Small farmers	Large farmers	Overall	Chi-square
	(n = 47)	(n = 33)	(n = 80)	value
Urea				
Broadcasting	10(25.0)	7(21.9)	17(23.6)	0.096
Floating in perforated container	30(75.0)	25(78.1)	55(76.4)	
Total	40(100.0)	32(100.0)	72(100.0)	
DAP				
Broadcasting	10(25.0)	7(21.9)	17(23.6)	0.096
Floating in perorated container	30(75.0)	25(78.1)	55(76.4)	
Total	40(100.0)	32(100.0)	72(100.0)	

Table 17: Method of application of inorganic fertilizers.

Notes: Figures inside the parentheses denote percentage.

Diammonium phosphate (DAP)

The majority of farmers (90%) used DAP as the source of fertilization in the pond. The average amount of use of DAP was found to be 47.12 kg per ha. Similar to urea, the majority of farmers applied DAP by floating in a perforated container (76.4%) followed by broadcasting (23.6%). The average frequency of application of DAP was 8.66 times a year which was significant at a 10% level among different types of farmers. The average cost of DAP was found to be NRs 2164.97 per ha.

Lime

Nearly all fish farmers (98.8%) used lime in their ponds for maintaining pH and other water quality parameters. Most of the respondents (87.3%) used Agricultural lime because of its easy access and low cost followed by Quicklime (12.7%). Most of the fish farmers broadcasted lime (58.2%) at the time of field preparation followed by dissolving in water and spraying all over the pond (41.8%) which was significant at 1% level among the types of farmers. The average amount of lime used in the study area was 564.62 kg per ha which was significant at a 1% level among the types of farmers. The average high amount of lime used could be due to the high use of fertilizers as the water quality get deteriorate. The average frequency of application of lime was 1.43 times a year which was significant at a 1% level among the types of farmers. The average cost of lime used was NRs 12817.91 per ha which was significant at a 1% level among the types of farmers (Table 21).

Time of application of fertilizers

Most of the respondent fish farmers in the study area applied fertilizers in the morning (52.5%) followed by at noon (35%) and in the evening (12.5%). The result obtained was significant among the type of farmers at the 10% level (Table 22).

Constraints of fish production

During the process of production of fishes, farmers encountered different problems. In this regard, timely unavailability of fertili-

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Mean difference	t-value
Urea					
Amount	44.34(18.54)	50.77(18.27)	47.19(18.57)	-6.43	-1.472
Frequency	8.22(1.25)	7.62(1.29)	7.95(1.29)	0.6	1.996*
Cost	712.27(292.96)	817.72(294.20)	759.14(296.18)	-105.45	-1.515
DAP					
Amount	44.27(19.23)	50.67(16.80)	47.12(18.35)	-6.40	-1.483
Frequency	8.23(1.25)	7.62(1.29)	8.66(1.15)	0.6	1.996*
Cost	2068.37(895.64)	2285.73(757.03)	2164.97(838.26)	-217.36	-1.095

Table 18: Amount (per ha), frequency (per year), and cost (per ha) of inorganic fertilizers.

Notes: Figures inside the parentheses denote standard deviation. * indicates a significant difference at the 10% level.

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Lime used	46(97.9)	33(100.0)	79(98.8)	0.711
Type of lime				
Agricultural lime	42(91.3)	27(81.8)	69(87.3)	
Quicklime	4(8.7)	6(18.2)	10(12.7)	1.564
Total	46(100.0)	33(100.0)	79(100.0)	

Table 19: Distribution of respondents by type of lime use.

Notes: Figures inside the parentheses denote percentage.

Method of application	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Broadcasting	33(71.7)	13(39.4)	46(58.2)	8.265***
Dissolve in water and spray	13(28.3)	20(60.6)	33(41.8)	
Total	46(100.0)	33(100.0)	79(100.0)	

Table 20: Method of application of lime.

Notes: Figures inside the parentheses denote percentage.

*** indicates a significant difference at the 1% level.

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Mean difference	t-value
Amount	481.84(129.70)	680(194.24)	564.62(186.70)	-198.15	-5.101***
Frequency	1.25(0.49)	1.69(0.54)	1.43(0.56)	-0.45	-3.817***
Cost	10877.71(3323.20)	15522.42(4656.69)	12817.91(4536.76)	-4644.70	-4.904***

Table 21: Amount (per ha), frequency (per year), and cost (per ha) of lime.

Notes: Figures inside the parentheses denote percentage. *** indicates a significant difference at the 1% level.

Time of application of fertilizers	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Morning	23(48.9)	19(57.6)	42(52.5)	
Noon	15(31.9)	13(39.4)	28(35.0)	4.615*
Evening	9(19.1)	1(3.0)	10(12.5)	
Total	47(100.0)	33(100.0)	80(100.0)	

Table 22: Distribution of respondents by the time of application of fertilizers.

Notes: Figures inside the parentheses denote percentage.

