Introduction

Contribution of indigenous fish in total production is declining worldwide as most fresh and marine fishes have been over fished (FAO 2008). Previously, many such over fished waters were introduced with non-native fish for providing immediate reliance to fishers through enhancing capture fisheries; and protection of native fish being over exploitation by diverting fisher to non-indigenous species. Details of scientific review might need either those strategies could be fruitful or not. However, recently, more focus has been given to develop the technologies of native fish species for enhancing their fishery and aquaculture from biodiversity perspectives. Knowledge and information on native species from the present perspective has seldom been synthesized and analyzed. Therefore, it is essential to collect the scattered data and prioritize the strategies for sustainable technological generation of these species in the country. The current proposal for organizing a workshop on such a crucial subject would be highly fruitful to give the direction of future research in development of fisheries and aquaculture technologies prioritizing values of indigenous fishes and re-positioning the fisheries and aquaculture to more rewarding, environment friendly, socially acceptable and economically profitable activity.

The overall objective of the workshop is aquaculture development of native fish species for biodiversity and aquaculture practices. The symposium would attract the scientific attention on review, cross interaction, situation analysis, planning focused research, intervention program to make fisheries and aquaculture technology of indigenous fishes more competitive and advantageous. To address these issues, technical sessions are planned in following major themes:

A. Conservation measures, environmental issues, conservation act, problems and future direction for conservation.
B. Domestication and possibilities of cultivation of native fish species.
C. Indigenous fishes, their biology, reproduction and future scope of cultivable native fish species.
D. Status of breeding, fry rearing and nursery management.

Program Highlight and Objective of the Workshop

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''स्वदेशी माछा र जीविकोपार्जन'' कार्यशाला गोष्ठीका आदरणीय अध्यक्ष महोदय, आमन्त्रित अतिथि ज्यु, निर्देशकज्युहरु, प्रमुखज्यु, वैज्ञानिक मित्र, जिल्लाबाट पाल्नु भएका मत्स्य पेशामा संलग्न दाजु भाई दिदी बहिनी, पत्रकार, आदरणीय प्राचार्य महोदय, प्रतिनिधिज्यू, सभामा उपस्थित सम्पूर्ण सहभागी मित्रहरुलाई पुन: एक पटक आजका यस कार्यक्रममा आफ्ना अमुल्य समय प्रदान गरी यस कार्यक्रममा सक्रिय सहभागी हुनु भएकोमा आभार प्रकट गर्दछु ।

आजका यस कार्यक्रमको आयोजना बारे भन्नु पर्दा, मत्स्य अनुसन्धान महाशाखा मत्स्य विकास निर्देशनालय, नेपाल मत्स्य सोसाईटीको संयुक्त प्रयासमा देशका कृषि अनुसन्धान र विकासको राष्ट्रीय नीति र कार्यक्रम अनुसार स्वदेशी माछाको संरक्षण, कषि जैबिक बिविधता र विकासलाई बढावा दिन चालु त्रिबर्षीय योजनामा कार्यक्रम भए अनुरुप आज विश्व वातावरण दिवसका अवुसरमा यो कार्यक्रम आयोजना भएको हो । यस कार्यक्रममा हामी कृषि नीति र कार्यक्रम अनुसार मत्स्य अनुसन्धान केन्द्र पोखरा, गोदावरी, त्रिशुली, कालीगण्डकी र विकास केन्द्रमा संचालन गरिएका स्वदेशी माछाहरुको अध्ययन अनुसन्धान र विकासका उपलब्धि, बिधमान संकट, र समस्या, बढदो स्थानीय माछामा परेका चाप, जलचर ऐनसंबधी विषयलाई समेटर किसान, मत्स्य पेशामा संलग्न समुदाय, योजनाबिद्ध, पत्रकार, वैज्ञानिक एवं विकास कार्यमा संलग्न कार्यकर्ताहरु एउटै थलोमा एकत्रित भई बिवेचना र समस्याको सैद्धान्तिक निराकरण गर्ने जमर्को गर्ने छौ । स्वदेशी माछाको विकास एवं सम्बर्धनमा बिद्यमान समस्याहरुको विबेचना गर्ने यो सामुहिक औपचारिक प्रयास देशमा पहिलो हो । यस्ता प्रयासले हाम्रा आगामी दिनहरुको नीति र कार्यक्रम तर्जुमा गर्न मद्धत पुऱ्याउने छ भनी आशा गर्न सकिन्छ । तर, यस तर्फ उल्लेखनीय प्रगतिका लागि संयुक्त प्रतिबद्धताको आवश्यकता रहको छ ।

मुलुकका समनवयात्मक आर्थिक, प्राविधिक, सामाजिक र वातावरणीय विकास कसरी होला भन्ने बिषय नै देशको प्रमुख आवश्यकता रहेको छ । एक पक्षीय प्रयासले कही तात्कालिक फाईदा त हुन सक्छ तर अन्य पक्षको अवहेलना हुने सम्भावना रही नै रहन्छ । जुन कदापी सही कदम नहुने कुरा सर्वबिदितै छ । तसर्थ बिजुली र सिंचाईको लागि कार्य गर्दा माछाको संरक्षण र विकास तर्फ बिवेक पुऱ्याउनु टड्कारो रहेको ब्यहोरा अनुरोध छ । किन भने नेपालमा पौराणिक काल देखिनै माछाको पेशा अंगालेका समुदाय हरुको अस्तित्व रहेको छ । पानीबाट माछाको विनास भन्नु पौराणिक काल देखिनै माछाको पेशा अंगालेका समुदायहरुलाई भोका र नांगा तुल्याउनु हो । जस्ले गर्दा हाम्रो मुलुकमा सधैं द्वन्द बिद्यमान रही रहने अवस्था सृजना गर्नु कदापी हाम्रो विकासका प्रयासको प्रतिफल हुन सक्दैन भन्ने मान्यता बुझ्नु पर्ने आवश्यकता हो ।

नेपालमा समुन्द्रको अस्तित्व नभए पनि यो मुलुक पानी नै पानी भएको मुलुक हो भन्नुमा अतिशयोक्ति नहोला । तर, आज पानीको आवश्यकता खाने पानी, बिद्युत, सिंचाईकोसाथै अन्य विभिन्न प्रयोजनका लागि टडकारो छ । जुन आफनो ठाउंमा छदैंछ । पानी नै पानी भएको मुलुकमा माछाको

प्रचुरता हुनु पनि कुनै खास नौलो विषय होईन । तर, यतिका माछाका प्रजातिको उपस्थिति हाम्रो पानीहरुमा रहेता पनि विभिन्न कारणले गर्दा यी माछाका संख्या र प्रजाति न्युन हुदै गएको, जैविकी, ब्यबहार, प्रजनन र माछा र मानिस बीचको अन्तरसम्बन्ध अझै पनि धेरै नौलो विषयनै रहेको छ । तर, आस लाग्दो विषय चाहिँ, यति धरै माछाका प्रजाति मध्ये एउटै माछाका मात्रै पनि मत्स्य पालनका प्रविविका बिकास हुन सके, त्यसैबाट मात्र धैरे किसानको मुहार फेर्न सक्नेमा आश्वस्त हुन सक्ने ठाउँ रहेको अनुरोध गर्न चाहन्छु ।

यिनै समसामयिक समस्यामा आधारित रही आज यहाँ पाँचगोटा कार्यपत्र प्रस्तुत गरिने छ । तत्पश्चात आज उपस्थित सम्पूर्ण सहभागी मित्रको सहयोगले हाम्रा स्वदेशी माछाको संरक्षण र विकास कसरी गर्न सकिन्छ भनी दुई भागमा विभक्त भई Brain Storming.गर्ने छौ । र नतिजाको रुपमा ती दुबै समुहबाट प्रस्तुत गरिने सुझावहरुलाई आगामी दिनहरुमा कार्यान्वयन गरिने नीति र कार्यक्रमको स्वरुप प्रदान गरी आजको यो कार्यक्रम टुंगिंने आशाका साथ कार्यक्रम प्रायोजन गरिएको हो । आशा छ, आज दिन सम्पूर्ण सहभागी हरुले आफ्नो अमूल्य ज्ञान हामीलाई प्रदान गरी यस प्रयासलाई सफल तुल्याई दिनु हुने छ । यिनै अनुरोधका साथ मेरो आफ्नो मन्तब्य र कार्यक्रममा प्रकाश पार्ने मेरो क्रम यही अन्त गर्दछु ।

Fish Diversity of Nepal and Potentiality of Indigenous Fishes for Future Development of Aquaculture

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ABSTRACT

Nepal has large network of mighty rivers and tributaries and several criss-crossing channels, offering immense scope for expanding aquaculture in this country. More than 200 species of fishes live and breed in this country. Habitat alterations continue to have major impart on the distribution, abundance of fishes in large rivers of Nepal Himalayas. The fishes of upper Ganges river system in Nepalese territory are perhaps least studied and poorest known natural resources. In Himalayan large rivers (Gandaki, Koshi, Karnali and Mahakali) where peoplelived, fished and settled, the natural fish habitat has been modified by man for centuries. High dams and barrages have drastically altered fish habitat and communities and blocked seasonal movement of pristine migratory fishes such as *Tor tor, Schizothorax richardsoni, Anguilla bengalensis, Bagarius bagarius* and *Clupisoma garua* etc. Reservoirs created beyond the dam provide aquaculture opportunity as well as sport fishing and other recreational opportunities. Aquaculture development problems connected with indigenous food and game fishes are carefully reviewed. Development of recreational fishing in the reservoirs is highlighted. Biotechnological innovation for Indigenous fish propagation in lakes and reservoirs and establishment of more fish hatcheries and ranching centres are suggested as means to revive economically valuable fisheries and preserve them for future.

Keywords**:** Hydropower, game fish, recreational fisheries, fish hatcheries, reservoir fisheries, fish propagation.

Introduction

Fishes of Himalaya and Indo-Gangetic plain were studied by various ichthyologists in the past (Hora 1937, 1939, Menon 1974, Bhatt and Shrestha 1973, Shrestha 1979, 1990, Shrestha,1994, Talwar and Jhingran, 1991). Shrestha (1990b) gave an account and habitats of ecology of studied rare fishes of the Himalayan waters.

The Nepal Himalayas are well known for their running and standing waters supporting more than 200 species of fish are described from the Himalayan drainage system of Nepal (Shrestha 1995). High diversity fishes in the rivers of Nepal calls for concerted efforts to preserve them for posterity. The lotic water mass of the Himalayan region comprises many torrential rivers and streams, which provide a wide variety of ecological niches for important fresh water fishes. However, the effects of land use on fresh water systems are growing. In the Nepalese rivers, the ecological studies of these water bodies have started only recently. The rivers of Himalayan region differ from the other rivers in carrying much larger sediment loads and having more frequent floods. The present paper deals with important indigenous fresh water fishes of major rivers and lakes of Nepal with reference to biodiversity and aquacultural development.

Nepal falls in between two major zoo-geographic regions the palearctic in the north and oriental to south with an interdigreation of these faunal elements throughout the country. Basically the fish fauna of upland head waters is Palaeartic, while midland strictly Indo-Chinese (sub-region of oriental) and lowland Nepal is that of Indian (sub-region of oriental).

Physiochemical parameters of rivers of Nepal in relation to indigenous fish species diversity

The major river systems of Nepal consist of Koshi in east, Gandaki in the central and Mahakali and Karnali in western part of the country (Figure 1). These rivers support diverse kind of fish species having food esthetic and recreational value.

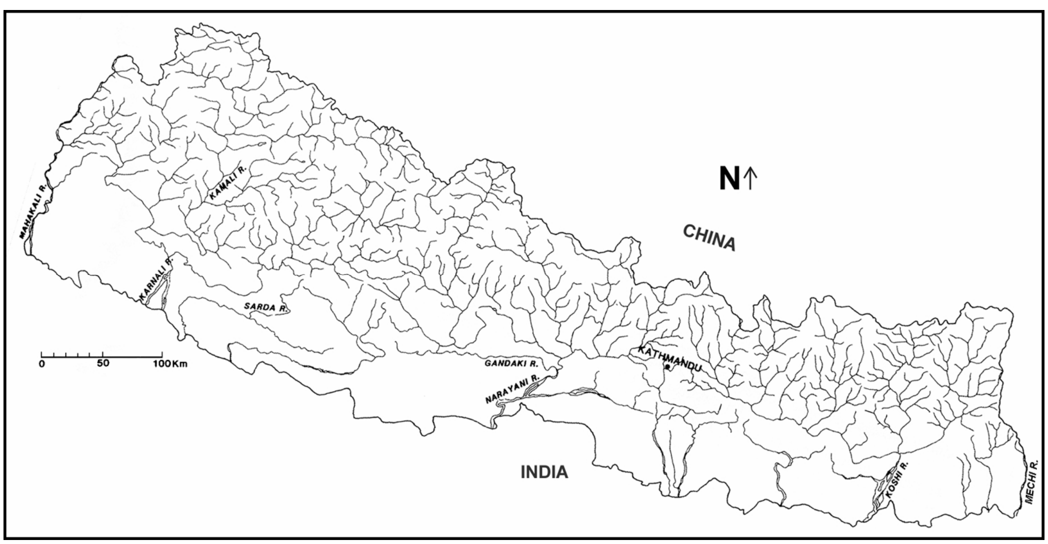

Figure 1. Map of Nepal showing river systems

1. Mahakali River (Sharda Rivers)

It is a perennial, torrential river at its upper headwater. This river originates from Milan glacier near Indian territory. The river bed is rocky and sandy with poor algal growth. The average depth at selected sites ranges from 5.0-13.0 m. The pH ranges from 6.5 to 7.8, water temperature from 20.0 to 31.8 ^oC, DO from 5.5 to 15.2 $mg.L^{-1}$. The water is clear throughout the year except the rainy season. Many small-scale water mills, industries and power-stations are situated near the lowland catchment area with a few pollutants naturally coming into the river. The Sarada and Tanakpur barrage is located in the lower reaches of Mahakali River near Indo-Nepal border. The Mahakali River harbours a variety of fishes comprising 69 species (Shrestha 1990a).

2. Karnali River

The Karnali River is a perennial, torrential, turbulent and undisturbed river of the Himalayas. It originates from Mansarovar and Rakas Lake and receives many snow fed rivers such as Mugu Karnali and Humla Karnali. It makes a spectacular gorge near Chisapani which contains diverse kinds of trans-Himalayan and sub-Himalayan fish species of Indo-Chinese affinities. The bottom of the Karnali River is mostly boulder-strewn at its upper reaches and sandy at its lower reaches and the river water is clean except in rainy season. Its depth ranges from 3-10m but in deep gorges depth varies from 50-100m. DO varies from 7.0-13.8ppm, water temperature from 22.8-31.5^oC and pH from 7.0-8.5. This river carries a high sediment load. The upland watershed of this river is sparsely populated with fish and has least human interference in its aquatic system. The river is very rich in fish fauna, comprising more than 74 species of fish (Shrestha, 1990a). The Kailashpuri and Girjapuri barrage erected at Indian border provide threat to fish migration in Nepal.

3. Koshi River

It is Perennial River arising from Pei-ko-Tso and Tso-Nu-Che lakes of Tibet. It has as many as seven tributaries such as Sun Koshi, Dudh Koshi, Tama Koshi, Likhu, Arun, Tamur and Indrawati. The Koshi River harbors 108 species of fish (Shrestha 1990a). The bottom of the river is gravelly sandy with some rocks and boulders in certain places. The algal growth and aquatic weeds in downstream regions of the river are fairly high. One of the feeder stream Arun supports the largest concentration of game and rare ornamental fish species than any other river in Nepal. The pH of the Koshi River at lower reaches varies from 6.0 to 7.5, water temperature 13 to 28.5 ^oC, DO from 6.0 to 12 $mg.L^{-1}$ during March and April. The Koshi barrage provides threat to fish migration because there is no fish ladder to facilitate fish migration.

4. Narayani River

This perennial and torrential river originates from the southern slope of Himalayas. It has seven tributaries such as Kali Gandaki, Budi Gandaki, Trisuli, Marsyangdi, Madi and Seti rivers. The pH ranges from 6.7 to 7.5, water temperature from 18.0 to 28.5 ^oC, DO from 7.8 to 13.8 $mg.L^{-1}$, during March to April. The river water now contains high pollution load added by household garbage, sewage, water materials and biocides from paper mills and beer factories. The fish mortality has been observed in the month of each year in the month of June. The algal growth and aquatic weeds at certain places are luxuriant, possibly owing to slow current. The river is very rich in fish fauna has recorded 102 species of the fish from the Narayani River. The Gandak barrages have disrupted fish migration in this river.

The river wise investigation by the present author extending from 1990-2007 found that Koshi river supporting biologically diverse fishes and highly potential for indigenous fisheries development.

Potential fish stock composition and in Rivers and Lakes

The fish diversity in the large rivers of Nepal is given in the Table 1. Dominance of cyprinids particularly Schizothoracids was clearly expressed in glacier fed and snow-fed rivers of upper reaches. In rainfed hill-streams and snow fed river of middle reaches mixed groups of cyprinids, particularly Cyprinidae, Balitoridae, Cobitidae, Ophiocephalidae, Anguellidae, Sisoridae and Amblycepidae are dominants. Many slim bodied cyprinids such as riverine major carps Mahseer (*Tor tor, Tor putitora*), Copper mahseer (*Neolissochilus hexagonolepis*) and Rhou (*Labeo angra, L. dero*) occur in transitional zone between lower reaches and middle reaches of rivers of Nepal. Cyprinid particularly deep bodied and heavy forms occupying main channel of river in lower reaches. In all lowland river minnows (*Barilius*), knife fish (*Notopterus*), perches (*Anabas*), stone eels (*Macrognathus*), mud eel (*Monopterus*), mosquito fish (*Gambusia*), glass perches (*Chanda*) are much more important elements of river in lowland. In swamp, marshes and oxbows weedy area or mud perches and snakeheads are dominant there.

Present status of fish production and domestication potential in Lakes and Reservoir

In Nepal there are about 6,500 ha of pondage area about (0.8% of total water surface area) of the country. If aquaculture is well managed, it will have the capacity of 20,000 MT production (DoFD, 2061/72). The water resource of lakes is estimated to be 5,000 ha (0.6%) of the water resources in the country. Only about 1,000 ha, water mass of the lakes of Pokhara valley in midhill region are under multipurpose aquaculture uses. Pokhara's Phewa Lake is used for electricity power generation, irrigation and aquaculture as well as recreation for tourists. The nearby lakes Begnas and Rupa are also used for irrigation, aquaculture and recreation. In these lakes, aquaculture mainly involves cage fish culture and open water fish stocking. More than 300 family members are engaged in about 23,700 m³ of fish cage aquaculture in these three lakes, producing 100 MT of fish per year. The people are basically fishers by profession, and are poor and landless or have very low income and land holdings. In Pokhara valley the major role in cage fish culture is played by fisher women, which therefore benefit the community. The three lakes of Pokhara valley are good examples of the multipurpose use of water mass for aquaculture, including cage fish and open water fish stocking and penculture. There is an excellent possibility of domestication of selected indigenous fish stocks.

Table 1. Biodiversity of fishes of Nepal with reference to status and stock composition (Fishes of the Himalayan waters, showing preferred habitat and distribution in Nepal. Fish species that are colourful fish throughout life history (CL), colourful during early life history only (EL), preserved in temple ponds for religious purpose (TP), used in ethnomedicine (EM), gamefish for recreation and angling fit for large aquaria and river park (GF), fishes used by Buddhist monks for propagation in ponds in monasteries (BM), exotic species (*), common species (C), rare species needing conservation (R). Pristine rare ornamental species of Himalayan drainage (PR) are species needing strict conservation and management in recreational ponds and large sized public aquaria and exhibits).

