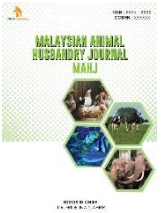
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2805-5500 (Online)
CODEN: MAHJAQ

Malaysian Animal Husbandry Journal (MAHJ)

DOI: http://doi.org/10.26480/mahj.01.2021.14.25



RESEARCH ARTICLE

STATUS OF FISH HATCHERY AND NURSERY MANAGEMENT IN, DHANUSHA, NEPAL

Priti Chaudhary [a], Pankaj Kumar Yadav[a*] and Dilip Kumar Jha[b]

[a]Faculty of Agriculture, Agriculture and Forestry University, Rampur, Chitwan, Nepal
[b]Department of Aquatic Resources, Agriculture and Forestry University, Rampur
[*]Corresponding Author Email: premsaimon2@gmail.com

ARTICLE DETAILS

Article History:

Received 29 July 2021
Accepted 30 August 2021
Available online 03 September 2021

ABSTRACT

The study was conducted to overview status of fish hatchery and nursery management. The main occupation of owners is hatchery business and 23% owners run as side business. 23% of respondents reared fifteen species including major seven species Rupchand, Puntius, Basai, Bhagi, Bata, Magur and Black carp. 30.8% respondents use brood stock from other hatchery of different place for cross breeding to reduce stress, inbreeding depression and to increase disease resistance, growth, performance and production. 61.53% respondents do not monitor the pond to check water quality pararameters like DO, pH and turbidity of water. The average hatchlings, fish fry and fingerling survivality was found 31.10%, 57% and 64% respectively. The problem encountered were flood, predator, unavailability of feed, hormone, fertilizer, skilled manpower and water shortage. The B/C ratio in private hatchery was 1.59 and 1.31 in government hatchery. Most of the respondents use motorcycle (53.8%) as means of transportation of fish seed. The main severe disease was *learnaea* followed by *argulus*. The inputs used in nursery management were less than that of recommended dose. High stocking density of fingerlings found (546.15kg/kattha). 69.23% of respondents sold fish, fry and fingerlings to distant market and 30.8% of fish farmers sold their fish seed products in local market. About 75%, 20% and 5% of hatchery fish seed production transferred through channel 1, channel 2 and channel 3 respectively. The problems faced in market were trader monopoly followed by open boarder, road inaccessibility, transportation loss and lack of market information

KEYWORDS

Fish, Hatchery, Market, Nursery, Status

1. INTRODUCTION

Nepal is an agrarian country and rich in fresh water resources. Fisheries is one of the major components of agricultural activities and plays a vital role in nutrition, employment, income generation and foreign exchange earnings. Nearly three percent of the total area of Nepal is occupied by water resources of which about 500,000 hectares may be available for fish farming (shrestha, 1999). Aquaculture in Nepal is speedily increasing and access to adequate high quality seed is the basis for sustainable development. Fish seed production in Nepal is mostly limited to seven species of indigenous and exotic cultivated carps. The carps are major fishes, which occupied around 95% of total fish production in Nepal, have the potential to expand in rural area and to generate income up to four times (Mishra, 2014).

Nepal is endowed with more than 6,000 rivers and streams serving a good source of water for the aquaculture. The major part of the pond fish production takes place in the southern part of the country-The terai plain -where 94% of the fish ponds are located. Cupture fishery is relatively a new in Nepal and was initiated in small scale in mid-1940s with the introduction of Indian major Carps seed (FAO, 2016). The introduction of exotic common carp (*cyprinus carpio*) in the 1950s and three exotic Chinese carps, namely silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*) and grass carp (*Ctenopharyngodon idella)* in the 1970s provided a major impetus in the development of cultured fishery in Nepal.

Most of the Nepalese people rely on agriculture sector to fulfill the basic needs and to sustain the livelihood. Out of the total population 2,90,50,690 the total population involved in agriculture is 66% with the contribution of agriculture sector in country GDP by 33.1%. (CPFCC,2018/19) Fish has also the great contribution to raise the economic condition of people and has the nutrition value which contains omega-3 fatty acids. It provides employment opportunity to 65 % of active person. The contribution of fish in National GDP is 1.13% and contribution of GDP in agriculture sector is 4.18%. (CPFCC,2018/19)

In Nepal the total fish production is 91,832 mt with productivity 4.9 t/ha. (CPFCC, 2018/19). Similarly in Dhanusha 5502mt with 4.89 t/ha (CFPCC,2018/19). Dhanusha district has great potentialities in terms of fish production, income, nutrition, and overall rural development. Fish production is recently becoming very popular due to its high demand, income generating and preparation of value added products.

Aquaculture is rapidly increasing in Nepal as a result seed production is increasing. Due to quick and high profitability, and encouraging government policy, a number of private hatcheries are increasing in Dhanusha district. Due to degradation of ecological balance and natural disasters, natural resources of fish seeds are destroyed .So, hatchery is now the main source of fish seed production. The term 'Hatchery is considered broadest sense as a facility where fish fry and fingerlings

Quick Response Code	Access this article online	
	Website: www.mahj.org.my	DOI: 10.26480/mahj.01.2021.14.25

Cite The Article: Priti Chaudhary, Pankaj Kumar Yadav, Dilip Kumar Jha (2021). Status of Fish Hatchery and Nursery Management in, Dhanusha, Nepal. *Malaysian Animal Husbandry Journal, 1(1): 14-25.*

suitable for stocking in growth ponds produced in an artificial manner by the process of induced breeding technique. Induced breeding is a technique whereby ripe brood fishes are stimulated by treating them with inducing agents to breed in captivity. The stimulation promotes a timely release of eggs and milt from ripe breeders. It is now used as a widely accepted means of artificial propagation to overcome constraints in fish seed supply particularly for species that do not breed in captivity. A hatchery is a mix of laboratory and a farm, where fish and shellfish are spawned, then hatched and then cared for. Hatchery plays an important role in seed production and supplies seeds for sustainable development of aquaculture. Besides supplying fish seed production, it has the following advantages:

- Off season production: constant supply of fish seed enhances the scope of market for fish. Supply can be further guaranteed by sourcing from hatcheries in the opposite hemisphere i.e. with opposite seasons.
- Genetic improvement: Genetic modification is conducted to improve production characteristics such as growth rate, disease resistance, survival, increased fecundity and lower age of maturation through artificial fertilization of selected broods.

1.2 Statement of problem

Dhanusha district has the great potential in terms of fish production, income, nutrition and overall rural development. Due to unmanaged and no technical knowledge of Fish farming, its production is low. Lack of proper facility at local levels is challenging issue for expanding the market demand and trade management in national and international market for produced fish**.** Poor quality of water, lack of knowledge on improved technology to farmer and trader. High mortality of hatchling , lack of skilled manpower and incidence of disease is major problem of hatchery. Flood, transportation and marketing is also found to be major problem in Dhanusha district. Lack of knowledge on pond drying and maintenance of water quality parameters for fish production is also found to be major problem in this area which causes high incidence of germs in water. Shortage in fish seed supply, lack of marketing infrastructure, and post-harvest management, mismanaged marketing channel ,high competition with Indian fish, non- technical pond design are the major reasons that hinders commercial and competitive market. So, considering this study was done to know the hatchery condition ,its production ,survival rate ,marketing systems ,feed, disease and nursery management in hatchery. Lack of knowledge of proper dose and suitable hormone is also the major problems of fish survival in hatchery.

1.3 Rationale of study

Dhanusha district is favorable for fish farming. Climate and temperature is suitable for fish farming. Dhanusha is the capital city of fish farming. Fishery enterprise development is highly feasible in Dhanusha district. If awareness can be raised through extension, technical support, different training to the farmers, assistance programs, improvement in agri-mechanization, proper solution to the predatory problems and market security, there is no doubt the district will be self-sufficient that leads to food and economic security in the country. Fish seed is very important for sustainable development of aquaculture. So this study is done to know the condition of hatchery, management, .disease, fish fry production, marketing and problems faced by farmers during hatchling of eggs and fish fry production. This research gives idea about the farmers perception toward fish farming, its feasibility in Dhanusha district for fishery enterprise development.

