Training Manual on Good Aquaculture Practices (GAqP) of Fish Production with special focus on Lake Cluster of Pokhara Valley (LCPV)

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Training Manual on Good Aquaculture Practices (GAqP) of Fish Production with special focus on Lake Cluster of Pokhara Valley (LCPV)

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Foreword

The necessity of food safety has gained popularity due to its impact on the health of consumers. Production of safe fish is essential for protecting consumers from the hazards of foodborne illnesses. The hazards of food safety starts from culture environment, harvest, handling and processing of fish. It is therefore very important to address food safety starting from the farm level. Implementing good aquaculture practices during on-farm production and post-production processes is of immense importance for assuring a safe food supply to the consumers

The manual is accomplished by LI-BIRD (Local Initiatives for Biodiversity, Research and Development) in collaboration with Nepal Agricultural Research Council (NARC), Fishery Research Station, Pokhara. This document shall be used as reference document which shall provide basic tools for Good Aquaculture Practices (GAqP) for the lakes of Pokhara Valley. This manual is developed by following references from internationally recognized standards and will help to improve local fish farms in areas such as farm management, farm husbandry, fish health management and farm environment management.

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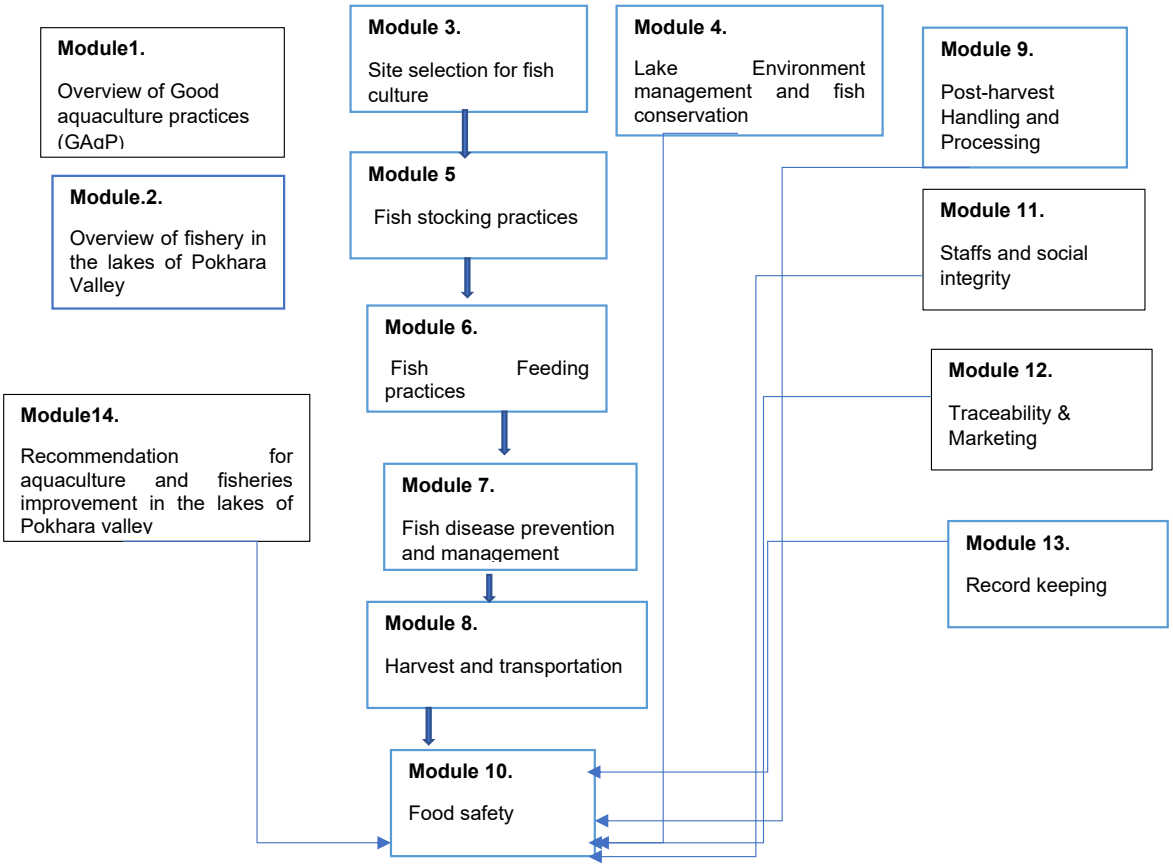
About the manual

This training manual is a teaching materials for training/raising the awareness of the farmer's related to fishery in the lakes of Pokhara valley. Good Aquaculture Practices (GAqP) is a set of guidelines with activities and procedures which ensure product quality and safety by maximizing environmental and economic sustainability and minimizing the chances of disease outbreak by considering safety of the worker involved. This manual covers 14 module with sessions. The first module introduces the Good Aquaculture Practices (GAqP). The second module has highlights the fishery activities in the lakes of Pokhara Valley. The modules 3-6 covers the fish culture requirement, culture practices and especially the forth module covers the Lake Environment management and fish conservation which is the heart of this training manual. The modules from 8-13 covers the harvest and post-harvest of fish with food safety. Last modules briefly recommended the fishery improvement in the lakes of Pokhara valley. Ultimate goal of this manual to trained fisher community to produce fish with food safety at consumer health acceptance level.

Good aquaculture practices (GAqP) in the lakes of Pokhara Valley



Lakes of the Pokhara valley

The Lake Cluster of Pokhara Valley (LCPV) of Gandaki Province, Nepal consists of nine lakes, which include Phewa, Begnas, Rupa, Khaste, Neureni, Dipang, Gunde, Kamalpokhari, and Maidi lakes. These lakes cover 262 km2 basin with the water bodies covering an area of around 9 km2. Lake Phewa is the largest in the cluster and the second largest in the country. All these lakes are sub-surface drainage type. Phewa is *meso-eutro*phic while Lake Begnas is *oligo-mesotrophic*. Rest of the lakes are *eutrophic*. The LCPV was listed as Nepal's 10th Ramsar sites in 2016 (MoFE, 2018).

Table 1. Catchment area (km2), Water body (km2), % Water body of Lake Cluster of Pokhara valley

Lake	Catchment area (km2)	Water body(km2)	% Water body
Phewa	119.39	4.33	3.6
Begnas	18.6	3.13	16.8
Rupa	26.02	1.11	4.3
Khaste	2.69	0.13	4.8
Dipang	2.39	0.14	6.2
Maidi	1.6	0.007	0.4
Gunde	0.61	0.08	13.1
Neurani	0.18	0.027	15
Kamalpokhari	1.35	0.013	1
	172.8	8.97	5.2

(Souce: MoFE, 2018).

Module 1. Overview of Good aquaculture practices (GAqP)

Objectives

To introduce the Good aquaculture practices (GAqP)

1.1. Introduction to Good aquaculture practices (GAqP)

Good aquaculture practices (GAqP) are activities, procedures, or considerations that maximize environ¬mental and economic sustainability, product quality and safety, animal health, and worker safety, while also mini¬mizing the likelihood of a disease outbreak on the farm (Schwarz et al. 2017). GAqP can be defined as more responsible and environmental friendly practices at the farm level to ensure product quality, safety and consistency production and remain competitive in the global market. Thus, GAqP is a farm management practice or guidelines prepared to minimize the potential for farm-raised fishery products to be contaminated with pathogens, chemicals, filth, and unapproved or misused animal drugs.

Good aquaculture practices (GAqP) mainly includes four component: Food Safety, Animal Health and Welfare, Socio-economic Aspects, and Environmental Integrity (ASEAN, 2015).

Food Safety: The main principle is that the aquaculture activities for fish production must follow the national and international food safety standards and regulation including defined by FAO (FAO 2011a, FAO 2011b) /WHO to ensure food safety for consumers.

Animal Health and Welfare: The main principle is that aquaculture activities in all phases of production cycle should be carried out in such a way that the produced fish should be healthy and hygienic.

Socio-economic Aspects: The principle is that aquaculture should be conducted in a socially responsible manner, within national rules and regulations to benefit the society.

Environmental Integrity: The principle is that the aquaculture activities must be well planned and practiced to reduce the impact on the environment.

In many Asian countries, aquaculture holds great promise for increasing the availability of affordable food, protein and nutrients for human consumption and a healthier future for the people (ASEAN, 2015). Meanwhile, in the more developed countries, aquaculture has become one of the fastest growing food production sectors. However, there is now an increasing demand among consumers for high-quality, eco-friendly, and safe aquaculture products. Hence, it has become more important than ever to adopt innovative technologies and management schemes that will ensure the preservation of the aquaculture ecosystem and its surrounding environment, and which will guarantee food safety or the protection of aquaculture products from any form of hazard or contamination. Meeting safety requirements [e.g. Hazard Analysis and Critical Control Point (HACCP), Good Aquaculture Practice (GAqP), etc.] in all stages of the production and handling process has now become an uncompromising condition in most countries. However, complying with these rigid safety requirements has been difficult for small-scale fish farmers, owing to their little knowledge about sustainable aquaculture practices (ASEAN, 2015).

1.2. GAP Standards

1.2.1. The GLOBAL G.A.P. Aquaculture Standard (GLOBALG.A.P, 2020)

The GLOBALG.A.P. Aquaculture Standard sets strict criteria for Legal compliance, Food safety, Workers' occupational health & safety, GLOBALG.A.P. Risk Assessment on Social Practice (GRASP), Animal welfare and Environmental and ecological care.

The GLOBALG.A.P. Aquaculture Standard has been successfully assessed against the Global Food Safety Initiative (GFSI) benchmarking requirements and achieved GFSI recognition for scope A2 farming of Fish - the only aquaculture farming standard to have achieved this.

The Standard has also been benchmarked against the Global Sustainable Seafood Initiative's (GSSI) Global Benchmark Tool Version 1 and are recognized by the GSSI Steering Board. A seafood certification scheme is recognized after successfully completing the 7-step Benchmark Process. The expert-led process involves objective assessments made against the Benchmark Framework. The Standard covers the entire production chain from feed to fork. The Tool's 7-step Benchmark Process (1.Application, 2.desktop review, 3. office visit, 4. benchmark meeting 5. public consultation 6. Recognition decision by steering board, 7. Monitoring of continued alignment) is voluntary and designed to be independent, impartial and transparent (GLOBALG.A.P, 2020). The expert-led process involves objective assessments made against performance areas covering scheme governance, operational management (including chain of custody) and standards for aquaculture and fisheries certification.

1.3 Why Good aquaculture practices (GAqP)?

The GAqP practice is essential:

- To produce high-quality products conforming to food safety requirements.
- To establish the potential for sustainable fish farming
- To improved management systems like environmentally sound poly-eco-aquaculture and organic aquaculture.