Systematic Order/Length in cm ENGLISH NAME\LOCAL NAME	Distribution and Status	Remark
Order – Anguilliformes **Family – Anguillidae**		
1. *Anguilla bengalensis bengalensis* (Gray) L=80-200, LONGFIN FRESHWATER EEL, INDIAN MOTTLED EEL \ RAJ BAM, REM	Koshi, Gandaki, Trisuli Karnali, Mahakali	TP, PR
Order – Clupeiformes **Family – Clupeidae**		
Subfamily – Alosinae		
2. *Gudusia chapra* (Hamilton-Buchanan) L=15 RIVER SHAD \ SUIYA	Bagmati, Koshi, Gandaki, Karnali, Mahakali, Terai rivers, lakes	C
3. *Gudusia variegata* (Day) L=16 BURMESE RIVER SHAD, VARIEGATED HERRING \ SUIYA	Bagmati river (Terai)	C
Family – Engraulididae		
4. *Setipinna phasa* (Hamilton-Buchanan) L=28 GANGETIC HAIRFIN ANCHOVY \ GANKABAU, PHASI	Koshi	C
Order – Osteoglossiformes		
Suborder – Notopteroides		
Family – Notopteridae		
5. *Chitala chitala* (Hamilton-Buchanan) L=26-122 HUMPED FEATHERBACK \ MOI, PATARA, VUNA	Gandaki, Karnali, Mahakali	C
6. *Notopterus notopterus* (Pallas) L=25-60 GREY FEATHERBACK \ LEPSI, GOLHAI	Gandaki, Koshi, Karnali, Mahakali	C

Order – Cypriniformes			
Family – Cyprinidae			
7.	*Carassius auratus* (Linnaeus) L= 30 GOLDFISH, GOLDCARP	Garden ponds	*
8.	*Carassius carassius* (Linnaeus) L=20 CRUCIAN CARP	Garden ponds	*
Subfamily – Cyprininae			
9.	*Catla catla* (Hamilton-Buchanan) L=65-120 CATLA \ VAKUR	Koshi,Narayani, Karnali, Mahakali Introduced in 1947	***C**
10.	*Chagunius chagunio* (Hamilton-Buchanan) L=20-50 CHAGUNI \ CHAGUNI, PATHARCHATTI	Bagmati, Trisuli, Gandaki, Phewa, Begnas, Bheri, Karnali, Mahakali	**R**
11.	*Cirrhinus mrigala mrigala* (Hamilton-Buchanan) L=90 MRIGALA \ MRIGAL, NAINI	Throughout Terai.Introduced in 1947	***C**
12.	*Cirrhinus reba* (Hamilton-Buchanan) *Labeo ariza* L=30 REBA CARP \ MRIGAL, STRIPED CARP	Koshi, Bagmati, Gandaki, Karnali, Mahakali midland Nepal	**C**
13.	*Ctenopharyngodon idellus* (Valenciennes) L=90 GRASS CARP \ GHASE MACHA	Introduced between 1965-1968	*
14.	*Cyclocheilichthys apogon* (Valenciennes) L=10-18	Gandaki, Koshi	*Introduced in 1966
15.	*Cyprinon semiplotus* (McClelland) L=60 ASSAMESE KINGFISH \ KHURPE, CHEPTI	Trisuli, Koshi, Karnali, Mahakali, Kaligandaki, Phewa Lake, Begnas Lake	**C**
16.	*Cyprinus carpio* (Linnaeus) *C. carpio specularis* *C. carpio communis* *L=50 COMMON CARP*	Introduced in 1955-1958	*
17.	*Labeo angra* (Hamilton-Buchanan) L=70 ANGRA LABEO \ THED	Koshi, Gandaki, Karnali and Mahakali	**C**
18.	*Labeo bata* (Hamilton-Buchanan) L=30 BATA LABEO \ ROHU	Gandaki, Koshi, Karnali	**C**
19.	*Labeo boga* (Hamilton-Buchanan) L=30 BOGA LABEO \ BOGA TIKAULI	Gandaki, Karnali, Mahakali	**C**
20.	*Labeo caeruleus* Day L=30 SIND LABEO \ BISHARI	Gandaki, Koshi, Kamala, Karnali	**C**
21.	*Labeo calbasu* (Hamilton-Buchanan) L=90 KALBASU, BLACK ROHU \ GERDI	Koshi, Bagmati, Kamala, Gandaki, Karnali, Bheri, Mahakali	**C**
22.	*Labeo dero* (Hamilton-Buchanan) *Sinilabeo dero* L=60 KALABANS, RIVER ROHU \GURDI, BASHARI	Koshi, Gandaki, Trisuli, Bagmati, Bheri, Karnali Mahakali	**C**
23.	*Labeo dyocheilus* (McClelland) ***Labeo dero*** *L=20-90 BRAHMAPUTRA LABEO \ GARDI*	Koshi, Gandaki, Karnali, Mahakali, Bheri, Seti	**C**
24.	*Labeo fimbriatus* (Bloch) ***Labeo pangusia*** L=25-90 FINGED-LIPPED PENINSULA CARP\BOI	Koshi, Gandaki, Karnali, Mahakali	**C**
25.	*Labeo gonius* (Hamilton-Buchanan) L=100 KURIA LABEO\KARSA	Bagmati, Gandaki, (downstream Koshi)	**C**
26.	*Labeo pangusia* (Hamilton-Buchanan) L=60, PANGUSIA LABEO \ KALAACHA, TERMASSA	Koshi, Gandaki, Bagmati, Kamala, Karnali	**C**
27.	*Labeo rohita* (Hamilton-Buchanan) L=80 ROHU \ ROHU	Bagmati, Kamala, Koshi, Gandaki Introduced between 1957-1970	**C**
28.	*Neolissochilus hexagonolepis* (McClelland) L=60 KATLI \ KATLAE	Torrential waters of Gandaki, Trisuli, Koshi, Karnali, Mahakali	**GF,TP**
29.	*Oreichthys cosuatis* (Hamilton-Buchanan) L=8 COSUATIS BARB \ PATHARCHATTI	Narayani, Koshi	**Uncommon**
30.	**Schismatorhynchus nukta** (Sykes) L=30 NUKTA	Koshi, Narayani	**Uncommon**
31.	*Osteobrama cotio cotio* (Hamilton-Buchanan) L=20 COTIO \ GURDA	Koshi, Kamala, Bagmati, Gandaki, Bheri, Karnali	**C**

32.	*Osteobrama neilli* (Day) L=12 NILGIRI OSTEOBRAMA \ GURDA	Bagmati, Kamala	**C**
33.	*Puntius chola* (Hamilton-Buchanan) L=12 SWAMP BARB OR CHOLA BARB \ SIDHRE, POTHIYA	Gandaki, Koshi, Karnali	C
34.	*Puntius clavatus* (McClelland) ***Poropuntius clavatus*** L=24 STEDMAN BARB \ BADA POTHI	Koshi	**Uncommon**
35.	*Puntius conchonius* (Hamilton-Buchanan) L=9 ROSY BARB OR RED BARB \ POTHI, SIDRE	Throughout midland and lowland	C
36.	*Puntius gelius* (Hamilton-Buchanan) L=5 GOLDEN BARB, GOLDEN DWARF BARB	Koshi, Bagmati and Karnali	**Uncommon**
37.	*Puntius gonionotus* (Bleeker) *Puntius javanicus* L=33 SILVER BARB	Koshi, Bagmati, Kamala and Rapti. Exotic, introduced in 1990	*
38.	*Puntius guganio* (Hamilton-Buchanan) L=8 GLASS BARB \ TILKE POTHI	Koshi, Gandaki, Karnali	**Uncommon**
39.	*Puntius phutunio* (Hamilton-Buchanan) ***Barbodes sarana*** L=3.5 DWARF BARB, PIGMY BARB \ POTHI	Narayani, Rapti	**Uncommon**
40.	*Puntius sarana sarana* (Hamilton-Buchanan) ***Barbodes sarana*** L=40 OLIVE BARB \ THUB POTHI, KANDE, BHITTE, BADA POTHI	Mid and low land of Koshi, Gandaki, Karnali, Mahakali	**Uncommon**
41.	*Puntius sophore* (Hamilton-Buchanan) L=8 SPOTFIN SWAMP BARB \ POTHI	Mid and low land throughout Nepal	C
42.	*Puntius terio* (Hamilton-Buchanan) L=9 ONE-SPOT BARB \ POTHI	Koshi, Bagmati, Naryani, Karnali	**Uncommon**
43.	*Puntius ticto* (Hamilton-Buchanan) L=6.5 TICTO BARB, FIREFIN BARB, TWO- SPOTBARB \ TITE POTHI	Gandaki, Koshi, Trisuli, Karnali, Mahakali	**Uncommon**
44.	*Tor chelynoides* (McClelland) ***Naziritor chelynoides*** L=80 DARK MAHSEER	Trisuli, Gadaki, Karnali	**GF,TP**
45.	*Tor putitora* (Hamilton-Buchanan) L=100-250 PUTITOR MAHSEER \ PAHALE SAHAR MAHSEER, MANSAR, RATAR	Koshi, Gandaki, Trisuli, Karnali, Mahakali	**GF,PR,TP**
46.	*Tor tor* (Hamilton-Buchanan) L=90-200 TOR MAHSEER \FALAME SAHAR	Gandaki, Koshi, Trisuli, Karnali, Mahakali	**GF,PR,TP**
Subfamily – Cultrinae			
47.	*Chela cachius* (Hamilton-Buchanan) L=6 SILVER HATCHET CHELA \ CHANE	Rapti, Babai, Gandaki, Koshi, Karnali	C
48.	*Chela labuca* (Hamilton-Buchanan) L=9 GLASS-BARB, CHALWA, DEDUWA	Koshi, Kankaimai, Mechi, Gandaki, Karnali, Mahakali, Rapti, Babi, Bheri	C
49.	*Salmostoma acinaces* (Valenciennes) L=15 SILVER RAZOR BELLY MINNOW	Koshi, Narayani, Karnali, Mahakali	C
50.	**Salmostoma bacaila** (Hamilton-Buchanan) L=15 LARGE RAZORBELLY MINNOW \ CHILWA, GALPHULANI	Koshi, Gandaki, Kamala, Narayani, Tamur	C
51.	*Salmostoma phulo* (Hamilton-Buchanan) L=12 FINESCALE RAZORBELLY MINNOW	Koshi and other regions of Terai	C
52.	*Securicula gora* (Hamilton -Buchanan) L=23 GORA-CHELA \ CHILWA	Bagmati, Kamala, Koshi, Gandaki, Karnali, Mahakali	**C**
Subfamily – Leuciscinae			
53.	*Hypophthalmichthys molitrix* (Valenciennes) L=82 SILVER CARP \ CHADE MACHHA	Introduced in 1965-1968	*
54.	*Aristichthys nobilis* (Richardson) L=60 BIGHEAD CARP \ THUL TAUKE, THULO TILKE	Introduced in 1971 in Phewa, Begnas, Rupa lakes and Kulekhani reservoir	*
55.	*Amblyphryngodon microlepis* (Bleeker) L=10 INDIAN CARPLET \ MADA, DHAWAI	Karnali	**C**

56. *Amblyphryngodon mola* (Hamilton-Buchanan) L=20 MOLA CARPLET, PALE CARPLET \ MADA, DHAWAI	Koshi, Gandaki, Karnali, Mahakali, Bagmati	C
Subfamily – Rasborinae		
57. *Aspidoparia jaya* (Hamilton-Buchanan) L=15 JAYA \ BHEGNA, MARA	Gandaki, Koshi, Karnali	C
58. *Aspidoparia morar* (Hamilton-Buchanan) L=17.5 ASPIDOPARIA \ CHAKALE, KARANGI	Bagmati, Koshi, Gandaki, Karnali, Mahakali	C
59. *Barilius barila* (Hamilton-Buchanan) L=10 BARRED BARIL \ FAKETA CHAHALE	Bagmati, Kamala, Narayani, Karnali C,CL	
60. *Barilius barna* (Hamilton-Buchanan) L=10 BARNA BARIL \ PATI PATTAURE, TITERKANE FAKETA	Kamala, Bagmati, Koahi, Gandaki, Karnali, Mahakali	**C**
61. *Barilius bendelisis* (Hamilton-Buchanan) L=15 HAMILTON'S BARILA \ CHIPLE FAKETA,GURDERE	Koshi, Gandaki, Bagmati, Bheri, Karnali, Mahakali,Trisuli	**C**
62. *Barilus radiolatus* (Gunther) L=5.5 GUNTHER'S BARIL	Babai	**R**
63. *Barilius shacra* (Hamilton-Buchanan) L=14 SHACRA BARIL \ FAKETE	Bagmati, Kamala, Narayani, Koshi, Trisuli	**Uncommon, CL**
64. *Barilius tileo* (Hamilton-Buchanan) L=15 TILEO BARIL \ FAKETA	Bagmati, Koshi, Gandaki	**Uncommon**
65. *Barilius vagra* (Hamilton-Buchanan) L=12.5 VAGRA BARIL \ LAM FAKETA	Gandaki, Koshi, Karnali, Trisuli, Mahakali	**Uncommon**
66. *Bengala elanga* (Hamilton-Buchanan) L=15 BENGALA BARB \ DEDHAURA	Bagmati, Kamala, Koshi, Gandaki, Karnali and Mahakali	**C,CL**
67. *Brachydanio rerio* (Hamilton-Buchanan) ***Danio rerio*** L=4 ZEBRA DANIO, ZEBRA FISH \ CHITHARIPOTHI	Bagmati, Koshi, Karnali and Terai region	**C,CL**
68. *Danio aequipinnatus* (McClelland) L=15 GIANT DANIO \ CHITHARIPOTHI	Gandaki, Koshi, Karnali, Mahakali, Pokhara valley, Chitwan	**CL,PR**
69. *Danio dangila* (Hamilton-Buchanan) L=15 DANGILA DANIO \ POTHI	Andhi, Chabdi, Buldi Khola, Madi river, Karnali, Kamala, Koshi	**C**
70. *Danio devario* (Hamilton-Buchanan) *Devario devario* *L=10 DEVARIO DANIO \ CHITHARIPOTHI, BHITTI*	Bagmati, Gandaki, Koshi, Karnali, Mahakali	**C,CL**
71. *Esomus danricus* (Hamilton-Buchanan) L=12.5 FLYING BARB \ DEDHAWA	Bagmati, Koshi Gandaki, Karnali, Mahakali	**C,CL**
72. *Parluciosoma daniconius* (Hamilton-Buchanan) L=10 BLACKLINE RASBORA \ DEDHAURA	Bagmati, Kamala, Koshi, Gandaki,Karnali, Mahakali	**C**
73. *Raiamas bola* (Hamilton-Buchanan) L=30 TROUT \ GOHA, CHIPLAE FAKETA	Koshi, Kaligandaki, Narayani, Krnali, Behri, Seti, Mahakali	**CL,PR**
74. *Riamas guttatus* (Day) L=17.5 BURMESE TROUT, BLOTCHED MINNOW \ SUIREE FAKETO	Bagmati, Koshi, Karnali, Narayani, Babai	**CL**
Subfamily- Schizothoracinae		
75. *Diptychus maculatus* (Steindachner) L=35 TIBETAN SNOWTROUT	Bagmati, Koshi, Karnali	**PR**
76. *Schizopyge esocinus* (Heckel)Schizothoraichthys esocinus L= 20 CHIRRUH SNOWTROUT	Lake Rara.	**R**
77. *Schizothoraichthys* curvifrons (Heckel) L= 40 SNOWTROUT	Kaligandaki river Uncommon	
78. *Schizothoraichthys labiatus* (McClelland) Rara lake ***Racoma progasta*** L=13.5 NEPALESE SNOWTROUT	Upper reaches of Koshi, Gandaki, Karnali and Mahakali feeder streams	**PR, BM**
79. *Schizothoraichthys macrophthalmus* (Tarashima) ***Racoma progasta*** L=13.5 NEPALESE SNOWTROUT	Rara lake **PR, BM** Endemic to Lake Rara	
80. *Schizothoraichthys niger* (Heckel) *Schizothorax niger* L= 30 SNOWTROUT	Rara lake, Trisuli river	**Declining**

81. *Schizothoraichthys progastus* (McClelland) ***Racoma progasta*** L=50 POINTNOSED SNOWTROUT \ CHUCHE ASLA	Sunkoshi, Trisuli, Gandaki, Chamelia, Behri, Rapti, Naryani, Karnali, Mahakali **C**
82. *Schizothorax molesworthi* (Chaudhuri) L=21 BLUNTNOSED SNOWTROUT \ASLA	Kaligandaki, Chameli, Khimti, Sunkoshi, Arun and Tamur **Declining**
83. *Schizothorax plagiostomus* (Heckel) L=32 GOLDEN SNOWTROUT, SPOTTED	Roshi, Bhotekoshi, Khimti, Trisuli, Gandaki, Koshi, Karnali **Declining**
84. *Schizothorax nepalensis* (Tarashima) L=24.5 ASLA SNOWTROUT \ SUN ASLA	Rara Lake **PR** Endemic to Lake Rara
85. *Schizothorax rarensis* (Tarashima) L=24.5 RARA SNOWTROUT \ RARA ASLA	Rara Lake **PR** Endemic to Lake Rara
86. *Schizothorax richardsonii* (Gray) ***Oreinus richardsoni*** L=60 BLUNTNOSED SNOWTROUT\BUCHE ASLA, BUDHE ASLA	Trisuli, Gandaki, Koshi, Karnali, Mahakali **Declining**
Subfamily- Garrinae	
87. *Crossocheilus latius latius* (Hamilton-Buchanan) L=12.5 GANGETIC LAITA, STONE ROLLER \ LOHARI, MATE BUDUNA	Midland Nepal, Koshi, Gandaki, Karnali, Mahakali, Trisuli **C**
88. *Garra annandalei* (Hora) L=15 ANNANDALE GARRA \ LAHARE BUDUNA	Koshi, Gandaki, Karnali, Mahakali, Trisuli **Uncommon**
89. *Garra gotyla gotyla* (Gray) L=15 STONE SUCKER \ BUDUNA, DHUMKE BUDUNA	Hill streams of Bagmati, Koshi, Gandaki, Karnali, Mahakali **C**
90. *Garra lamta* (Hamilton-Buchanan) L=15 LAMTA GARRA, STONE SUCKER \ MATE BUDUNA, PATTHER CHATTI	Roshi, Kamala, Bagmati, Bhotekoshi **C**
91. *Garra mullya* (Sykes) L=15 MYULLYA GARRA, SUCKER FISH \ MATE BUDUNA, KHURPE BUDUNA	Trisuli, Kaligandaki, Myagdi, Chamelis, Koshi, Kamala, Bagmati **C**
92. *Garra rupecula* (McCelland) L=6.5 \ BUDUNA	Melamchi, Tamakoshi, Dudhkoshi, Sunkoshi, Trisuli **C**
Family- Psilorhynchidae	
93. Psilorhynchus balitora (Hamilton-Buchanan) *L=12 BALITORA MINNOW*	Kaligandaki, Rapti, Khimti, Arun, Tamur, Narayani, Trisuli **CL,PR**
94. Psilorhynchus gracilis (Rainboth) *L= 12 RAINBOTH MINNOW*	Mechi, Kankai, Kaligandaki, Narayani, Koshi
95. *Psilorhynchus homaloptera* (Hora and Mukerji) *Psilorhynchoids homaloptera* L=8 TORRENT STONE CARP, HOMALOPTERA MINNOW \ PATHARCHATI	Koshi, Tamakoshi, Narayani **EL, PR**
96. *Psilorhynchus pseudecheneis* (Menon & Datta) L=15 NEPALESE MINNOW, STONE CARP \ TITAE, RAIGADELO	Sunkoshi, Dudhkoshi, Tadi, Koshi, Gandaki, Karnali **CL,PR**
97. *Psilorhynchus sucatio* (Hamilton-Buchanan) L=15 SUCATIO MINNOW \ TITAE	Gandaki,Koshi, Kamala, Rapti, Narayani, Karnali, Mahakali **CL,PR**
Family- Balitoridae	
Subfamily- Balitorinae	
98. Balitora brucei (Gray) L=10.5 GRAY'S STONE LOACH \ PATHERTATA	Kaligandaki, Madi, Seti, Koshi, Gandaki, Karnali, Mahakali, Trisuli **CL,PR**
99. Homaloptera bilineata (Blyth) L=4 BURMESE LOACH \ PATHERCHATTI	Kaligandaki, Trisuli **CL,PR**
Subfamily – Nemacheilinae	
100. Acanthocobotis botia (Hamilton-Buchanan) *Nemacheilus botia* *L=8 \ PATE GADELA \ BAGHE*	Koshi, Gandaki, Karnali, Mahakali, Trisuli, Bagmati, Kamala, Narayani **CL**
101. *Nemacheilus corica* (Hamilton-Buchanan) L=4.2 STONE LOACH\ RAIGADERO	Bagmati,Kamala, Indrayani, Trisuli, Gandaki, Koshi, Karnali **CL**
102. *Schistura beavani* (Gunther) *Nemacheilus beavani* L=8 \ DHARKEE GADERO	Roshi, Bagmati, Sunkoshi, Melamchi, Arun, Trisuli, Gandaki, Karnali, Mahakali **CL,PR**

103. *Schistura horai* (Menon) *Nemacheilus horai* *L=4.8 \ GADELA*	Arun, Tamur, Bhotekoshi, Gandaki	**CL**
104. *Schistura rupecula* (McClelland) *Nemacheilus rupecula* L=8 \ BHOTEE GADELO	Bagmati, Kamala, Koshi, Gandaki, Narayani, Trisuli, Bheri	**CL,PR**
105. *Schistura savona* (Hamilton-Buchanan) *Nemacheilus savona* L=3 RING LOACH \ GADELA	Hill stream of Mechi, Koshi, Gandaki, Chemalia, Karnali	**Uncommon**
106. *Schistura scaturigina* (McClelland) *Nemacheilus scaturigina* L=10 \ GADELA	Hill stream of Bagmati and Koshi	**Uncommon**
Family – Cobitidae		
Subfamily – Cobitinae		
107. *Lepidocephalus guntea* (Hamilton-Buchanan) L=8 GUNTEA LOACH \ LATA, KANDE GAINCHE	Koshi, Gandaki, Karnali, Mahakali Uncommon,	**Uncommon,CL**
108. *Lepidocephalichthys menoni* (Pillai and Yazdani) L=5.2	Koshi	**Uncommon,CL**
109. *Neoeucirrhichthys maydelli* (Banarescu and Nalbant) L=3.6 GOLPARA LOACH	Mechi, Koshi and Chudar	
110. *Pangio pangia* (Hamilton-Buchanan) L=6.5 PANGIA COOLIE-LOACH	Kaligandaki, Koshi	**Uncommon**
111. *Somileptes gongota* (Hamilton-Buchanan) L=10 SPINDLE LOACH, GONGOTA LOACH \ LATAI, BALUWARI, GOIRA	Koshi, Gandaki,Karnali, Mahakali, Rapti	**C,CL**
Subfamily – Botiinae		
112. *Botia almorhae* (Gray) L=15 ALMORHA LOACH \ BAGHI, BAGHUWA	Sunkoshi, Khimti, Jimruk, Gandaki, Rapti, Babai, Chamelia, Karnali, Mahakali	**CL,PR**
113. *Botia dario* (Hamilton-Buchanan) L=9 NECKTIE LOACH, STRIPED STONE LOACH \ BOTHN	Arun, Sunkoshi, gandaki, Koshi, Karnali	**CL,PR**
114. *Botia geto* (Hamilton-Buchanan) L=12 BOTHN, RETICULATE LOACH	Seti River Damouli, Koshi	**CL,PR**
115. *Botia lohachata* (Chaudhuri) L=11 Y-LOACH, TIGER LOACH \ BAGHI, GETU	Kamala, Bagmati, Sunkoshi, Koshi, Trisuli Gandaki, Narayani, Karnali, Mahakali	**Uncommon,CL**
116. *Botia histrionica* (Blyth) L= 5 LOACH	Koshi	**R**
Order – Siluriformes		
Family – Bagridae		
117. *Aorichthys aor* (Hamilton-Buchanan) *Sperata aor* L=100-180 LONG-WHISKERED CATFISH \ KANTI	Koshi, Gandaki, Bagmati, Karnali	**C**
118. *Aorichthys seenghala* (Sykes) *Sperata seenghala* L=40-150 GIANT RIVER-CATFISH, TENGARA, SEENGHARI \ TENGER	Koshi, Gandaki, Karnali, Mahakali, Bagmati	**C**
119. *Batasio batasio* (Hamilton-Buchanan) L=10 TISTA BATASIO \ BATASIO	Gandaki, Koshi, Karnali	**C**
120. *Batasio macronotus* (Ng and Edds) L=10 BATASIO	Koshi and Trijuga	**C**
121. *Mystus bleekeri* (Day) L=10 DAY'S MYSTUS \ TENGER	Kamala, Koshi, Narayani, Karnali	**C**
122. *Mystus cavasius* (Hamilton-Buchanan) L=30 GANGETIC MYSTUS \ TENGER	Koshi, Gandaki, Mahakali, Bagmati	**C**
123. *Mystus gulio* (Sykes) L=40 LONG-WISKERED CATFISH	Koshi	**Uncommon**
124. *Mystus menoda* (Hamilton-Buchanan) *Hemibagrus menoda* L=45 MENODA CATFISH \ BELAUNI	Narayani, Bagmati, Koshi, Gandaki, Karnali, Mahakali	**C**