1.4 OBJECTIVES

1.4.1 General objective

- To study the status of fish hatchery and nursery management adopted in Dhanusha district

1.4.2 Specific objective

- To be familiar with the existing fish seed production technology adopted in study area.
- To estimate the cost, return and productivity of fish seed production in study area.
- To evaluate the marketing channel and remedial measures associated with fish seed production in study area

1.5 Scope and limitation

The findings of the study are very useful in hatchery fish fry production and can be utilized in fisheries sector by the concerned stakeholders in the similar socio-economic and geographical settings. The data from the result can be used by the planners for the proper amendment of the policies to support the farmers keeping in view the key problems. In Nepal, 81% is covered by private hatcheries and 19 % covered by government hatcheries (Shrestha and Mishra,2014).Present 10 hatcheries systems are running, besides this there is one Fisheries development and Training center (FDTC) who facilitates fry to the farmers. Hatchery farm is found to be greatest business to farmers as they can get rapid return of revenue from the investment. Initiation of hatchery not only supplies quality fish but also can be productive and enhance the profit within the short period of time. Hatchery requires trained and skilled manpower for artificial breeding i.e brood stock management, induced spawning eggs, incubation of eggs, nursery management of fry and fingerlings. Due to weak government policy, aquaculture is in slow pace of development. This study is conducted on the basis of farmer's assumptions and memory as there is no proper record of hatchery farm business so there may arise error in analysis. Development of reliable hatchery can resilience the fish production .Besides it, employment opportunity can be a bonus point to the marginal people to sustain their livelihood. Directly or indirectly the farm can contribute to increase fish productivity. Initiation of hatchery not only supplies quality fry but also can be productive and enhance the profit within the short period of time .Fish Hatchery requires highly skill manpower to operate hatchery operations o f i.e brood stock management, induced spawning eggs, incubation of eggs, nursery management of fry and fingerlings. Hatchery is successful only if all the operations go on smoothly .Government hatcheries are functional but are not able to address the importing of fry from foreign neighboring country. The demand of fish is increasing and the import of fish from the neighbour country is also increasing. So, to fulfill this demand quality seed is to be produced in hatchery so that quality fish fry and fingerlings are produced and demand of fish from neighbor country can be reduced. Fish hatchery is one of the good business enterprise for farmers in Dhanusha district. It provides employment opportunity to labours. Therefore, the conditions and management of fish hatchery should be well known for making self-reliant in fish seed production and fish fry, fingerlings production in Dhanusha district. The study will be conducted on the basis of memory of farmers so it may create problem in data analysis. Due to the weak government policy regarding aquaculture development, aquabusiness is at slow pace of development. It also requires skillful technicians for breeding of fish and to increase the survival rate of hatchlings, fish fry and fingerlings in hatchery.

2. LITERATURE REVIEW

2.1 Background of fish production in Nepal

Fish production in Nepal started with the introduction of Indian major carps (IMC) in 1940's. Meanwhile in 1950's slight development in fisheries and aquaculture sector was observed with the introduction of common carp (*Cyprinuscarpio*). The breeding success of common carp in 1960's further increased the scope of aquaculture (Shrestha, 1991). Introduction of chinese major carps like silver carp (*Hypophthalmichthysmolitrix*), grass carp (*Ctenopharyngodonidella*) and bighead carp (*Aristhichthysnobilis*) in 1970's and further successful breeding program of these species in captivity was a milestone for aquaculture development in Nepal (FAO, 2016). Later on induced breeding technique of Indian major carps; rohu (*Labeorohita*), catla/bhakur (*Catlacatla*) and naini/mrigal (*Cirrhinusmrigala*) opened the lock for the widespread carppolyculture technique in captivity (Gurung, 2003). Formation of Aquaculture development project supported by ADB and UNDP in 1980's paved the path for the modern fisheries in Nepal. Meanwhile, carp polyculture became the most widely accepted fish farming technique by about 90% of the fish farmers. The fisheries sector promoted rapidly on the southern belt of terai where 94% fish ponds are present due to the availability of abundant water and rapid fish growth in terai region. Terai region only covers the of the fish production of Nepal (CFPCC, 2019).Recently, nile, tilapia (*Oreochromisniloticus*) and striped cat fish (*Pangasiodonhypophthalmichthys*) are introduced in Nepal.

2.2 Present scenario of aquaculture in Nepal

Various types of aquaculture practices are being adopted in Nepal which all together produced 91,832mt fish in fiscal year 2075/76 (CFPCC, 2019). Pond aquaculture is the major contributor to aquaculture production contributing 68.30% (62,725MT). In pond aquaculture, Chinese carps and Indian major carps are the dominant species with average productivity of 4.92MT/ha. These species are generally stocked under polyculture system. However, monoculture of Common carp, Tilapia and striped cat fish has also been reported.

According to FAO country profile of Nepal, national production of fish was 500 MT in 1950. This production was entirely contributed by capture fisheries. Aquaculture production was recorded only from 1966 with only 3 MT of fish production. Aquaculture production kept increasing slowly and steadily because of growing aquaculture education and technologies. Capture fisheries shows increasing trend in the beginning but remained constant at 21500 MT since 2007/08. Keeping this capture level at stand still is a big challenge for all aquaculture and fisheries workers. Production status of fiscal year 2013/14 shows that out of 64900 MT fish production, 33.21% comes from capture fisheries whereas 68.79% from aquaculture (CFPCC, 2014). Per capita fish availability is also in increasing trend. From 1981/82 to 2013/14, it has significantly increased from 330 g to 2385 g due to improved national production (DoFD, 2014).Total fish production of our country is 77000 MT in the year of 2072/073 out of which contribution from aquaculture sector is 55500 MT and remaining from capture fisheries according to the statistics provided by the Directorate of Fisheries Development (DoFD) under the Ministry of Agricultural Development (DoFD, 2018). Around 57,520 metric tonnes, 64,900 metric tonnes and 69,500 metric tons of fish were produced in fiscal years 2069/70, 2070/71 and 20071/072 respectively (DoFD, 2018). The aquaculture sector in Nepal is currently small but has great potential for growth (Gurung, 2014). The total fish production was only 46779 tonnes in 2063/64 B.S. which increased up to 91832 mt in 2018/19.(CFPCC, 2018/19)This indicates that the demand and supply of healthy fish production in the country will not only solve the food security problems but also enhance the economic growth of the aqua farmers. Local production can meet only around 30 percent of the demand. In the last fiscal year2018/19, Nepal imported 9,334mt of fish compared to 11,176 in 2014/15. Fish farming is done in 12,749 hectares across the country (CFPCC, 2018/19).

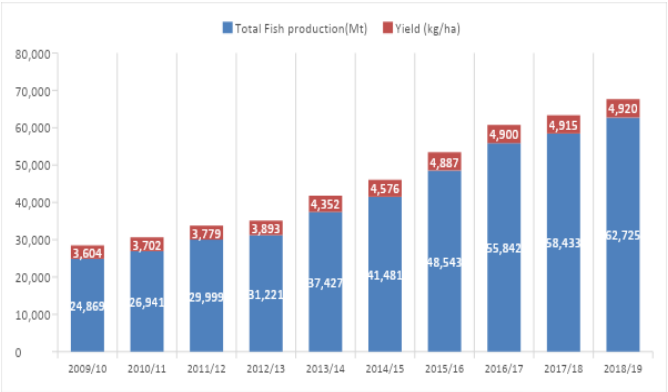


Figure 1: Pond fish production (mt/ha) and yield (kg/ha). (CFPCC, 2018/19)

The rate of increase in the demand for fish is greater than the rate of increase in fish production. People growing health concerns and nutritional awareness is the major reason for this increase in demand. People are consuming more fish in those past years but the level of production is not keeping up as demand rises. But demand of fisheries products has not increased to the extent necessary for human health. The national demand for fish should be around 131,000 metric tons for a healthy life, however, around 91362 metric tons were enough to address the current demand (CFPCC, 2018/19).

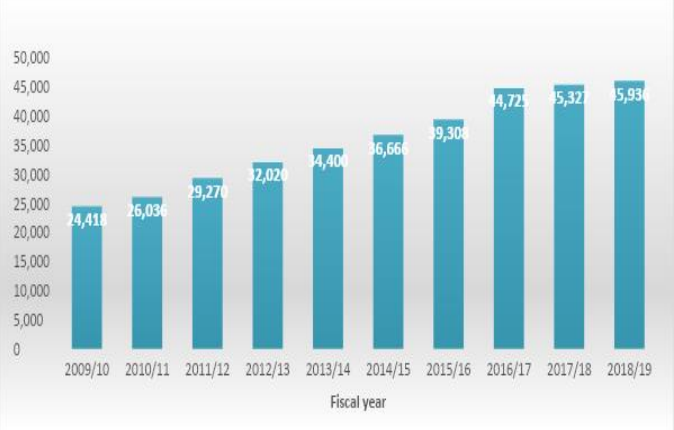


Figure 2: Pond's number in Nepal (CFPCC, 2018/19)

With the increasing demand, the import of fish has also been growing for the last five years because domestic production is unable to meet the growing demand. The import of fish rose by 4 percent in the last five years. The country imported 7,425 metric tons of fish in 2068/069, 9,963 metric tons in 2069/070, 12,869 metric tons in 2070/071 and 11,177 metric tons in 20071/072 (MOAD, 2015).

Table 1: Fish import trend from fiscal year 70/71-75/76

Year	70/71	71/72	72/73	73/74	74/75 75/76
Fish import(MT)	12,869	11,177	7,153	11,220	10,756 9334

Source: Central Fisheries Promotion and conservation center report, 2076

The import of fish declined to 9334 metric tons in fiscal year 75/76 as compared to the 74/75 i.e. 10,756.The income from fisheries has also been growing with the increase in area of pond increase in no of ponds and increase in production of fish. The total number of farmers involved in aquaculture is 54,237.(CFPCC,2018/19)The number of farmers involved in aquaculture and management is 14,23,241 and indirectly get benefitted from aquaculture is 4,21,334.(CFPCC 2018/19)

2.3 Contribution to national income

Currently aquaculture contributes to about 1.13% of total GDP and about 4.18% of total agriculture gross domestic product (CFPCC,2018/19). According to the statistics provided by MoAD, the economic growth of agriculture sector is 1.3 and 2.22 percent in the fiscal year 2072/073 and 13th fifth year plan respectively while during this same time period aquaculture achieved the economic growth rate of 10.79 and 18.64 percent respectively (CBS, 2015).

