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Cage fish farming in lakes and reservoirs of Nepal: a mini review and update

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ABSTRACT
Cage fish culture was introduced in Nepal in 1972 at Lake Phewa, Pokhara Valley as a means of holding brood of common carp. The farming of cage culture have been carried out in three lakes of Pokhara valley and in Kulekhani reservoir only. Traditionally, subsistence cage farming by use of planktivorous fish species (silver carp, *Hypophthalmichthys molitrix* /bighead carp, *Aristichthys nobilis*) in nylon cage of 50 m^3 cage volume with bamboo frame have been practiced by farmers and this technology is still popular. The production of planktivorous fish in extensive cage fish farming was found very low. Cage fish farming of grass carp in monoculture feeding with aquatic macrophytes was found profitable in comparison to planktivorous fish species. Recently, slow growth fish in cage culture due to change of Lake Environment, the cage numbers have been reduced in Phewa Lake by 83%, Begnas Lake by 88%, and Kulekhani reservoir by 62% in year 2017 as compared to 2011. Low productivity of cage culture from lakes and reservoirs in extensive cage culture (productivity≈1.0kg/m^3/2year) experienced by farmers of lakes and reservoirs. The unavailability of large size fingerlings to stock cages and quality cage knitting materials are the constraints faced by farmers.

Kew words: Cage culture, Indrasarober reservoir, Phewa Lake, Begnas Lake

INTRODUCTION

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; Schmitton, 1969). It is a method of farming aquatic organisms in the enclosure placed in a body of water (Beveridge and Stewart, 1998). Floating cage fish culture was probably originated from lower Mekong basin in Kampuchia, as a convenient holding facility for marketable fish (Pantulu, 1979). In freshwater cage fish farming, China dominates with a production exceeding 68.4 percent of total reported freshwater cage aquaculture, followed by Vietnam 12.2 % and Indonesia 6.6 % (Tacon and Halwart, 2007). Cage fish culture is considered to be an old tradition that has developed into a major sector in aquaculture only in the recent past (De Silva and Phillips, 2007; Tacon and Halwart, 2007).

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 Indrasarober reservoir (Kulekhani) only. The total volume of cages for fish culture in Nepal is 70,000 m^3 (DOFD, 2014/15). Traditionally, subsistence cage farming by use of planktivorous fish species (silver carp *Hypophthalmichthys molitrix* /bighead carp *Aristichthys nobilis*) in nylon cage of 50 m^3 cage volume with bamboo frame have been practiced by farmers(Fig.1 A,B) and this technology is still popular (Gurung and Bista, 2003; Wagle et al., 2007).

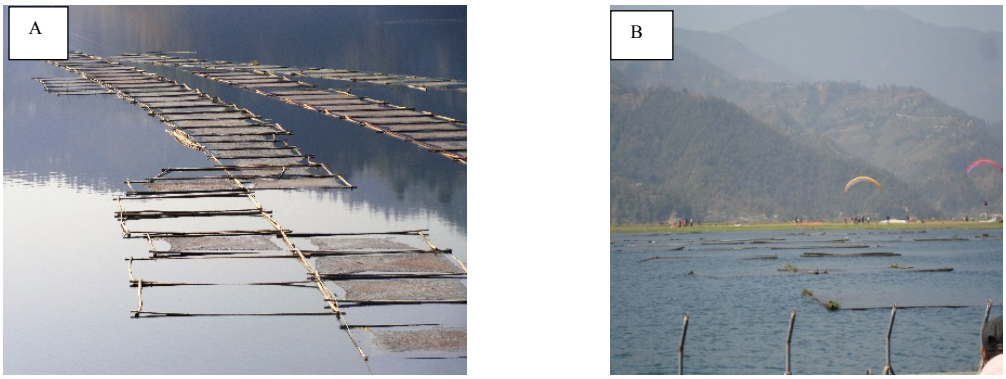


Figure 1: Fish culture in cages of Kulekhani Reservoir (A) and Phewa Lake (B)

This technique has extended to Kulekhani reservoir in 1984 for the local people as part of the mitigation efforts following reservoir construction and loss of farmland. Introduction of cage fish farming in the reservoir became successful strategies for an alternative livelihood option and also stimulated the development of a capture fishery, based on escapees and naturally recruited species, all of which have significantly contributed to increasing a fresh affordable animal protein source to the nearby communities (Gurung et al., 2009).