125. *Mystus tengara* (Hamilton-Buchanan) L=15 TENGARA MYSTUS \ TENGER	Koshi, Bagmati, Kamala, Narayani, Karnali **C,CL**
126. Mystus vittatus (Bloch) L=17 STRIPED DWARF CATFISH \ TERNGER KANTI	Koshi, Narayani, Seti, Karnali, Bheri, Mahakali **C,CL**
127. *Rita rita* (Hamilton-Buchanan) L=150 RITA \ BELAUNDA	Bheri, Kamala, Koshi, Gandaki, Karnali, Mygdi, Kathe Khola **C,CL,PR**
Family- Siluridae	
128. *Ompok bimaculatus* (Bloch) L=40 BUTTER-CATFISH \ PAPTA	Koshi, Bagmati, Gandaki, Karnali, Mahakali **C**
129. *Ompok pabda* (Hamilton-Buchanan) L=17 PABDAH CATFISH	Gandaki, Koshi, Karnali Uncommon
130. *Wallago attu* (Schneider) L=200 BOAL \ BOHARI	Koshi, Gandaki, Karnali, Mahakali **C**
Family – Schilbeidae	
Subfamily – Ailiinae	
131. *Ailia coila* (Hamilton-Buchanan) L=15-20 GANGETIC AILIA \ PATSI	Sunkoshi, Koshi, Gandaki, Karnali, Bheri Mahakali Terai midland **C**
Subfamily – Schilbeinae	
132. *Clupisoma garua* (Hamilton-Buchanan) L=70 GARUA BACHCHA, GUARCHCHA \ JALKAPOOR, BAIKHA	Tamur, Arun, Koshi, Gandaki, Karnali, Beri Mahakali **Uncommon**
133. *Clupisoma montana* (Hora) L=25 KOCHA GARUA \ JALKAPOOR	Koshi, Arun, Tamur **Uncommon**
134. *Eutropiichthys goongware* (Sykes) L=30 GOONGWAREE VACHA	Koshi, Gandaki, Karnali **C**
135. *Eutropiichthys murius* (Hamilton-Buchanan) L=28 MURIYS VACHA \ JALKAPOOR	Bagmati, Koshi, Karnali **Uncommon**
136. *Eutropiichthys vacha* (Hamilton-Buchanan) L=30-40 BATCHWA VACHA \ CHERKI, BACHAWA	Koshi, Gandaki, Karnali, Mahakali **Uncommon**
137. *Pseudeutropius atherinoides* (Bloch) L=15 POTASI \ PATASI	Koshi, Gandaki, Karnali, Mahakali **C**
138. *Silonia silondia* (Hamilton-Buchanan) L=90 SILONDIA VACHA	Gandaki, Koshi, Bagmati, Karnali **C**
Family – Pangasidae	
139. *Pangasius pangasius* (Hamilton-Buchanan) L=90 PUNGAS \ JALKAPOOR, PATASI	Koshi, Narayani, Bagmati **C**
Family- Amblycipitidae	
140. *Amblyceps mangois* (Hamilton-Buchanan) L=10 TORRENT CATFISH \ BALJUNG, BOKSHI MACHO	Koshi, Gandaki, Karnali, Mahakali, Arun, Tamur, Khimti **R**
Family- Sisoridae	
141. *Bagarius bagarius* (Hamilton-Buchanan) L=180 GANGETIC GOONCH, GAINT CATFISH, BAGARID CATFISH, FRESHWATER SHARK \ GOUNCH	Koshi, Gandaki, Karnali, Bheri, Seti, Mahakali**C**
142. *Bagarius yarrellii* (Sykes) L=200 GOONCH, BAGARID CATFISH \ GOUNCH	Gandaki, Koshi, Karnali **C**
143. *Conta conta* (Hamilton-Buchanan) L=8 CONTA CATFISH	Terai rivers, Koshi, Mahakali **R**
144. *Coraglanis kishinouyei* (Kimura) Euchiloglanis davidi L=12.6	Kulekhani, Bagmati, upper Kaligandaki, Karnali, Utterganga **R**
145. *Erethistes pussilus* (Muller & Troschel) L=5 GANGETIC ERETHISTES \ BHOOMI	Bagmati, Narayani, Koshi, Karnali, Orai, Babai, Rapti **C**
146. *Erethistoides montana montana* (Hora) L=4.8	Bhotekohsi, Koshi, Mechi
147. *Erethistoides ascita* (Ng & Edds) L=4	Mechi, Kankai, Trijuga, Koshi **R**
148. *Erethistoides cavatura* (Ng & Edds) L= 3.5	Narayani, Dhungre river, Buri Rapti river **R**

149. *Euchiloglanis hodgarti* (Hora) L=5 \ TELCAPRE	Narayani, Trisuli, Bagmati, Madi, Seti, Arun, Tamur **Uncommon**
150. *Exostoma labiatum* (McClelland) L=5.8	Kulekhani, Bagmati, Kaligandaki, Khimti, Chamelia, Sunkoshi **R**
151. *Gagata cenia* (Hamilton-Buchanan) L=10 GAGATA \ GANFAK	Koshi, Gandaki, Karnali, Mahakali **R**
152. *Gagata gagata* (Hamilton-Buchanan) L=31 GANGETIC GAGATA	Koshi, Karnali **R**
153. *Gagata sexualis* (Tilak) L=6 KOEL GAGATA \ BUHANI	Koshi, Kaligandaki **R**
154. *Glyptosternon maculatum* (Regan) L=25 TORRENT CATFISH \ KAPRE	Bagmati, Kamala, Rapti, Banai, Mahakali **R**
155. *Glyptosternon reticulatum* (McClelland) L=15	Sunkoshi, Tamakoshi, Likhu, Dudh Koshi, Mahakali Uncommon
156. *Glyptothorax alaknandi* (Tilak) L= 9 \ KAPRE	Koshi, Kaligandaki, Mahakali **R**
157. *Glyptothorax annandalei* (Hora) L=11.5 \ KAPRE	Gandaki, Koshi, Karnali **R**
158. *Glyptothorax botius* (Hamilton-Buchanan) L=6 \ TELCAPRE	Koshi **R**
159. *Glyptothorax cavia* (Hamilton-Buchanan) L=28 \ VEDRO	Koshi, Gandaki, Karnali, Mahakali, Madi, Seti, Khimti Uncommon, **CL**
160. *Glyptothorax conirostre conirostre* (Steindachner) L=14	Koshi, Kaligandaki, Chamelia, Karnali, Mahakali **I**
161. *Glyptothorax garhwali* (Tilak) L=8 \ CAPRE	Kaligandaki, Myagdi, Madi, Koshi **R**
162. *Glyptothorax gracilis* (Gunther) L=12.7 \ CAPRE	Koshi **R,CL**
163. *Glyptothorax indicus* (Talwar) L=11 \ CAPRE	Koshi, Gandaki, Bagmati, Karnali and tributaries **I**
164. *Glyptothorax kashmirensis* (Hora) L= 11	Mahakali, Chamelia, Babai **Uncommon**
165. *Glyptothorax pectinopterus* (McClelland) L=18 \ CAPRE	Bagmati, Madi, Seti, Gandaki, Koshi, Karnali **Uncommon**
166. *Glyptothorax telchitta* (Hamilton-Buchanan) L=10 \ TELCAPRE	Koshi, Bagmati, Trisuli, Rapti, Narayani, Karnali and Mahakali **Common**
167. *Glyptothorax trilineatus* (Blyth) L=30 / TELCAPRE	Gandaki, Koshi, Trisuli, Madi, Seti, Khimti, Karnali, Bagmati **CL, PR**
168. *Hara hara* (Hamilton-Buchanan) *Erethites hara* L=2.5 KOSHI HARA \ TINKANA	Koshi, Narayani **R**
169. *Hara jerdoni* (Day) *Erethites jerdoni* L=4 SYLHET HARA	Koshi, Karnali **R**
170. *Pseudolaguvia kapuri* (Tilak and Husain) *Laguvia kapuri* L=4 \ TINKANTIYA	Koshi, Gandaki, Narayani, Karnali **CL,PR**
171. *Pseudolaguvia ribeiroi* (Hora) *Laguvia ribeiroi* L=10 \ TINKANTIYA	Koshi, Narayani, Karnali **CL,PR**
172. *Myersglanis blythi* (Day) L=7.5 PHARPING CATFISH	Pharping **Uncommon**
173. *Nangra assamensis* (Sen and Biswas) L=10 NANGRA	Koshi, Narayani **R**
174. *Nangra nangra* (Hamilton-Buchanan) ***Gagata nangra*** L=5 KOSHI NANGRA \ BEFUNI	Koshi, Karnlai and Narayani **Uncommon**
175. *Nangra viridescens* (Hamilton-Buchanan) *Gogangra viridescens* ***Gagata viridescens*** L=12 HUDDAH NANGRA	Koshi, Narayani and Karnali **Uncommon**

176. *Pseudecheneis eddsi* (Ng) L=15 \ GOTEL, KABRE	Seti, Gandaki	**CL,PR**
177. Pseudecheneis crassicauda (Ng & Edds) L=15 \ KABRE	Mewa Khola, Tamur	**CL,PR**
178. *Pseudecheneis seracula* (Ng & Edds) L=15	Sunkoshi, Gandaki, Trisuli, Narayani, Seti, Mahakali	**CL,PR**
179. *Pseudecheneis sulcatus* (McClelland) L=15 SULCATUS CATFISH \ KABRE	Gandaki, Seti, Koshi	**CL,PR**
180. *Sisor rhabdophorus* (Hamilton-Buchanan) L=18 SISOR CATFISH \ KIRKIREE, SING PUCHHARE MACHHO	Gandaki, Koshi and Karnali	
181. *Sisor rheophilus* (Ng) L=15.5 \ KIRKIREE, SING PUCHHARE MACHHO	Koshi, Narayani, Karnli and Mahakali	
Family – Clariidae		
182. *Clarias gariepinus* (Burehell) L= 170 AFRICAN CATFISH	Introduced in 1990	*
183. *Clarias batrachus* (Linnaeus) L=47 MAGUR, WALKING CATFSIH \ MANGUR, MUNGAR, MUNGRI	Gandaki, Koshi, Karnali, Mahakali	**C**
Family – Heteropneustidae		
184. *Heteropneustes fossilis* (Bloch) L=30 STINGING CATFISH \ SINGHI	Koshi, Bagmati, Trisuli, Gandaki, Karnali, Mahakali	**C**
Family – Chacidae		
185. *Chaca chaca* (Hamilton-Buchanan) L=20 SQUAREHEAD CATFISH, MUD FISH, TOAD FISH \ PAUNA, KURKUREE	Gandaki, Koshi, Karnali, Mahakali	**R**
Family – Olyridae		
186. *Olyra longicaudata* (McClelland) L=11 HIMALAYAN OLYRA	Gandaki, Koshi	**Uncommon**
Order – Salmoniformes		
Family – Salmonidae		
187. *Oncorhynchus rhodurus* (Jordonel Mcgregor) L=40 JAPANESE AMAGO \ TATE	Sunkoshi	*
188. *Oncorhynchus mykiss* (Walbaum) *Salmo gairdnerii gairdnerii* (Richardson) L=38 RAINBOW TROUT \ TROUT	Godwari, Trisuli	*
Family – Belonidae		
189. *Xenentodon cancila* (Hamilton-Buchanan) L=30-40 FRESHWATER GARFISH \ KAUWA	Koshi, Kamala, Bagmati, Rapti, Seti, Fewa, Rupa, Begnas Gandaki, Narayani, Karnali, Mahakali	**C**
Order – Cyprinodontiformes		
Suborder – Cyprinodontoidei		
Family – Aplocheilidae		
190. *Aplocheilus panchax* (Hamilton-Buchanan) L=9 PANCHAX MINNOW, BLUE PANCHAX \ TIKULI	Koshi, Narayani, Karnali	**C**
Family- Poeciliidae		
191. *Gambusia affinis* (Baird & Girard) L=6 MOSQUITOFISH \ MACHARMACHHA	Koshi, Narayani (Exotic)	*

Order- Synbranchiformes		
Family- Synbranchidae		
192. *Monopterus cuchia* (Hamilton-Buchanan) L=60 CHUCHIA, GANGETIC MUD EEL \ ANDHO BAM, ANALI, ANAHI	Koshi, Kamala, Bagmati, Gandaki, Karnali, Mahakali	**R**
Suborder – Mastacembeloidei		
Family – Mastacembelidae		
193. *Macrognathus aral* (Bloch & Schneider) L=38 \ BAMI,GAINCHI *Macrognathus aculeata*	Koshi, Gandaki, Karnali,Mahakali	**C,CL**
194. *Macrognathus pancalus* (Hamilton-Buchanan) L=18 \ BAMI, KATHGAINCHI	Koshi, Gandaki, Karnali	**C,CL**
195. *Mastacembelus armatus* (Lacepede) L=61 TIRE-TRACK, SPINY EEL \ GARCHI,CHUCHE BAM	Koshi, Narayani, Karnali, Mahakai	**CL**
Order – Perciformes		
Suborder – Percoidei		
Family – Ambassidae		
196. *Chanda nama* (Hamilton-Buchanan) L=10 ELONGATE GLASS-PERCHLET \ CHANERBIJUWA	Koshi, Gandaki, Karnali, Mahakali	**C,CL**
197. *Pseudambassis baculis* (Hamilton-Buchanan) L=5 HIMALAYAN GLASSY PERCHLET \ CHANARI	Koshi, Bagmati, Narayani and Karnali	**C**
198. *Pseudambassis ranga* (Hamilton-Buchanan) L=3-7 GLASSY FISH \ CAHNERBIJUWA	Koshi, Narayani and Karnali	**C,CL**
Family- Sciaenidae		
199. *Daysciaena albida* (Cuvier) L=90 TWO-BEARDED CROAKER \ BHOLA	Koshi	**R**
Family – Nandidae		
Subfamily – Nandinae		
200. *Nandus nandus* (Hamilton-Buchanan) L=20 MOTTLED NANDUS \ DALAHAI	Koshi, Gandaki, Karnali, Mahakali	**C**
Subfamily – Badinae		
201. *Badis badis* (Hamilton-Buchanan) L=5 BADIS, DWARF CHAMELEONFISH \ PASARI, KHESALEI	Koshi, Narayani, Karnali, Mahakali	**C,CL**
Family – Cichlidae		
202. *Oreochromis mossambica* (Peters) L=45 MOZAMBIQUE CICHLID \ TILAPIA	Exotic in marshes of Terai	*
203. *Oreochromis niloticus* (Linnaeus) L=30 NILE TILAPIA	Exotic introduced in 1983/84	*
Suborder – Mugiloidei		
Family – Mugilidae		
204. *Rhinomugil corsula* (Hamilton-Buchanan) L=25 CORSULA MULLET \ KARSUL	Koshi, Narayani	**C**
205. *Sicamugil cascasia* (Hamilton-Buchanan) L=8 YELLOWTAIL MULLET	Koshi, Karnali, Mahakai	**R**

Suborder – Gobiodei		
Family – Gobiidae		
Subfamily – Gobiinae		
206. *Glossogobius giuris* (Hamilton-Buchanan) L=18 TANK GOBY \ BULLE	Koshi, Gandaki, Karnali, Bheri, Mahakali	**C,CL**
Suborder – Anabantoidei		
Family – Anabantidae		
207. *Anabas cobojius* (Hamilton-Buchanan) L=25 CLIMBING PERCH, GANGETIC KOI \ KABAI	Koshi, Narayani	**C**
208. *Anabas testudineus* (Bloch) L=25 CLIMBING PERCH \ KABAI	Koshi, Narayani, Karnali, Mahakali	**C**
Family – Belontiidae		
Subfamily – Trichogasterinae		
209. *Colisa faciatus* (Bloch & Schneider) ***Polycanthus faciatus*** L=15 STRIPLED GOURAMI, GIANT GOURAMI \KOTARI	Koshi, Gandaki, Karnali, Mahakali	**C,CL**
210. *Colisa lalius* (Hamilton-Buchanan) ***Polycanthus lalius*** L=5 DWARF GOURAMI	Koshi, Narayani and Karnali	**Uncommon**
Suborder – Channoidei		
Family – Channidae		
211. *Channa barca* (Hamilton-Buchanan) L=105 SNAKEHEAD	Koshi, Narayani and Karnali	**Uncommon**
212. *Channa marulius* (Hamilton-Buchanan) L=46-122 GIANT SNAKEHEAD \ SAUR, BHAURA	Koshi, Gandaki, Karnali, Mahakali	**C**
213. *Channa orientalis* (Bloch & Schneider) L=16 ASIATIC SNAKEHEAD \ GARAHI, BHOTI, GHAUNIAYA (Newari L.)	Koshi, Jagdishpur (Lumbini), Karnali	**C,BM,EM**
214. *Channa punctatus* (Bloch) L=30 SPOTTED SNAKEHEAD \ HELAE, GARAI	Koshi, Gandaki, Karnali, Mahakali	**C,EM**
215. *Channa stewartii* (Playfair) L=25 ASSAMESE SNAKEHEAD \ CHARANGI	Koshi, Kankai, Kamala, Bagmati, Gandaki, Karnali	**R**
216. *Channa striatus* (Bloch) L=40-75 STRIPED OR BANDED SNAKEHEAD \ HELAE	Koshi, Trisuli, Gandaki, Karnali	**C**
Order – Tetraodontiformes		
Family – Tetraodontidae		
217. *Tetraodon cutcutia* (Hamilton-Buchanan) L=13 OCELLATED PUFFER FISH\GALPHALANI,POKCHA	Koshi, Gandaki, Karnali, Mahakali	**CL,PR**
Total No. of Fish= 217, Exotic No.= 16, Indigenous No.=201		

The Scientific names given in Bold letters are according to Menon (1999)

In past Kulekhani reservoir covering 220 ha at an elevation of 1430 msl, was constructed in 1982 by damming the Kulekhani River and its tributaries at Markhu, Makwanpur District, in the southern foot hills of Kathmandu valley. So far, it is the first large-sized reservoir constructed in Nepal for electricity power generation. It is a storage type of reservoir with a catchment area of 126 km². The functioning of this reservoir depends mainly on seasonal rainfall and water accumulated mainly during the monsoon season (June-September). Despite its size, however, the annual run-off from the river and its tributaries is insufficient to meet electrical power demand.

The Kulekhani reservoir was the first manmade reservoir in Nepal introducing the cage fish aquaculture technology. The aquaculture component was implemented in 1984 by the Nepal government with assistance from IDRC, the Canadian International Development Research Centre. The project assessed the feasibility of fisheries development program by gathering indepth information on the limnological/biological parameters, which helped to establish the foundation for fisheries development programs and future storage type reservoirs. This storage reservoir is leached with rich nutrients flows from surrounding villages and farms during rainfall, which in turn helps to produce plankton, the natural food of such planktivorous fish species as silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*). The cage type aquaculture at Kulekhani provided job opportunities forthe local people as part of the mitigation efforts following reservoir construction and loss off armland. More than 210 farmers are engaged in the cage fish culture at Kulekhani using more than 32,000 m³ cages for table fish production, and more than 7,100 m³ of nursery andrearing cages for fingerling production. Altogether, more than 34,000 m³ production cages produce fish in excess of 136 MT/year at a rate of more than 4 kg/m³ (DoFD).

The Kaligandaki Hydropower Project (KGA) is one of the nation's largest high capacity run-of-the river projects, at a capacity of 144 MW. This project is constructed by impounding the KaliGandaki River at Mirmi, Syangja District, in the central midhills region (EIA, 1996). The KaliGandaki Hydropower dam has adversely affected fish biodiversity and the fishing community, who depend on fishing for their livelihood. This reservoir is a run-of-the-river type, and aquaculture is not feasible to mitigate such negative impacts. Therefore, a fish hatchery was constructed near the project site for mass production of fries economically high value indigenous riverine fish species to allow the stocking both up and down river from the damsite, to mitigate the negative effects of the dam on the pre-existing fisheries and to providenew income generation opportunities to the local fisher community.

The fish hatchery is under supervision of NARC and NEA. To some extent this program is successful; this technology can be applied to future run-of-the-river type reservoirs. Out of 200 Shrestha (2007), 57 species have been recorded in the Kali Gandaki river (Shrestha, 1996); of them Mahseer, snow trout, river carps are successfully bred and stocked in the river each year, as project mitigation activities.

To increase local fish production to replenish fish loss due to over fishing and pollution and impact of dam indigenous fish propagation and stocking to be intensified near tail water of the dam and reservoirs to mitigate or compensate for adverse effects of some activity within the water basins and these are some of the means to maintain or improve fish populations in the environment. Besides this, long term research work has to be made to study the behavior, growth, reproduction and adaptability of local commercially important indigenous riverine fish species, and to develop techniques for environmentally friendly conservation and development in the dammed river systems. Such baseline should provide significant knowledge on the biodiversity of the river system in order to develop appropriate fisheries management technologies.