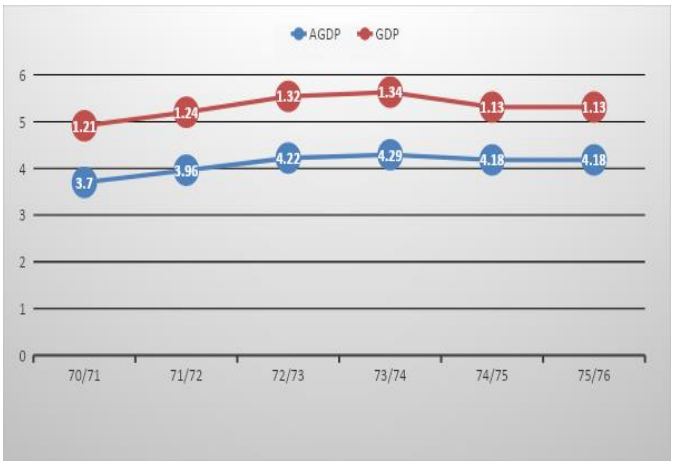


Figure 3: Contribution of fish in national economy (CFPCC,2019)

2.4 Fisheries production in Dhanusha district

Dhanusha district is the capital city of fish farming. Dhanusha district has the favourable climate and temperature for fish farming. Dhanusha district is known for fish farming from ancient period of time. It is known for having huge numbers of pond. Farmers earn livelihood out of fish farming in this region but still it is in semi-commercial level in many parts of the district.

During the last seven years, the fish production is in increasing trend and area of pond is also expanding. The fish production in Dhanusha district is 5502(mt) with productivity 4.89(mt/ha).

(CFPCC 2076)

Table 2: Fish production and productivity trend in Dhanusha

Year	Area(ha)	Production(mt)	Productivity(mt/ha)
2069/70	778.3	2305	2.96
2070/71	808	2626	3.25
2071/72	853	2985	3.5
2072/73	878	3951	4.5
2073/74	963.17	4620	4.7
2074/75	973.17	5100	4.86
2075/76	1123.17	5502	4.89

(Sources: CFPCC,2075/76)

2.5 Fish seed production technique

2.5.1 Brood selection technique

- The selection of fish with desirable hereditary qualities, typical of improved strains such as rapid growth potential, higher resistance to dissolved oxygen deficiency and adverse water quality, strong appetite, omnivorous feeding regime.
- The selection of fish with well-developed sexual organs.
- The rearing of these selected fish to produce healthy potential spawners, with dormant eggs well developed in the females.

Basis to select good future breeders

- The selected fish should be in good health,
- with no body wounds,
- no parasites,
- a typical scale distribution, and
- no fin or body deformation,
- The body should possess the required shape and proportion, being neither too fat,
- nor too thin

Brood stock selection and harmone

Brood stock conditioning is the process of bringing healthy adults into spawning condition by promoting the development of gonads. Another important aspect of brood stock conditioning is ensuring the production of high quality eggs to improve growth and survival of larvae by optimizing the health and welfare of brood stock individuals.

Table 3: Recommended Hormone Dose

	Fish Species	Name of Hormone and its Quantity					
		P.G. ml/ kg		L.R.H.A. ml/ kg		Oriprim ml/ kg	
		Female	Male	Female	Male	Female	Male
1	Bhakur	4-6	2-2.5	50-60	15-30	0.5	0.25
2	Naini	3-4	1.5-2	50-60	25-30	0.3-0.5	0.20
3	Rohu	3-4	1.5-2	50-60	25-30	0.4-0.5	0.20
4	Grass Carp	3-5	1.5-2	10-20	5-10	0.5	0.25
5	Bighead Carp	3-6	1.5-2.5	10-20	5-10	0.5	0.25
6	Silver Carp	3-6	1.5-2.5	10-20	5-10	0.5	0.25

2.5.2 Spawning

It is the process of releasing the eggs and sperm, and the act of both species is called spawning. The process of spawning typically involves females releasing ova into the water, often in large quantities, while males simultaneously or sequentially release spermatozoa (milt) to fertilize the eggs. Natural spawning generally occurs if spawning season is favorable and artificial spawning can be carried out through.

2.5.3 Manual striping

In this method, gonads are generally removed and gametes are extracted and washed free. Fish can be manually stripped of eggs and sperm by stroking the anaesthetized fish under the pectoral fins towards the anus causing gametes to freely flow out.

2.5.4 Environmental manipulation

Thermal shock is facilitated where cool water is alternated with warmer water in flow-through tanks which can induce spawning. Alternatively, if environmental cues that stimulate natural spawning are known, these can be mimicked in the tank e.g. changing salinity to stimulate the behavior.

2.5.5 Chemical injection

Various hormones like extract of PG, ova prim, HCG, ovulin or LHRH-a harmones are widely used in hatchery farms to induce spawning.

2.5.6 Fertilization

Sexual reproduction starts with the combination of sperm and an egg in a process called fertilization. This can be either natural or artificial. Artificial reproduction takes place through injection of harmones. After injecting harmones, eggs are released from female fish and milt from male fish. Prior to fertilization, eggs can be gently washed to remove wastes and bacteria that may contaminate cultures. Batches of eggs are kept separate and after fertilized with sperm obtained from several males and allowed to stand for an hour. Samples can be analyzed under a microscope to ensure high rates of fertilization and to estimate numbers to be transferred to larval rearing tanks. At initial phase, hatchlings feed on yolk. After 2-3 weeks they are transfer to nursery pond followed by rearing pond. Artificial high protein feed is essential during rearing process.

2.6 Fish seed production and distribution system in Nepal

Quality seed is necessary for sustainable development of aquaculture. Expansion and development of aquaculture mainly depends on seed which comes from hatchery .The major input in culture fishery is the quality seed, and the expansion and development of aquaculture production depend mainly on the availability of seed. There is a need to support the development of a reliable hatchery setup for sufficient fingerling production .In Nepal, fish seed production has been governed mainly by two sectors i.e. government based fish farm (Public sector) and private hatchery and nurseries (Private sector). According to CFPCC 2019, the total fish seed production was 3,39,224,000 in which contribution of Public sector and Private sector was 74,505,000 and 2,73,100,000 with 19.49 % and 80.41%, respectively. This figure reveals that production of fish seed by private sector is four times greater than the public sector in Nepal. In Nepal, 81% is covered by private hatcheries and 19 % covered by government hatcheries.(Shrestha and Mishra,2014) Carp contribute more than 95% in total aquaculture production in Nepal. Exotic Carps contribute nearly 70% of aquaculture production. Fish seed production trend in Nepal is improving yearly and there was a significant demand of fish seeds based on different sizes for public and private actors (Mishra R. , 2013).The summary of fish seed production of Nepal over five year trends form 2071/72 to 2075/76 B.S are highlighted below.

Table 4: Fish Seed Production/Distribution (No. in '000) (CFPCC 2075/76)

Particulars	2071/72	2072/73	2073/74	2074/75	2075/76
Fish Seed Production and Distribution (No. in '000)	191,345	212,355	252585	295130	33924
1.Public sector	40,000	40,911	63666	74505	74505
I.Hatchling*	1885,00	186,928	220438	257427	257427
ii.Fry	15,700	16,971	17163	18037	18037
iii.Fingerlings**	12,150	11970	13332	16650	15360
2.Private sector	151,345	171,444	218919	220625	273100
i.Fry	15,345	171,444	218919	220625	273100

* Hatchling of public sector is distributed for fry production in private sector ** Aquarium fish included in Fingerling and count double number for Fry fish seed

3. METHODOLOGY

Research methodology consists of the procedures used by the investigator to answer the research question with logic (Kothari, 2002). Research methodology consists of the procedures involved in selection of research sites, preparation of sampling frame, sample design, sources of information, data collection techniques, analysis of the data and their interpretation.

3.1 Description of the study area

Dhanusha District, a part of Province No. 2, is one of the seventy-seven districts of Nepal. The district, with Janakpur as its district headquarter, covers an area of 1,180 km^2 and has a population (2011) of 754,777. The most common language spoken in Dhanusha is Maithili (85%). Among the major places to visit in Dhanusha are its famous temples and ponds. Dhanusha district has Super zone Implementation Unit namely fish Superzone. The fish production and productivity in Dhanusha is 5502 mt and 4.82Mt/ha (CFPCC, 2075/76). The government aims to increase the productivity of fish in this district.Considering the potential role of aquaculture for improving food security, income and nutrition among small-scale, resource-poor farmers, the Government of Nepal and a few I/NGOs have recently attempted to promote commercial aquaculture across the Dhanusha district.