Module 2. Overview of fisheries in the lakes of Pokhara Valley

Objective of this module

- To introduce the aquaculture and fisheries activities in the lakes of Pokhara Valley
- To know the catch statistics of lakes
- To know the fish species of these lakes

2.1 Cage aquaculture

Cage fish culture was introduced in Nepal in 1972 at Lake Phewa, Pokhara Valley as a means of holding brood of common carp (Swar and Pradhan, 1992). The farming of cage culture has been carried out in three lakes of Pokhara valley and in Kulekhani reservoir only. The total volume of cages for fish culture in Nepal is 71,000 m3, production and productivity is 299 metric ton and 4.21 kg/m3 of cage volume respectively (DOFD, 2016/17). Traditionally, subsistence cage farming by use of planktivorous fish species (silver carp *Hypophthalmichthys* molitrix /bighead carp *Aristichthys nobilis*) in nylon cage of 50 m3 cage volume with bamboo frame have been practiced by farmers. Cage fish culture with planktivorous carps in the lakes of Pokhara Valley is lucrative and profitable.

In 2011, 35,750 m3 of cages were used for cage culture in the Pokhara valley lakes. At present, the number of cages were only 309 with volume 14,160 m3 in which fish farming in cages is still continuing in the lakes of Pokhara Valley. The cage numbers have been reduced in Phewa Lake by 83%, Begnas Lake by 88%, in year 2017 as compared to 2011 while it has been increased in Rupa Lake (Husen, 2018). The major reasons for cage number and volume reduction in these lakes are due to change of environment, change of flow direction of feeding streams.

2.2 Pen aquaculture

Enclosure fish culture was started in 1984 in Nepal in the lakes of Pokhara Valley. At present the enclosure culture is practiced in Begnas and Rupa lakes. From 75 ha area of enclosure area, fish production and productivity have been reached to 98 ton and 1.3 ton/ha, respectively in Nepal.

The total numbers of enclosure are 14 with estimated total area 21.1 ha in Pokhara valley Lakes. 10 enclosures (6.6 ha) in Begnas Lake and 4 enclosures (14.5 ha) in Rupa Lake. Total production from cage fish farming was 34.4 ton in 2017. Total fish production from enclosure is 34.44 ton in lakes of Pokhara valley with 10.4 ton in Lake Begnas and 24.04 ton in Rupa Lake. Productivity is 1.58 t and 1.67 t/ha area of enclosure in Begnas and Rupa Lake respectively (Husen et al., 2010)

2.3. Open water fishery

Open water fisheries has a long history in the lakes of Pokhara valley. The Jalari (community that has traditionally been dependent on fish harvesting for their livelihood) fisher have been harvesting fish and sales to adjacent market. They use gillnet, cast net, hook and line to harvest fish from these lakes. Among nine lakes of Pokhara valley fishery activities are mainly practiced in the Phewa, Begnas, and Rupa lakes. Recently Gunde, Neurani, Khaste and Deepang Lake have started the fishery activities. However, lake catch records have been maintained in the Phewa, Begnas and Rupa lakes only. 26 fish species have been recorded in the catches and fish species survey of Phewa, Begnas and Rupa lakes (Table 2). Among these recorded species, 20 are native fish and six are exotic fish. Total fish harvested from the three lakes of Pokhara Valley (Phewa, Begnas and Rupa) in FY 2016/17 was 118.5 metric ton. The fish production is higher in Phewa Lake followed by Rupa Lake and Begnas Lake (Fig.1). Seasonal variations in the catches from three lakes showed that highest catch was obtained during winter months. Species contribution to the total catch of each lake varied greatly. The percent contribution by exotic fish species to total catch were 88.9, 78.9, and 86.1 while native species contributed only 11.1%, 21.1%,13.9% in Phewa, Begnas and Rupa lakes respectively in FY 2016/17. Nile tilapia (*Oreochromis niloticus*) species was the major species contributing 71.3%, 51.9 % and 42.8 % of total exotic fish catch

from Phewa, Begnas and Rupa respectively. Nile tilapia has now established in these lakes and the composition of fish species in the catches from these three lakes have shifted (Husen et al. 2016).

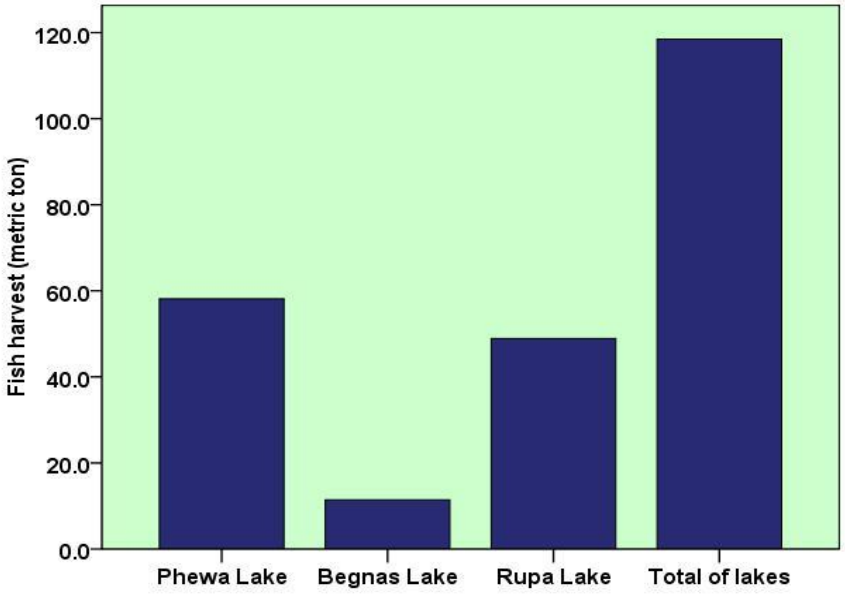


Fig.1. Fish harvest (metric ton) from Phewa, Begnas and Rupa lakes in FY 2016/17.

Other major species in these lakes were bighead carp, silver carp, common carp and grass carp. Among native species, Bhitta (*Puntius* spp.) contribution was highest in lakes Phewa and Begnas while Naini (*Cirrhinus mrigala*) species dominated in the catches of Lake Rupa. The productivity of Rupa lake is higher (489.1 kg/ha) followed by Phewa Lake (132.1 kg/ha), and Begnas Lake (34.8 kg/ha). The productivity of fish directly related to trophic status of lakes. The Rupa Lake is much productive followed by Phewa and Begnas lakes. The restocking of native fish species have been practiced in each lake.

Table. 2. Fish species of Phewa, Begnas and Rupa lakes appeared in the catches and fish survey in FY 2016/17.

SN.	Scientific name	Local name
A.	**Native fish species**	
1	*Tor putitora*	Sahar
2	*Neolissochilus hexagonolepis*	Katle
3	*Cirrhinus reba*	Rewa
4	*Barilius barna*	Lam Fageta
5	*B. bola*	Fageta
6	*B. vagra*	Fageta
7	*B. bendelisis*	Fageta
8	*Puntius sarana*	Kande
9	*P. sophore*	Bhitte/Bhitta
10	*P. titius*	Bhitte/Bhitta
11	*P. ticto*	Bhitte/Bhitta
12	*Cirrhinus mrigala*	Naini

13	*Catla catla*	Bhakur
14	*Labeo rohita*	Rohu
15	*Mastacembelus armatus*	Chuche Bam
16	*Xenentodon cancila*	Dhunge Bam
17	*Clarias batrachus*	Magur
18	*Mystus bleekeri*	Junge
19	*Channa orientalis/ Channa gachua*	Bhoti
20	*Channa punctatus*	Bhoti
B.	**Exotic fish species**	
21	*Aristichthys nobilis*	Bighead carp
22	*Hypophthalmichthys molitrix*	Silver carp
23	*Ctenopharyngodon idella*	Grass carp
24	*Cyprinus carpio*	Common carp
25	*Clarias gariepinus*	African magur
26	*Oreochromis niloticus*	Nile tilapia

Module 3. Site selection and construction for aquaculture

Objectives

To provide adequate level of understanding about the criteria of site selection for aquaculture.

Introduction

Site is the first priority which farmer shall consider prior to farming commencement. The location of freshwater aquatic animal farm shall be complied with relevant laws and meet the technical requirements in order to obtain quality products with minimal problems. Aquaculture facilities should be located in areas where the risk of contamination is minimized or where sources of pollution can be controlled or mitigated.

3.1 Cage aquaculture

Cage culture of fish consists of raising fish from the juvenile stage to commercial size in a volume of water enclosed on all sides, including the bottom, while permitting the free circulation of water through the 'cage' (Coche, 1979).

Cage culture of fish is one of the proven methods of aquaculture. Cage culture is being looked up as an opportunity to utilize existing inland water sources with great production potential to enhance production from inland open waters and posed as an answer to the rising demand for animal protein in the country. Freshwater cage culture is an important industry as it provides a source of protein and fulfills the high market demand for freshwater fishes.

General consideration for site selection for cage fish farming

1) Protection from high winds or typhoons.
2) Adequate water exchange that will enable the flow of nutrient-laden water through the pens/cages.
3) Firm bottom mud to allow pen framework to be driven deep into substrate for better support.
4) Freedom from predators and natural hazards.
5) Accessibility to sources of inputs, including labor and markets, and
6) Good peace and Law and order condition in the location of farm.

Cage site shall be located away from polluted sources. In case the cage is subjected to tide or upstream or downstream area, farmer shall acquire information demonstrating the cage is not affected by such pollution. For instance, information of pesticide analyses shall be obtained if there is waste water discharging from upstream paddy field, or information of Biochemical Oxygen Demand (BOD) analyses needed.

Besides the concern of the environment, placement of cages shall be in the area where it will not obstruct the water flow and the water passage; otherwise the cages may reduce the flow speed of water or cause social problems and water transportation. In addition, area for cage culture shall be open, no strong flow of water or wind nor crowed by aquatic plants as it hinder water flow through the cage.

3.1.1 Water quality parameters

Poor water quality can result in low profit, low product quality and potential human health risks. Success, however, of the new aquaculture businesses greatly depended upon the suitability of the lakes water quality, its water quality variability, pollution and seasonal climatic and mixing events occurring in the new aquatic ecosystem. Water quality parameters such as water temperature, pH, dissolved oxygen, biological oxygen demand, chemical oxygen demand, alkalinity, hardness, nitrite, nitrate, ammonia, phosphate, sulphate, total dissolved solids and total suspended solids in freshwater fish culture should be optimum (Devi et al. 2017).

Cages and pens rely on tides, currents, and other natural water movement to provide a continual supply of high-quality water to the cultured fish. Fish cultured in net pens are directly dependent on the quality of the environment around them. Cage shall be located in the area where water source is of good quality, suitable, sufficient and of good circulation. Water quality suitable for cage aquaculture are presented in the table 3.