Hydropower and indigenous riverine fisheries

About 6,000 rivers drain the Nepal from Himalayas totaling length of 21,000 km. The head water rivers and tributaries which provides an excellent opportunity for creation dam and reservoir. The pristine Himalayan Rivers such as Gandaki, Koshi, Karnali, Mahakali and their tributaries are teeming with variety of fresh water fish. In past many diversion dam are constructed in Gandaki, Koshi and Mahakali for the generation of electricity. A comparison of pre-project and post project stream and riparian corridor conditions serve to emphasize how severally degraded, mismanaged and unused river stream ecosystem can be converted into a valuable and highly used public asset. For example, the historic river channel and riparian corridor of Gandaki, Koshi, Karnali and Mahakali Rivers are severally changed and channelized at many place. The most negative impacts to the stream corridors are (1) habitat changes (2) dewatering by irrigation and diversion (3) fluctuating flows (4) development and encroachment. Therefore time has come in Nepal to manage for aquaculture as well as for the development of recreational fisheries. The terrain of Nepal rises from the Indo-Gangetic plain to high Himalayas over a short distance. This geography has blessed the country with a theoretical hydropower potential of 83,000 MW (based on average flow). Of this potential, to date about 42,000 MW has been assessed to be economically feasible. The mountainous topography of the country provides the possibility of a series of high dams which can hold immense quantities of water for multiplicity of uses. This storage has the potential to augment dry season flow by about 5400 m^3/sec.

Impact of dams on the migratory fisheries of Nepal

During past two decades river fish in Nepal have steeply declined due to pollution harmful fishing practices, habitat modification, environmental degradation and barrier effects of dams. Many game fishes such as mahseer (*Tor tor, T. putitora*) and Copper mahseer (*Neolissochilus hexagonolepis*) are declining due to barrier effects of dam, water quality changes, erratic flow fluctuations in water levels and destruction of spawning beds. To stop the destruction of habitat and extinction of these species artificial breeding and propagation are under development (Shrestha 1979, 1990, 1997). Migratory fishes such as the Bagarid catfish (*Bagarius bagarius*), eel (*Anguilla bengalensis*), and Jalkapoor (*Clupisoma garua*) have been the least studied. The impact of dam or physical barrier on cold water catfishes are not clearly known. Better methodology and propagation techniques are yet to be developed for these species in the reservoir.

Information on rare fishes of Nepal and their habitat is given by Shrestha (1990). As some of these species are migratory, additional information on status, abundance and distribution in the different river is given in the Table 1.

Power dam and fish passes

Most of dams installed during recent past do not have fish ladders and they obstruct and prevent upstream and downstream movement of fish. Rare migratory fishes like the species of mahseer (*Tor putitora, Tor tor*) and snow trout (*Schizothorax plagiostomus, S. richardsonii*) are also affected by changes in water velocity and fluctuating levels that sometime expose their spawning beds. The shallow zone of reservoirs, tail water of dams where fish congregate are exploited by fisherman. The overall phenomena has been described by Shreshta (1997)

Reservoir siltation and fish life

In most reservoirs spawning beds of major migratory game fishes are inundated and lost. Unscientific watershed management and changes in land use practice and deforestation has caused massive soil erosion. Many new reservoirs such as Kulekhani, Marsyangdi, Trisuli and Sunkoshi are loaded with heavy silt during rainy season or monsoon. Over siltation is determental to the growth and development of mahseer and snow trout.

Rare, declining and endangered fishes of reservoirs

Up to this time there are no fish species that are officially listed or protected by Nepal Government or other international lists such as CITES or IUCN. Many species have been reported to be threatened with extinction in the scientific literature. Shrestha (1990a) has given the list of several of the species occurring in the various power project areas as being in danger of extinction, threatened or restricted in range. These are summarized below in Table 1. None of these fish are listed in the IUCN or CITES lists. The causes for population declines include impacts of water use projects, pollution, improper harvest methods such as dynamite and various toxins, the absence of fishery laws and poor enforcement of existing laws.

Exotic fishes and impact on indigenous fishes

Up to now a total of seventeen exotic fishes (*Carassius carassius, C. auratus, Catla catla, Cirrhinus mrigala, Ctenopharyngodon idellus, Cyclocheilichthys apogon, Puntius gonionotus, Cyprinus carpio, Hypophthalmichthys molitrix, Aristichthys nobilis, Clarias gariepinus, Oncorhynchus rhodurus, O. mykiss, Salmo trutta fario, Gambusia affinis, Oreochromis mossambica, Oreochromis nilotica*) have been introduced into Nepal, since first known introduction of carps *Cyprinus carpio*. This number of exotic amount to negligible total of fish biodiversity of Nepal. The role of exotic particularly carps and Tilapia is often harmful to the aquatic ecosystem in developed world. Exotic such as carps has been migrated into river system and reservoir of Nepal since their introduction in rice paddies fish culture system. It is feared that in long run exotic may replace indigenous species such as Golden mahseer and Deep-bodied mahseer and many other species (Shrestha, 1990).

Elimination of natural riverine habitats and impact on aquatic life other than fish

In order to conserve sport fisheries in reservoir, suitable water level to be maintained in tail water region of dam during breeding season of May-June and September and October. The provision of spawning and incubating channels would help to maintain population of mahseer, snow trout, stone carp and torrent catfishes. A hydropower future development will create many a reservoir in highland and lowlands of Nepal may necessitate elimination of habitat of superior game fishes such as mahseers, freshwater eels and mountain trout and catfishes. Even fresh habitat of water mammal and reptiles such as Gangetic dolphin (*Platanista gangetica*) and fresh water otter (*Lutra perspicillata*), crocodile (*Gavialis gangetius, Crocodilus palustris*), turtles (*Lessimyspunctata, Hardella thurgi, Aspideretes gangeticus*) will be displaced. Therefore consideration should be given for the creation of more fish park, river parks and dolphinarium near the reservoir and tail water of dam to compensate serious habitat loss.

Establishment of fish sanctuary

Very often problems of fish conservation are not appreciated until rare fishes lost forever. It is praiseworthy that handful of aquarist and fish lovers of Nepal have been able to awaken public interest in time to save the fish species of the country. Now

Nepal Government have taken more active interest in protecting fishes through extensive prohibitions and revitalizing aquatic life conservation act. There is an intense popular support for government effort at protecting fish near spill way and tail water of dam. In its endeavor to redress the equilibrium between man and his environment and rare fishes, which can still be saved for this purpose, fish sanctuary in major rivers should be established by Nepal Government.

Conservation education for protection sport or game fishes

Studies of the fishes of Nepal have centered on a few game species found in Midland River Valleys of lowland Terai. There is a great need and opportunity to study ecology and behaviour of fishes of upper Gandaki, Karnali, Koshi and Mahalaki River valleys. There is an urgent need to determine status of abundance of Himalayan, sub-Himalayan and temperate forms of fishes in Nepal. Much research efforts are to be directed to generalize data on fishermen conflict, fishing and fishery activities. Environmental education program should be mounted to indoctrinate local fishermen of various community and to inform them about the importance of rare fishes Table 2.

Use of fish diversity of economically important indigenous fishes

Culturally, fish is considered as an auspicious item in Nepal. Thus fish is used in all social and religious ceremonies. A fish dish is always considered as delicacy and valued food in Nepalese society. Out of the reported fresh water fishes, a number of fishes have high economic value are shown in Table 3.

These economically important fishes are famous for their specific values, e.g. food, sport for recreation, decorative and academic study. In compare to food valued fishes, the sport valued fish grow to big size however, the decorative and academic valued fishes like *Danio, Botia* are small and smaller in size. These cold water fishes are a good source of nutritional food and incomes to the local people of mountain and hill regions. Therefore, thee fishes have due importance to the local people.

A number of fishes, e.g. *Schizothorax* spp., *Schizothoraicthys* spp., *Clupisoma* spp., *Barilius* spp., *Tor* spp. and *Neolissochilus* spp. are considered exceptionally good quality food fish of which the former five groups of fishes are highly esteemed for their delicacy. The fish - Asala (*Schizothorax / Schizothoraicthys* spp.) and carp minnow (*Barilius bola*) are the most widely known for their taste since time immemorial.

Fish are mostly consumed in fresh but in case of surplus catches they are sun dried and smoked. The sun dried and smoked fish are also considered a delicacy and has high demand. They fetch considerably high price in the market. The cold water fish is based on capture fishery and it is at subsistence level. The capture fishery is widely scattered throughout the country and is not well organized. To date no reliable statistics are available however, efforts are being made to established database on the production of cold water fishes, their composition of species, number of fishermen and their families involved.

Table 2. Fishermen community and major catch

Fishermen community	Geographical area	Major catch	Fishing gears
Bote/Majhi	Midland, hill and plain	Mahseer (*Tor tor*), Katle (*Neolissochilus hexagonolepis*)	Cast net
Tharu	Terai	Eel (*Anguilla bengalensis*)	Hook line, spear
Muser	Terai	Jalkapoor (*Pseudotropus*)	Gill net, drift net
Kumale	Hills and Terai	Snow trout (*Schizothorax*)	Nets and traps
Dharahi	Terai and hills	Tenger (*Mystus*)	Nets and traps, hookline
Chepang/Tamang	Hill and plains	*Puntius, Garra, Xenentodon, Monopterus cuchia*	Bow and arrow, spear, cat net
Chetri/Ghatri	Midland hills	Stone carp (*Garra*), Stone eel (*Mastacemblus*)	Gradient fish trap, Cast net
Pode/Sunuwar/ Kami/Damai	Midland hills	Minor carps (*Puntius*), Carp minnow (*Barilus*)	Cast net, lift net
Sunaha	Hills and Terai of Western Nepal	Mahseer, river carps and catfishes (*Aorichthys aor*)	Cast net, gill net, traps, fish poison
Badi	Western Nepal	Mahseer, eels, catfishes	Hookline, spear, line lines
Magar/Gurung	Midland hills	Snow trout (*Schizothorax*), Katle (*Neolissochilus hexagonolepis)*	Fish snaring, trapping, lift nets, cover pots

Table 3. Important indigenous fishes having high aquacutural Potential, used for food, game and recreation

Local name of fish	Scientific name	Maximum weight recorded (Kg)
Raj Ram	*Anguilla bengalensis*	10.0
Gounch	*Bagarius bagarius*	73.0
Gounch	*Bagarius yarrellii*	80.0
Sahar (Kalo Sahar)	*Tor tor*	60.0
Sahar (Pahelo Sahar), Ratar	*Tor putitora*	48.0
Gardi or Thed	*Labeo angra*	3.0
Karsa	*Labeo gonius*	3.0
Banga or Thed	*Labeo dero*	3.9
Bata	*Labeo bata*	3.0
Karnoch or Bishari	*Labeo calbasu*	3.0
Saur or Saul or Bhoura	*Channa maurilus*	15.0
Buhari	*Wallago attu*	5.0
Dhunge Bam or Gaichi	*Macrognathus aral*	5.0
Bami, Kathgainchi	*Macrognathus pancalus*	1.0
Banai	*Mastacembelus armatus*	1.0
Jakapoor or Pottasi	*Clupisoma gaura*	3.0
Jalkapoor	*Eutropichthys goongware*	5.0
Bachawa	*Eutropichthys vacha*	2.0
Moi	*Chitala chitala*	2.0
Chunche Bam or Kauwa	*Xenentoden cancila*	0.5
Mugri	*Clarias batrachus*	2.0
Singhi	*Heteropneustes fossilis*	1.0
Pabata	*Pangasius pangasius*	2.0
Tenger, Sujaha	*Aorichthys seenghala*	10.0
Kanti	*Aorichthys aor*	10.0
Voktari	*Ompok bimaculatus*	0.5
Rewa	*Chagunio chagunio*	0.5

Indigenous food fish of hill region

Fish as food is accepted by most of the people. There is no bar on the species and its size for its consumption. The cold water fishes are considered tastier than other fishes. Therefore, they are preferred most and have high demand. Because of this reason, the cold water fish always fetches higher market price in all markets (rural as well as urban).

With all these valued fishes, very little effort has been made in studying their biology, behavior, propagation, domestication and developing culture practice. Recently only, efforts have been made in studying economically important indigenous fishes, e.g. *Tor* spp., *Neolissochilus* spp., *Schizothorax* spp., *Schizothoraicthys* spp., and *Barilius* spp. for their domestication as well as for their use in culture practice too.

Indigenous food fish of Terai region

A strategy needs to be developed to screen more indigenous fishes having aquacultural potential, this need along term research. Also effort should be made for optimal utilization of the fresh water bodies of lakes and reservoirs of Nepal for intensive aquaculture. Many carnivorous fish species such as murrel (*Channa marulius*), catfish (*Wallago attu*), tenger catfish (*Aorichthys seenghala*) and mud eel (*Monopterus cuchia*), Jalkapoor (*Clupisoma garua, Pseudeutropius antherinoids, Silonia silondia, Pangasius pangasius*) live and breed fast in reservoirs. Therefore efforts should be directed for the optimal utilization of these carnivores. These fishes can be best caught in hooklines, longlines and driftlines and can be stocked in the reservoirs. Catch periodicity shows that these species effectively exploited during dusk and dawn using baited gear than laying driftnet and gillnets.

Hormone induced captive breeding

From past two decades captive breeding of exotic carps has been highly successful in government fish farms of Nepal. Fisheries Department of fisheries is also making trail for large scale captive breeding of snow trout (*Schizothorax richardsonii*) and mahseer (*Tor tor*), river rohu (*Labeo* spp.). The present author has been successful to evoke captive breeding in golden and deep-bodied mahseer by hormone induction (Shrestha 1986). Captive breeding of other indigenous fish stock of Nepal should be encouraged. This effort will be helpful to preserve gene pools of fishes.

Indigenous game fish or sport fish

The cold water fishes, e.g. *Tor tor, T. putitora* and *Neolisochilus* spp., *Schizothorax* spp., *Schizothoraicthys* spp. and *Barilius spp.* are well known for their high sport value. The three species of *Tor* spp. and *Neolissochilus* spp. are widely known for the sport fishery and recreation since time immemorial. These fishes migrate downward in winter and up stream in summer invading the turbulent water of the river. They are very strong and grow to big size. The last three groups of fishes: *Schizothorax* spp., *Schizothoraichthys* spp. and *Barilius spp*. are small in size but very active as trout, therefore the former group of fish is also called "Snowtrout" and the latter fish as "Himalayan Trout". These fishes are also well known for angling but due to their small size, they don't have fighting spirit and it is easy to land into net. Therefore, it is said that the small sized fishes are exciting for angling until they don't bite while in case of *Tor* spp. and *Neolissochilus*, they are most exciting once they bite as it requires a very tactful fight to land in net.

Besides, to catch the small sized fish "Snowtrout", the local people have innovated a simple but very interesting device of "loop". The loop is made of monofilament thread and the fishing method is called snare. A study has revealed that the fishing device "snaring loop" has been found as one of the simple but most effective device specially in hill streams. The fishing method has been observed in wide use amongst the locals along the hill streams of Nepal. A certain number of water bodies have regulated fishing with license otherwise it is considered as a free activity.

These sportive fishes as well as the typical indigenous fishing devices are the good asset for the country. These assets need to be commercialized by developing eco-tourism at feasible places with the involvement of locals, so that the local remains beneficiaries with increased job opportunities and income. Such activity is not only to boost the eco-tourism industry to earn foreign currency but also supports in improving the nutritional status and income of the local people also.

Local fishes with decorative and academic values

The fishes of hill region, e.g. *Nemacheilus, Pangio, Botia* spp. are multicolored. They preferred to be used in aquarium. Moreover, the changes of morphological structures due to the adaptation against the fast flowing torrential water as seen in various group of hill stream fishes and some of the rare fishes with are of great academic interest also.

Future opportunities with indigenous fishes

The indigenous cold water fishes with all these values are good assets to the country and they offer good opportunity for research and innovation. Now there is need to be used these fishes for economic purposes as per their specific values so that the locals get economic benefit of these fishes. Therefore, efforts need to be made in studying these valued fishes to develop their culture practice for increased production and sport fishery at feasible places of hill and mountain region with the involvement of the local enterprises. The establishment of commercial fish centers as well as sports centers in the form of eco-tourism will promote the development activities in remote areas. Such increased development activity may offer the job and income opportunities to the locals for their upliftment of their living style. The decorative and academic valued fishes could also be used as a source of income provided they are explored on their specific values.

Research priorities in indigenous fishes

To ensure survival of many declining indigenous game fish species living in the Himalayan rivers of Nepal, long term research will be needed. However, such species occur in inaccessible parts of the country far flung from Kathmandu valley and studies on species ecology and behaviors are therefore very challenging. To achieve such coveted goal international funding agency such as FAO, WWF and IUCN should provide support are needed for interesting and rewarding applied studies. Detailed survey, exploration and documentation of kind, occurrence and distribution of fishes in feeder streams of Major River are much needed in Nepal. Besides these, studies on migratory ecology and behaviour of game fishes must be carried out using biotelemetry so that finds may be directly applied for the preservation of the species and drafting management plans. So far monograph of only one species, the Golden mahseer (*Tor putitora*) is available (Shrestha, 1997).

Discussion

Nepal has entirely ignored the problem of its rivers, Shrestha (1981). No definite plan has been made to attempt restoration habitat of damaged river by dam, reservoir development and irrigation facilities development. Negative impact over-siltation, dredging and spoil disposal have been encountered in many rivers. Pollution has largely affected fish and aquatic life of Gandaki River (Narayani River). Explicit and enforceable conservation and pollution laws are needed. Active restoration and habitat enhancement programs are needed for riverine fish stocks.

Problem affecting mountain river ecosystem includes dam construction, reservoir creation, alteration of hydro biological regime in tail water, paper mill effluents, domestic and industrial pollutants, agricultural run off, canalization, dredging and subsequent spoil disposal, removal of stream bank cover, eutrophication, riverine flood plain encroachment, degradation of wetlands, alteration of natural hydro-periods, watershed urbanization and development. Fishermen with novel harmful fishing gear such as electrical shocker and dynamite also affected fish population by over fishing.

Conclusion and recommendation

For the development of fisheries of indigenous species a far sighted, dynamic research plan should be developed. The following are the recommendations in this regard.

- Fisheries resource of Nepali including rivers, lakes, reservoirs and ponds supporting diverse species of cold water and warm water fishes potential for the development of recreational sport fisheries and export promotion of ornamental fishes. Proper screening of fishes for aquaculture should be made by studying their ecology and life history.
- Out of total fisheries resources available in the water mass of Nepal it is essential to assess the potential fisheries resources which can be utilized in sustainable manner to maximize the production of fish and thereby filling the protein gap.
- The overfishing and overexploitation of fisheries resources is multidimensional. Some ofthe factors related to over-exploitation are due to lack of education, social consciousness and non-enhancement of the productivity. These socio-economic factors are to be considered in planning.
- For the development of the cold water fisheries watershed model should be evolved for future planning and development. Also ecosystem model should be fitted in them.
- Fish habitat restoration enhancement work should be prompted in areas displaced by human activities, dam and pollution.
- Innovative cultural technology of mahseer, snowtrout and river rhou (Thed, Gurdi) and other fishes is to be developed and used for rapid propagation ranching of the fishes of the rivers and lakes.
- Attempt should be made to ecological studies of local fish fauna as well as compatible exotic fish introduction throughout confined water of ponds, ghoals and vagars, jheels without affecting habitat and threatening survival of existing species.
- Systematic biological surveys of freshwater of Nepal to be conducted to know status, abundance, distribution and life history of indigenous fishes.
- The Aquatic Life Conservation Act should be made simple, practical and applicable for sustainable fishery development and conservation of endangered and vanishing fishes.

Nepal should make strategic national plans for improving the indigenous fishery. For this, sport fishery and tourism should be interlinked. The sport fishing in reservoirs of

Himalayan region is mostly unrecognized. There are several potential water bodies where good sized game species live and breed. Some deep gorges of river, placid lakes and reservoirs can be considered for sport fishing and promotion of tourism. In some isolated water bodies where rare and endangered fish species occur in high diversity, they should be protected and no sport fishery should be allowed.

Technology transfer of cold water, fish breeding, ranching operation, habitat restoration should be carried out in our water mass. Investigate migratory movement and behavour of fishes at dams in order to assess the efficiency of any management method is needed. Understanding movements of game fish stocks is crucial for developing model of population movement that can be used to predict different management measures, closed season and closed areas of fishing. Fishing laws, regulations and controls should be formulated and implemented with consideration with social and cultural taboos.

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Indigenous Fishes and their Contribution in Rural Livelihoods in Nepal

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ABSTRACTS

Inland water resources of Nepal harbor 187 indigenous fish species of food, sport and ornamental value. Capture fisheries comprised mostly of indigenous fish contributes approximately 43% of the national fish production. Twenty of the 103 ethnic/caste community of Nepal are largely depends on aquatic and fisheries resources for sustaining livelihoods. As common property resources, to which access is open to all, fisheries provide households a means for diversifying their subsistence and income-generating activities, optimizing their labor resources during different seasons, and "insuring" against the risks of agricultural failures. Moreover, people with no land, little money for capital investments, and few alternative livelihood opportunities can still often fish for subsistence. Nepal's aquatic and fisheries resources not only provide a foundation for food security, income, and employment for most of the wetland dependent population, but also an essential "safety net" for the rural poor.

Illegal and unsustainable harvests of indigenous fish and a growing rural population have resulted in a reduction in the productive value of fisheries. Information is provided on fish production, the importance of indigenous fish to rural livelihoods, the status and challenges of fisheries management and cross-sector impacts to fisheries. A number of potential areas for future research and development are suggested based on assessment of the needs.

Key Words: Capture Fisheries, Fisher Community, Fisheries Resources, Food Security, Wetlands

Introduction

Being landlocked, Nepal is deprived of any oceanic resources and overwhelmed by mountains, which comprise about 83% of the total area of 147,181 sq. km. Approximately, 5% of the total area of the country is known to be occupied by different freshwater aquatic habitats (Bhandari, 1992) where some 187 indigenous fish species are reported to thrive (Rajbanshi, 2005).

Of the more than 20 million Nepalese currently living in rural areas, over 2.8 million depend on aquatic and fisheries resources to support their livelihoods (CBS, 2006; IUCN Nepal, 2004). Most are subsistent, relying on one crop of cereal, indigenous fish and other aquatic resources, and a range of forest products. Although cereal crop farming remains the dominant activity in rural areas, fisheries resources also play a critical role in supporting livelihoods. However, despite a large number of wetland communities, 12.62% of national population (CBS, 2006), are dependable upon fishing and wetland products or services for livelihood; with few exceptions, these most marginalized peoples are not financially rewarding enough for sustaining a family, with their traditional occupations (Gurung, 2003a).