Figure 4: Map of Nepal showing Dhanusha district and study area

3.2 Selection of the study area

LEE site at Janakpur sub metropolitan city situated at Janakpur, the capital of Province no.2 under the superzone of fish in PMAMP. Janakpurdham sub-metropolitan city, Hansapur municipality, Bideha municipality, Sahidnagar municipality, Kamala municipality, Janaknandani municipality, Aurahi rural municipality, Dhanauji rural municipality, Sawaila municipality, Laxminiya rural municipality, Mithila bihari municipality, and Dhanushadham municipality of Dhanusha district are under this fish superzone. Among them only five local body have hatcheries in Dhanusha. Majority of farmers in this sub-sector are involved in fish production and aquaculture as the main occupation.

3.3 Data and data type

Both primary and secondary data were collected and analyzed during the study. The fish farmers of Action area under Fish Superzone are the major sources of the primary data and this data are collected through semi structured questionnaire applying face to face interviews technique. Apart from these the information were obtained through observation, informal group discussion and key informant survey was also given due consideration. The secondary data were the articles, reports, books that are published by different institute and organization like Nepal Agriculture Research Council (NARC), Central bureau of statistics (CBS), Agro-Enterprise Center (AEC), District Agriculture Development Office (DADO), Dhanusha.

3.4 Data collection technique

Data collection was done through Interview, Focal Group Discussion, Observation, Survey design and data collection procedure, Reconaissance survey, Interview schedule design, Pre-testing of questionnaire, Field survey, Data analysis technique, Socio- economic and farm characteristics

3.5 Indexing

Problems faced by respondents on adoption of improved production technology of fish were ranked with the use of index. Scaling techniques, which provides the direction and extremity attitude of the respondent towards any proposition (Miah, 1993)was used to construct index. The intensity of problems and measures were identified by using eightpoint scaling technique using scores of 1.00, 0.875, 0.75, 0.625, 0.50, 0.375, 0.25and 0.125. The formula given below was used to find the index.

$I_{prob} = \Sigma S_i F_i / N$

Where,

I_{prob} = Index value for intensity

Σ = Summation

S_i = Scale value of i^{th} intensity

F_i = Frequency of i^{th} response

N = Total number of respondents

4. CONCLUSION

4.1 Socio-economic characteristics of the respondents

4.1.1 Gender of the respondents

According to the study, it was found that hatchery enterprise was dominated by male respondents (84.61%) as compared to the female respondents (15.38%).

Table 5: Gender of the respondents

Gender	Frequency	percentage
Male	11	84.62
Female	2	15.38
Total	13	100.0

Source: Household survey 2020

4.1.2 Age of respondents

According to study, it was found that all the owners in hatchery enterprise were more than 35 years of age. The mean age of all owners found to be 47.384 having elder age 70 years and younger age 38 years.

Table 6: Age of Respondents

	Mean	Standard deviation	Maximum	Minimum
Age	47.3864	9.48277	70	38

Source: Household survey 2020

4.1.3 Family size of respondents

Out of total respondents, it was found that mean female population was (3.53) with SD 1.898 slightly greater than that mean male population (2.846) with SD 2.846.

Table 7: Family size of Respondents

Variable	Mean	Standard Deviation	Minimum	Maximum
Male	2.846	1.405	1	6
Female	3.538	1.893	0	7
Total	6.384	3.303	1	13

Source: Household survey 2020

4.1.4 Education level of respondents

The study shows that there is no illiterate, (23%) had attained primary level education, (15.38%) had attained secondary, (46.15%) had attained higher secondary education and (15.38%) had attained university level of education respectively. It was found that most of the respondents had attained higher secondary education (46.15%).

Table 8: Education level of respondent

Education level	Frequency	Percentage
Primary	3	23
Secondary	2	15.38
Higher Secondary	6	46.15
University	2	15.38
Total	13	100

Source: Household survey 2020

4.1.5 Occupation of respondents

Out of total respondents, it was found that 77% of total respondents are actively involved in hatchery enterprise whereas 23% of total respondents are involved in government service and run hatchery enterprise as a side business.

Table 9: Occupation of respondents

Occupation	Frequency	Percentage
Agriculture	10	77
Service	3	23
Total	13	100

Source: Household survey 2020

4.1.6 Total land holding of respondents

From the study, it was found that average total land holdings of overall hatcheries were found to be 11.421 ha. Out of which average owned land was found to be 5.14 ha and remaining 6.3 ha was rented in by hatchery owners.

Table 10: Total land holdings by respondents in study area

	Owned Land	Land on leased	Total land holding(land in ha)
Mean	5.14	6.3	11.421
Standard deviation	5.744	7.21	9.85
Minimum	0.675	0	1.35
Maximum	20.92	20.25	33.75

Sources: Household survey 2020

4.1.7 Farming experience of the respondents

The data was categorized on the basis of mean and standard deviation. Majority of the total surveyed (53.8%) had farming experience of 6-20 years followed by greater than 20 years and less than or equal to 5 years having percentage of 30.8% and 15.4% respectively.

Table 11: Farming experience of respondents (in years).

Farming experience(in years)	Frequency	Percentage
<=5	2	15.4
5- 20	7	53.8
>20	4	30.8
Total	13	100

Sources: Household survey 2020

4.1.8 Distribution of economically active population

The study population was classified into three groups age below 15 years, 15-59Years and above 59 years. The age ranging from 15-59 years is classified as economically active Population and other two age below 15 years and above 59 years is considered as economically inactive population. From the study, it was found that out of total household population, 56.6 percent was economically active with average of 3.91 economically active sizes per household. The dependency ratio was calculated as the ratio of total number of dependent population to total number of active population. The dependency ratio was found to be 0.76, it means hundred economically active members had to fulfill the necessities of 76 dependent members in the study area.

Table 12: Economically active population

Variables	Mean ±_SD
Economically active size	3.91±2.23(56.6)
children numbers	2.8±0.91(33.7)
Elderly size	1.14±0.377(9.7)
Total	7.85±3.51(100)

Note: Figure inside the( ) indicates percentage

4.2 Number of species rearing by respondent in study area

According to study, it was found that 77% of the hatchery respondents reared seven species i.e. Rohu, Naini, Bhakur, Silver carp, common carp, Bighead carp and Grass carp. And 23% of respondents managed to rear other species including seven species i.e. Rupchand, puntius, Basari, Bhagin bata, Magur Mungri and Black carp.

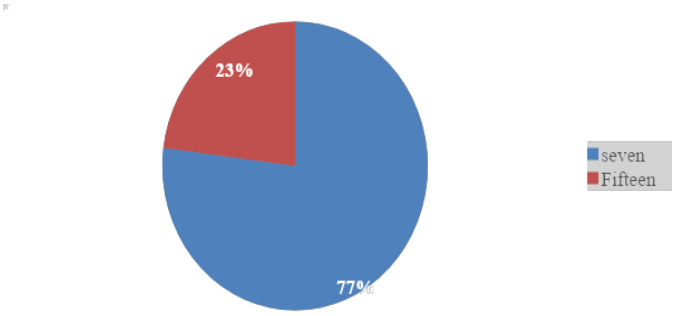


Figure 5: Number of species reared by respondent in study area

4.3 Selection of brood fish by respondents in study area

From the study area, it was found that 69.20% of total respondents use broodstocks from own farm for breeding process in hatchery where as 30.80% of hatchery respondents use brood from other farm of different place like Kapilbastu, Rupandehi, Sarlahi, Siraha for the process of cross-breeding in hatchery.

It is found that use of brood stock from other farm of other place helps to increase production, fast growth rate, reduce inbreeding depression, reduce diseases, stress, increase performance of fish and demand of fish by farmers found high as compared to that of brood stock selection from own farm.

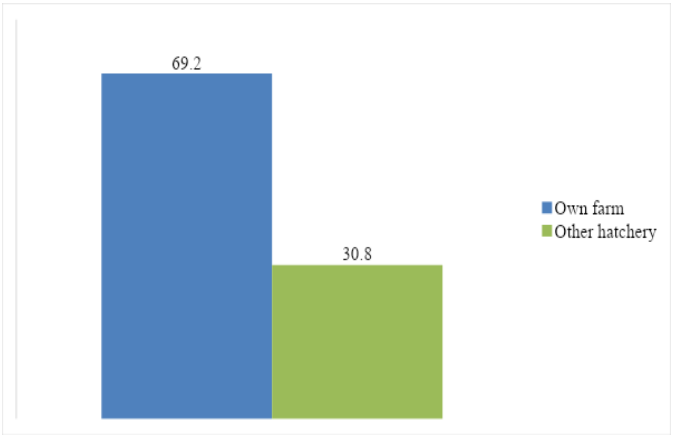


Figure 6: Selection of brood fish by respondents in study area

4.4 Monitoring the pond by respondents in study area

It was found that only 38.50% monitor the pond to know dissolve oxygen and pH of water for better growth and performance of fish whereas 61.53% of respondents do not monitor the pond.