MATERIALS AND METHODS

Study sites

Phewa Lake is situated in the southwestern part of the Kaski district at 28.1°N and 82.5°E, 742 m above mean sea level (Fig. 2A). The watershed area of this lake is 110 km^2 (Ferro and Swar 1978). Lamichhane (2000) estimated the water surface area of this lake to be 443 ha with a maximum depth of 23 m. Phewa Lake is fed by two perennial streams. This lake fluctuates between mesotrophic and eutrophic in different seasons (Husen and Dhakal, 2009; Husen et al., 2012a).

Begnas Lake is the second biggest lake (328 ha) at 28°10'26.2″N and 84°05'50.4″E, 650 m above mean sea level (Figure 2A). It is fed by a perennial stream with a catchment area of 19 km^2 and an average depth of 6.6 m (Rai et al. 1995). This lake fluctuates between oligotrophic and mesotrophic in different seasons (Husen et al., 2012a).

Lake Rupa (100 ha) is the third biggest lake and its watershed is located between 28°08'N to 28°10'N and 84°06'E to 84°07'E, at 600 m above mean sea level (Gurung, 2007) (Figure 2A). The lake's total catchment area is 30 km^2. The surface area, maximum depth, and average depth of the lake are 1.35 km^2, 6 m, and 3 m, respectively. This lake is eutrohic (Husen et al., 2012a, Husen et al., 2013)

Kulekhani Reservoir (27°23'25″–27°41'31″N; 85°2'46″–85°16 '16″E) is located in the northeastern part of Makawanpur district situated in the mid hills of central Nepal at 1,430 m above sea level. It was impounded in 1982. It is a small reservoir (220 ha) with a catchment of 126 km^2 water body (Figure 2.B). The reservoir was designed with an anticipated lifespan of more than 50 years (Gurung et al., 2009).

Figure 2: Nepal map showing location of lakes of Pokhara valley (A) and Kulekhani reservoirs (B).

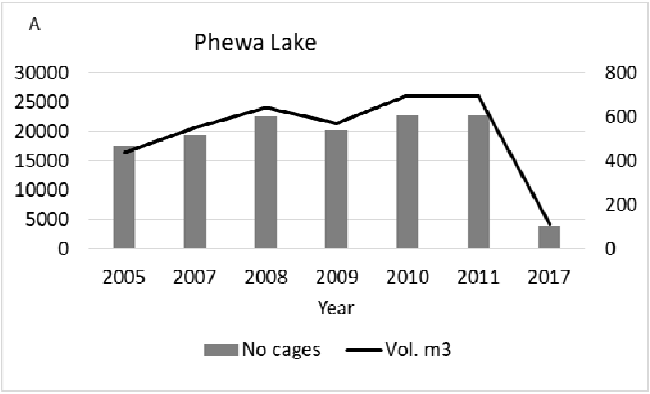
Data collection

Field survey were carried out to gather information's about the present status of cage culture in lakes of Pokhara valley and Kulekhani reservoir. The cage fish farming farmers were interviewed with developed questionnaire. Interaction meetings with stakeholders, key informants were carried out to obtain information on cage fish farming. Literature review of published article in the journal, proceeding were done to compare the present data to the past.