Over the past decade, rural livelihoods have faced increasing challenges due to a rapid decline in resources. Illegal and unsustainable harvests of fish and a growing rural population have resulted in reduction in the productive value of fisheries. Meanwhile, greater competition for land has led to an increase in the landless population. Increasing pressures on fisheries will make the maintenance of rural subsistence a serious challenge in the coming decade. In light of this pressure, and the importance of aquatic resources to rural livelihoods, one of the central components of future poverty reduction efforts must be effective aquatic resource management. This paper examines the current status of fisheries of Nepal, with a focus on indigenous fish resources because of their greater role in supporting rural livelihoods.

Aquatic resources

Nepal is the second richest country in the world possessing about 2.27% of the world water resources (CBS, 2003). Altogether 6000 rivers including rivulets and tributaries flow in the country making about 45,000 kms in length. Koshi, Gandaki, Karnali and Mahakali are the main river systems, which play major part for supplying water from snow, glaciers and small tributaries and fish species are diversified richly in the river systems. Rivers in Nepal cover an estimated area of 395,000 hectare. Similarly, a number of small to medium sized lakes in various parts of the country cover 5,000 hectare and about 1,500 hectare of small reservoirs have been constructed in the country. In addition, there is a considerable amount of surface area present in village ponds (6,000 hectare) and irrigated paddy field covering about 398,000 hectare (**Table 1**). Furthermore, growth in hydroelectric and irrigation project would add more water surface area in future. The future addition of reservoirs proposed in different rivers may extend the total water surface area approximately 6.5% (Pradhan 1987). It is estimated that about 4-5% of the irrigated area in Terai region are low laying, generally unsuitable for crops cultivation, and can suitably be developed into fish ponds (NFC, 1994). The existing water resources of the country and their future potential reveal that there is tremendous scope for expansion and intensification of fishery activities in the country.

Table 1. Estimated water surface area in Nepal (DoFD, 2007).

Resource details	Estimated area (ha)	Percent coverage	Potential area (ha)
Natural water	401500	49.14	
Rivers	395000	48.34	
Lakes	5000	0.61	
Reservoirs	1500	0.18	78000
Village ponds	6500	0.80	14000
Seasonal water			
Marginal swamps	11100	1.36	
Irrigated rice fields	398000	48.71	
Total	817100	100	92000

Indigenous Fish Resources

A total of 187 indigenous fish species represented by 10 orders, 30 families and 94 genera have been reported in Nepal (Rajbanshi, 2005). The distribution of indigenous fish within the country exhibit very diverse ecological conditions ranging from trophic climate to Terai to alpine climate of Himalayan region. The indigenous fish species are distributed in the different water bodies of Nepal from 60-3323 m altitude (Shrestha 1995). A large number of fish species remain confined to a limited range of the water body. A number of other species distinctly exhibit migratory habitat either with the change of ecological conditions, for feeding, breeding or for all purposes. Cold water fishes, *Tor spp., Neolissocheilus hexagonolepis, Anguilla bengalensis,* etc are good example of migratory fish. The fish diversity appears less in high altitude water bodies due to the low water temperature as well as torrential nature while they are rich at lower altitude (plain area) with warm and warmer climatic conditions **(Table 2).**

Table 2. Distribution of native species by habitat and ecological region in Nepal (Sources: Rajbanshi, 1981; Shrestha, 1981, 1994a; Edds 1993).

Type	Species diversity (Nos.)	Percent of 187 species
Ecological Region		
High hill	20	10.7
Hills, valleys	77	41.2
Terai	127	68.0
Habitats		
River	98	52.4
Stream	63	34.0
Lake	54	28.9
Swamps/ghols	37	20.0
Flood plain	24	12.8
Ponds	41	23.0

A large number of indigenous fish are of high economic value in the form of food fish as well as sportive and decorative fish (see Rajbanshi, 2002, 2005). Asala (*Shizothorax progastomus* and *S. richardsoni*), Sahar (*Tor putitora* and *T. tor*) and Katle (*Neolissochilus hexagonolepis*) have been identified as high value fish and common in the high hill water bodies that need to be conserved. Three warm water fish species (*Labeo rohita, Cirrhinus mrigala* and *Catla catla*) are being used in various practices of fish culture. Other potential indigenous fish species from warm water regions belong to families *Siluridae, Ophiocephalidae* and *Heteropnestidae* which need to be exploited for increasing species diversity for aquaculture.

Production and productivity of natural water resources

The total national fish production is 46779 mt and capture fisheries from natural waters shares about 43% of the national production (**Table 3**). Since the capture fisheries practiced in natural water, the fish production solely comprised of indigenous fish. The range of fish production varies from 17.4 kg/ha in irrigated rice field to 449.3 kg/ha in marginal swamps. Although information on species wise contribution from the categories of aquatic resources are meager, the indigenous fish catch comprised by over 90% with the minor carps from the lakes of Pokhara valley (Bista et al., 2005). Major catch composition of lower basin of Koshi River includes *Schizothorax spp., Labeo spp., Tor putitora, Puntius spp., Barilius spp., Clupisoma spp, Mystus spp.,* and other minor carps (Yadav, 2002; Bhujel et al., 2007). Surveys conducted at key fishing grounds; Kali Gandaki (KGFH, 2006), Karnali and Seti valley (Swar, 2002), upper Sunkoshi (Ranjit, 2002), Narayani River basin (Dhital and Jha, 2002), Koshi River basin (Yadav, 2002; Bhujel et al., 2007) revealed that annual landing solely comprised of indigenous fish species. These imply that native fish contribute substantially in the total production from natural waters and livelihood of fishers in Nepal.

Table 3. Estimated fish production from capture fisheries in year 2006/07. Source: DoFD, 2007

Aquatic resource	Fish production (mt.)	Productivity (kg/ha)	Percent contribution in total production
Total fish production	**46779**		100.0
Fish production from aquaculture	*26679*		*57.0*
Fish production from capture fisheries	*20100*		*43.0*
Rivers	7031	17.8	15.0
Lakes	805	161.0	1.7
Reservoirs	364	242.7	0.8
Marginal/swamps/ghols	4987	449.3	10.7
Irrigated rice fields	6913	17.4	14.8

Sustainability of annual catch

Although estimates of total inland fish catch are higher now than anytime in the past, this is probably due to increased fishing effort rather than improved health of fish stocks; the current catch levels are not necessarily sustainable. In light of the trend toward increasing habitat destruction, destructive fishing, barrier in waterway and fishing pressure, the catch of large migratory fish species, which typically reproduce more slowly, could decline while the catch of small and fast reproducing species would appear as high as ever. Decline in fish fauna and catch have been reported from lower basin of Narayani River (Dhital and Jha, 2002), and sharp depletion of fish stock in many water bodies around densely populated areas (Rajbanshi, 1996). Since, some of the high value and migratory native fish species of the country are listed as vulnerable and endangered (Swar, 2002; Shrestha, 2002) (**Table 4**), in the long run a potential future "Bangladesh effect" may be warn- the significant reduction in fish stocks and bio-diversity to the point where fish production consists of a limited number of small, low-value species (Degen et al., 2000). This occurs because these fish species typically require more than a one-year cycle for reproduction, which makes them more vulnerable to fishing pressure. In contrast, the small, low-value species that reproduce within the limits of a one-year cycle are more resilient to fishing pressure and become an increasing proportion of the total fish catch. This change in the species composition reduces catch values per unit of fishing effort (Degen et al. 2000).

Table 4. Status of native fish species in Nepal, Source: Swar, 2002.

Status	Number of species	Scientific name (common name)	Migration trend
Common/ occasional	90		
Insufficiently known	61		
Vulnerable	9	*Tor putitora* (Mahseer)	LR
		Anguilla bengalensis (Rajbam)	LR
		Neolissocheilus hexagonolepis (Katle)	MR
		Chagunius chagunio (Rewa)	
		Danio rario (Zebra machha)	
		Schizothorax plagiostomus (Buchhe asala)	MR
		Schizothorax richadsonii (Asala soal)	MR
		Schizothoraichthys progastus (Chuche asala)	MR
		Psilorhynchus pseudecheneis (Tite machha)	
Endangered	1	*Tor tor* (Sahar)	LR

LR= long range, MR= mid range

Fishing implements and methods

Fishing in the major fishing grounds changes with the season, physiography of water body and the tradition of specific ethnic community in Nepal. A number of fishing devices are used. Capture fishery is using both conventional and non-conventional fishing methods. Shrestha (1994 b) described the five basic conventional methods used for fishing in different water bodies in Nepal namely, nets, basket implements, rod and line, spearing and manual method of killing. Most of the fishermen living in the river basin use a small wooden canoe and cast net. The most common fishing devices are cast net, gill nets, lift nets, thakauli net (helka), trammel net tregodia net and bangle net for catching fish in lakes, reservoirs and shallow waters with low current. The use of Ghorlang (scoop net), paso and pahai (unique in Karnali River) are the common devices in fast flowing waters. Various other nets with indigenous names, such as tunny jal, chatti jal, chauki or chanki jal, sohat, hapa, different types of traps, baskets, rod and line are used in Koshi River basin (Yadav, 2002; Bhujel et al., 2007).

One of the several traditional methods is the use of extracts from local plants as fish poison. In the shalow lakes, swamps, streams and oxbows the plants *Agave americana*, *Sapium insinge*, *Dioscorea deltoidea, Euphorbia voyelana,Polygonum flacidum*, *P. hydropiper*, *Ficus pumila* and *Acacia pennata* are commonly used as toxicant to kill the fish (Yadav, 2002, Shrestha, 2002). Construction of bahi in the shallow stream of western Terai is typical method to attract the fish (FRC, 2006).

Non-conventional methods are the use of explosives, electrofishing and poisoning. The ever-increasing human population has become the main cause of illegal fishing on the aquatic ecosystem (Swar, 2002). The rampant use of hazardous chemicals, misuse of explosives and, wet cell batteries and electricity are usually not selective and destroy inland fish fauna. These illegal and non-conventional fishing methods are usually practiced by non-professional occasional fishers (Ranjit, 2002). Reduced fish stocks and destruction of habitat in several rivers and streams by the use of illegal fishing have been reported by Swar (2002), Ranjit (2002) and Shrestha (2002).

Aquaculture of indigenous fish: status and prospects

Aquaculture in Nepal revolves the cultivation of native and exotic carps. Presently seven species of commercially valuable carps are being cultured in Nepal. These includes three indigenous species: Rohu (*Labeo rohita*), Naini (*Cirrhinus mrigala*), Bhakur (*Catla catla*) and four exotic species: Common carp (*Cyprinus carpio*), Silver carp (*Hypophthalmichthys molitrix*), Bighead carp (*Aristichthys nobilis*) and Grass carp (*Ctenopharyngodon idella*). In Nepal, major aquaculture systems adopted are:

carp polyculture in ponds; carp polyculture in lake and enclosures; cage culture of herbivorous carp species and common carp in rice - fish culture.

DoFD (2007) estimated that 26679 mt. of fish was produced from aquaculture practices during 2006/2007 which is about 57% of the total national production. Aquaculture in Nepal involves about 87000 active members and the number of direct beneficiaries is 182000 peoples. Although information on shares of indigenous fish species in aquaculture production is lacking / unavailable**,** increased preferences of growers and consumers toward these high valued indigenous fish species would have substantially contributed to the livelihood of rural people.

Domestication and aquaculture prospects of indigenous fish

Presently inland aquaculture is mostly based on exotic carps in Nepal because of their well established seed production technology. However, expansion of exotic species for aquaculture and enhancement in relatively virgin mid-hill natural waters may cause changes in predation, competition for food, introduction of disease and genetic pollution. Comparative advantages of promotion of indigenous species into aquaculture in such waters has been advocated as they may be preferred locally, may have less chance of introducing disease, may grow better under local conditions, may contribute to preservation of biodiversity, and help maintain integrity of aquatic communities and ecosystems by appropriate management (FAO, 1997; Vibol and Mattson, 2002). Integration of aquaculture of native species into rural development has been augmented as it has the potential for poverty alleviation through direct involvement of rural people in aquaculture production (Haylor and Bland, 2001).

At present aquaculture in Nepal has only a small role in supporting the livelihood in mountainous region due to the lack of appropriate farming technologies for most of the indigenous species. In view of the conservational value and the aquaculture potential of several indigenous species, there has been a concerted effort to artificially propagate these species (**Table 5**). Among them *Neolissocheilus hexagonolepis* (Katle), *Tor tor, Tor putitora* (sahar, mahseer), *Schizothorax richardsoni, Schizothoraichthys progastus* (snow trout or asala), *Clarias batrachus* have been identified as important for food fish and, they fetch a very high market price and is of high cultural value. Recognizing the importance of these indigenous fish, NARC, made a concerted attempts to evaluate their aquaculture potential, including captive breeding using long term pond reared broodstocks commencing in the period late 1980s.

Table 5. Status of indigenous fish under domestication and captive breeding

Species	Status	Work place
Tor putitora (Mahseer)	Domesticated, seed production technology developed, under growth and production evaluation at different agro-ecoregion	FRC, Pokhara; FRC, Trishuli; KGFH, Syanja; IAAS, Rampur
Tor tor (Mahseer)	Under domestication (wild caught fish are being reared in ponds)	KGFH, Syanja
Neolissocheilus hexagonolepis (Katle)	Domesticated, seed production technology under verification	FRC, Trishuli, KGFH, Syanja
Schizothorax richardsoni, (Asla)	Domesticated, seed production technology developed, rearing trials with different diets are being carried out	FRC, Trishuli; FRD, Godawari
Schizothoraichthys progastus (Chuche asla)	Domesticated, seed production technology developed, rearing trials with different diets are being carried out	
Schizothorax plagiostomus (Buche asla)	Seed produced from hatchery reared wild caught fish	KGFH, Syanja
*Clarias batrachus (M*agur)	Domesticated, seed production and nursing technology developed, stock improvement initiated	FRC, Pokhara; RARS, Tarahara
Labeo dero (Gardi)	Domesticated, seed production and nursing technology developed, under growth and production evaluation	KGFH, Syanja; FRC, Pokhara
Labeo pangusia Hande)	Seed produced from hatchery reared wild caught fish	KGFH, Syanja
Labeo angra (Thend)	Seed produced from hatchery reared wild caught fish	KGFH, Syanja
Garra annadelai (Lahare)	Seed produced from hatchery reared wild caught fish	KGFH, Syanja
Garra gotyla (Buduna)	Seed produced from hatchery reared wild caught fish	KGFH, Syanja
Botia lohachata (Baghi)	Seed produced from hatchery reared wild caught fish	KGFH, Syanja
Pseudeutrotius muries (Jal kapoor)	Under domestication	KGFH, Syanja
Bagarius yarelii (Goach)	Under domestication	KGFH, Syanja
Anguila bengalensis (Raja bam)	Under domestication	KGFH, Syanja
Chagunius chagunio (Rewa)	Under domestication	KGFH, Syanja

In early days of *T. putitora* domestication process, captive breeding of this species was based on wild caught, mature fish from lake and rivers. Later in 1995, Fisheries Research Centres (FRCs), Pokhara and Trishuli were able to captive breed *T. putitora* derived directly from progeny of the wild stocks. Recent hatchery productions of *T. putitora*, without using hormone injection, are coming from the second generation of hatchery bred broodstocks. Hatchery produced offspring of this species are being used to stock enhancement in several natural water and to evaluate aquaculture potential in ponds (Wagle et al., 2007a). *Neolissocheilus hexagonolepis* has been bred every year in FRC, Trishuli. Besides its propagation and domestication, feeding, behavior, growth and reproductive aspects of this species have been studied by Swar (1994). *Schizothorax Richardsoni* and *Schizothoraichthys progastus* (asla) are also bred in FRC, Trishuli and Kali Gandaki Fish Hatchery (KGFH- jointly operated by Nepal Electricity Authority and NARC) every year and observations of growth in response to different diets are in progress in Fisheries Research Division (FRD), Godawari. Success in captive breeding (artificial and natural) of a warm water fish *Clarias batrachus* have been achieved in FRC, Pokhara and RARS, Tarahara. Currently stock improvement of this species and participatory growth and production evaluation is being carried out (Wagle et. al., 2006). In recent year, successes in captive breeding have been achieved from wild caught brood fish of nine native species in KGFH (Baidya et al., 2008). Attempts are being made to domesticate the two long range migratory fish species goach (*Bagarius yarelii*) and rajabam (*Anguila bengalensis)*; and mid distance migratory fish jalkapoor (*Pseudeutrotius muries*) and rewa (*Chagunius chagunio*). Wild caught fish of these species are being reared in ponds at KGFH for possibility of breeding and rearing technology development.

The indigenous fish in the warm water regions of the country are more numerous. Fish species belong to families *Siluridae, Ophiocephalida* and *Heteropnestidae have the* potential to be included in the list of cultivable species. Besides the air breathing fish, there are number of other varieties of indigenous fish (*Mystus oar, Wallago attu* and *Ompak bimaculatus*) if produced in a large scale there may be greater economic benefits derived from aquaculture. Consequently, development and dissemination of aquaculture technologies for all native species under domestication and evaluation will explore the immense opportunities of job and income to rural community for enhancing their livelihoods.

Contribution of indigenous fish to rural livelihoods

Aquaculture of indigenous fish has a low diversity both in fish species and technology. Despite the fact that aquaculture has poor access to mountain region of the country, production of indigenous fish from aquaculture significantly contributing for economic wellbeing of the people in southern plain. As a rich common property resource, capture fisheries of indigenous fish play a critical role in rural livelihoods by providing for households to:

(1) Diversify their livelihood activities and better insure against the risk of failures of other activities e.g. agricultural production.
(2) Optimize labor resources among different livelihood activities during different season.
(3) Access on income generating activity with very little capital investment and no land,
(4) Maintain/improve nutrition, as fresh/processed fish represent a significant source of protein.

In Nepal capture fishery of native species is widely scattered throughout the country and is not well organized. Fishermen, dispersed along water bodies, such as rivers, lakes and other natural wetlands, use their traditional gears predominantly for their own and their families' benefit. Fishing is an important source of jobs, nutrition, food security and income for fisher and other minor community.

Ethnicity/caste of fishing community and gender issues in Nepal

While all Nepali people benefit directly or indirectly from wetlands, the livelihoods of several communities are based on products or services from the aquatic resources. By tradition, Nepalese society has distinctly identified ethnic communities for fishing, which, entirely depend upon fishing and water related occupations such as boating and fishing net mending as a family profession. Nepal has some 103 ethnic and caste group (CBS, 2006). Twenty of these group are largely lived on the bank of water resources and heavily dependent on the wetland products or services (IUCN, 2004). The prominent groups are Pode or Jalari, Suneha, Mallah, Bote or Majhis, Mushahar, Mukhiya, Danuwars, Darai, Kumal and Tharu. These fisher communities settled in the bank of wetland areas of the country by ethnicity and comprised of 12.62% of the total population of Nepal (**Table 6**). For instance, the majhis largely lived on the bank of Koshi River, podes on the bank of lakes of Pokhara valley and botes on the bank of mid hill rivers. Tharus, indigenous people of Terai, distributed throughout the Terai and inner Terai of the country. Although Sunaha, Gongi, Mukhiya, Sahani, Kushar, Kachhare Pahari and Pode/Jalari do not find mention in the 2001 census (CBS, 2001), the IUCN (2004) lists them as being wetland dependent communities. The fishing occupation within the caste system by tradition can be attributed both to abundant water resources in the country, and honoring fish as a valuable food resource.

Gender issues in fisheries are poorly documented in Nepal, although involvement of women in capture fishery is about 60% of the 427000 active members engaged in capture fisheries (DoFD, 2007). Women are very active in most activities including fish catch from shallow waters, processing, marketing and selling, tending fish culture in ponds and cages, and maintaining fishing gear. The practice of harvesting fish from inundated rice fields is probably as old as rice farming itself. Tharu and Wadi women fish in rice fields as "favorite past time and supplementary means of subsistence". Women from pode or jalari community in Pokhara have formed groups on their own initiative to patrol inlet streams during the breeding season (monsoon) of mahseer and suppress illegal fishing (Gurung, 2003b). Generally men are often responsible for activities requiring more physical strength, such as using fishing gear in rivers or traveling to remote locations for fishing.

Livelihood strategies of the fisher and wetland dependent community

Originally, the word livelihood meant nothing more than occupation or employment, that is, a way of making a living. More recently, the meaning of term has expanded to include boarder systems that encompass social, economic and other attributes. (TAB, 2006). These may be their assets, their work and other cultural activities, and factors that help people get access to these assets and activities.

Diversity in livelihood strategies has been found among fisher community with different approaches and magnitude depending on ethnicity, cultural practices and available resource base. From place to place and from season to season, different ethnic/caste groups of fisher take advantage of the natural wealth of the basin in different ways. However, fishing is the most common and predominant occupation amongst all other strategies for sustaining livelihood of the fisher community **(Table 7).** Generally fishing dependent community in Terai and periurban areas (eg. the jalaris) has more livelihood activities than the communities in remote hill areas.

Table 6. Ethnic groups of fisher community in Nepal and their population (Source: CBS, 2001)

Ethnic/ caste groups	Population	Percentage of total population	Distribution
Tharu (Rana/ Dangaura)	1533879	6.75	Terai, Inner valley
Mushar	172434	0.76	Terai
Mallah	115986	0.51	Terai
Bote	7969	0.04	Hill and mountain
Bantar	35839	0.16	Terai
Danuwars	53229	0.23	Terai
Majhis	72614	0.32	Hill and mountain
Darai	14859	0.07	Terai and hill
Kumal	99389	0.44	
Barhamus/ Baramu	7383	0.03	
Dhangar/Jhagar	41764	0.18	
Dusadh/Paswan/Pasi	158525	0.70	Terai
Kewat	136953	0.60	Terai
Kachhare Pahari	11505	0.05	Hill and mountain
Kushar			
Pode/Jalari			Pokhara valley
Gongi			Terai
Sahani			Terai
Suneha			Terai
Mukhiya			Terai
Dalit/unidentified dalit	173401	0.76	Across all region
Unidentified caste/ethnic group	231641	1.02	Across all region
Total	2867370	12.62	
Other communities	Harijan, Kahar, Gaun, Pali, Yadav, Dhami, Godhi, Bin, Mukhiya and other castes (eg. Brahman, Chhetri, Shahi. Thapa, Malla, Gurung, Magar etc.) of low profile.		