Table 3. Water quality Requirement for cage aquaculture

Parameters	Optimum requirements
Temperature(° C)	18-28
Transparency(cm)	30-50
Dissolves oxygen(mg/L)	5-8
pH	7.5-8.5
Alkalinity(mg/L)	50-200(as CaCO3)
Total Hardness(mg/L)	50-200.0
Carbon dioxide(mg/L	15.0-20.0
Ammonia (NH3-N) (mg/L)	<0.02
Nitrite(NO2-N) (mg/L)	<0.01
Phosphate(mg/L)	0.01-0.02

The following water quality (Table 3) are required for cage aquaculture, pen aquaculture and open water fisheries also. Prior the starting of fishery activities in the lakes, water quality should be measured to know about the suitability of fish species. These water quality parameters should be measured by monthly basis to know the variation in the lakes. The stocking of fish species, stocking density in cage/pen aquaculture as well in open water fishery depends on the water quality of lakes. On the basis of water quality, the fishery can be recommended in the lakes of Pokhara valley. Therefore the knowledge of water quality is essential to manage the sustainable fishery in the lake and Lake Environment. The water quality parameters can be measured by electronic meter as well as by water quality testing kit.

Water temperature

Water temperature is controlling factor for all aquatic life. All biological and chemical processes in an aquaculture operation are influenced by temperature. It is one of the most important external factors which influence fish production. At temperatures above or below optimum, fish growth is reduced and mortalities may occur at extreme temperatures. The range of water temperature from 18 to 28 ºC is suitable for warm water fish culture. Temperature can be measured by general mercury thermometer.

pH

Hydrogen ion concentration plays a significant role in the productivity of a Lakes. Normally pH range from 6.4 to 8.3 is favorable for fish growth. The pH limit for protection of aquatic life is 6.0 to 8.5 and the value ranging from 6.5 to 9.0 is good for fish culture. The pH may drop in fish cage culture because of waste deposits. pH can be measured by pH meter.

Dissolved Oxygen (DO)

Dissolved oxygen is an important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water. DO concentration of 5 mg/l throughout the year in the lakes is productive for fish culture. The DO values indicate the degree of pollution in water bodies (Amankwa ah et al., 2014). It is important in the production and support of life. It is also necessary for the decomposition and decay of organic matter. Higher range of dissolved oxygen is usually recorded during rainy season due to mixing of water by heavy wind action and mixing of monsoon rains. DO has been attributed a great significance as an indicator of water quality especially the magnitude of eutrophication. DO concentration in water is mainly dependent upon temperature, dissolved salts, velocity of wind, pollution load, photosynthetic activity and respiration rate (Tamot et al., 2008). The level of DO of 6.5 mg/l or above 5 mg/l is the ideal level for warm water fishes (Nsonga 2014). It has been reported that oxygen depletion in water surrounding cages is due to the respiration of the caged fish. Dissolve oxygen (D.O.) can be measured by electronic D.O meter.

Alkalinity

The total alkalinity is the sum total of carbonates and bicarbonates alkalinity. Water with a high alkalinity is more strongly buffered than water with a low alkalinity. Moreover, bicarbonates can act as a storage area for surplus carbon dioxide, thus carbon dioxide will not be limited during photosynthesis. This will then ensure that there will be a continuous supply of oxygen in the system. The recommended level of alkalinity for freshwater system is 5-200 mg/l. Total alkalinity may be used as tool for the measurement of productivity and conditions of water bodies. The alkalinity ranged from 90 to 160 mg/l in lakes water could be considered as nutrient rich. Alkalinity can be measured by Water quality testing Kit.

Hardness

The hardness of water is mainly governed by the content of calcium and magnesium salts, largely combined with bicarbonates and carbonates (temporary hardness) with sulphates, chlorides and other anions of minerals (permanent hardness). Soft water refers to water with 0 to 75 ppm CaCO3 and has lowest buffering capacity. Moderately hard water has 75 to 150 ppm CaCO3. Hard water has 150 to 300 ppm CaCO3 and very hard water had a concentration of CaCO3 greater than 300 ppm, which has the highest buffering capacity (Boyd, 1990; 1998). Hujare (2008) reported higher total hardness during summer than rainy and winter season. Hardness value of more than 15 mg/l is required for optimum health of warm water fishes. Hardness can be measured by Water quality testing Kit.

Nitrite-N (NO2-N)

Nitrite is a by-product of oxidized NH3 or NH4+, an intermediary in the conversion of NH3 or NH4+ into NO3. This

process is completed through nitrification which is done by the highly aerobic, gram-negative, chemoautotropic bacteria found naturally in the system. The conversation is quick, thus high nitrite concentrations are not commonly found. However, if high levels do occur, it can cause hypoxia, due to deactivation of hemoglobin in fish blood, a condition known as the "brown blood disease". According to Boyd (1998), the desired concentration of nitrite in the water is less than 0.3 mg/l in aquaculture. There were studies reported that the concentration of nitrite-N ranged from 0.001 to 0.28 mg/l in the cage culture systems (Mondal et al., 2010; Nyanti et al. 2012). It is found that increasing pH, low dissolved oxygen and high ammonia can increase its toxicity. Nitrite-N (NO2-N) can be measured by water quality testing kit.

Nitrate-N (NO3-N)

Nitrate is formed through nitrification process, i.e. oxidation of NO2 to NO3 by the action of aerobic bacteria. Nitrate not taken up directly by aquatic plants is denitrified in anaerobic sediments. Boyd (1998) reported the desired nitrate concentration for the aquaculture is 0.2 to 10 mg/l. Nitrate can be measured by water quality testing kit.

Ammonia-N (NH3-N)

It is the principal nitrogenous waste produced by aquatic animals, via metabolism and is excreted across the gills. Ammonia was higher at fish culture site due to feces released by the fish (Nyanti et al., 2012). Ammonia strongly influences the dynamics of the dissolved oxygen in water, since 4.6 mg of oxygen is needed to oxidize 1.0 mg of ammonia. It is concluded that ammonia concentration of more than 0.2 mg/l is undesirable for fish farming. Safe concentration of ammonia for freshwater fish is less than 0.05 mg/l and ammonia concentration of 0.02 mg/l is required for optimum health of warm water fish culture. Some reports showed that the ammonia concentration ranging from 0.01 to 1.15 mg/l in the cage culture system (Zanatta et al., 2010; Mallasen et al., 2012; Nyanti et al., 2012). Gorlach-Lira et al. (2013) reviewed that the high fish densities, along with the high feeding rates, often reduce dissolved oxygen and increase ammonia concentration in and around the cage, especially if there is no water movement through the cage. Ammonia-N (NH3-N) can be measured by water quality testing kit.

Phosphate-P (PO4-P)

Phosphate is one of the important nutrient and limiting factor in the maintenance of lakes fertility. It is recognized as the principal factor produced by the fish farm that has an effect in the lake environment (Jones and Lee, 1982). The primary route by which phosphorus enters the aquatic environment from cage farming is through the feed administered to the fish. A large number of cages in area can exceed the carrying capacity of the aquatic environment, which may cause problems by high levels of phosphorus (Mallasen et al., 2012). Boyd (1998) reported that desired concentration of phosphate in the water is in the range of 0.005 to 0.2 mg/l. Phosphate can be measured by Water quality testing Kit.

The water quality improvement in the lakes of Pokhara valley have been detailed in the module 4. On the basis of measured water quality parameters, the lake environment management should be initiated.

3.1.2 Others criteria

Cage site shall be conveniently accessed such as road for cars, river or canal for boats to facilitate the transport of fry, feed and inputs. This convenience is essential for cost-effective production and for maintaining freshness of products to markets or processing plants. It is also convenient for visitors and inspectors to visit the farm.

Cage shall have necessary basic infrastructures according to farm area condition for convenience of farm management such as electricity for water pump, aerator, or diesel engine water pump, tap, or underground water, or rain water or clean water that fits for consumption. Permission from competent authority shall be obtained to orderly place cages such that it will not have negative impact on water source surrounding the cages.

3.1.3 Cage construction

Nylon or polyethylene net cage have been most popular among cage fish farmers of lakes of Pokhara valley. Generally, farmers are using nylon or polyethylene knot-less floating type cages of 50 m3 (5m x 5m x 2m) size and cage frame of bamboo structure act as frame and float (Fig.2). However, some farmers are using large sizes cages of 62.5-150 m3. Almost 90% of nursery cage is made by netlon cage (Kalo jal) and production cages by nylon or polyethylene threads.

Figure 2. Fish culture in bamboo floating nylon cages in Phewa Lake

3.2 Pen aquaculture

A pen a fixed enclosure in which the bottom is the bed of the water body. The sites for pen culture should be constructed in the shallow region of lake or in shore line with maximum depth up to 2.0 meter. The bottom of lake should be flat and free from large stones.

3.2.1. Selection of sites for pen aquaculture

- Low tidal amplitude
- Fish pen - site must be sheltered as much as possible against high winds
- Depth not less than 1 meter during lowest water level
- The best site is on the leeward side of the prevailing winds with moderate flow of current especially in a place where current in overturning
- Muddy clay and clay - loam soils are best types of bottom soil. Too much still and decomposing organic matter must be avoided.

3.2.1Water quality Requirement for pen aquaculture

Water with stable PH slight variation is best. Avoid turbid and polluted water (See detail in section 3.1.1.).

3.2.2 Others criteria

Others criteria is same as section 3.1.2

Pen construction

Pens should be built in shallow waters area of 2-3 m deep in Begnas Lake and 1-2 m deep area in Rupa Lake. It should be located near the shore of lakes in both lakes. Pens should be constructed with nylon or polyethylene with mesh (25mm) nets. The nets should be attached to post set in every few meters, and the bottom of the net should be pinned to the substrate with long wooden pegs or stones. The farmers generally construct enclosures by the use of bamboo poles, wooden flakes and net, anchoring with stones in Begnas Lake and wooden poles in Rupa (Fig.3) and Phewa Lake (Fig.4). However, farmers could make enclosure by use of concrete masonry works with netlon nylon screen for long durability but it cost high. When wooden flakes is used to construct the pen, the durability extend toover 15-20 years. However, enclosure is made by use of netlon net and bamboo stripes and anchoring by stones has durability only 3-8 years.

Figure 3. Pen fish farming in Rupa Lake

Figure 4. Pen fish farming in Phewa Lake

Recommendations for specific lakes

Site selection for cage aquaculture

Phewa Lake

In this lake, best cage locations is Khapaudi and adjacent area /area where the tide works for the circulation of water through cage. The nursery cage and production cage could be installed. The depth of 5-8m is enough for cage aquaculture.

Begnas Lake

The cage culture could be done in Libdi, Kasunde, Majhikuna and Piple danda area of lake. Due to low productive water, cage practice with supplementary feeding could be done to increase the fish production. If feeding is practiced, the cage location should be near to outlet area of lake.