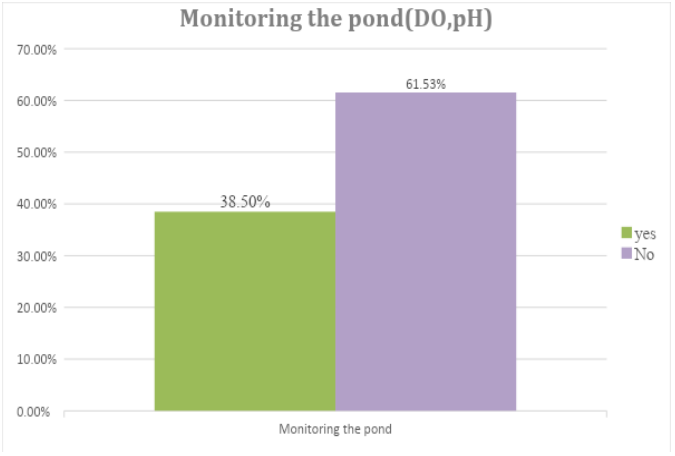


Figure 7: Monitoring of pond by respondent in study area

4.5 Sources of water

From the study ,it was found that 53.8% of respondents use deep boring, 15.4% of respondents use shallow boring and 30.8% use pump set as source of water in hatchery operations.

Table 13: Sources of water

Sources	Frequency	Percentage
Shallow boring	2	15.4
Deep boring	7	53.8
Pump set	4	30.8
Total	13	100

Source: Household survey 2020

4.6 Hatchlings, fish fry and fingerlings survivality

From the study, it was revealed that survivality of hatchlings, fish fry and fingerlings were 31.10%,57% and 74%. From this, it is clear that survivality is directly linked with the growth stages of fish as the growth rate of fish increases, the survivality of fish also increases.

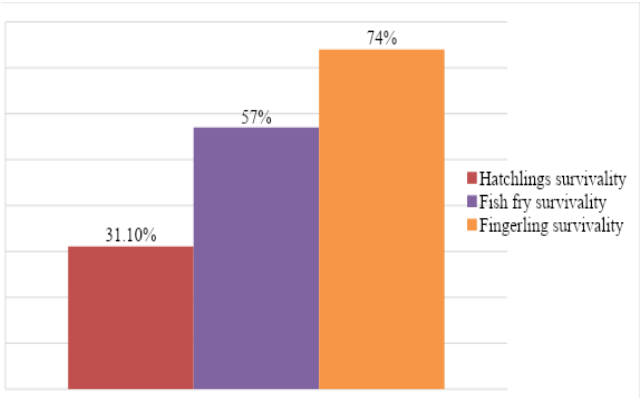


Figure 8: Hatchlings, Fish fry and fingerling survivality in study area

4.7 Feed status used by hatchery in the study area

Feed is the most important inputs for aquaculture,the type, quantity and quality of feed used are key factors influencing fish growth, production cycle, water quality yields and profitability. It was found that 46% of respondents use all types of feed i.e. Rice bran, Mustard cake, wheat flour, soyaben flour mix, 31% use wheat flour and mustard cake and 23% of respondents use rice bran and mustard cake.

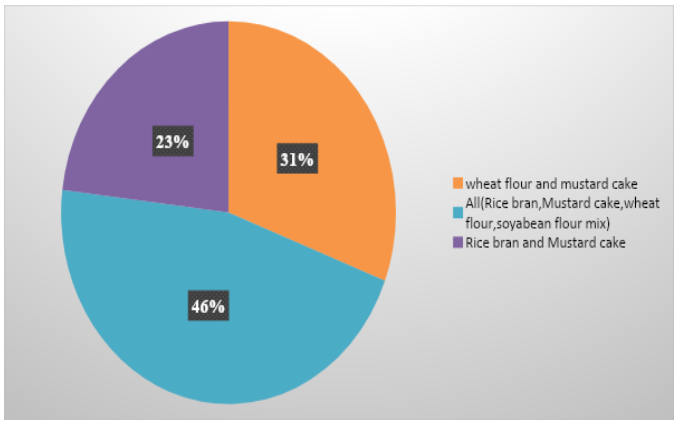


Figure 9: Feed status used by respondents in study area

4.8 Feeding Frequency

Feeding in time is one of the most important factor for growth, development and reduction of mortality of fingerlings. Study revealed that 53.8 % of respondents feed twice a day. i.e. at morning and evening, 30.8% of respondents were feeding once a day at morning and 15.4% of respondents were feeding feed thrice a day.

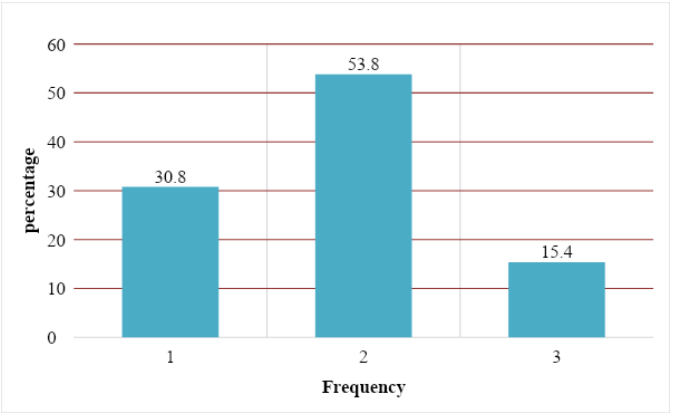


Figure 10: Feeding Frequency

4.9 Cost of production

The study depicted that total cost(TC) of production of hatchlings, fish fry and fingerlings Per ha per year was NRs.2600000 in private hatcheries and NRs. 2310000 in government hatchery. The total variable cost was NRs.990000 per ha in private hatcheries and 600000 in government hatchery. The variable cost includes cost for labour, lime, fertilizer, medicines, vaccines, palstics, fuel, electricity, diesel and other costs. Similarly, the total fixed costs in fish seed production per ha per year include the pond rent per year, pond digging and depreciation of machinery and equipments.

4.9.1 Benefit-cost (B/C) Ratio

It is the ratio of gross return to the total variable cost incurred throughout the year .It gives the clear idea about recovery of total cost incurred during the production process by total return obtained from sale of product that same year. The B/C ratio was found to be 1.59 in private hatcheries and 1.31 in government hatchery. The B/C ratio was found significant at 5% level of significance($p<0.05$). Thus, the results portray that the fish hatchery in study area is profitable in both cases. However, private hatcheries can provide high return in case of hatchery enterprise.

Table 14: Cost, Return, profit and B/C ratio of per ha area of nursery pond and hatchery business of private hatchery and government hatchery

	Private hatchery			Government hatchery		
Variable	Hatchlings	Fish fry	Fingerlings	Hatchlings	Fish Fry	Fingerlings
production (in000)	40000	3098	2800	20000	3000	1900
Rate(NRS/000)	21.73	415.31	713.5	21.73	415.31	713.5
Return	869200	1286630	1997800	434600	1245930	1284300
Total sales revenue	4153630			3036180		
Total cost	2600000			2310000		
Gross margin	2543630			1710000		
B/C ratio	1.59			1.31		

t-test value of B/C ratio: 3.064** indicates significance level at 5% ($p<0.05$)

4.10 Disease found in hatchery of study area

From the study, it was found that learrnea disease is one of the severe problem in hatchery. 54% of the respondents revealed that learnea disease is one of the major problem, 23% reveal that argulus is major problem followed by fin rot and ulcer and asphyxiation having 15% and 8% respectively.

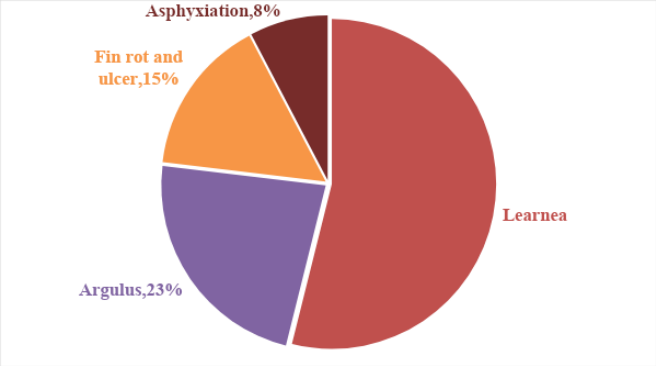


Figure 11: Disease seen in Fish hatchery of study area

4.11 Problem encountered during seed production

The study revealed that problem index of flood was highest i.e.0.67. It means hatchery facing the problem of flood ,followed by predator problems, followed by unavailability of harmone, feed, fertilizers, followed by of skilled manpower and water shortage having problem index 0.67,0.66,0.63,0.53 and 0.49 respectively.

Table 16: Problem of fish seed production in Dhanusha

Problems	1	0.8	0.6	0.4	0.2	total	weightage	index	Rank
Predator problems	5	2	1	2	3	13	8.6	0.661538	II
Unavailability of harmone feed ,fertilizers	2	4	2	4	1	13	8.2	0.630737	III
Flood	4	2	4	1	2	13	8.8	0.676923	I
Lack of skilled manpower	1	1	5	1	1	13	7	0.538462	IV
Water shortage	1	4	1	1	6	13	6.4	0.492308	V

4.12 Ingredients used in hatchery enterprise and nursery management in study area

From the study, it was found that farmers practice were below the recommended dose. So, inputs used in hatchery enterprise and nursery management in study area found low and it needs to be improved whereas fingerlings used in nursery pond was higher than that of recommended dose i.e.546.15 kg/kattha.