Fish consumption and food security

Fish is widely accepted to all strata of population, with estimates of average consumption of 1770 g per person per year in Nepal (DoFD, 2007). This is about 5.3 fold increase in fish consumption from merely 330 g per caput during 1981/82 (FDS, 1983). Average fish consumption per person of fishing and wetland dependent community exceeds this national average, with estimates varying widely from 2.6 kg to over 14.0 kg in some areas (**Table 8**). The contribution of indigenous fish to national fish consumption approximates 43%, based on its share to national fish production, and over 90% to the fishing communities since capture fisheries in Nepal mostly comprised of indigenous fish.

Table 7. Livelihood strategies of several fisher communities settled in different water body.

Livelihood strategies	Lakes of Pokhara valley	Terai wetlands (Ghodaghodi, Narkodi)	Koshi River	Kali Gandaki River	Upper Sunkoshi
Fisher community	Pode or Jalari	Tharus, Freed Kamaiyas	Bantar, Majhi, Mallah, Bhardar	Bote, Majhis	Majhi, Dhami
Fisheries and Aquaculture					
Cage and net repair	++	+	+	+	+
Fish catch	+++	++	+++	+++	++
Cage culture	++				
Pond fish culture	+	++			
Fish marketing	++	+	+		+
Farming					
Cereal crops	+	++	+	+	+
Livestock's	+	+	+	+	+
Wage employments					
Government service	+				
Private service	+			+	
Agricultural wages	+	++	++	++	+
Industrial wages	+	+			
Overseas employments	+	+			
Skilled labor (eg. carpenter)		+			
Small business					
Hotel	+				
Shops	+	+	+		
Tourism	+				
Boat operation/ navigation	++	+		+	+
Others			+		
Driving	+				
Sources	Wagle et al,	FRC, 2005	Bhujel et al., 2007	KGFH, 2003	Ranjit, 2002

2007(b)

Table 8. Number of fisher, fishing efforts and share of capture fishery to annual income of fisher in some fishing areas

Attributes	Upper Sunkoshi	Koshi River basin	Kali Gandaki (NEA site)	Phewa Lake	Danda stream	% fisher by seasonality
Ethnic/caste	Majhi, Dhami, Others	Bantar, Majhi, Mallah, Bhardar	Bote, Majhi	Pode or Jalari	Tharu, Mallah, Mushar	
Full time fisher						
Family No.	45	445	57	18		5.0
Fishing days/year	180	217	222	235		
Catch, kg/day/HH	0.7	2.7	0.7	3.0		
Part time fisher						
Family No.	211		17	37	110	60.0
Fishing days/year	105		118	138	160	
Catch, kg/day/HH	1.8		0.76	2.6	2.4	
Occasional fisher						
Family No.	500					35.0
Fishing days/year/HH	6					
Catch, kg/day/HH	0.4					
Annual income (NRs)						
Full time fisher	27000	21926	13379	68624		
Part time fisher	15000		6500	37800	28800	
% share of capture fishery of native fish to annual income	49.0	64.0	45.0	54.1		
Fish consumption, kg / year / person	2.6	12.4	3.0	7.2	14.3	
Engel's coefficients (savings included in expenditure)			60.9	33.3		
Reference	Ranjit, 2002	Bhujel et al., 2007; Yadav, 2002	KGAR, 2004	Wagle et al., 2007	FRC, 2005	Swar, 2002

Employment and Income Generation

Many rural household living around wetlands subsist on a combination of fishing and agricultural activities, but most view fishing as their primary employment and agriculture as a vital secondary occupation (**Table 7**). National statistics focused on agriculture may not adequately capture the dual importance of subsistence agriculture and fishing for employment and income generation.

DoFD (2007) estimated that a total of about 107000 families are involved in capture fisheries of indigenous fish in natural waters. Capture fisheries involve about 427000 active members and the number of direct beneficiaries approximates 580000 peoples (**Table 9**). It has been estimated that about 6.6%, of the 6496222 economically active populations in agriculture sector (CBS, 2006), engaged in capture fishery. Labor force in micro level based on fishing frequency from different types of water bodies, Swar (2002) estimated only 5% fishing households (HH) are full time fisher (>9months) while 60% and 35% HHs ranked as part time (3 months) and occasional fisher (1 month).

Table 9. Families involved active numbers, beneficiaries, and value in million Rupees from the capture fisheries of indigenous fish in natural waters.

Resource	Families involved	Active members	Beneficiaries	Values (million NRs)
Natural waters	74840	298360	387100	1714.3
Rivers				
Lakes / reservoir				
Marginal/swamps				
Irrigated rice fields	32160	128640	192900	898.7
Total	107000	427000	580000	2613.0
Contribution in AGDP, %				1.15
Contribution in GDP, %				0.37

Monetary value of Nepal's native fish catches is estimated to about 2613 million rupees (DoFD, 2007), excluding aquaculture production of native fish (Table 9). The estimates do not include the value of people involved in marketing, production and sales of fishing gear. By the year 2007, the growth of capture fisheries in natural water has increased by 68% and the number of dependent (families) in aquatic resources increased by 110% compared to the statistics of capture fisheries of year 1998 (Swar, 2002; Yadav, 2002). At present capture fisheries of native species contributes about 1.15% to AGDP and 0.37% to GDP. Although subsistence fishery and sport fishery are practiced at different levels of intensity on different natural waters, the current growth of capture fishery and an increased involvement of fishing community indicated that fish stocks in most of the water resources are under intensive fishing pressure.

Capture fishery of indigenous fish made up about 53% of the total annual income of the fishers from different types water bodies (Table 8). Fishers with diversified fisheries activities would generate substantially high income from the aquatic resources. For example, cage aquaculture and recapture fishery contributing over 75% of the total annual income of jalari community in Phewa Lake (Wagle et al., 2007b). However, this average income of jalari fishers conceals the poverty of about 30%.

Socioeconomic of fishing community

Socioeconomic status of fisher community has rarely been comprehensively reviewed in Nepal. Only occasional descriptions of livelihoods of these communities are available (Bhujel et al., 2007; Wagle et al., 2007b; Ranjit, 2002) but in most of the cases no meaningful data exist upon which an analysis of changes in living standard of fishers due to changes in fish catch over time could be undertaken.

The standard of living of a household depends largely on its disposable income relative to its size as well as on the availability of public services and social amenities. The preliminary results of a socioeconomic study of the jalari community revealed that the living standard indicated by access to a variety of social amenities and community services has improved considerably over the past three decades with the adoption of cage aquaculture and recapture fisheries management under the frame of community based fisheries management in the lakes of Pokhara valley (Wagle et al., 2007b). Improvement in quality of life for Pode community in Phewa Lake is also evidenced by the low value (<33.3%) of Engel's coefficient. Expenditure on food as a percentage of total household expenditure, known as the Engle's coefficient, is important indicator of standard of living; the poorer a family or a nation, the larger is the percentage of expenditure that must go to food – at the limit, a very low income may be spent entirely for biological needs. As income rises, an increasing proportion of expenditure goes to other less mandatory items such as clothing, transport, and education. KGAR (2004) reported the relatively high value (60.9%) of Engle's coefficient for bote or majhi fisher living near by Kali Gandaki River. Bote community posses few numbers of livelihood strategies with less diversity in fisheries activities which often results in risk for livelihoods.

Current management of aquatic resources and capture fisheries

Water bodies in Nepal are usually uncontrolled for local access, and usually, the poorest most deprived people are known to harness nearby natural resources such as water bodies or forest for their livelihood. Nowadays, most forests are managed through a community approach involving local inhabitants, for conservation as well as for the benefit from the forest. However, rivers and few natural water bodies have yet been managed in such a way and most remain a "free-for-all".

A few lakes in the mid-hills have been stocked with cultivable carp for increased production as strategies to reduce the fishing pressure on thinly populated native species without losing the fisher's employment and income opportunities, until measures for conservation practices of locally vulnerable native species are developed. However, rivers and streams were never viewed for aquaculture production or development as recreational fishing grounds. Development of fish sanctuaries for commercial recreational places such as wildlife resorts might help to conserve fisheries resources.

Fish diversity and conservation is one of the neglected areas of research and development in fisheries sector. For conservation of the aquatic life the "Aquatic Life Protection Act-1961 (ALPA)" was promulgated. However, due to insufficient enforcement, the rules and regulations set out in this act are hardly followed.

Recently, a program has been initiated to restore the diminishing Lake Rupa (135 ha) of the Pokhara Valley. A cooperative comprising of 360 people has been established for conservation and income generating fisheries activities, and a large share of the benefit from fish harvest from the lake has been utilized for cleaning and restoration of the lake. The cooperative has initiated payment system for watershed management in upper hierarchy so that the life of water basin in lower hierarchy can be saved for future generation. This model of sustainable conservation and wise use of the resources can be applied to other wetlands of the country for restoration, economical, environmental and social benefits.

Livelihood focused management problems and constraints

Fisheries reshuffle is needed to address the sector's long-standing management problems:

- Lack of secure access and rights to open access areas for small-scale fishers and resource poor communities. Leasing of part or whole water bodies to private individuals for fishing or farming is a common practice in Terai, and the profit generated is often shared by a few. Local government reserves the rights to auction. Due to these social and institutional problems in fishery management, large-scale unemployment leading to social dislocation could develop among fragile fisher community over the time.
- Almost all reports on Nepal's inland fisheries note illegal fishing as a serious problem due to the high incidences of these practices and their severe impacts on fish stocks and habitat (for example, Gurung, 2003b; Swar, 2002; Ranjit, 2002). Common illegal practices include electro-fishing and poisoning.

- Competing uses of land and water for agricultural and fishing purposes**:** Conflicts arise over land and water use in riparian areas because these resources play important roles in supporting both agriculture and capture fisheries.
- Irrigation and water control projects improve agricultural yields but decrease fisheries productivity by reducing available fisheries habitat, especially dry season refuges.
- Pesticides and chemical fertilizers may reduce water quality and fisheries productivity. Agricultural chemical runoff may affect nearby fisheries and directly impact rice field's fish productivity
- Infrastructure projects may affect fish migration, habitat, and production: infrastructure projects, such as dams, weirs, and roads, can significantly affect fisheries production by blocking migration, reducing water quality, and degrading and/or reducing available habitat. Dam projects, in particular, can have severe impacts on fisheries and overall water quality.
- Weak management and enforcement practices of rules and regulations set out by ALPA-1961.
- Lack of accurate fisheries statistics from which effective monitoring might be possible.

Fisheries and aquaculture will be expected to be more compatible with its environment and other users of resources and has to become more sustainable. The constraints confronting fisheries and aquaculture development on indigenous fish in the country are:

Poor fisheries development policies: lack of comprehensive fisheries policies or appropriate fisheries legislation that is needed to promote sustained growth of the fisheries sector. Policy should address the issues of environmental protection, biodiversity conservation and livelihood rights of prime dependents (community water).

Few fish farming traditions: agriculture, being traditional subsistence crops, has an established base and dominate many economics of the country. On the other hand, no traditional aquaculture knowledge exists among farmers/fishers in the country.

Inadequate technologies: As aquaculture technologies did not exist in Nepal in traditional setting. Most of the introduced technologies are appropriate and suited to the introduced exotic species and intended beneficiaries. However, at present there is inadequate effort to develop fish farming technologies of indigenous fish by which prevailing social, cultural and economic factors could be appreciated.

Inadequate participation of resource users: Efforts on natural water fisheries is more effective and sustainable where the users assume the responsibilities and costs of management. The use of community based management strategies, whereby the responsibility for the fishery is developed to the local people, should also be considered as ultimate implementing agency for fisheries development program in natural water. Potential of local community control in development program will provide use of local knowledge, empowerment of poor, adaptation of technical input to local conditions and sense of program ownership by the community.

Weak research and extension activities: Research and extension activities are hindered by the general economic difficulties. Although there are few fisheries research and development centers in the country, the contribution of these centers to real development is limited, either because of inappropriate research targets or because of the absence of effective fisheries extension. As fisheries research and extension advanced worldwide, the main impediment in the country is lack of access to current knowledge and technologies.

Limited coordination between research and development sectors: In many cases the research and development efforts carried out are not responsive to the needs of targeted stakeholders. For the needs to be appreciated in community settings, research and development should be used to evaluate (a) those social aspects found in many rural areas that negatively affect the adoption of new technologies, (b) the role of gender, (c) labor supply and demand and (d) marketing.

Inadequate information management system: Access to fisheries information is inadequate, limiting the scope, quality and utility of fisheries research and development activities. There is a lack of information flow (networking) between institutions in the country.

Inadequate human resources: The current lack of trained fishery and aquaculture human resources is a constraint that needs to be addressed in order to effectively purse research and development in fisheries, and accurate impact assessment protocols. A critical mass of people with suitable postgraduate training is needed to maintain and generate research designs required to meet fisheries development needs.

Conclusion

Increasing fishing pressure, in combination with destructive fishing practices and habitat degradation and loss, threaten the sustainability of fisheries of indigenous fish in Nepal. A continuation of this trend could threaten the food security and income of the more than 2.8 million populations dependent on the wetland resources, and the fisheries is one of the critical activities for their livelihoods. Population growth estimates suggest a significant increase in the number of rural youth entering the labor force in the years to come, which will likely exacerbate current fishing pressure problems. Many of rural poor will seek to earn or supplement their livelihoods through subsistence fishing because the entry barriers are low – no land or other costly investments are required. Ensuring sustainable fisheries and livelihoods will require significant improvements in several areas, including: enforcement measures to reduce illegal fishing, management reforms that appropriately address the fishing access and user rights issues of fishers/rural poor and sustainability issues, and development planning that takes into account cross-sector impacts to fisheries from agriculture, forestry, and infrastructure development.

Practical policymaking for the fisheries sector requires substantial data and information inputs, which are in many cases meager. There is a need for more socio-economic research on the relationship between fisheries resources and rural livelihoods. While it is widely recognized that many rural people depend on fisheries for their livelihoods, major issue remain about how best to manage native fisheries resources to achieve rural development and poverty alleviation objectives.

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Domestication and Breeding Status of Some Native Fishes in Nepal

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ABSTRACT

The growth, reproduction, cares and feeding of domesticated organisms are more or less controlled by man. At sex maturation, some fish can spawn spontaneously in captivity, but some fish will spawn if properly induced under controlled conditions. A total of 187 native fish species are reported in different rivers and other water bodies of Nepal. Among these species, the economically important native fish species are Sahar, *Tor* spp.; Katle, *Neolissocheilus hexagonolepis*; Asala, *Schizothorax* spp.; *Schizothoraichthys* spp.; Gardi, *Labeo dero*; Hade, *L. pangusia*; Thend *L. angra*; Jalkapur, *Clupisoma garua*; *Pseudeotropius murius*; etc. The population of native fishes is declining in their natural habitat due to over fishing, damming, degradation of the aquatic environment and biological changes in the ecosystem. Developments of captive breeding and culture techniques are the means for conservation and promotion of a sustainable population of native fishes. Breeding technology of some native fishes such as Sahar, *T. putitora*; Katle, Asala, *S. plagiostomus* and Gardi have been developed in Nepal after many years of study. Preliminary observation on induced breeding of some native fish species resulted in successful breeding of Hade, Thend, Lahare, *Garra annandelai*; Buduna, *G. gotyla* and Baghi, *Botia lohachata* last year in Kali Gandaki Fish Hatchery after few years of domestication of these species. The objective of this paper is to evaluate the present status of domestication and breeding of some native fish species. The paper is documented based on the compilation of the past works and experiences gained and from the information cited in literatures.

Key words: Domestication, breeding, native, stripping, hormone treatment

Introduction

Domestication is the process of hereditary reorganization of wild animals and plants into domestic and cultivated forms according to the interests of people. Domestication is that condition wherein the breeding, care and feeding of organisms are more or less controlled by man (Hale, 1969). The advantages of domestication are: (i) the growth (quantity and quality); (ii) the reproduction (timing and hybridization); and (iii) the costs (time and labour) of domesticated animals can be controlled or manipulated. Fish culture may exist in the Nile delta of Egypt and China as long ago as 2500 BC (Bargese, 1980). The origin of domestication of the wild common carp, *Cyprinus carpio*, acquired 2000 years ago by the Romans in Southcentral Europe (Balon, 1974) and the goldfish, *Carassius auratus*, was started 1000 years ago in China (Chen, 1956). According to FAO yearbook (1998), there are about 465 species of cultivated aquatic organisms in 107 families. However, success in domestication has only been achieved on a small number of species, such as carp, trout, catfish, tilapia (Eknath *et al.*, 1993; Pullin, 1996) and freshwater shrimp (Liao and Chao, 1983).

In aquaculture, domestication is regarded as acclimatization to captive conditions, the two key points being rapid growth rate and a potential for induced spawning in captivity (Hassin *et al.*, 1997). Domestication for aquaculture is regarded as the total control of the life cycle of an organism as well as the manipulation of breeding in captivity. The assurance of reproduction is quite important to domestication. Domesticated fish can spawn spontaneously in captivity. At sex maturation, some fish can spawn spontaneously in captivity, but some fish will spawn under controlled conditions only if properly induced. The most common used method is by the injection of hormonal materials. After hormonal injection, some fish will spawn in ponds, but others would require stripping to get the gametes. However, these methods are questionable because they inflict physiological stress and injury to the fish, particularly during stripping, making fish susceptible to diseases, sometimes, causing death. Fry produced using this method have low fertilization rate and are weak (Liao, 1993). Spontaneous spawning involves the use of well-balanced and sound approaches to hatchery practice, thus, high percentages of healthy fry can be obtained (Liao, 1993). Some prominent farmed aquatic species, such as the Chinese and Indian carps, have long been farmed on a massive scale, but have been bred in captivity only since the 1960's (Pullin *et al.*, 1998).

A total of 187 native fish species belonging to 92 genera, 31 families and 11 orders are reported in different rivers and other water bodies of Nepal (Rajbanshi, 2005; Shrestha and Chaudhary, 2004). Out of 187 species, 127 species are reported from Koshi, 157 from Gandaki, and 119 from Karnali River system (Shrestha, 1992). The native fish species of Nepal are distributed from few meters in Terai to 3323 meters in Langtang Khola, located in Langtang National Park (Shrestha, 1995). Out of 187 species, 77 are common, 13 occasional, 61 insufficiently known, 25 rare, 10 vulnerable and one endangered species (Shrestha, 1995). Six native species found in Nepal are given endemic status. Out of 157 species reported from the Gandaki river system , 57 species were recorded from the Kali Gandaki River (Shrestha and Chaudhary, 2004) and 24 species recorded from Trishuli River (FRC, Trishuli, 1993). A total of 18 native fish species are reported from the lakes of Pokhara valley (Wagle and Bista, 1999). A total of 81 cold water native fish species belonging to 37 genera, 7 families and 2 orders are reported (Shrestha, 2002). Among these species, the economically important native fish species are Sahar, *Tor* spp.; Katle, *Neolissocheilus hexagonolepis*; Asala, *Schizothorax* spp.; *Schizothoraichthys* spp.; Gardi, *Labeo dero*; Hade, *L. pangusia*; Thend *L. angra*; Jalkapur, *Clupisoma garua*; *Pseudeotropius murius*; etc.

The population of native fishes is declining in their natural habitat due to over fishing, damming, degradation of the aquatic environment and biological changes in the ecosystem. Native fishes are over fished in their natural habitat from illegal catching methods such as electro-fishing, poisoning and dynamiting. As a result, the population has become unsustainable with fish catch from fisher communities being low in most parts of the country. This has led to efforts to conserve, manage and propagate the native fish species. Developments of captive breeding and culture techniques are the means for conservation and promotion of a sustainable population of native fishes. Breeding technology of some native fishes such as Sahar, *T. putitora*; Katle, Asala, *S. plagiostomus* and Gardi have been developed in Nepal after many years of study. Preliminary observation on induced breeding of some native fish species resulted in successful breeding of Hade, Thend, Lahare, *Garra annandelai*; Buduna, *G. gotyla* and Baghi, *Botia lohachata* last year in Kali Gandaki Fish Hatchery after few years of domestication of these species. This result shows that there are possibilities of induced breeding of other native fish species after domestication in captive condition. The main objective of this paper is to evaluate the present status of domestication and breeding of some native fish species, which will be potential candidates for aquaculture. The paper is documented based on the compilation of the past works and experiences gained and from the information cited in literatures.

Materials and Methods

A. Acquisition of eggs by hand stripping (Sahar, Katle and Asala)

The breeding activity of Sahar was conducted at Fisheries Research Centre, Pokhara (Begnas), Fisheries Research Centre, Trishuli and Kali Gandaki Fish Hatchery. Similarly, the breeding activities of Katle and Asala were conducted at Fisheries Research Centre, Trishuli and Kaligandaki Fish Hatchery.

Most of the females were checked at 4-7 days intervals during the breeding season for maturity by applying gentle pressure on the abdomen by hand near the genital opening. Sometimes, they were checked at 2-3 days interval on the basis of maturity condition during breeding season. The females that released eggs on slight pressure were transported inside the hatchery then stripped gently to receive eggs in a clean, dry bowl.

Milt from healthy males was gently mixed with the eggs using feather for dry fertilization. The eggs were weighed and counted, then washed with clean water. One ml of newly released eggs was weighed and counted visually. This process of washing was repeated several times. The eggs were incubated for hatching in Atkin's incubators trays by allowing one layer of eggs on single mesh screen trays in flow through system. The fertilized eggs in incubation trays were covered with black plastic screen. Water flow in incubation trays was maintained at a discharge rate of 4-5 L/min. Dead eggs were removed using forceps without touching other eggs to protect the eggs from fungal infection. Unremoved dead eggs were easily infected with fungus, which could spread rapidly to the adjacent healthy eggs. Early hatched larvae possessed large yolk sacs and settled near corners of the incubation trays. After attaining free-swimming stage the larvae were transferred into a tank of 2.5m x 0.40m x 0.30m dimension. Supplementary feed was fed to hatchlings after yolk sac absorption. The advanced larvae were also fed with zooplankton screened through plankton net.