Rupa Lake

Rupa Lake is shallow lake and the cage could be installed in the middle area of lake or the deeper area of lake. Both production and nursing cage should be installed. If feeding is practiced, the cage location should be near to outlet area of lake (Fig.5).

Fig.5. Nursery cage at Rupa Lake

Deepang Lake, Khaste and Neurani Lake

Nursing cage for fish seed nursing up to advanced size to stock in to lake is recommended. The cage could be installed at the depth of 3m in each Lake and considering the tide for the circulation of water through cage. Production cage is not recommended in these lakes.

Gunde, Kamal Pokhari and Maidi

Cage culture is not recommended in these lake

Site selection for pen aquaculture

In each lake pen aquaculture could be done. In each lake shallow area less than 2 m will be better. Begnas, Phewa and Rupa lakes are recommended for pen aquaculture for table fish production. Small size pen could be used to grow fry to advanced size fingerlings in each lakes. The pen location should be placed in the shore line and levelled bottom of lake with depth less than 2m. For production of table fish, pen area should be > 0.5 ha. In Begnas and Rupa Lake, pens are already installed.

3.3 Open water fisheries in the lakes

Lakes are closed systems consisting of a defined body of water. Lake ecology is stable relative to rivers. Some lakes may become severely reduced in area when flows are reduced. Lakes are classified according to their nutrient richness—oligotrophic lakes being the lowest in nutrients and the least productive, and eutrophic lakes being high in nutrients and highly productive. Changes in water quality are the major driver of lake ecology and shifts in water transparency, dissolved oxygen regimes and resident organisms occur with nutrient enrichment (eutrophication). Oligotrophication, reversion to lower nutrient status, may occur if nutrient inputs are reduced. Pollution from other sources, and sedimentation, are additional pressures.

3.3.1 Water quality requirement for open water fisheries

Water quality of Lake Water determine the stocking of fish, production and productivity as well as safety fish production. The Lake water should be free from pollution, entering of high nutrient load water in to Lake could deteriorate the water quality of lakes (See detail in section 3.1.1.).

3.3.2 Others criteria

The fisheries activities in the lakes are influenced by many factors. The lakes of Pokhara valley have multipurpose uses. The understanding of Lake have different opinion of different stakeholders. Therefore, coordination with different stakeholder needed for sustainable fishery. The tourism may affect aquaculture and fisheries activities as many anthropogenic activities will increased around the lake, which in turns deteriorate the lake water.

Module 4. Lake Environment management and fish conservation

Objectives

To acquainted with importance of lake environment management, Impacts of aquaculture on the environment and fish biodiversity conservation

Introduction

Lakes are important landscape, which are not only the source of precious water, but also provide valuable habitats to plants and animals, moderate hydrological cycles, influence microclimate, enhance the aesthetic beauty of the landscape and provide recreational opportunities to humankind. The lakes are also used for meeting drinking, irrigation water, fishing, eco-tourism demands etc. The lakes suffer from numerous problems owing to increasing anthropogenic activities in the catchment. These problems include lake shrinkage, shoreline erosion, deteriorating water quality, biodiversity, changes in lake hydrology and climatic regimes. In view of the deteriorating lake health, it becomes necessary to restore and manage the lakes environmentally by employing suitable restoration technologies that may help in improving lake health.

4.1 Lake Environment management

4.1.1 Water quality monitoring and management

Water quality in aquaculture encompasses all physical, chemical, and biological variables that effect aquaculture production (Boyd, 1990).Water quality is the prime requisite for the healthy fish production. Any deterioration in water quality causes stress to fish and causes disease. The maintenance of good water quality is essential for both survival and optimum growth of cultured aquatic organisms. Disease outbreaks, poor growth, poor feed conversion efficiency and similar management problems are directly related to poor water quality. Management strategies need to be developed that use a variety of techniques to address water quality problems in the lakes. In most of the aquaculture and fisheries practices, water quality is monitored (temperature, dissolves oxygen, pH, Ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, and transparency). Each water quality factor interacts with and influences the other parameters, sometimes in complex ways. Good quality of water resources depends on a large number of physico-chemical parameters. Assessing and monitoring of these parameters is essential to identify the magnitude and source of any pollution load.

The water quality of Pokhara valley lakes should be monitored regularly on monthly basis to know the status and plan for the management of lakes. On the basis of water quality the lake should be managed. Pokhara valley lakes water quality affected by anthropogenic activity in the catchment area. At present, Phewa and Rupa lakes are eutrophic condition (FRS, 2018). These lakes water quality could be managed by reducing the directly enter of discharge of urban pollution, nutrient enrichment form agriculture runoff, landslides control, re-vegetation in the in the catchment area, awareness to local people, organic farming in the catchment area.

4.1.2 Control of sources of pollution

Pollution affects water quality in lakes and other freshwater resources around the globe. It can take many forms from industrial, agricultural, or municipal sources; a few common examples include pesticides, herbicides, sewage, and litter. Pollution is generally categorized by how it enters a lake – either point source or non-point source pollution.

Point Source Pollution: Contaminants that enter a water body that can be traced back to a specific source, location, and offender. Point source pollution is easier to manage compared to non-point source pollution. Examples of point source pollution include dumping of industrial waste, effluent from sewage treatment facilities, discharge of sewage and other chemicals.

Non-Point Source Pollution: Contaminants that enter a water body that cannot be traced back to a specific source, location, and offender. Rather, this pollution comes from many diffuse sources and often enters in small amounts but can become concentrated in lakes and other freshwater resources. Non-point source pollution includes agricultural runoff (pesticides, fertilizers, manure), acid rain, nitrate deposition, and leaching from septic tanks. Non-point source pollution accounts for most of the contamination in water systems

The Pokhara flat valley floors are intensely cultivated with rice, maize, finger millet, and vegetables and fertilizes, manure and pesticides enters into Lake Phewa by the feeding streams (MOFE 2018). Due to heavy pollution in lake water, increase in mercury level in the fish species of Phewa lake have been reported that can make a risk for health when fish over consumed by local people (Sharma et al. 2013; Thapa et al. 2014) and also metabolites of DDT and endosulfan sulfate were found in the muscle sample of fish (Basnet 2011). Water quality of Phewa become more eutrophic due to nutrient rich municipal sewage entry to lake (Fleming and Fleming 2009; Gurung et al. 2010; Husen et al. 2012).

In the lakes of Pokhara valley, the urban pollution could be controlled by checking direct entry point to the lake water and use of waste treatment plant. Mandatory provision of roadside bio-engineering and drainage system has to be developed to control the further degradation of Pokhara valley lakes. Point and non-point sources of pollutions should be controlled. The Pokhara Metropolitan City (PMC) should lead to make mandatory and regulatory provision and awareness to check the pollution.

4.1.3 Control of water hyacinth

Water hyacinth have posing many problems for fisheries activities in the lakes of Pokhara valley. Manual removal of water hyacinth are laborious and costly in the lakes of Pokhara valley. Therefore, biological control of water hyacinth using beetles *Neochetina eichhorniae* and *N. bruchi* could be ecofriendly approach. The potential use of water hyacinth should be promoted to reduce the cost of management for water hyacinth removal from Pokhara valley lakes. Several studies showed that water hyacinth have various uses such as phyto remediation, paper, organic fertilizer, biogas production, biofuels, briquette, fiber, animal fodder (Jafari 2010; Rezania et al. 2017; Sindhu et al. 2017).

4.1.4 Control of eutrophication

Eutrophication is the increase in the rate of supply of organic matter to an ecosystem because of excess enrichment of nutrients, particularly phosphorus and nitrogen, within a body of water such as a lake or reservoir. High concentration of phosphorus is a major problem in many lakes and reservoirs. This can lead to a host of detrimental effects with the most notable. This can result in other adverse effects such as reduced oxygen levels in the water once the algae die, deaths of other organisms such as fish due to the reduced oxygen levels, taste and odor problems with drinking water, and reduced recreational opportunities because of aesthetic issues and potential toxicity levels (Schindler, 2006; Yu et al., 2016). Although increases in nutrient levels enhance fish production, the loss of habitat, e.g., by sediment buildup, deoxygenation undesirable proliferation of macrophytes, and food web simplification cause a shift from fish diversity to less desirable species, especially in more extreme cases of eutrophication.

Eutrophication of lakes and reservoirs is a major water quality problem that poses significant environmental, economic and social threats around the world. Monitoring and managing lakes and reservoirs to prevent or limit eutrophication, therefore, has significant value. Eutrophication of Pokhara valley lakes should be controlled by preventing the direct entry of water from surface runoff and drainage from urban area, agricultural land.

4.1.5 Control of sedimentation and siltation

Landslides should be controlled by improvements in vegetation in the catchment areas of lakes and adaptation of improved agricultural practices. Sediment load in the inlet water could be lessen by construction of diversion canal, check dams and retaining structures for the reduction of sediment load in lake water and eco-zoning of Lake Shoreline. Lake shrinkage could be mitigated by managing landslide and sediment transport in the watershed (Watson et al. 2019).

4.2. Native fish biodiversity conservation

Jalari fisher community firstly organized a fish entrepreneurs committee. Jalari fisherman should be regularly sensitized for the conservation of native fish species. Women group of Jalari community should be mobilized for protection of native fish by patrolling of the breeding ground during the spawning season and campaigning for native fish protection. Manual removal of water hyacinth have been continuously done every year by Jalari community of respective lakes.

Continuous and regular monitoring of the biological and population parameters of fish, fish catch data, limnological study should be continued to provide updated information relevant to fisheries management in these Lakes of Pokhara valley. Populations of Nile tilapia must be balanced in these lakes for the sustainable yield and to decrease the vulnerability of native fish species by regular stocking of native fish species and intentional harvesting of Nile tilapia (Husen et al. 2016). The introduction and invasion of exotic fish in the lakes should be controlled to avoid further invasion of new exotic species. Recently two new exotic species have been recorded in the Begnas. It is assumed that it is due to myth of Buddhism people to release of fish for the peace (Husen et al. 2019)

4.2.1 Control of illegal fishing methods

To keep up the native fish diversity intact and sustainable fisheries harvest, drivers of fisheries of these lakes need to be mitigated by applying suitable strategy and coordinated approach, laws enforcement. The illegal fishing methods should be discouraged by coordinating with local government and fisher community, and making awareness to local people.

4.2.2 Fish sanctuary area

Fish sanctuary should be made in each lake as in Phewa Lake as certain area is allocated where fishing is prohibited. This will protect the native fish species to become vulnerable.

4.2.4 Awareness of peoples

Placement of hording board in different protected places and campaign for the conservation of native fish on the wetland day, world fisheries day (Fig.6) should be arranged to make local people and in the schools should be organized to aware regarding conservation of native fish species. In Pokhara valley, the Buddhist people should be made aware about the introduction of exotic fish species and their effects on the native fish species in the lakes. Generally, Buddhist people buy fish species from any supplier and release in the lakes. Due to which, some exotic fish species have been introduced in the lakes of Pokhara valley.