RESULTS AND DISCUSSION

Cage volume and number

At present, the number of cages are only 521 with volume 21,712 m^3 in which fish farming in cages is still continuing in the lakes of Pokhara Valley and Kulekhani reservoirs. The cage numbers have been reduced in Phewa Lake by 83%, Begnas Lake by 88%, Indrasarober reservoir (Kulekhani) by 62% in year 2017 as compared to 2011 while it has been increased in Rupa Lake (Figure 3 A-D). In 2011, 35,750 m^3 of cages were used for cage culture in the Pokhara valley lakes (Prasad et al., 2013). Likewise, 230 farmers (110 women and 120 men) involved in fish culture in the Kulekhani reservoir using 75,000 $m^3$of cage volume for production, nursery and grow-out and cage volume has increased to 81,500 m^3 (Shrestha et al., 2012), however, it reduced to 27,900 m^3 in 2011 (Prasad et al., 2013).



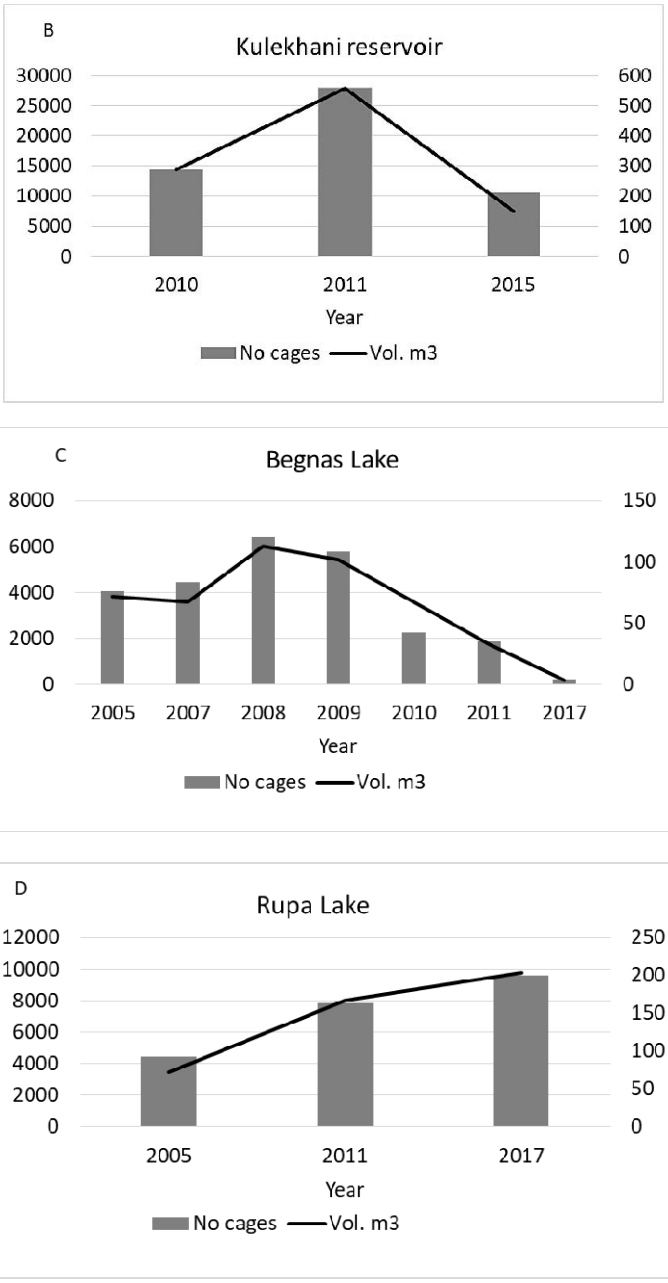


Figure 3: Cage number and volume (m^3) in lakes and reservoir: Phewa Lake (A), Kulekhani reservoir (B), Begnas Lake(C), and Rupa Lake (D).

Cage type and fish species

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 size 50 m^3

(5m x 5m x 2m) and cage frame of bamboo structure act as frame and float (Wagle et al., 2007; Gurung et al., 2009). Local fisherman could weave their own netting of mesh size more than 25 mm locally. Almost 90% of nursery cage is made by netlon cage (Kalo jal) and production cages by nylon or polyethylene threads (Husen, 2010).