Table 17: Input used status of hatchery enterprise in Dhanusha

Ingredients	Units	Recommended dose	Farmer's practice(Average)
Lime	Kg/kattha	25	10.5
Urea	kg/kattha	15	8.5
DAP	kg/kattha	15	11
Feed	kg/kattha	550-600	455
Cow dungs	kg/kattha	200-300	150
Ovaprim	ml/kg	0.5	0.4
LHRH	ml/kg	30	27
PG	ml/kg	5	3
Fingerlings	Number/kattha	350-450	546.15

4.13 Perception of farmers about government support and training programme

From the study, it was found that 69.23% had attained training programme while 30.77% were unware about it. 61.53% respondents were benefitted by government in form of subsidy, and 38.47% had not got any benefit till now.

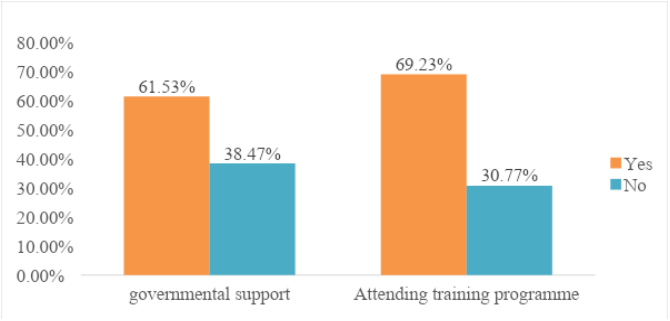


Figure 12: Perception of farmers towards government support and training programme

4.14 Location of market

According to study,it was found that 69.23% of respondents sold fish fry, fry and fingerlings to distant market whereas 30.8% of respondents sold fish, fry fingerlings to local market.

Table 18: Location of market

Categories	Frequency
Local market	4(30.8)
Distant market	9(69.23)
Total	13(100)

4.15 Means of transportation

From the study, it was found that means of transportation of fish seed done on motorbike by 53.8% respondants,30.8% of respondents done on pickup van and remaining 15.4% of respondents done on cycle. It shows that major transportation is done on motorbike for local distant market whereas distant market is done on pickup van.

Table 19: Means of transportation

Means	Frequency
Cycle	2(15.4)
Motorbike	7(53.8)
Pickup van	4(30.8)
Total	13(100)

4.16 Marketing channel

Market channel signifies how the product is transfer from producer level to consumer level through different channel. Out of total respondents, it was found that 38.5% of respondents transfer fish seed from hatchery to local tradors followed by wholesaler to retailer and finally to consumer.23.1% of respondents sold fish seed from hatchery to wholesaler, retailer and finally to consumer. 15.4% of respondents sold fish seed directly to retailer and then to consumer. 23.4% of respondents directly sold fish seed to local farmers.

Table 20: Marketing channel of fish seed production

Categories	Frequency	percentage
H-L-W-R-F	5	38.5
H-W-R-F	3	23.1
H-N-F	3	23.1
H-F	3	15.3
Total	13	100

Where, H=Hatchery, L=Local tradors, W=wholesaler, R=Retailer, N=Nursery and F=Fish farmrs

- About 75% of hatchery fish seed transfers through marketing channel 1 i.e. Hatchery-Local tradors- Wholesaler-Retailer-Fish farmer.
- About 20% of hatchery fish seed production transfers through marketing channel 2 i.e. Hatchery-nursery-Fish farmer
- About 5% of hatchery fish seed production transfers through marketing channel 3 i.e. Hatchery- Fish farmer

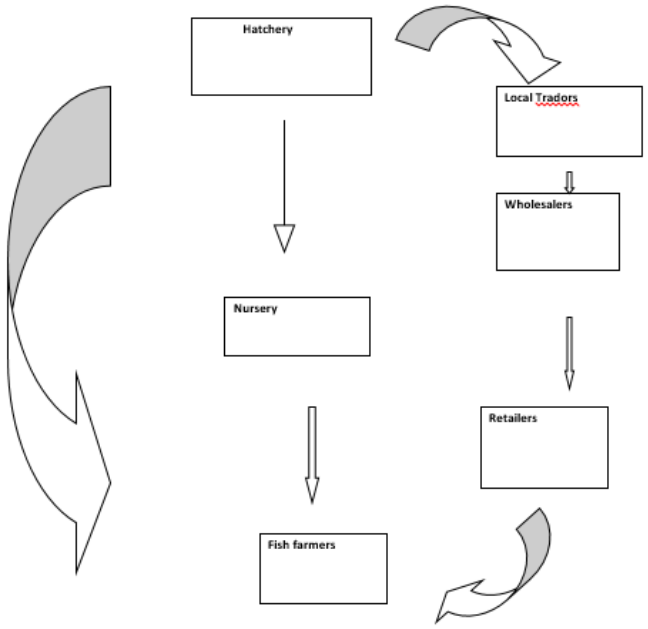


Figure 13: Fish seed supply chain diagram

4.17 Problem of marketing of fish seed in Dhanusha

The study found that trader monopoly was highest with problem index 0.73 and lack of market information has lowest rank it means farmers were well known about market. The major problem found trader monopoly followed by open boarder, followed by road problem, followed by transportation loss and then market information.

Table 20: Problem of marketing of fish seed in Dhanusha

Problem	1	0.8	0.6	0.4	0.2	Weightage	Index	Rank
Trader monopoly	5	2	4	1	1	9.6	0.73	I
Road problem	3	3	2	1	4	7.8	0.6	III
open border	2	4	2	4	1	8.2	0.63	II
Transportation loss	2	4	2	1	4	7.4	0.57	IV
Lack of market information	1	0	4	5	3	6	0.46	V

6. Conclusion

The fish hatchery enterprise was obtained to be profitable business under study with B/C ratio was 1.5. Farmer's input practices were below the recommended dose and it needs to be increased. The major problem encountered during fish seed production was flood. Most of the farmers do not monitor the water quality parameters like DO and pH for the proper growth and performance of fish. Some of the farmers use brood stock from other hatchery of different places for breeding purpose in order to reduce stress, inbreeding depression and to improve the growth, performance and production of fish. Learnea is one of the severe disease problem of hatchery. In the study area, the major problems of market were trader monopoly followed by open boarder, road problem, transportation loss and lack of market information.

References

(2074/75). Annual Statistics Book. Government of Nepal.

Adewuyi, S. A., Phillip, B. B., Ayinde, I. A., & Akerele, D. 2010. Analysis of Profitability of Fish Farming in Ogun State, Nigeria. Journal of Human Ecology, 31(3), 179-189.

Adhikari, C. B., & Bjorndal, T. 2009. Measuring the Extent of Technical Inefficiency in Nepalese Agriculture Using SDF and DEA Models. Institute for Research in Economics and Business Administration, 41.

Adhikari, S. 2003. Fertilization, soil and water quality management in small scale ponds: fertilization requirements and soil properties. Aquaculture Asia Vol. VIII No. 4.

AGRICULTURE, S. I. (2016/17).

Allan, G. &. 2009. Inland saline aquaculture. Cambridge: Woodhead publishing Limited.

AOP. 1999b. State of the System Report: Fish Seed Quality in Asia: Northeast Thailand. AIT Aquaculture outreach Program (AOP). Asian Institute of Technology, 23.

APP. 1995. Agriculture Prospective Plan. Washington DC: JhonMellor Associates Inc.

Awoyemi, T. T., Amao, J. O., & Ehirim, N. C. 2003. Technical Efficiency in Aquaculture in Oyo State Nigeria. Indian Journal of Agricultural Economics; Vol.58 No.4 October- December, 812-819.

Bista, A. 2017. A study on fish production and marketing in Morang district of Nepal.

Boyd, C. 1998. Pond aquaculture water quality management. Kulwer. Kulwer.

Boyd, C. E. 1974. Lime requirements of Albama fish ponds. Alabama Agricultural Experiment Station, Auburn University, USA.

Boyd, C. E. 1990. Water Quality in Ponds for Aquaculture. Alabama Agricultural Experiment Station, Auburn University, USA.

Boyd, C. E., & Snow, J. R. 1975. Fertilizing farm fish ponds. Agricultural Experiment Station, Auburn University.

Brunson, M. W., Stone, N., & Hargreaves, J. 1999. Fertilization of fish ponds. South Regional Aquaculture Centre. SRAC publication No.471.

C. Bhujel, R. 2014. Partnership of African Fisheries (PAF) Aquaculture Working Group:Strategic review on Sub-Saharan African Aquaculture Seed Supply. pp8.

C.T.F.T. 1972b. Contribution a l'tude de l'utilisation de la fumure organique en piscicuiturs tropicale. Annexe no. 6 au rapport final du C.T.F.T. pour FAQ project. (FI:SF/RAF/66/O5L).