Fig.6. World fisheries day celebration for awareness to conserve native fish

4.2.5 Restocking of native fish species

Stock enhancement of native fish species: Sahar (*Tor putitora*), Rohu (*Labeo rohita*), Naini (*Cirrhinus mrigala*), Bhakur (*Catla catla*), and Gardi (*Labeo dero*) should be done every year to increase the stock of fish in these in these lakes (Fig.7).

Fig.7. Native fish released in Begnas Lake.

4.2.6 Habitat and Breeding ground management

The spawning ground of fish species should be restored and further protected area should be declared to increase native fish population in these lakes. Regular monitoring of breeding ground of fish should be continued mainly in the river entering to lakes during breeding season to reduce the fish vulnerability by human activities.

GAqP guidelines for Lake Environment management and fish conservation

- Regular monitoring of water quality should be carried out to understand the lake environment. Suitable strategy should be adopted to promote efficient lake environment management.
- Control of pollution, water hyacinth, eutrophication, sedimentation and siltation should be made mandatory in each lake.
- Control of illegal fishing methods, provision of fish sanctuary area, awareness of peoples, restocking of native fish species, and fish habitat and breeding ground management should be carried out on regular basis.
- Only hatchery produced fish seed from authorized farm should be used for culture. Feeds, feed additives, should be used responsibly to minimize their adverse impacts on the environment.
- Farm workers and managers should be trained in environmental management and mitigation of impact to ensure they are aware of their responsibilities in protecting the environments.
- Environmental impact assessments should be conducted if required by national law and according to national legislation, prior to approval of establishment of new aquaculture facilities (Cage aquaculture, pen fish farming).

Way forward for lakes of Pokhara valley

Formation of an umbrella institution including different stakeholders of lake fisheries and environment management of Pokhara valley lakes could ensure the viability of fisheries as well as tourism in this area. Additionally, public awareness need to be raised to control the further expansion of other exotic fish species and water hyacinth in the lakes of Pokhara valley.

The efforts for fishery and lake management of the lakes of Pokhara valley should be continued and it should be managed with its changing context. Drivers of fisheries (population, pollution, siltation, encroachment of lake area, destructive fishing etc.) should be addressed as soon as possible to get sustainable fish yields from these lakes.

Enforcement of fisheries and lake management strategy by government authority with community involvement could be the best option for the implementation and to get success in mitigating the drivers of fisheries.

Module 5. Fish stocking practices

Objectives

To know the proper stocking of fish species, density in different aquaculture and in open water fisheries

Introduction

Stocking of fish in aquaculture facilities as well for open water fisheries is important for the production of targeted fish species. For sustainable harvest from lake, in open water stock enhancement should be carried out with stocking of fish species.

5.1 Selection of fish species

Fish species for cage and pen farming

Fish species recommended for culture in cages are silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*) and grass carp (*Ctenopharyngodon idella*) in the lakes of Pokhara valley. Monosex Nile tilapia (*Oreochromis niloticus*), Common carp (*Cyprinus carpio*) could be used for the cage culture. For pen fish farming, mainly Indian major carps: Rohu (*Labeo rohita*), Naini (*Cirrhina mrigala*), Bhakur (*Catla catla*) and Chinese carp: Bighead carp (*Aristichthys nobilis*), Silver carp (*Hypophthalmichthys molitrix*), and Grass carp (*Ctenopharyngodon idella*) should be stocked in the Pokhara valley lakes.

5.2. Sources of fish seed

Choose reputable suppliers and pay site visits to fish nurseries. Fish fry should be of good quality and healthy.

5.3. Fish seed quality

Quality of fry (fig.8) is an important factor for the success of farming. Good quality and healthy fry, which can better adapt to the environment, or fry from the brood stock with good growth rate are other factors for farmer shall be taken into account. Before purchasing, farmer shall request for reliable documents. In addition, appropriate stocking density of the fry shall be considered as over stocking density will cause stress and sickness easily, which will create problems and slow growth.

Fig.8. Fish fingerlings

The source of brood stock, and seed for culture (larvae, post larvae, fry and fingerling) should be such that it reduces the risk of carryover of potential human health hazards into the growing stocks.

5.4. Fish seed transportation and loading density

The survival rate of fry during delivery has a direct impact on the harvest and economic effectiveness of fish farming. The following procedures can increase the survival rate of fry. Make adequate preparations before the journey. Stop feeding one to two days before delivery so that the fish may have sufficient time to excrete and reduce body surface mucus. This can prevent water quality from deteriorating during delivery. 24 hour conditioning of fish seed done by placing fish seed in hapa in flowing water fixed in tank. Make up a detailed plan and make good transport arrangements. Delayed delivery will incur mortality and losses during transit. For transportation, the fish fry should be packed in the plastic bag at the rate of 50g/liter of water with oxygen.

5.5. Fish stocking practices

5.5.1 Fish stocking density and size

The growth of fish in the lakes depends on the live feed present in the lake water. Fish stocking density in the cage and pen aquaculture as well as open water fisheries depends on the Lake Environment and lake productivity and carrying capacity of Lake. The productive water having adequate amount of live feed (Phytoplankton and Zooplankton) could be stocked with higher stocking density. The growth of fish will be higher in the productive water. If the lake is productive such as Phewa and Rupa Lake which is eutrophic, higher stocking density can be done. In the case of Begnas Lake which is oligo-mesotrophic means low productive water, it can be stocked with fish in low density. The detail of stocking size, and density in cage and pen aquaculture, and open water are given below.

5.5.2 Cage aquaculture

In the Pokhara valley, farmers use to grow the 1-2 g of silver carp and bighead carp in the nursery cages and in around 9 months they reach to sizes of 50-100 g, and there after they are stocked in table size fish production cages .

The recommendation is to stock 20-25 g size fish in cages at stocking density 10 fingerlings/m3. Depending on the type of plankton dominance and the market demands, stocking of fish usually constitutes 60% bighead carp and 40% silver carp and vice versa (Wagle et al., 2007). The best stocking density in Phewa Lake found was 70% bighead and 30% silver carp at 10 fingerlings/m3 of cage volume (Husen et al., 2012).

5.5.3 Pen aquaculture

In the pen culture, fish stocking could be done at the rate of 7000-10000/ha depending on the productivity of lakes. The fish size range from 10-25 gm for stocking of cage. The species composition will 50 % surface feeder (Silver carp, Bighead carp and Bhakur), 30 % column feeder (Grass carp and Rohu) and bottom feeder (Naini).

5.5.4 Open water fisheries

The main characteristic of lakes and streams, in so far as stocking is concerned, is that they have significant autochthonous populations of fish, and stocking is generally intended to enhance the economically important ones or to occupy ecological niches in the fauna. Unlike newly formed reservoirs, these natural water bodies have more or less stabilized ecosystems and therefore call for appropriate studies to determine the need and desirability for stocking. Although there are several instances where natural lakes have been stocked and managed along the same lines as reservoirs, as described above, it would appear that the majority of enhancement programs in lakes and streams have been for establishing or augmenting sport fisheries.

Stock enhancement of native fish species: Sahar (*Tor putitora*), Rohu (*Labeo rohita*), Naini (*Cirrhinus mrigala*), Bhakur (*Catla catla*), and Gardi (*Labeo dero*) have been done every year by FRS, Pokhara as well as by fish entrepreneurs committee and cooperative of these lakes. The exotic fish species includes, Bighead carp, Grass carp, and Common carp. The stocking density, size and species are provided in the table 4.

Table 4. Stocking density (ha), stocking size (gm) and fish species recommended in each lake

Lake	Stocking density(ha)	Stocking size(gm)	Fish species
Phewa	1500-2000	5- 25	Sahar, Gardi, Rohu, Naini, Bhakur, Silver carp, Bighead carp, Grass carp, Common carp
Begnas	1000-1200	5- 25	
Rupa	1500-2000	5- 25	
Khaste and Neurani	1200-1500	10-25(75%) 200-500(25%)- only Grass carp, Common carp	Sahar, Gardi, Rohu, Naini, Bhakur, Silver carp, Bighead carp, Grass carp, Common carp
Deepang	1200-1500	10-25(75%) 200-500(25%) only Grass carp, Common carp	Sahar, Gardi, Rohu, Naini, Bhakur, Silver carp, Bighead carp, Grass carp, Common carp
Gunde	1200-1500	5-10	Sahar, Gardi, Rohu, Naini, Bhakur, Silver carp, Bighead carp, Common carp
Maidi	800-1000	200-500	Grass carp, Common carp
Kamal Pokahari	800-1000	5-10	Sahar, Rohu, Bighead carp, Common carp

Module 6. Fish Feeding practices

Objectives

To know about the right feed, using a correct feeding method, calculating the feeding cost and ensuring the cost effectiveness.

Introduction

Fish feed is a major expenditure for fish farmers. Good fish feed management can reduce overall culture cost, improve fish farm environment and ensure healthy growth of fish stock. Fish feed management includes choosing the right feed, using a correct feeding method, calculating the feeding cost and ensuring the cost effectiveness of fish farm. Protein, fat, carbohydrates, vitamins and minerals are the essential nutrients for fish. It is noteworthy that nutritional requirements of fish vary with different species, sizes, growth stages and feeding habits. For example carnivorous fish require a higher intake of protein and fat than the omnivorous and herbivorous species, while marine fish require more protein and fat than freshwater fish do. For this reason, fish feed should be specifically chosen to suit different species.

6.2. Quality of feed and feed type

Feed management GAqP range from nutritional composition to storage and application (Schwarz et al. 2017). Aquaculture feeds come in many formulations, sizes, and types. It is impor¬tant to feed the correct nutritional composition, feed size, and feed type (floating, sinking, or slow-sink) to match the species, life stage, and production system being used. Feed rations are affected by water quality parameters such as dissolved oxygen and temperature. For outdoor extensive systems, these two parameters can vary widely and need to be closely monitored and adjusted.

In indoor intensive systems, these variables are controlled by the system and come into play only when there is a system malfunction.

Fish can be fed manually or with demand and auto feeders (Schwarz et al. 2017). Feed equipment should always be kept clean and in proper operating condition. Animals should never be overfed; an appropriate feeding level is about 80 percent of satiation daily. Splitting a daily feed ration into several smaller feed amounts and feeding several times a day can enhance fish growth and feed conversion ratios and minimize the water quality fluctuations associated with increased oxygen demand during and after feeding, as well as spikes in nitrogenous wastes.

Aquaculture operations should use feeds and feed ingredients which do not contain unsafe levels of biological, chemical and physical contaminants and/or other adulterated substances. All ingredients which are used in feed manufactured or prepared on farm must be free from prohibited substances. Farmers should only purchase commercial feed that has been registered to the competent authority and properly labelled in compliance with requirements of the competent authority.