The fish species used for culture in cages were silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*) and grass carp (*Ctenophyryngodon idella*) in the lakes of Pokhara valley and reservoirs. Monosex Nile tilapia *(Oreochromis niloticus*), Common carp (*Cyprinus carpio*) could be used in the cage culture of lakes and reservoirs. Studies have shown that trout farming in lakes and reservoirs of the mid-hills in winter could be one of the alternative opportunities for cage farmers to increase their income (Bista et al., 2004; Gurung, 2008).

Stocking density

Generally, at stocking density 10-12 fingerlings/m^3 of 20-25-gram size recommended for the stoking in cages of lakes and reservoirs. In the Pokhara valley, farmers have been used to grow the 1-2 gram of silver carp and bighead carp in the nursery cages around 9 months reached to sizes of 50-100 g and then stocked to production cages (Wagle et al., 2007; Husen, 2010). Depending upon the type of plankton dominance and the market, stocking 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/m^3 of cage volume (Husen et al., 2012b).

Productivity of cage fish farming

According to Wagle et al. (2007), fish production ranged from 1.3-5.0 kg/m^3/yr in 12-18 months from cage culture in the Pokhara Valley Lake. Nepal (2008) reported that the average yield in cage fish culture of Phewa Lake was 1.41 kg/m^3/yr. In an experiment, the cage productivity was found 1.55 kg/m^3/yr at 3:7 stocking ratio of silver carp to bighead carp at stocking density of 10 fingerlings/ m^3 in Phewa Lake at Khapuadi in the year 2010 (Husen et al., 2012b). The fish production from cage was 4.0kg/m^3 / yr. during early year into Kulekhani reservoir. Later the production from cage decreased in the reservoir due to slow growth of fish. This problem of slow growth is due to the shortage of natural food, which is associated with the increased volume of cages and number of fish in the reservoir (Shrestha et al., 2012). The production of planktivorous fish in extensive cage fish farming was found decreasing from lakes and reservoirs (Prasad et. al. 2013). Cage fish farming of grass carp in monoculture feeding with aquatic macrophytes was found profitable in comparison to planktivorous fish species as it approximately doubles the fish production (Prasad et al., 2012).

At present, low productivity of fish from lakes and reservoirs in extensive cage culture (productivity≈ 1.0kg/m^3/2year) experienced by farmers of lakes and reservoirs. It is due to slow growth fish in cage culture due to change of Lake Environment and low stocking of fish. To solve the problem of low productivity, recently, cage fed aquaculture have been tested in Kulekhani reservoir and Begnas Lake. The results showed that feeding with 20% CP feed, fish yield was significantly higher in supplementary feeding (1.25 kg/m^3/year) in comparison to without feeding (0.89kg/m^3/year) in Kulekhani reservoir in 2016 (Prasad et al., 2017). Likewise, in Begnas Lake, fish yield of supplementary feeding was higher (0.75±0.1 to 0.92±0.1 kg /m^3/year) of cage volume in comparison to without feeding (0.33±0.1 kg /m^3/year) in 2016 (FRS, 2017).

The unavailability of large size fingerlings (20-25g) to stock cages, quality cage knitting materials over siltation, landslides, periodic heavy storm in lakes are the some constraints faced by cage fish growing

farmers. Fish fry nursing in the community nursery of fisher group will be an option for the timely stocking of cages with large size fingerlings (20-25g) in the lakes and reservoirs.

WAY FORWARD

The potential of cage fish culture in the upcoming reservoirs of hydropower and in irrigation canal is tremendous in Nepal. It is estimated that 92,400 ha of reservoir will be available for the cage fish farming in near future (Pradhan, 2009). Cage culture could be a livelihood option for displaced people due to hydropower dam construction in the country. Possibilities of cage culture in irrigation canal should be explored. Cage culture should be extended other potential lakes of Nepal.

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