CBS. 2005. Statistical Year Book. Kathmandu, Nepal: Nepal Government; Ministry of Agriculture Development; Central Bureau of Statistics.

CBS. 2011. National Population and Housing Census 2011. Kathmandu, Nepal: Government of Nepal, National Planning Commission.

CBS. 2011. Statistical Information of Nepal.

CBS. 2015. Statistical Information on Nepalese Agriculture. Kathmandu: CBS, Ramshah path, Kathmandu.

CBS. 2017. National Population and Housing Census 2011. Kathmandu, Nepal: Government of Nepal, National Planning Commission.

CBS. 2017. Statistical Year Book. Ramshahpath, Thapathali,Kathmandu, Nepal: Central Bureau of Statistics.

CBS. 2075. Economic Survey. Government of Nepal; Central Bureau of Statistics.

CBS. 2075. Hariharbhawan, Lalitpur: Nepal Government; Ministry of Agricultural Development; Agricultural Information and Communication Center.

CFPCC. 2018. Annual Book of Fish. Machhapokhari; Balaju; Kathmandu: Government of Nepal; Ministry of Agriculture and Livestock Development; Department of Livestock services; Central Fisheries Promotion and Conservation Center.

CFPCC. 2018. Country Profile: Fisheries. Kathmandu.

Chopra, P. N. 2016. Principles of Economics. Kalyani Publishers.

Cobb, C. W., & Douglas, P. H. 1928. A Theory of Production. American Economic Review, 139-165.

Cohen, A. J., & Harcourt, G. C. 2003. Retrospectives: Whatever Happened to the Cambridge Capital Theory Controversies?. Economic Perspectives, 199-214.

DADO. 2017. Annual progress report. Janakpur: DADO-Dhanusa.

DADO. 2073. Annual Agriculture Development Program and Progress Book. Inaruwa, Sunsari: Government of Nepal; Ministrty of Agriculture Development; Department of Agriculture; District Agriculture Development Office.

DADO. 2075. Fish Profile. DADO Bara.

DADO-RUP. 2017. Annual progress report. Bhairahawa: DADO-Rupandehi.

Delgado CL, W. N. 2003. The Future of fish: Issues and Trends to 2020. International Food Policy Research Institute, Washington DC, US.

Delgado CL, W. N. 2003. The Future of Fish: Issues and Trends to 2020. Washington DC: International Food Policy Research Institute, Washington DC, USA.

Devi, S. Z., Singh, N. R., Singh, N. A., & TH., L. 2014. Fish Production in Manipur-an economic analysis. Journal of crop and weed, 10, 19-23.

DoFD. 2005/6. Annual Progress Reoprt. Balaju, Kathmandu: HMG, MoAC, DOA, Fisheries Development Directorate, Balaju.

DOFD. 2014.

DoFD. 2014. Annual Progress Report. Balaju, Kathmandu, Nepal: Govt. of Nepal.

DoFD. 2014. Country profile: fisheries. Balaju, Kathmandu.

DoFD. 2016. Country profile: Fisheries. Kathmandu: DoFD. MoAD, DoA, Balaju.

DoFD. 2016. Journal article.

DoFD. 2017. Fish Statistics and Annual Progress Report (Annual Report 2016/17). Balaju, Kathmandu: Government of Nepal, Ministry of Agriculture Development, Directorate of Fisheries Development.

DoFD. 2018. Country profile: Fisheries. Kathmandu: DoFD. MoAD, DoA, Balaju.

DoFD. 2018. Journal article.

DoFD. 2072/73. Fish Statistics and Annual Progress Report. Balaju, Kathmandu: Government of Nepal, Agriculture Development Ministry, Directorate of Fisheries Development.

Egna, H. S., & Boyd, C. E. 1997. Dynamics of Pond Aquaculture. CRC Press, Boca Raton, New York.

Ekong, E. 2003. An introduction to rural sociology (2nd edition). Uyo state: Nigeria Dove educational publishers.

Elhendy, A. M., & Alzoom, A. A. 2008. Economics of fish farming in Saudi Arabia: Analysis of costs of tilapia production. Aquaculture Economics and Management, 229-238.

Emerson, K. R. 1975. Aqueous ammonia equilibrium calculations: effect of pH and temperature. Journal of the Fisheries Research Board of Canada, 32:2379-2383.

FAO. 1988. The State of World Fisheries and Aquaculture.

FAO. 1991. Review of the Economics of Fish Farming and culture-Based Fisheries in Ghana.

FAO. 2004. The state of world fisheries and aquaculture. Rome: FAO Fisheries.

FAO. 2014. Food and Agriculture Organization. Rome, Italy: E-bulletin.

FAO. 2014. The State of World Fisheries and Aquaculture; Opportunities and Challenges. Rome, Italy.

FAO. 2016. National Aquaculture Sector Overview Nepal.

FAO. 2016. State of World Fisheries and Aquaculture. In FAO Fisheries. Rome.

FAO. 2016. The State of World Fisheries and Aquaculture 2016; Contributing to fod security and nutrition for all. Rome, Italy: Food and Agricultural organizations of the United Nations.

FAO. 2018. The State of World Fisheries and Aquaculture; Meeting the Sustainable Development Goals. Rome.

FDF. 2005. FD Report of Presidential Committee on Fisheries and Aquaculture Development, Volume One: Consolidated report. September 2005. 63pp. Rome: FDF, Rome.

Funchess, M. J. 1947. Experiments on Pond fertilization. Auburn, Albama: Agricultural Experiment Station.

FY. 2074/75. Annual statistical book.

Getu, A., Misganaw, K., & Bazezew, M. 2015. Post-harvesting and Major Related Problems of Fish Production. Fisheries and Aquaculture Journal 6: 4.

Goni, Umar, M., & Usman, S. 2013. Analysis of Resource-Use Efficiency in Dry Season Vegetable. Journal of Biology, Agriculture and Healthcare, 3, 19.

Gurung, T. B. 2003. Fisheries and aquaculture activities in Nepal. Aquaculture Asia, 8, 1: 14-19.

Gurung, T. B. 2003. Fisheries and Aquaculture Activities in Nepal. Aquaculture Asia, 7, 1: 14-19.

Gurung, T. B. 2014. Harnessing Fisheries Innovation for Transformational Impact in Nepal. Hydro Nepal, 15, 53-59.

Gurung, T. B. 2014. Harnessing Fisheries Innovation for Transformational Impact in Nepal. Journal of Water, Energy Environment.

Gurung, T. B. 2016. Rol of Inland Fisheries and Aquaculture for Food and Nutrition Security in Nepal. Agriculture and Food Security 20165:18.

Gurung, T. B., & Basnet, S. R. (n.d.). Introduction of rainbow trout Onchorynchus mykiss in Nepal: Constraints and prospects.

Gurung, T. U. 2012. Fisheries and aquaculture policy for education, research and extension in Nepal. Small-scale Aquaculture for Rural Livelihoods, 6-9.

Gurung, T.B., Mulmi, R.M., Kalyan, K.C., Wagle, G., Pradhan, G.B., Upadhayaya, K. and Rai, A.K. 2010. Cage fish culture: an alternative livelihood option for communities displaced by reservoir impoundment in Kulekhani, Nepal. In: Success stories in AsiKathmandu

Ideba, E., Otu, W.I., Essien, A.A. and Iniobong, E.O. 2013. Economic Analysis of Fish Farming in Calabar, Cross River State, Nigeria. Greener Journal of Agricultural Sciences, 3(7), 542-549.

Islam, M., R.K, & Talukder, M. 2007. Technical efficiency of the hatchery operators in fish seed production farms in Bangladesh. Agric. Econs.

Jha D.K, B. R. 2015. Carp seed survival in private hatchery of Nepal. Nepalese Journal of Agriculture and Fisheries, 2: 65-75.

Jha, D.K. and Bhujel, R.C. 2012. Incidence of fish diseases and management practices in Nepal.Small-scale Aquaculture for Rural Livelihoods, 160-165.

Karkee, N. P. 2016. Fish Farming in Nepal; Trends, opportunities and constraints. Nepalese Journal of Agriculture Sciences.

Knud-Hansen, C. F. 1992. Pond history as a source of error in fish culture experiments: a quantitative assessment using covariate analysis. Aquaculture, 105: 21-36.

Kothari, C. R. 1990. Research methods and techniques.

Kothari, C. R. 2002. Research Methodology - Methods and Techniques. New Delhi: Wishwa Prakashan.

Kung, R. 2018. Three stages of Production in Economics. In bizfluent.

Labh, S. N., Kayastha, B. L., Shakya, S. R., Kushwaha, M. P., Vaidya, S. R., Chitrakar, P., et al. 2017. Present status and future prospectives of freshwater fisheries in Nepal: A short overview. International Journal of Fisheries and Aquatic Studies.

Lakra W.S. and Ayyappans A.F. 2003. Recent Advances on Biotechnology Applications to Aquaculture. Indian Council of Agricultural Research, Versova, Mumbai.