6.2. Quality of feed and feed type

Feed shall preferably be sourced from suppliers/manufacturers who are verifiably processing sustainable and high-quality feed ingredients. Sourced feed shall meet the following requirements:

- nutritionally balanced for cultured species
- reduced use of fish meal and fish oil
- clearly separated production lines for different feed qualities
- implemented measures to prevent any contamination
- Use of, for example, pro-biotics, compost and algae is recommended.
- routine analysis for mycotoxins
- no synthetic pigments added

Feed shall be handled and stored in a safe, clean and dry manner, clearly separated from any sources of potential contamination and pests such as insects. Commercial feeds, feed ingredients, additives and premixes should be obtained from a company registered and monitored by the competent authority. Packages should be properly labeled with the description of composition, storage conditions, expiry date, and feeding rate.

6.3. Feeding frequency

6.3.1 Cage aquaculture

For nursing of fish fry in the nursery cages the feeding with high quality feed preferably floating crumble feed should be fed three times a day. For the feeding for grow out, feeding should be done once a day.

6.3.2 Pen aquaculture

Generally, in pen culture feeding is recommended considering the Lake Environment and pen location area. Only high quality floating feed should be used.

6.3.3 Open water fisheries

In open water, feeding is not recommended.

6.4. Monitoring growth of fish

Growth of fry should be carried out in every 15 days interval. On the basis of weight of fry the feeding dose should be calculated. The fry should be fed at the rate of 3-5% of body weight. The grow-out fish growth should be taken monthly. The grow-out fish should be fed at rate of 2-3 % of body weight.

A complete and up to date farm diary shall include data such as:

- Origin and initial numbers of stock
- Type and quantity of feed used
- Occurrence of disease
- Any treatments applied
- Reason for and number of mortalities
- Final numbers harvested
- Calculations of Food Conversation Ratio (FCR). (FCR= feed used / fish biomass increase)

6.5. Feeding norms for Pokhara Valley lakes

No feeding is needed in the farming of planktivoruos fish species for cage fish farming. For monoculture of grass carp in cages, submerged macrophytes should be feed which should be collected from the lake bottom. In the pen culture only high quality floating feed should be used.

Consideration for specific lakes

Phewa Lake

This lake is eutrophic. The feeding in the nursery cages to grow juveniles will justify with high quality floating feed. Feeding of fish directly to lake and cage and pen aquaculture is not recommended. If feed practice is allowed, the cage and pen location should be located in the outlet area of lake. The feed should be high quality floating and over feeding should be avoided. As the water of this lake is used for the irrigation to crops, the nutrients will be useful to these crops.

Begnas Lake

Begnas Lake is ololigo-mesotriophic Lake. The growth of fish is not good due to low productive water. For the uniform growth of fish in the cages of nursery and production supplementary feeding practice will be one option. For feeding of fish to increase fish production in the cages or open water fisheries, the site selection should be near the outlet area of lake. Due to feeding of fish the water eutrophication will increase in the autumn to spring season. As, the lake is used for the irrigation of the crops, it is justified to use feed to produce fish in the lake. However, the feed should be good quality, highly nutritive and floating type.

Rupa Lake

This lake is eutrophic. The feeding in the nursery cages to grow juveniles will justify with high quality floating feed. Feeding of fish directly to lake and cage and pen aquaculture is not recommended. If feed practice is allowed, the cage and pen location should be located in the outlet area of lake. The feed should be high quality floating and over feeding should be avoided. As the water of this lake is used for the irrigation to crops, the nutrients will be useful to these crops.

Deepang Lake, Khaste and Neurani Lake

Nursing cage for fish seed nursing up to advanced size to stock in to lake is recommended. The feeding in the nursery cages to grow juveniles will justify with high quality floating feed.

Module 7. Fish disease prevention and management

Objectives

- To acquainted with welfare of farmed aquatic animals
- To know about how to optimize health through minimizing stress, reducing aquatic animal disease risks and maintaining a healthy culture environment at all phases of the production cycle

7.1. Introduction

A culture environment should be maintained at all phases of the production cycle adapted to the species raised, to benefit aquatic animal health and welfare, and reduce the risks of introduction and spread of aquatic animal diseases. In particular, by:

a. Routine monitoring of stock and environmental conditions for early detection of aquatic animal health problems; and
b. Implementation of management practices that reduce the likelihood of disease transmission within and between aquaculture facilities and natural aquatic fauna, and reduce stress on animals for the purpose of optimizing health.

7.2 General guidelines

1. All medicines should be used in a responsible manner and in accordance with applicable national legislation or relevant international agreements/guidelines that ensure effectiveness for animal health with consideration of safety of public and protection of the environment.
2. Use of species in polyculture or integrated multitrophic aquaculture should be carefully considered in order to reduce potential risk of disease transmission.
3. Farm workers and managers should be trained on good aquatic animal health and welfare management practices to ensure they are aware of their roles and responsibilities in maintaining aquatic animal health and welfare in Aquaculture.
4. Fish seed should be of good quality/healthy and from reliable source.
5. Record keeping of animal health and movement for traceability purposes should be maintained during culture and for at least 24 months after harvesting.

7.3 Prevention of fish diseases

To minimize the occurrence of disease following efforts shall should be followed by fish growers:

- selection of healthy fry/fingerlings for stocking
- safe handling of fish
- avoidance of stress during grow-out
- avoidance of disease transfer from other stock/farms
- use of hand wash and disinfectant points
- monitoring of fish for the occurrence of disease
- preference of alternatives to synthetic chemical treatments

7.4. Treatment of fish diseases

7.4.1 Rules for using fish drugs

All veterinary drugs and chemicals for use in aquaculture shall comply with national regulations, as well as international guidelines. If veterinary drugs and chemical treatment is necessary, use only registered veterinary drugs and chemicals and follow the instruction on the manufacturers label or as advised by competent authority. Water used for aquaculture should be of a quality suitable for the production of fish which is safe for human consumption (Aqua GAP, 2018).

7.4.2 Correct use of fish drugs

Substances requiring prescription should be procured under adequate supervision by qualified experts and used by a trained technician authorized by the competent authority. Non-prescription substances should be used according to manufacturer's instructions and as specified on the label. Veterinary drugs, medicated feeds, chemical and biological substances should only be those permitted and registered according to national regulations and obtained from registered manufacturers and suppliers. Drug residues should not be present in the body of fish by observing withdrawal period to ensure that the maximum residue level (MRL) is acceptable based on the standards set by Codex or trading partners.

7.4.3 Safety rules for using fish drugs

Every application of a drug or chemical shall be recorded (date, agent, dose, reason for use, vet recommendation, residence time). Medical treatments shall only be applied after identification of a health problem and prescription by fish disease expert. Records of fish expert prescriptions shall be kept.

7.4.4 Handling of drugs and chemicals

Drugs and chemicals include, among others: detergents, disinfectants, fuels, lubricants, fertilizers, liming materials, paints, insecticides, herbicides, parasiticides, algaecides, anesthetics, medication/treatments, vaccinations etc., and any other agent that may be hazardous (e.g. flammable, toxic, irritant) to staff, the environment or to the aquaculture stock (Aqua GAP, 2018).

All chemicals and drugs shall be handled (use, mixing, storage) according to label instructions and national regulation and in a way that reduces the risk of health and environmental impacts. Chemicals and drugs should only be ordered for a specific reason and in a precise quantity, (there should be no excess / unused quantity of e.g. medicated feed).

Storage

All chemicals shall be stored in a designated area, with access limited to responsible staff. All containers shall be stored conform to label instructions (e.g. chilled, darkened, only glass) and be labeled correctly at all times, even if refilled from larger containers. For toxic liquids, operators shall ensure that secondary measures (e.g. collector) can contain 110% of the chemical in the event of a leak. For powders, operators shall ensure they are stored in sealed and well-ventilated areas protected from flooding.

Prevention of impacts from chemical use

All staff shall be trained on first appointment and continuously thereafter in internal emergency procedures Where applicable, clear warning signs shall be placed to inform staff and visitors of areas where special precautions are required (e.g. flammable store, slippery surfaces).

Current list of drugs approved for aquaculture

- Chorionic gonadotropin (HCG)
- Formalin

- Oxytetracycline
- Sulfadimethoxine-ormetoprim
- Sulfamerazine
- Tricaine methanesulfonate (MS-222)
- Florfenicol

Aquaculture Drugs (Low Regulatory Priority)

1. Acetic acid
2. Calcium chloride
3. Calcium oxide
4. Carbon dioxide gas
5. Fuller's earth
6. Garlic (whole form)
7. Hydrogen peroxide
8. Ice
9. Magnesium sulfate
10. Onion (whole form)
11. Papain
12. Potassium chloride
13. Povidone iodine
14. Sodium bicarbonate
15. Sodium chloride
16. Sodium sulfite

Module 8. Harvest and transportation of fish

Objectives

To know the methods of safe harvest and transportation of fish

Introduction

The harvest, transportation and slaughter of fish shall be carried out with consideration given to the environment (e.g. sediment release, escapes), fish welfare (e.g. stress, physical damage, suffocation) and product quality (e.g. clean harvest bins, blood spotting/gaping, immediate cooling after slaughtering) (Aqua GAP, 2018).

Good aquaculture practices for pre-harvest and harvest focus on maximizing the quality of the product and minimizing stress on the animal. It is also critical to make sure all harvest equipment is in proper working order, that containers for receiving the product are prop¬erly cleaned and sanitized, and that sufficient high-quality ice is ready to properly chill-kill the product.

Chill-killing in water/ice slurry is critical to rapidly lowering the core temperature of the harvested product, which reduces spoilage. Once harvested, the product must be kept below 38 °F (3.3 °C) before, during, and after processing. Proper records must be kept from production through sales. Clean packing containers/boxes/ice must be used for the packing of fish. Fish to be packed/transported chilled must be packed with sufficient ice till point of retail

8.1 Harvest

Good aquaculture practices (GAqP) for harvesting of fish from lakes of Pokhara valley

Only healthy fish should be harvested for sale (GAP-FF, 2014). Harvesting of fish from the gill net should be done in the morning time when temperature is low. Immediate after harvesting fish should be kept in the ice for chilling in the boat. The farmers should kept ice in an insulated box or in a plastic tray. The handling of fish should be done carefully to avoid any injuries to fish. If the fish is harvest from cage, harvesting shall be carried out as quickly and orderly as possible in order to limit the fishes' stress, e.g. time out of the water, to a minimum.

8.2 Transportation

Minimize risk during fish transportation by ensuring that the transportation vehicle is clean. The vehicle should be cleaned and sanitized between uses. During transporta¬tion, the fish should be properly packaged and must be kept frozen or cool to maintain product quality and safety. Digital temperature loggers can be used to track the temperature of fish throughout the process-ing, packaging, storage, and transportation steps. Transport should be carried out in clean and easy to clean facilities (boxes, containers, vehicle etc.). Fish should be transported and maintained at a temperature of 0.0-4.0 ºC.