All the spawned and over matured females of Sahar were kept in separate pond after spawning to check whether these spent females would be matured again or not in next breeding season from September to November. After segregation of all the responded females, these females were reared in same brood pond for next breeding season.

Brood fish were fed with 30-40% protein diets (Table 1). The feeding rate was 2-5% of total body weight. Pond water quality parameters such as temperature, pH and dissolved oxygen were measured.

Table 1. Feed ingredients and the composition of pellets (30% protein) fed to Sahar

Ingredients	Proportion
Shrimp (Jawla)	20
Soybean	35
Wheat	15
Maize	10
Rice bran	10
Mustard oil cake	09
Vitamin and mineral mix	01

B. Acquisition of eggs by hormone treatment (Gardi)

The breeding activity of Gardi was conducted at Kali Gandaki Fish Hatchery since 2002. The females with a soft, distended abdomen showing unripe light grey eggs near genital aperture on gentle pressure on the abdomen were selected for hormone treatment. The males were selected which oozed milt with gentle pressure near the genital pore.

The fish were treated with a commercially available hormone Ovaprim. Ovaprim (Syndel International Inc., Canada) contains the sGnRHa (D-ARG^6, Trp^7, Leu^8, Pro^9, Net) LHRH and domperidone (a dopamine antagonist) dissolved in distilled water at 20 µg/ml and 10 mg/ml, respectively. The required amount of Ovaprim was filled in a syringe. The female and male fish were injected with 0.5 $ml.kg^{-1}$ and 0.25 $ml.kg^{-1}$ of Ovaprim, respectively at the basal section of the pectoral fin.

At onset of ovulation, the female fish were chased by the males. The eggs were released in the tank by self spawning method and fertilized eggs were incubated in the same tank until hatching occurred. After spawning, spent brood were collected, measured body weight and transferred to spent brood tank. Another method of egg collection was stripping of eggs and milt from the broods and fertilized the eggs by artificial dry method as described for sahar, katle and Asala. Fertlized eggs were incubated in tank providing flowing water with slight current.

C. Preliminary observation on induced breeding of some other native fishes
The breeding activities of Hade, Thend, Lahare, Buduna and Baghi were conducted at Kali Gandaki Fish Hatchery in 2007. The process for brood selection, hormone treatment, egg collection, fertilization and incubation of the eggs were similar as described above for Gardi breeding.

Results

A. Acquisition of eggs by hand stripping (Sahar, Katle and Asala)

A. 1. Sahar

Preliminary work on breeding of Sahar has been carried out in Nepal since the early 1960's (Gurung *et al*., 2002). In earlier years wild matured brood fish caught by gill net were used for spawning. At this time, it is considered that female Sahar never be sexually matured in captivity though males are sexually matured (Masuda and Bastola, 1985). They studied breeding of naturally matured Sahar in Tadi River on August 1979 and concluded the possibility of mass seed production of Sahar. Shrestha (1986) also reported the breeding of naturally matured Sahar in Trishuli River. Spawning of Sahar collected as mature brood fish from lakes started around 1982 in Lake Phewa with the objective of maintaining pure strains. There is a limited opportunity to obtain matured brood of Sahar from wild habitat and not possible to get as required every time. Since such practice is highly unreliable thus attempts were made for reliable methodologies. Shrestha *et al*. (1990) reported successful spawning of hormone induced Sahar reared in captivity with supplementary feed on September 1988. However, this success is in the rim of uncertainty. Later this work was followed by Morimoto et al. (1995), Baidya *et al*. (1998 and 2000) using different methods for

Sahar breeding. Most authors agreed that Sahar is a partial spawner due to the low number of released eggs during a single spawning event (Joshi, 1994; Shrestha, 1997; Shrestha *et al*., 1990).

The techniques of Sahar breeding gradually developed from stripping naturally mature brood collected in lakes to rearing of broods in pond conditions (Fig. 1). The compilation of 146 spawning data showed that Sahar could breed in most months of the year (Figure 1). Since pond reared females were not examined in December and January, it is not yet clear whether they could breed in these months or not. Results showed that Sahar could spawn from March to November at 19.5-35 °C (Figure 2). Joshi *et al*. (2002) reported that wild Sahar, which have been domesticated since 1989, responded to hand stripping without any hormonal treatment on 6 April 1993 at Fisheries Research Centre, Trishuli.

Baidya *et al*. (2007) reported that the pond reared Sahar bred in two breeding seasons from February to April and September to November (Fig. 3). The spawning success rate was higher in February to April than in September to November (Fig. 4). The fertilization and hatching rates were also observed higher in the first breeding season than in the second breeding season. Out of 50 females, 12-18% females released viable eggs from February to April, whereas 0-14% females released viable eggs from September to November by maturity examination of female Sahar at 3-7 days intervals in 2001-2004. In 2005 from February to March, all the pond reared female Sahar were sexually matured, among which 52% females spawned viable eggs, 48% were found overripe during the maturity examination. While about 46% females responded among which only 6% females spawned viable eggs from September to November, 2005 (Fig. 4). Similar result was observed at Kali Gandaki Fish Hatchery also in 2007 indicating that same brood spawned two times with higher fecundity in March/April (Table 2).

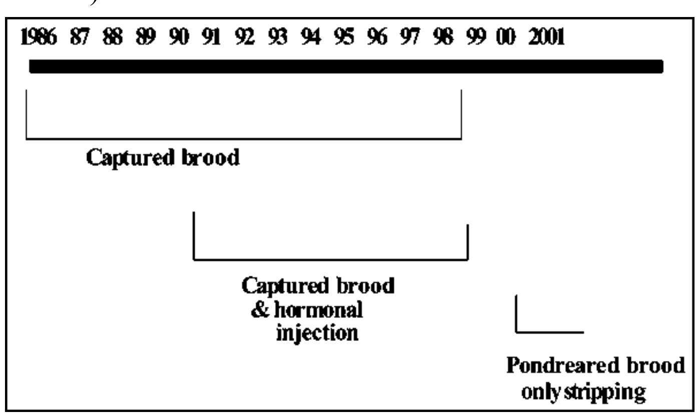

Figure 1. Methodological progression of obtaining Sahar broodstock from lakes and rivers and breeding in ponds (Source: Gurung *et al*., 2002)

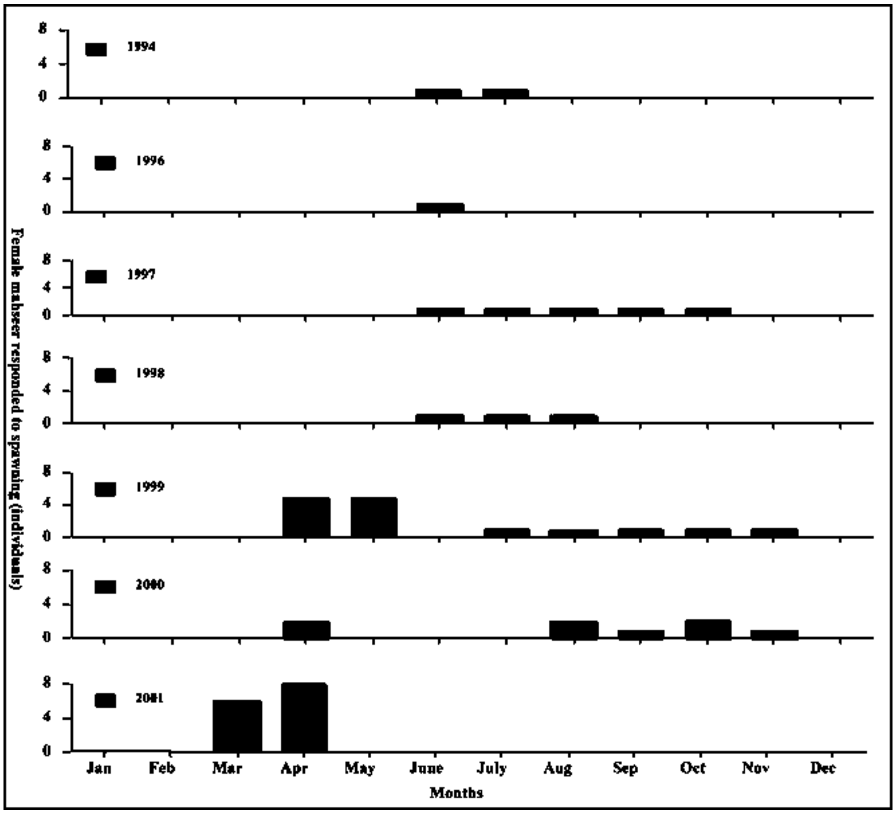

Figure 2. Response of Sahar in different months showing intermittent breeding (Source: Gurung *et al*., 2002)

During maturity examination 90-95% population was seined from experimental ponds. Usually, most females were found overripe and only a few were at the right stage for releasing viable eggs during September-November and more than 50% females were found releasing viable eggs during February-March, 2005. Overripe females were identified as releasing poor quality eggs, which turned opaque white soon after fertilization resulting in poor fertilization and hatching rates; or those releasing degenerated eggs with orange fluid at slight pressure on abdomen and the fluid turned white immediately when it came in contact with water.

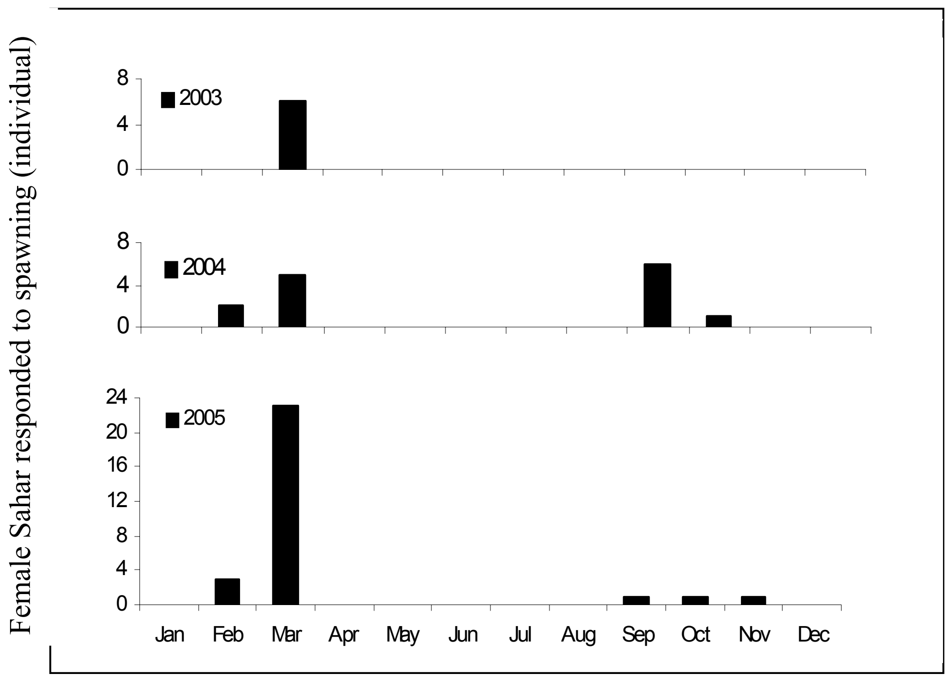

Figure 3. Spawning number of Sahar brood with viable eggs in different months (Source: Baidya *et al*., 2007)

Table 2. Breeding record of Sahar at Kali Gandaki Fish Hatchery in 2007.

Date	Water temp (°C)	Female No.	Female wt (kg)	Egg wt (g)	No. of eggs	Fecundity
21-Mar	19-20	3	6.2	471	48984	7900
22-Mar	19-20	2	4.3	349	36296	8440
23-Mar	19-20	2	4.6	380	39520	8590
28-Apr	24-25	2	3.6	210	21840	6066
Mar-Ap		9		1410	146640	7840
16-Sep	25-27	1	0.784	75.22	7822	9977
17-Sept	25-27	1	1.4	21.60	2246	1604
24-Sept	24-25	2	3.4	221.15	23000	6764
28-Sept	24-25	1	0.8	15.64	1626	2032
02-Oct	24-27	4	5.65	469.58	48836	8643
03-Oct	24-27	1	0.7	69.20	7196	10280
25-Oct	23-24	1	1.7	62.0	6448	3793
Sep-Oct		11		934.39	97174	6700

Date	Fertilization rate	Hatching rate	Incubation time	Larvae production
	(%)	(%)	(hours)	
21-Mar	90	80	120	33100
22-Mar	95	95	120	33900
23-Mar	95	95	120	36400
28-Apr	95	95	72	19800
Mar-Ap				123200
16-Sep	95	95	72	7000
17-Sept	90	80	72	1600
24-Sept	95	95	72	20000
28-Sept	95	90	72	1400
02-Oct	95	90	72	42600
03-Oct	95	90	72	6000
25-Oct	95	95	96	5800
Sep-Oct				92100

A.2. Katle

Rai (1978) reported that Katle female weighing 600 g from Trishuli power plant reservoir released 30 g (3461 nos.) with 43% hatching rate and other female weighing 264 g of the pond released 24 g (2526 nos.) eggs with 75% hatching rate. The diameter of ripe eggs was ranged from 1-8 mm to 2.0 mm. Hatching began to appear after 6 days of fertilization and completed in 7 days at 18-21°C. The average size of hatchlings was 1 cm in total length. Rai (1990) reported that Katle released eggs during September in 1989 and during August-September in 1990 at Fisheries Research Centre Trishuli. Eyed eggs showed up after 54 h of fertilization and hatching commenced after 114 h and completed at 163 h after fertilization at 22-23°C. Total 15 females released eggs during October in 2006 at Kali Gandaki Fish Hatchery (Table 3)

Table 3. Breeding record of Sahar at Kali Gandaki Fish Hatchery in 2007.

Date	Water temp (°C)	Female No.	Female wt (kg)	Egg wt (g)	No. of eggs	Fecundity
13 Oct	25-27	7	1.956	68.10	7763	3969
15 Oct	25-27	3	0.718	56.25	6412	8930
17 Oct	25-27	5	1.568	77.5	8835	5634
		15	4.242	201.85	23010	5424

Date	Fertilization rate (%)	Hatching rate (%)	Incubation time (hours)	Larvae production
13 Oct	95	90	96	6900
15 Oct	80	70	96	5000
17 Oct	90	80	96	4100
				16000

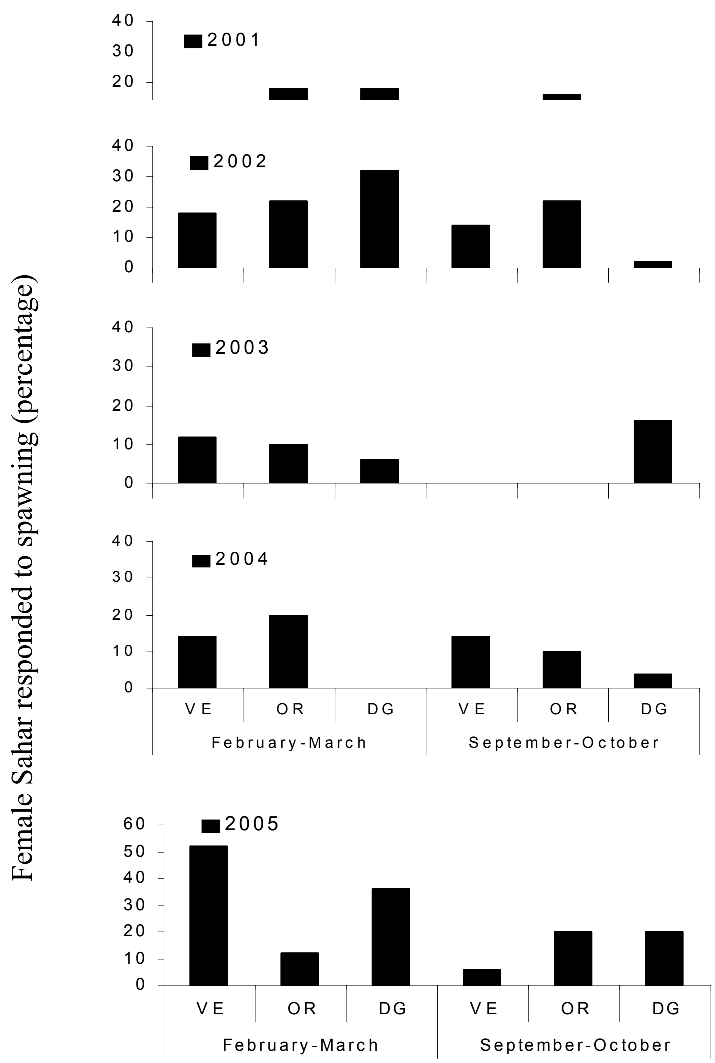

Figure 4. Spawning percentage of Sahar brood showing viable, overripe and degenerated eggs in two breeding seasons (Source: Baidya *et al*., 2007)

3. Asala

Asala were spawned by manually stripping in two consecutive breeding periods: October/November and February/March at FRC, Trishuli during 1992/93 and 1993/94 (Joshi *et al*., 1996). Hatching rate was higher in October/November (>50%) than in February/March (<25%). Incubation period was 10-12 days at 11-16°C. Mean fecundity was 12,000 eggs/kg fish. The mean diameter and weight of individual egg were 2.54 (±0.19) mm and 13.3 (±3.0) mg, respectively. Artificial breeding of Asala has been successful in FRC, Trishuli since 1971, but the culture technology is still under study (Rai *et al*., 2002). Asala spawned with higher fecundity during February 2007 than in first breeding season during November in 2007 at Kali Gandaki Fish Hatchery (Table 4).

Table 4. Breeding record of Asala at Kali Gandaki Fish Hatchery in 2007/08

Date	Water temp (°C)	Female No.	Female wt (kg)	Egg wt (g)	No. of eggs	Fecundity
19 Nov	15-16	5	1.2	141.95	17460	14550
21 Nov	14-15	3	0.307	60.25	7410	24136
23 Nov	14-15	3	0.518	65.48	8054	15548
25 Nov	15-16	1	0.082	12.05	1482	18073
(2007)		**12**	**2.107**	**279.73**	**34406**	**16329**
02 Feb	11-12	3	0.416	73.43	9032	21712
04 Feb	11-12	1	0.150	17.5	2153	14353
06 Feb	11-12	2	0.244	25.55	3143	12881
09 Feb	13-14	1	0.414	47.48	5840	14106
10 Feb	13-14	2	0.325	57.5	7072	21760
12 Feb	13-14	3	0.240	25.5	3136	13067
(2008)		**12**	**1.789**	**246.96**	**30376**	**16979**

Date	Fertilization rate (%)	Hatching rate (%)	Incubation time (hours)	Larvae production
19 Nov	80	75	192	10000
21 Nov	90	80	240	5000
23 Nov	90	85	240	6000
25 Nov	90	80	192	1000
(2007)				**22,000**
02 Feb	80	70	264	5000
04 Feb	90	85	264	1600
06 Feb	90	80	264	2200
09 Feb	95	90	240	5000
10 Feb	90	90	240	5700
12 Feb	70	70	240	1500
(2008)				**21000**

B. Acquisition of eggs by hormone treatment

B.1. Gardi

Breeding of Gardi was started since 2002 at Kali Gandaki Fish Hatchery by hormone treatment. Breeding performance showed peak spawning season was June-July when water temperature increased above 24°C. During breeding season Gardi prominently exhibited sexual dimorphism. Well riped fishes were given single Ovaprim hormone injection at a dose of 0.5 ml/kg for female and 0.25 ml/kg for male. Ovulation time varied 6-9 h after hormone treatment at 26-29°C. After ovulation, females released eggs self in the tank or hand stripped into a bowl. The mean fecundity ranged from 334000 eggs per kg of body weight. Hatching time ranged from 12-18 h at 26-29°C. The average fertilization and hatching rates were 70% and 50%, respectively. Breeding performance of Gardi at Kali Gandaki Fish Hatchery in 2007 is summarized in Table 5.

Table 5. Breeding record of Gardi at Kali Gandaki Fish Hatchery in 2007

Date	Water temp (°C)	Female no.	Female wt (g)	Egg wt (g)	No. of eggs	Fecundity	Incubation time (hours)	Larvae Production
10 Jun	27	3	992	150	270000	272000	16	105000
13 Jun	28	3	1746	300	540000	309000	14	210000
15 Jun	26	3	1052	210	378000	359000	18	147000
22 Jun	29	3	1302	222	399600	307000	12	155000
25 Jun	28	5	1732	345	621000	359000	14	232000
27 June	28	4	1504	255	459000	305000	14	107000
29 June	28	3	930	186	334800	360000	14	130000
01 July	28	5	1364	232	417600	306000	14	146000
06 July	29	4	1362	273	491400	360000	12	191000
08 July	29	3	874	175	315000	360000	12	122000
12 July	28	4	1214	243	437400	360000	14	152000
18 July	26	4	1042	202	363600	349000	18	128000
20 July	26	4	1122	224	403200	359000	18	127000
	26-29	48	16236	3017	5430600	334000	12-18	1952000

C. Preliminary observation on induced breeding on some other native fishes

Some other native fishes, such as Hade, Thend, Lahare, Buduna and Baghi were treated with hormone treatment and resulted in successful induced breeding producing some fries. These species were also bred in same breeding season of Gardi, which usually spawn once a year during the summer season when water temperature remains above 25°C. Fries of Hade, Lahare and Buduna were released in upstream Mirmi reservoir first time, which were produced in Kali Gandaki Fish Hatchery. Results obtained from preliminary observation on induced breeding of Hade, Thend, Lahare, Buduna and Baghi is summarized in Table 6.

Discussion

In Nepal, Sahar, Asala and Katle are the most economically important cold water fish species as being excellent food fish and high value sport fish. The breeding of Sahar, Asala and Katle commenced at similar period and they are considered as multiple spawner. Sahar spawned in two consecutive breeding periods: from February to April and from September to November (Baidya *et al*., 2007; Gurung *et al*., 2002; Joshi *et al*., 2002). Katle spawn from August to September (Rai, 1978 and 1990). Asala spawn from October to November and from February to March best spawning in February to March (Joshi *et al*., 1996). Breeding technology of Gardi has been developed in Kali Gandaki Fish Hatchery. Preliminary observation on breeding of Hade, Thend, Lahare, Buduna and Baghi showed that there are possibilities of breeding of other native fishes at Kali Gandaki Fish Hatchery.