* indicates significant difference at 10% level.

zers and lime was the major issue in the study area. As fish farmers were majorly dependent on cooperatives for the supply of fertilizers and lime, but cooperatives were unable to supply fertilizers and lime timely to all fish farmers. As priority was given to crop cultivation before fish farming for supply. The following second most important problem was the unavailability of quality fish seed and feed. The third major problem was the water shortage. Since not all fish farmers have access to motor pump or boring and volume of water coming from the pump or boring decreased in the dry season due to low groundwater table. The fourth and fifth most important problems in the study area were the incidence of diseases and pests and market problems as indicated by index and rank (Table 23). The important determinants of fish production in the study area were various inputs like fish seed, manures, and fertilizers.

Problems	Index	Rank
Timely unavailability of fertilizers and lime	0.8025	I
Unavailability of quality fish seed and feed	0.715	II
Water shortage	0.575	III
Incidence of diseases and pests	0.455	IV
Market problems	0.4525	V

Table 23: Ranking of major fish problems encountered by farmers.

Adoption of various improved technologies in fish production

Only 11.3% of respondents had water testing kits for DO, acidity/alkalinity, and fertility measurement which was found to be significant at 1% level among small (2.1%) and large farmers (24.2%). The majority of farmers (77.5%) used improved techniques in pond construction and maintenance as the subsidy was proved by super zone for new pond construction as well as its maintenance. The chi-square value shows it was significant at 5% level among types of farmers. Almost all farmers used prevention and control measures in case of the incidence of fish diseases and pests which was a significant 10% level among types of farmers. 63.7% of respondents followed daily sanitation and record-keeping practices. As for most small farmers, fish farming was a side occupation so they mostly neglect daily sanitation and record-keeping practices which showed significant difference at a 1% level among types of farmers. 65% of fish farmers changed pond water regularly. Improved breeds of fish seeds were stocked by 63.7% of respondents which was found significant at the 1% level. Only 36.3% of respondents used floating feeds due to their expensiveness. They mostly used homemade feeds by mixing various ingredients. Its chi-square value shows a significant difference at the 5% level among farmers.

Conclusion

Nepal holds great potential for freshwater fisheries. Although the quantity of fish production is low in comparison to the world fish production however as one of the important sub-sector of agriculture in Nepal, fisheries contribution to national GDP is in increment rate in recent years. Fertilization and Liming play a crucial role in fish production. Fertilization provides inorganic nutrients for the rapid growth of phytoplankton (i.e. natural food) which eventually decreases the feed requirement of fish species. The main purpose of the lime application is to balance the soil pH and make the pond suitable for fish stocking and production by neutralizing acidity and increasing base saturation by exchanging basic for acidic ions on the cation exchange site.

The majority of farmers were found to have a positive attitude, good perception, and sound knowledge towards pond fertilization and liming. FYM as organic fertilizer and urea and DAP as inorganic fertilizers were used by the majority of farmers followed by other organic and inorganic fertilizers for pond fertilization. But the quantity of FYM used was higher than the recommended i.e. 3000kg

Descriptions	Small farmers (n = 47)	Large farmers (n = 33)	Overall (n = 80)	Chi-square value
Water testing kits for DO, acidity/ alkalinity, and fertility measurement	1(2.1)	8(24.2)	9(11.3)	9.497***
Improved techniques in pond construction and maintenance	32(68.1)	30(90.9)	62(77.5)	5.792**
Prevention and control of fish diseases	42(89.4)	33(100.0)	75(93.8)	3.745*
Daily sanitation and record keeping practices	23(48.9)	28(84.8)	51(63.7)	13.747***
Change pond water regularly	29(55.8)	23(69.7)	52(65.0)	0.545
Stock improved breeds of fish seeds	19(37.3)	32(97)	51(63.7)	26.823***
Use floating feeds	12(25.5)	17(51.5)	29(36.3)	5.664**

Table 24: Adoption of various improved technologies in fish production by respondents.

Notes: Figures inside the parentheses denote standard deviation. ***, ** and * indicates significant difference at 1%, 5% and 10% level respectively.

well-decomposed FYM per ha as a starter dose. However, the quantity of urea and DAP used was lower than the recommended i.e. 120kg Urea and 90kg DAP per ha as a starter dose. Agricultural lime was used by most of the farmers for liming in the ponds and the average amount was higher than the recommended (450 kg per ha initially and other amount based on water quality) since high use of FYM deteriorate pond water quality.

The major constraints faced by fish farmers during fish production were timely unavailability of lime and fertilizers followed by unavailability of quality fish seeds and feed, water shortage, the incidence of diseases and pests, and market problems.

This research suggests that more access to inorganic fertilizers should be improvised along with quality seeds, feeds and water facilities by the government and co-operatives at local to enhance the productivity of the pond. This would aid up in water quality improvisation also. More training and awareness program should be adopted for farmer's welfare. Further research can be done on the linkage between farmers, cooperatives, government, and external agents for the depth knowledge of farmer's further necessities and problems.

Authors Contributions

Min Saru performed the survey, analyzed the data, and wrote the paper Om Prakash Singh supervised the entire research and manuscript preparation. Puja Thapa and Sandeep Lamichhane were responsible for the edition and the revision of the paper. Santosh Kandel was involved in the literature review and the preparation of the questionnaires. All members were involved in the publication process.

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