8.3 Slaughtering

Slaughtering shall always be monitored and carried out using appropriate methods in hygiene condition. Immediately after slaughtering, fish shall be put on ice/in ice-slurry to cool as quickly as possible to a temperature of < 5ºC.

Module 9. Post-harvest handling and processing

9.1 Post-harvest handling

Post-harvesting equipment should be kept in clean condition. Temperature shall be maintained below 5ºC throughout chilled processing. Temperatures shall be monitored and recorded. Incoming goods and enclosed documents shall be verified for their quality and compliance with this standard according to internal checklists. Operations such as sorting, weighing, and washing, draining and packing should be carried out quickly, hygienically and without damage to the fish product.

9.2 Processing

Processing GAqP include rapid cooling, rapid freez¬ing, and temperature control during storage. Reduce the temperature of the fish as fast as you can using an ice bath or blast freezer, or by spreading the product out in single layers in a refrigerator or freezer. To minimize bacterial contamination, all surfaces and utensils that might come in contact with the harvested fish must be cleaned and sanitized before processing begins and after each batch of product is processed. This includes items such as utensils, knives, totes, tables, cutting boards, ice makers, ice storage containers, hands, gloves, aprons, trucks, and nets.

9.3 Product specification

For each product and client there shall be a detailed product specification. Processing additives and processing aids (e.g. phosphates, metabisulfite) shall only be used according to client product specifications and shall comply with regulations in the country of production as well as in the country of import.

9.4 Cleaning

The quality manual shall contain a section on cleaning including a cleaning plan, a list of approved cleaning agents and

methods of use, as well as approved protocols to be completed on site during cleaning (Aqua GAP, 2018). All cleaning agents shall be approved for food quality processing. The same shall apply to facility pest management. No pest control shall be used where direct contact with the food product may occur. A pest management plan shall be included in the quality manual.

9.5 Separation

Separation of processing shall be ensured for products with different risk levels (e.g. the varying risk of pathogenic microorganisms in primary processing vs. ready to eat products). Temporal or spatial separation of processing shall be ensured for different qualities (AquaGAP certified and non-certified) (Aqua GAP, 2018). If products of different qualities are processed on the same line separated in time, the production line shall be cleaned between processing the two lots of different quality. All machines used shall be maintained in good working condition

Module 10: Food safety

Objectives

To acquainted with food safety requirement for the certification of products.

Introduction

Food safety is a scientific discipline describing the handling, preparation, and storage of food in ways that prevent food-borne illness. This includes a number of routines that should be followed to avoid potentially severe health hazards. Food safety is important as it helps to protect consumer from the risk of food borne illnesses. It also helps to prevent consumers from risks of health –related conditions such as allergy and even death.

At peoples are health conscious and aware about the food safety. The aquaculture products is only acceptable when it is produced under the good aquaculture practices. Aquaculture activities should be conducted in a manner that ensures food safety by implementing appropriate national or international food safety standards and regulations.

The following GAqP practices will ensure the production and distributions of healthy certified food to consumers.

- Aquaculture facilities should be located in areas where the risk of contamination is minimized or where sources of pollution can be controlled or mitigated **(see details in Module 3)**.
- Where feed is used, aquaculture operations should include procedures for avoiding feed contamination in compliance with international standards or national regulations as determined by internationally agreed standards **(see detail in Module 5. Fish Feeding practices)**.
- Aquaculture operations should use feeds and feed ingredients which do not contain unsafe levels of biological, chemical and physical contaminants and/or other adulterated substances. All ingredients which are used in feed manufactured or prepared on farm must be free from prohibited substances **(see details in Module 5. Fish Feeding practices)**.
- Farmers should only purchase commercial feed that has been registered to the competent authority and properly labelled in compliance with requirements of the competent authority **(see details in Module 5. Fish Feeding practices)**.
- All veterinary drugs and chemicals for use in aquaculture shall comply with national regulations, as well as international guidelines. If veterinary drugs and chemical treatment is necessary, use only registered veterinary drugs and chemicals and follow the instruction on the manufacturers label or as advised by competent authority Water used for aquaculture should be of a quality suitable for the production of fish which is safe for human consumption **(see details in Module 6. Fish disease prevention and management)**.
- The source of seed for culture (fry and fingerling) should be such that it reduces the risk of carryover of potential

human health hazards into the growing stocks **(see details in Module 4. Fish stocking practices)**.
- Data related to food safety should be recorded, kept, maintained and made accessible during culture and for at least 24 months after production **(see details in Module 12. Record keeping)**.
- Aquaculture facilities should be designed, operated and maintained in ways that prevent contamination from workers, sewage/toilets, domestic animals, machinery oil/fuel and other possible sources in order to maintain hygienic conditions **(see details in Module 11 Staffs and social integrity)**.
- Appropriate harvesting and post-harvest handling, of aquaculture products within the farm should be practiced to minimize contamination and physical damage **(see details in Module 8 Harvest and transportation and Module 9 Post Harvest Handling and Processing)**.
- Workers should be trained on farm level hygienic practices to ensure they are aware of their roles and responsibilities for protecting aquaculture products from contamination and deterioration throughout the production cycle **(see detail in Module 11 Staffs and social integrity)**.
- Hazard Analysis Critical Control Point (HACCP) should be strictly followed to obtain safe food.

Hazard Analysis Critical Control Point (HACCP)

The Hazard Analysis Critical Control Point (HACCP) principles can be used as a preventive risk management system to control the introduction of pathogens at aquaculture facilities. The HACCP approach is based on prevention and requires a hazard analysis that identifies a potential hazard in the system and then a Critical Limit, with a maximum and or minimum point, is set for each component of the system. When monitoring the aquaculture system and a critical limit has been in violation, then a corrective action is taken to bring the system back into compliance.

These HACCP principles provide a step by step approach to identify and control hazards found inthe environment and production process for both freshwater and marine aquaculture. The following are the seven basic principles.

1. Hazard and Risk Analysis
2. Identify Critical Control Point (CCP)
3. Establish Critical Limits
4. Establish Monitoring Procedures
5. Establish Corrective Actions
6. Establish Verification Procedures
7. Establish Record Keeping Procedures

Module 11. Staffs and social integrity

11.1 Occupational health and safety policy

It is recommended to appoint a senior staff representative responsible for the health and safety of all personnel (Aqua GAP, 2018). It shall be ensured that staff is not exposed to dust, noise, harmful gases or other hazardous substances.

Depending on the nature of the work, appropriate protective equipment shall be provided by the operator and staff shall be trained in its correct use. Protective equipment may include, but is not limited to, the following:

- Respiratory and eye protection devices (e.g. for staff working with chemical agents)
- Ear protection devices (e.g. for staff working in machine rooms)
- Gloves (e.g. for staff handling liming materials)
- Life jackets (e.g. for staff working at offshore cage sites)

Similarly, first aid and emergency equipment (e.g. fire extinguishers) and important contact numbers shall be displayed in a prominent place available to all staff. The operator shall ensure that any emergency and warning postings are written in a language understood by all staff.

Aquaculture facilities should be designed, operated and maintained in ways that prevent contamination from workers, sewage/toilets, domestic animals, machinery oil/fuel and other possible sources in order to maintain hygienic conditions

11.2 Staff Training

All staff shall be trained on first appointment and annually thereafter (Aqua GAP, 2018). Training shall include information on:

1. Handling of fish
2. First aid
3. Work safety and the use of safety equipment
4. Biosecurity
5. Hygiene and food safety
6. Workers' social rights and duties

11.3 Workers health and hygiene

Workers should be trained on farm level hygienic practices to ensure they are aware of their roles and responsibilities for protecting aquaculture products from contamination and deterioration throughout the production cycle. Personnel should be physically fit to work in the aquaculture facilities and those personnel who could contaminate the products should not be allowed. Workers should wear suitable and appropriate working clothes.

Smoking, spitting or drinking alcohol in the working and storage premises shall not be allowed. Workers should be trained on farm level hygienic practices to ensure they are aware of their roles and responsibilities for protecting aquaculture products from contamination and deterioration throughout the production cycle.

Employees must wash hands before work, after using the restroom and after breaks. If gloves are used for food handling, such as during harvest (this does not include activities such as pruning, irrigating, etc.), they must be intact, clean and in sanitary condition.

Procedure for Hygiene

1. Water-testing records must be available for drinking water *provided* to employees, showing the water is potable.
2. Employees must wash hands before work, after using the restroom and after breaks.
3. If gloves are used for food handling, such as during harvest (this does not include activities such as pruning, irrigating, etc.), they must be intact, clean and in sanitary condition.
4. Eating food, chewing gum, drinking beverages (except bottled water) or using tobacco are restricted to areas outside the production area.

Eating and drinking may take place at the edges of the production area, on grove roads or in areas already harvested in current harvest cycle.

Procedure for Hand Washing

Note: Hand washing with soap and water is required. Sanitizer use alone is not an acceptable practice.

1. Water-testing records must be available, showing the water being used for hand washing is potable.
2. All employees must wash their hands with soap and water at the beginning of the workday, after using the toilet, after eating and after breaks.

a. Wet hands with potable water; apply soap and work to lather.
b. Rub hands together.
c. Rinse under clean water.
d. Dry hands with a single-use towel.
e. Dispose of towel in trash can

11.4 Social responsibility

The operator shall comply with national labor laws and have a copy on site. The operator shall take responsibility to set up additional requirements to ensure the workers' safety and minimum social rights and duties.

Employment conditions

The operator shall ensure that there is no form of forced labor, bonded labor or corporal punishment. All permanent staff must hold a written contract

Society relation

Farm operation shall demonstrate equal rights on public land and water use for local communities following national laws and regulations. Farms should minimize the potential adverse impact on the local community during all phases of operation. Farms owners and workers should maintain a harmonious relationship with the community.

Module 12 Traceability & Marketing

Objective

To keep data up to date to trace the products and market the products

12.1 Traceability

Traceability is the ability to follow and document the origin and history of a food or feed product. Traceability systems are record keeping systems used for tracking the flow of product through the production process and supply chain. Traceability helps companies track multiple products, monitor food safety and food quality issues, and control distribution of unsafe or poor quality products. An effective traceability program can minimize the potential for negative news, reduce product recalls, and control liability issues.

Fish stocked shall be traceable to the respective cage/ pen/ open water. A record system providing a permanent documentation of each generation/cycle shall be in place. The data recorded shall include origin and initial quantity of stock, type and quantity of feed used, occurrence of disease, any treatments applied, reason for and number of mortalities and final quantities harvested and sold. With each harvest, a traceability sheet shall be provided, indicating the quality and history of the fish. Traceability of every finished product shall be ensured in order to control any potential contamination.