Madu, C. 2004. The Privatisation of government fish hatchery:a positive step towards self sufficiency in fish fingerling production in Nigeria. Proceedings of the 18th Annual Conference of Fisheries Society of Nigeria, 78-81.

Mair, G. 2002. Genes and Fish: Supply of good quality fish seed for Sustainable Aquaculture. Aquaculture Asia, 7, 2: 25-27.

Marion, J. E. 1998. Water quality for pond aquaculture. International Center for Aquaculture and Aquatic Environment; Alabama Agricultural Experiment Station. Auburn University.

Miah, A. Q. 1993. Applied Statistics: A Course Handbook for Human Settlements. Bangkok, Thailand: Asian Institute of Technology, Division of Human Settlements Development.

Miao, W. 2014. Improving National Carp Seed Production System in Nepal. Bangkok: FAO Regional Office for Asia and the Pacific. Inception workshop of TCP/BGD/350.

Mijindadi, N. B. 1980. Production efficiency on farms in northern Nigeria, Ph. D. Dissertation. USA: Cornell University.

Miller, J. W. 1976. Fertilization and feeding practices in warm-water pond fish culture in Africa. Report of the Symposium on Aquaculture in Africa.

Ministry of Agriculture and Livestock Development. 2018. Retrieved from http://www.moad.gov.np/en/post/welcome

Ministry of Agriculture, L. M. (2018). Report on Zone profile preparation and publication of Super Zone Fish. Bafal, Kathmandu, Nepal: Centre for Food and Agriculture studies.

Mishra, R. 2013. Carp Seed Quality Improvement Program in Nepal. Kathmandu, Nepal: Paper presented at seminar on Aquaculture in Nepal, recent development and future prospects.

Mishra, R. 2014. status of aquaculture in Nepal. Nepalese Journal of Aquaculture and Fisheries, 1-17.

Mishra, R. N. (2015). Status of Aquaculture in Nepal. Nepalese Journal of Aquaculture and Fisheries, 2, 1-12.

MoAD. 2017. Statistical Information on Nepalese Agriculture. Singhdurbar, Kathmandu, Nepal: Government of Nepal, Ministry of Agriculture Development; Monitoring, Evaluation and Statistics Division; Agriculture Statistics Section.

MoAD. 2073/74. Statistical Year Book of Nepalese Agriculture. Kathmandu.

MoALD. 2018. Statistical Information on Nepalese Agriculture. Kathmandu, Nepal: Government of Nepal; Ministry of Agriculture and Livestock Development.

Mollah, A. R., Chowdhary, S., & Ashanhabib, M. 1991. Input-Output Relationship in Fish Production Under Various Pond Size, Ownership Pattern and Constraints. Bangladesh Trade and Development, 3, 2: 87-101.

Moysan, & Senouci, M. 2016. A note on 2-input neoclassical production functions. Journal of Mathematical Economics.

Nepal, A.P., Basnyat, S.R., Lamsal, G.P., Joshi, P.L. and Mulmi, R.M. 2002. Economics of rainbow trout farming system in Nepal. Cold water fisheries in the trans-Himalayan countries, 431, 179-192.

NPC. 2016. National Planning Commission report-2016. Kathmandu.

Okpeke, M. Y., & Akarue, B. O. 2015. Analysis of The Profitability of Fish Farming in Warri South. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), 45-51.

Olagunju, F. I., Adesiyan, I. O., & Ezekiel, A. A. (2007). Economic Viability of Cat Fish Production in Oyo State, Nigeria. Journal of Human Ecology, 2, (12): 121-124.

Olaoye, O.J., Ashley-Dejo, S.S., Fakoya, E.O., Ikeweinwe, N.B., Alegbeleye, W.O., Ashaolu, F.O., Adelaja, O.A. 2013. Assessment of Socio-Economic Analysis of Fish Farming. Journal of Science Frontier Research Agriculture and Veterinary, 13(9): 45-50.

Olaoye, O. J., Idowu, A. A., Omoyinmi, G. K., Ezeri, G. O., & Oke, A. O. 2011. Factors determining Fish hatchery operations in Ogun State, Nigeria. Journal of Agricultural Extension and Rural Development, 3(10): 172-181.

Olasunkanmi, J. B. 2012. Economics Analysis of Fish Farming in Osun state, south-Western Nigeria. IIFET 2012 Tanzania Proceedings.

P.J.B. Rana, & Rajbhanshi, K. National Plan for Development of Aquaculture in Nepal. Fisheries and Aquaculture department.

PMAMP Fish Superzone, B. 2018. Fish Superzone Profile.

Pradhan, N. 2005. National Aquaculture Sector Overview. FAO Fisheries and Aquaculture Department.

Rahman, H., Mirza, J. A., Hossain, A., & Asif, A. A. 2017. Economics of fish production in paddy fields in Bangladesh. Asian Journal of Medical and Biological Research.

Rai, A. k., Clausen, J., & Smith, S. F. 2008. Potential Development intervention for Fisheries and Aquaculture in Nepal. Asia Pacific Fishery Commission ADHOC FAO PP4.

Rai, A. K., Clausen, J., & Smith, S. F. 2008. Potential Development Intervention for Fisheries and Aquaculture in Nepal.

Reinerstein, D. a. 1993. A production technology of fish. New York.

Saha, N. C., Alam, J., Al-Imran, M., & Islam, M. S. 2004. Comparative economic analysis of pond fish production in Mymensingh and Jessore Districts, Bangladesh. Bangladesh Journal of Fish Research, 8(2): 151-156.

Sahni, K., & Yadav, S. 2012. Seasonal variations in physico-chemical parameters of Bharawas Pond, Rewari, Haryana. Asian Journal of Experimental Sciences, 26(1): 61-64.

Scheaffer, R. 1979. Elementary Survey Sampling. Massachusetts, USA: Duxbury Press.

Shrestha, J. 1991. Fishes of Nepal. Curriculum Development Center, Tribhuvan University, Kathmandu.

Shrestha, J. 1991. Fishes of Nepal. Curriculum Development Center, Tribhuvan University, Kathmandu, Nepal.

Shrestha, J. 1991. Fishes of Nepal. Kathmandu: Curriculum Development Centre.

Shrestha, J. 1998. Fishes of Nepal. Kathmandu, Nepal: Curriculum Development Center; Tribhuvan University; Kathmandu Nepal.

Shrestha, J. 2019. Fishes of Nepal. Curriculum Development Center, Tribhuvan University, Kathmandu, Nepal.

Shrestha, K. M., & Mishra, R. N. 2014. Fish Production Systems in Nepal.

Shrestha, M. 1999. Occurrence of epizootic ulcerative in pond fish of kapilvastu district of Nepal. 169-178.

Shrestha, M. K., & Mishra, R. N. 2014. Fish Production Systems in Nepal. Kathmandu: Annual Innovation Lab Council Partners Workshop.

Shrestha, M. K., & Pandit, N. P. 2017. A Text Book of Principles of Aquaculture. Aquaculture and Fisheries Program; Agriculture and Forestry University; Rampur, Chitwan, Nepal.

Singh, K. 2007. Economics and Determinants of Fish Production and Its Effects on Family Income Inequality in West Tripura District of Tripura. Indian Journal of Agricultural economics, 62.

Summerfelt, R. C. 1998. Water Quality Considerations for Aquaculture. Department of Animal Ecology; Iowa State University.

Svobadev, Z. M. 1993. Water quality and fish health. IFAC Technical paper, 54-67.

Tuladhar, B., & Gurung, K. 2017. The role of public partnership in the development of fish sector in Nepal. SMARTH. Nepal Market Development Programs.

Tunde, A. B., MP, K., Oladipo, A. A., & Olasunkanmi, L. H. 2015. Economic Analyze of Costs and Return of Fish Farming in Saki-East Local Government Area of Oyo State, Nigeria. Journal of Aquaculture Research and Development, 2155-9546.

Umar, A., Makinta, A., & Kwatanda, P. 2014. Analysis of Technical Efficiency of Small Scale Fish Farming in Maiduguri Metropolitan Area of Borno State, Nigeria. Nigerian Journal of Fisheries and Aquaculture, 2(2), 42-48.

Van der Lingen, M. I. 1976. Fertilization in warm-water pond fish culture in Africa. In: Proceedings of the World Symposium on Warm-water Pond Fish Culture.

Varvarigos, P. 1994. Production economics of the emerging private fish farming industry in Bulgaria. Aquaculture international ISSN 0967-6120, 2(3), 197-205.

Wurts, W. A., & Durborow, R. M. 1992. Interactions of pH, carbon dioxide, alkalinity and hardness in fish ponds. Southern Regional Aquyaculture Centre, publication 464.

Wurts, W. A., & Masser, M. P. 2004. Liming ponds for aquaculture. Southern Regional Aquaculture Center.

Yadav, R. K. 1990. Fish Productions in Nepal: Problems and Prospects- A Case study of Krishnapur Village Panchyat of Siraha District. Economic Journal of Nepal, 13(3): 67-74.

Yemi, M., & Okiemute, B. 2008. Analysis of the Profitability of Fish Farming in Warri South Local Government Area of Delta State, Nigeria. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), 8(12), 45-51.