During each stage of product receipt, processing and storage, the product shall be identifiable by lot and certification status. If products are stored for more than several hours or if there is a separate freezing unit, a stock record shall be maintained. All stored products (apart from temporary day storage) shall be labeled appropriately with direct

reference to traceability documentation. Traceability documentation shall allow reference to information on the history of the products (feed, treatment, farm, brood stock of origin etc.) and the certified quality.

The final processed product shall always be traceable back to the farm. All processing steps shall be documented and yields recorded. The history of each batch shall be recorded on a traceability sheet (alternatively in a software system), showing origin, identification number, date and number of harvest, any treatment and withdrawal period. A documented mock recall test shall be carried out annually. It shall be possible to follow batches of product received through processing to final sales data.

- Adequate records should be kept on aquaculture farm management activities (e.g. preparations and water quality control).
- Adequate records should be kept on the origin of fry and fingerling used.
- Adequate records should be kept on the date, type, origin and use of feeds and feed ingredients.
- Traceability records for animal health and movement of fish should be completed and maintained.
- Records on harvesting should be maintained for traceability purposes.
- Adequate records on the buyers of final products should be kept (one-step- forward traceability).
- All records should be kept, maintained and made accessible during culture and for at least 24 months after harvesting.

12.2 Branding

All fish products shall be clearly labelled as Aqua GAqP logo (Aqua GAP, 2018). The Aqua GAqP logo is a product label should be certified by the certification committee. Please note that any labeling or publications referring to Aqua GAqP must first be approved by the certification body prior to use. The certification body can be made at province level by forming a committee of expert team. The labeled pack should show branding slogan as organic fish from lakes of Pokhara valley, Date of packing and other required information. Shukuti made by Jalari fisher fetch higher price in the market (Fig.9). Visitors buy shukuti from them. The fish product as shukuti and other frozen pack should be well labelled and packed with logo of GAqP will ensure the consumers of safety and hygine product and trust of buyers will add product more worth.

Fig.9. Preparing smoked fish at Begnas Lake.

12.3 Fish marketing

Fish market is a place where the fishes and fish products of commercial importance are subjected to sale. Regulation of fish production and consumption through sale is known as fish mar¬keting. Market infrastructure includes wholesale market, retail market and fish retail outlets .To make fish available to consumers at the right time and in the right place requires an effective marketing system. The growth of fish production as well as development of fishery sector in terms of economy and infrastructure is highly dependent on an efficient fish marketing system. In general, there are four types of middlemen engaged in marketing fish Wholesalers, Wholesalers-retailers, Retailer. Price of fish depends on market structure, species quality, demand, size and weight of fish species.

The Rupa lake Restoration and Fishery Cooperative Ltd., Harpan Fewa Fish Cooperative and Begnas Fish Entrepreneur Committee have sell their fish from their fish landing sites(Fig.10) through Cooperative / committee. The fish collected at landing sites of Phewa, Begnas and Rupa lakes and sell to consumer directly. The fish sales mechanism from these lakes could be improved by upgrading the collection and sale center of each lake in terms of food safety. If fish collection is surplus and not sold from the collection center on that day, the fish quality will be deteriorated and marketing will not easier. For that circumstances the facilities like cold storage and blast freezing needed. These facilities should be provided in the larger lakes (Phewa, Begnas and Rupa). On other hand, the surplus fish could be used to make sukutie (dry fish) and after packing, can be sale to departmental store. The immediate blast freezing fish can be packed and labeled and send to departmental stores.

Fig.10. Fish collection center at Begnas Lake

Module 13. Record keeping

Records are a significant aquaculture facility in Good Aquaculture Practices (GAqP component. Keeping thorough records allows you to properly oversee the operation and comply with internal or external audits (some buyers may periodically review documentation of farm quality assurance program). The records of inventories: fish in and fish out, licenses and permits, cleaning and sanitation, inspections, repair and maintenance, feed, treatments, waste management, employee training, and employee health should be recorded. Keep records on the use of chemicals and antibiotics. Record when it was used, for how long, the dosage, and the reason for use. Keep this type of information in bound record books in a safe location.

Records should always include date, time, and individual entering the data, the required information, and any per¬tinent notes. Records should routinely be monitored by management and filed for future reference as needed.

Data related to food safety should be recorded, kept, maintained and made accessible during culture and for at least 24 months after production.

Module 14. Recommendations for aquaculture and fisheries improvement in the lakes of Pokhara valley

Phewa Lake

Water quality improvement is the prerequisite for the sustainable fish yield. Regular stocking of fish is needed to get regular harvest. Stocking of cages as well as open water fisheries, needs advanced size fingerlings. Partial feeding with the floating feed of good quality having 35% CP for nursing of fish fry to advanced size fingerlings is recommended. Feed should be floating for the fingerlings. The outlet area should be always screened to avoid escape of fish from the Lake. For rearing of fish fry, nursery cage operation is essential. It would be better, If PFEC (Phewa fisheries entrepreneur cooperative) could arrange nursery ponds near to lake. The breeding ground of native fish species should be maintained to get regular harvest of native fish species as it fetch higher prices. The protocol of closed season and mesh size should be always followed by Jalaris fisher.

Begnas Lake

Regular stocking of fish is needed to get regular harvest. Stocking of cages as well as open water fisheries, needs advanced size fingerlings. For rearing of fish fry, nursery cage operation is essential. Partial feeding with the floating feed of good quality having 35% CP for nursing of fish fry to advanced size fingerlings is recommended. Feed should be floating for the fingerlings. It would be better, If BFEC (Begnas fisheries entrepreneur committee) could arrange nursery ponds near to lake. The outlet area should be always screened to avoid escape of fish from the Lake. The breeding ground of native fish species should be maintained to get regular harvest of native fish species as it fetch higher prices.

Rupa Lake

Regular stocking of fish is needed to get regular harvest. Stocking of cages as well as open water fisheries, needs advanced size fingerlings. For rearing of fish fry, nursery cage operation is essential. Partial feeding with the floating feed of good quality having 35% CP for nursing of fish fry to advanced size fingerlings is recommended. Feed should be floating for the fingerlings. Rupa cooperative could utilize their nursery ponds for the production of fingerlings size fish. The outlet area should be always screened to avoid escape of fish from the Lake. The breeding ground of native fish species should be maintained to get regular harvest of native fish species as it fetch higher prices.

Khaste and Neureni Lakes

For recreational fisheries in the lake, Lake should be stocked with Sahar(*Tor putitora*).

This lake could be stocked with common carp (*Cyprinus carpio*) and bighead carp (*Aristichthys nobilis*) for regular production. Rohu (*Labeo Rohita*) and Naini (*Cirrhinus mrigala*) could be stocked at only 10 % of total stocked fish. For rearing of fish fry, nursery cage operation is essential. Partial feeding with the floating feed of good quality having 35% CP for nursing of fish fry to advanced size fingerlings is recommended. Feed should be floating for the fingerlings. It would be better, if it could be arrange nursery ponds near to lake. The outlet area should be always screened to avoid escape of fish from the Lake. The breeding ground of native fish species should be maintained to get regular harvest of native fish species as it fetch higher prices.

Dipang Lake

Larger size fish of Grass carp (> 400 gm) and common carp (> 500gm) needed to stock in the lakes for biological clearance of aquatic grasses from the lake. For recreational fisheries in the lake, Lake should be stocked with Sahar(*Tor putitora*).

This lake could be stocked with common carp (*Cyprinus carpio*) and bighead carp (*Aristichthys nobilis*) for regular production. Rohu (*Labeo Rohita*) and Naini (*Cirrhinus mrigala*) could be stocked at only 10 % of total stocked fish. The outlet area should be always screened to avoid escape of fish from the Lake. The breeding ground of native fish species should be maintained to get regular harvest of native fish species as it fetch higher prices.

Gunde Lake

For recreational fisheries in the lake, Lake should be stocked with Sahar(*Tor putitora*).

This lake could be stocked with common carp (*Cyprinus carpio*) and bighead carp (*Aristichthys nobilis*) for regular production. Rohu (*Labeo Rohita*) and Naini (*Cirrhinus mrigala*) could be stocked at only 10 % of total stocked fish. The outlet area should be always screened to avoid escape of fish from the Lake. The breeding ground of native fish species should be maintained to get regular harvest of native fish species as it fetch higher prices.

Kamalpokhari

Kamal Pokhari having very small area for culture of fish. It is recommended to use native fish species such as Sahar (*Tor putitora*) as recreation fisheries. This lake could be stocked with common carp (*Cyprinus carpio*) and bighead carp (*Aristichthys nobilis*) for regular production. Rohu (*Labeo rohita*) and Naini (*Cirrhinus mrigala*) could be stocked at only 5 % of total stocked fish. The outlet area should be always screened to avoid escape of fish from the Lake. The breeding ground of native fish species should be maintained to get regular harvest of native fish species as it fetch higher prices.

Maidi Lake

This Lake is occupied by marshy land area. Around 3 ha area is visible as water. Around 10 ha area from the North area should be screened. After screening, larger size fish of Grass carp (> 400 gm) and common carp (> 500gm) needed to be stocked in the lake for biological clearance of aquatic grasses from the lake. The nursery ponds should be constructed near to lake in the north part of lake for the growing fry up to 50-100 g. The fish hatchling and fry should be brought from the trusted nursery to avoid diseases.

Way forward

In each Lake, the development of fishing tourism will help to add income for the dependent fisher community, supporting livelihood and it will reduce the emerging risk of less fish harvest due to impact of drivers on fisheries in future. The fishing tourism has been a part of international and global concern. The fishing tourism will provide an ample job and income opportunities for poor fishers. Promoting tourism based recreational fisheries could be one of the safeguarding approaches for fish conservation by providing other livelihood options to traditional fishers through fishing tourism.

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Appendix-1: Photos of field visit and Interaction meeting with stakeholders of lakes of Pokhara valley

1. Gunde Lake

Gunde Lake

2.Khaste and 3. Neurani Lake

Field visit and interaction meetings at Khaste and Neurani

4.Kamal Pokhari

Field visit and interaction meetings at Kamal Pokhari

Kamal Pokhari

5. Deepang Lake

Field visit and Interaction with stakeholders of Deepang Lake

6. Maidi Lake

Field Visit to Maidi Lake

Maidi Lake

7. Phewa Lake

Interaction with chairman and members of Harpan Phewa fish entrepreneur Cooperative Hall, Khapaudi

Jalari fisher collecting grass from Phewa Lake to feed grass carp in cage

8. Begnas Lake

Fish collection and sale center at Begnas Lake

Interaction meeting with Begnas Fish Entrepreneur Committee

9. Rupa Lake

Field visit to Rupa Lake and Interaction meeting with Rupa Cooperative members

Fish collection and sale center at Rupa Lake

For more information

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