Table 6. Preliminary induced breeding records of some native fish species at Kali Gandaki Fish Hatchery in 2007

Particulars	Fish Species				
	5. Hade	**6. Thend**	**7. Lahare**	**8.Buduna**	**9. Baghi**
Date	17 Jun	29 July	20Jun,24Jul	24 July	20 Jun
No. & wt. of females treated with hormone	1, 0.654 kg	1, 0.454 kg	6, 0.252 kg	2, 0.148 kg	2, 0.128 kg
No. & wt. of female responded to release viable eggs	1, 0.654 kg	1, 0.454 kg	6, 0.252 kg	2, 0.148 kg	2, 0.128 kg
Average size of female (g)	650	450	40	74	64
Total no. of males used to fertilize the eggs	2	2	6	2	3
Average size of male (g)	500	500	30	40	50
Total eggs released (g)	131	91	38	22	20
Number of eggs/g	1,800	1,800	2,000	2,000	2,000
Total number of eggs released	235,800	163,800	76,000	44,000	40,000
Total number of hatchlings	60,000	40,000	24,800	10,000	8,000
Fertilization rate (%)	50	50	70	60	50
Hatching rate (%)	50	50	50	40	40
Average fecundity/kg female	360,000	360,000	300,000	297,000	312,000
Range of water temperature for incubation	29	26	26-27	26	27
Egg releasing time interval after injection (hours)	6	9	8-9	9	8
Range of incubation period (hours)	12	18	16-18	18	16
Expected no of fry and their survival rate (%) up to 2-3 cm	16,000 (25.0)	2,000 (5.0)	6,000 (24.2)	6,000 (60.0)	2,000 (25.0)

The techniques of Sahar breeding gradually developed from stripping naturally mature brood collected in lakes to rearing of broods in cultured conditions. Attempts were also made to study the possibilities of reproduction in captivity using sex hormone (Shrestha *et al*., 1990; Morimoto *et al*., 1995; Baidya *et al*., 1998). The compilation of spawning data showed that Sahar could breed in most months of the year. Naturally mature brood collected from inlet streams of lakes could spawn in monsoon and post monsoon seasons from July to October (Gurung *et al*., 2002). Pond reared broodstock could spawn from February to April and from September to November. Both naturally collected mature brood from inlet streams and pond reared broodstock could breed eight months in a year except from May to June and from December to January at 18.0-28.5°C.

The pond reared Sahar broodstock started to spawn from February at 18.0°C. These females again ripen after 5-6 months and responded from September to November until 19-20°C. In this way single brood responded twice in a year showing multiple spawning as in Common carp, *Cyprinus carpio,* 3-5 times in a year (Horvath 1978; Gurung *et al*., 1993), Grass carp, *Ctenopharyngodon idella* 2 times in a year and Catla, *Catla catla* 4 times in a year (Rath *et al*., 1999). Sahar broods were reared in net cages in lakes, raceways and ponds. But Sahar reared in ponds had shown better result by attaining sexual maturity and spawn by hand stripping. Therefore, this is also demonstrated that Sahar brood could be reared like other carps such as common carp, Chinese carps and Indian major carps. Breeding season of Sahar was also started at the same time of common carp breeding when the pond water temperature reaches to 18.0-19.0°C.

In this study overripe females were decreased by examining brood more frequently in 2-3 days interval. Delayed stripping of eggs following ovulation led to the aging phenomenon or over ripening, which is resulted in poor quality eggs with low fertilization and hatching rates (Sakai *et al*., 1975; Springate *et al*., 1984). Ovulated eggs of oviparous teleost become overripe if retained in the body cavity and these eggs show a progressive reduction in viability for many species. After ovulation, the optimum duration for egg stripping with the good quality eggs varied with different species of fish (Bromage, 1995). This duration ranges from 4-10 days in the Rainbow trout, *Oncorhynchus mykiss* (Nomura *et al*., 1974; Sakai *et al*., 1975; Bry 1981; Springate *et al*., 1984) to a few hours in the studied fish (Bromage, 1995). It is considered that optimum duration for egg stripping will be less than 2-3 days after ovulation in Sahar as the broods were undergo over matured on examining on 2-3 days interval. Therefore, it is recommended to study on the optimum time for egg stripping in Sahar after ovulation to obtain good quality eggs.

Egg releasing conditions can also be considered as an indicator of egg quality. During stripping, if eggs released timely with translucent shiny eggs on gentle pressure on the abdomen, we can estimate eggs are of the good quality and stripping time is coincided with ovulation time. If the released eggs are opaque white, we can estimate eggs are going to degenerate. If the eggs are released loosely with orange fluid at slight pressure on the abdomen, then we can estimate the eggs are of poor quality and it is too late for egg stripping.

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Strategies for the Conservation of Fish in Nepal

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Abundant water in the earth has given it a new recognition - blue planet. Water in the earth has 71.0 % of its surface coverage; out which, only 3.0 % exists as fresh water (Wetzel, 1983). Nepal, a small land-locked country lying in between Tibetan and Gangetic plain, has heavy rainfall due to the south west monsoon, intensity and pattern of monsoon is governed by the topography of Himalayas. The annual precipitation, on an average is about 1400mm, that is, 175 billion m^3 of water/year and natural water resources of Nepal comprise 1.5 percent of total global fresh water resource.

Table 1. Water resources and Estimated Water Surface Area

Types	Estimated Area (ha.)	Percentage (%)	Potential Area (ha.)
Rivers	395,000.0	48.0	
Lakes	5,000.0	0.6	
Reservoirs	1,500.0	0.2	
Village ponds	6,500.0	0.8	92,400
Marginal Swamps	12,500.0	1.4	14,000
Irrigated rice field	398,000.0	49.0	
Total	818,500.0	100.0	

Estimated water surface Area in Nepal (FDD, 1998)

Eternal glaciers, ice-cold torrents, clear-water rivers, lakes, reservoirs and swamps contribute to much of Nepal's hydrosphere. There are more than 6000 rivers exceeding 25000 km in total length. The Mahakali, Karnali, Gandaki and Saptakoshi are the four major rivers followed by Bagmati, West Rapti, Mechi, Karnali, Kankai, Kamala and Babai. Some rivers are originated in the Churia; discharge of these rivers is nominal and may dry up in dry season - Tilawe, Sirsia, Manusmars, Sunsari, Banganga. Lakes are natural water reservoirs of various size scattered all over the country covering an area of 5,000 ha. Lakes occur from southern low altitude plain of about 60m to more than 5000m. Based on the origin, lakes can be classified into three types: glacial lakes, tectonic and ox-bow lakes. There are 44 glacial lakes in the northern Himalayan region located above 4000 m. Tectonic lakes occur in the hilly region and the most of lake of Nepal are tectonic in origin which when drained out were replaced by flat basins like Kathmandu valley, Pokhara valley, Banepa, Panchkhal, Mariphant (Palpa), Dang, Surkhet. Oxbow lakes are mainly confined to the southern part of the country particularly between the middle to southern Terai region. More than two dozen ox-bow lakes are present in Nepal and most of them are located in Chitwan National Park, Nawalparasi, Bardiya and Kailali (Sharma, 1997).

Numerous small and large reservoirs are built at different parts of Nepal; the total area of reservoirs is about 1500 ha; but the potential for expansion of reservoir area is very high in Nepal for irrigation and hydropower development.

Fish biodiversity

These rivers, rivulet, lakes, reservoirs, swamps etc are rich in fish biodiversity and provide excellent fishing opportunities. The great fish diversity lies in modified structure to adapt the torrents and currents of the river water, climatic diversity etc. Fishes of Nepal share commonalities with fish fauna of south-east Asia such as carps, cat-fishes, sheat fishes, feather backs, eels, hill stream fishes etc. There are more than 187 species of warm water and coldwater fishes. The largest fish found in Nepal is *Bagarius bagarius* while the smallest is *Danio rario.* In Nepal, there are fresh water fishes of 11 orders and 31 families and 92 genera reported (Shrestha, 2001).

These fishes have shown diverse and characteristic biological, behavioral and structural adaptation related to different topographies and climates. The hill steam fishes have unique adaptive structural modifications to sustain themselves at fast flowing waters such as the flattening of head, presence small eyes, devoid of thick scales on the ventral surface of body, paired fins shifted outwards with modified outer rays for adhesion and the inner rays assisting in respiration by motion, presence of adhesive organ, mouth, jaws, lips, skin modified, reduced gill opening, air bladder, barbels etc. Fishes of cold water system show migrating behavior for food and breeding purpose in response to changes in water volume, water temperature and water chemistry at different seasons of a year. There are three categories of fishes: long distant migrants, short distant migrants and resident fishes (Table 2).

Table 2. Spawning and migratory season of different migratory fishes.

Species	Migratory Patterns Downstream Upstream	Spawning Time
Long distant Migratory Fishes		
Tor putitora (Golden mahaseer)	J F M A M J J A S A N D	Sept- Oct
Tor tor (Deep bodied sahar)	J F M A M J J A S A N D	Sept- Oct
Bagarius yarelli (Freshwater Shark	J F M A M J J A S A N D	June –July
Clupisoma garua (Jalkapoor)	J F M A M J J A S A N D	June –July
Anguila bengalensis (Fresh water eel)	J F M A M J J A S A N D	June –July
Short distant Migratory Fishes		
Schizothorax plagiostomus (Pointed nose -Asala)	J F M A M J J A S A N D	Sept-Oct
Schizothorax richardsoni (Blunt nose-Asala)	J F M A M J J A S A N D	Sept-Oct
Acrossocheilus hexagonolepis (Katle)	J F M A M J J A S A N D	Sept-Oct
Resident Fishes	**Habitat**	
Barbus chillinoids (Karange)	Habitat prefers ,rock gravel bed pool	Sept- Oct
Psilorhynchus pseudoecheinus (Tite)	Slow run rapid	June –July
Pseudoecheinus sulcatus (Kabre - torrent catfish)	Head water stream	May–June
Glyptothorax cavia (Capree)	Head water	May–June
Glyptothorax blythi (Tilkabre)	Rocky boarder stream	June
Garra gotyla (Buduna, rock carp)	Backwater pool, rock crevices,	May- June
Garra annandalei (Buduna - stone roller)	boulder, pool water , crevices of stone	Sept-Oct.

In Nepal, there are nine endemic fish species, following different indigenous food, larvivorous and sport fishes reported (Shrestha, 1994) (Table 3).

Table 3. Endemic, food, larvivorous and sport fishes of Nepal.

Endemic fish	Indigenous food fishes	Indigenous larvivorous fishes	Indigenous sport fishes
Myersglanis blyrhii	*Notopterus notopterus, N. chitala*	*Barilius barila, B. barna. B. bendelensis, B. bola, B. jalkapoorie, B. teleo, B. vagra*	*Acrossocheilus hexagonolepis*
Pseudotropius murius batraensis.	*Acrossocheilus hexagonolepis,*	*Danio acquipinnatus, D. dangaila, D. devario, D. rerio*	*Changinius changunio*
Lepidocephalichthy s nepalensis	*Barilius jalkapoorie, B. bendelisis*	*Esomus denricus*	*Labeo angra*
Psilorhynchus pseudoeceneis	*Catla catla, Cirrhinus mrigala, Labeo rohita*	*Osteobrama cotio*	*Puntius*
Schizothorax nepalensis	*Schizothorax plagiostomus, Schizothoraichtys progastus*	*Oxygaster bacaila*	*Semiplotus semiplotus*
Schizothorax annandalei	*Tor putitora, T. tor*	*Puntius apogon, P. chola,, P. conchonius, P. sarana, P. ticto, P. titus*	*Tor putitora, T. tor*
Schizothorax rarensis	*Mystus aor, M. seenghala,*	*Chela labuca*	*Schizothorax macrophthalmus*
Schizothorax macrophthalmus	*Ompok bimaculatus, Wallago wallago*	*Rasbora danioconiu, R. elonga*	*S. molesworthii, S. nepalensis*
Barilius jalkapoorei	*Clupisoma garua, Eutropichthy vacha*	*Lepidocephalichthys guntea, L. nepalensis*	*S. plagiostomus, Schizothorax raraensis*
	Bagarius bagarius	*Aplocheilus panchax*	*S. richardsonii*
	Channa marulius, C. striatus	*Channa gachua, C. marulius, C. punctatus, C. stewartii, C. striatus*	*Schithoraichthys annandalei,*
	Macrognathus aculeatus, Mastacembelus armatus	*Chanda nama, C. ranga*	*S. esocinus, S. progastus*
		Nandus nandus, Badis badi, Anabas testudinus	*Clupisoma garua*
		Colisa fasciatus, Glossobius giuris	*Bagarius bagarius*
		Carassius carassius, Gambusia afficinalis	

Status of Fishes

Threat status of indigenous fish species are given in Table 4.

Table 4. Threat staus of indigenous fish (Adapted from Shrestha, 1995)

Status (Global)	Number of Species
Common/Occasional	90
Insufficiently known	61
Vulnerable	10
Endangered	1
Rare	25
Total	187

Common/occasional (90 species)

Gadusia chapra, Setipinna phasa, Notopterus notopterus, Notopterus chitala, Amblypharyngodon mola, Aspidoparia jaya, Aspidoparia morar, Barilius barila, Barilius barna, Barilius bendelensis, Barilius bola, Barilius shacra, Barilius vagra, Danio devario, Esomus denricus, Rasbora danioconius, Chela labauca, Catla catla, Cirrhinus mrigala, Cirrhinus reba,Carassius carassius (Introduced), *Labeo angra, Labeo bata, Labeo boga, Labeo calbasu, Labeo dero, Labeo gonius, Labeo dyocheilus, Labeo rohita, Oxygaster bacaila, Crosssocheilus latius, Garra annandalei, Garra gotyla, Garra lamta, Osteobrama cotio, Puntius chillinoids, Puntius conchonius, Puntius sarana, Puntius sophore, Puntius ticto, Puntius guganio, Semiplotus semiplotus, Botia lohachata, Lepidocephalichthys guntea, Nemacheilus beavani, Nemacheilus botia, Nemacheilus devdevi, N. rupicola, N. rupicola var inglishi, Mystus aor, Mystus bleekeri, Mystus. cavasius, Mystus seenghala, Mystus tengra, Mystus vittatus, Ompok bimaculatus, Wallago attu, Clupisoma garua, Bagarius bagarius, Gagata cenia, Glyptothorax pectinopterus, Heteropneustes fosiilis, Clarias batrachus, Xenontedon cancila, Channa gachua, Channa marulius, Channa punctatus, Chanda nama, Chanda ranga, Nandus nandus, Badis badis, Anabas testudinus, Colisa fasciatus, Glossobius giuris, Macronathus aculeatus, Mastacembelus armatus, Mastacembelus puncalus.*

Occasional (13 species)

Danio dangaila, Barilius teleo, Psilorhychus sucatio, Somileptes gongota, Rita rita, Ailia colia, Eutropichthys vacha, Pseueutropius atherinoids, Pseudoecheneis sulcatus, Chaca chaca, Channa striatus, Amphipnous cuchia, Tetradon cutcutia

Insufficiently Known (61)

Gadusia godanahiae, Barilius radiolatus, Danio acquipinnatus, Rasbora elonga, Chela cachius, Oxygaster argentea, Oxygaster gora, Oxygaster phulo, Garra nasuta, Schizothorax *molesworthii, Schizothorax sinuatus, Schizothoraichthys labiatus, Schizothoraichthys niger, Schizothoraichthys curvifrons, Labeo caeruleus, Labeo fimbriatus, Labeo pangusia, Labeo sindensis, Oreichthys cosuatis, Puntius apogon, Puntius clavatus, Puntius gelius, Puntius* ***titus, Psilorhychus*** *balitora, Psilorhychus homaloptera, Botia almorhae, Botia dayi, Botia dario, Botia histrionica, Acanthophthalmus pangia, Nemacheilus corica, Batasio batasio, Ompok pabda, Ompok pabo, Clupisoma montana, Pseueutropius murius batarensis, Silonia silondia, Erethistes pussilus, Erethistes montana, Erethistes elongatus, Gagata nangra, Gagata sexualis, Glyptothorax annandalei, Glyptothorax conirostris, Glyptothorax gracilis, Glyptothorax ribeiroi, Glyptothorax pectinorai, Hara hara, Hara jerdoni, Laguvia ribeiroi, Nangra nangra, Nangra viridescens, Gambusia affinis patruelis, Aplochelus panchax, Channa barca, Channa stewartii, Colisa latius, Colisa sota, Ctenops nobilis, Macronathus oral, Rhinomugil corsula,*

Rare (25)

Balitora brucei, Schizothorax macrophthalmus, Schizothorax nepalensis, Schizothorax raraensis, Schizothoraichthys annandalei, Schizothoraichthys esocinus, Puntius chola, Lepidocephalichthys nepalensis, Nemacheilus savona, Nemacheilus scaturginia, Amblyceps mangois, Mystus. menoda, Euchiloglanis hodgartii, Glyptosternum blythi, Glyptothorax cavia, Glyptothorax horai, Glyptothorax telchitta, Glyptothorax trilineatus, Sissor rhabdophorus, Olyra longicaudata, Chanda baculis, Sciaena coitor, Sicamugil cascasia, Myersglanis blythi, Labeo nukta.

Vulnerable (10)

Acrossocheilus hexagonolepis, Barilius jalkapoorie, Danio rerio, Schizothorax plagiostomus, Schizothorax richardsonii, Schizothoraichthys progastus, Changunius changunio, Tor putitora, Psilorhychus peudecheneis, Anguilla bengalensis,

Endangered (1)

Tor tor,

Importance of Indigenous fishes

The indigenous fishes form an important component of region's bio-diversity and valuable genetic resource for food security and nation income. Indigenous fishes have 44.0% share of total national fish production and indigenous fishes alone contributes 1.21% in AGDP and 0.46% in National GDP. Fish is considered to be an auspicious item in Nepalese culture and displayed as a “sagun” during many religious and social functions apart from releasing them in religious ponds. These indigenous fishes have significant contributions in protein supply of nutrient deficient Nepalese people and also provide livelihood and income-generating opportunity for the local fisher communities such as Sarki, Raji, Baji, Badi, Bote, Bhujel, Kami/Damai, Danwar, Majhi, Magar etc.

Capture fishery has employed 4,25,027 people and 1, 06,257 families with 5,78,036 beneficiaries (DoFD 2005/06). Capture fishery has addressed gender issue as the involvement of female (2,54, 025) is about 1.4 times greater than male (1,71,002). Fisheries also provide opportunities for economic benefits through commercial production and establishment of sport or recreation centers to develop eco-tourism in the country to earn foreign currency.

Factors for the depletion of Indigenous fishes in Nepal

Once abundant indigenous fishes are in declining trend due to over-fishing/illegal fishing practices (electro-fishing, dynamiting, ago-chemicals etc.), introduction of exotic fishes, deforestation, siltation, pollution and developmental works.

Over fishing/illegal Fishing

With the increase of fisher community population and the involvement of non fisher community in fishing for occasional catches/ sports have decreased fish population considerably by over fishing. Use of small mesh sized fishing nets, gill net, electro-fishing, fish poisoning and blasting have depleted fish resource rapidly killing large fishes, fingerlings and fries indiscriminately. Different natural plant poisons like kettuke (*Agave Americana),* khirre (*Sapium insigne)*, kukur tarul *(Dioscorea deltoidea)* and sihudi *(Euphorbia voyelana)* are used by local people along with commercial chemicals for mass killing fish. Explosives used in road construction projects are misused in killing fishes.

Impact of exotic fishes

These days, 13 exotic fish species including crustacean (fresh water prawn) were introduced by the public and private sector in the country (Pantha, 1994). Out of these, S*almo gairdneri, Salmo trutta* and *Oncorhynclus rhodurus* do not exist any more. Chinese carps (Grass carp-*Ctenophayrngodon idella*, Bighead carp-*Aristichthys nobilis* and Silver carp-*Hypopthalmichthys molitrix*) and common carp (*Cyprinus carpio*) were introduced by Government of Nepal for adaptive culture practices (Table 5). In view of culture trial, exotic coldwater fish like Rainbow trout (*Oncorhynchus mykiss)* was first introduced in Nepal from England as gift in 1969 and second time from India in 1970 A.D. Later 50,000 eyed eggs were again brought from Japan in 1988 A.D. Trout is now being studied for commercial production in cold water raceways at government research stations and private fish farms. Seeing the great prospect of rainbow trout, Government of Nepal in collaboration with FNCCI have launched OVOP program in Nuwakot and Sindhupalchowk Districts.

Table 5. Exotic species (culture in Nepal)

Name of fish	Imported year	Source
Common carp (*cyprinus carpio*)	1956, 1960	India and Israel
Grasscarp (*Ctenopharyngodon idella*)	1967	India
Silver carp (*Hypophthamichthys molitrix*)	1968	Japan
Bighead carp(*Aristichthys nobilis*)	1971 and 1972	Hungary
Rainbow trout (*Oncorhynchus mykiss)*	1969, 1970, 1988	England, India and Japan

Besides above fishes, tilapia (*Tilapia nilotica* and *T. mossambica),* silver barb (*Puntius gonionotus*) and crustaceans such as giant fresh water prawn (*Macrobrachium rossenbergii*) are some of the exotic fishes officially introduced by the Government of Nepal from neighboring countries with the purpose of feasibility study of commercial production in Nepal. African catfish (*Clarias gariepinus*) is introduced by people themselves and production of it is being carried in plain areas of Nepal.

There are several examples about the adverse effects of exotic fishes on local fishes in our country and abroad. Nepal lacks extensive records; however, report showed 42% less production of *Mystus* and *Puntius* after the introduction of Chinese carps in Lake Begnas (Swar and Gurung, 1988). In the experience of India and Bangladesh, common carp competes with mrigal and kalbasu; similarly silver carp with catla and rohu for natural feed.

Deforestation

Population of Nepal is consistently increasing with an annual growth rate of 2.08 and the present estimated population has reached more than 26.0 million. Population growth has accelerated deforestation and the area covered by forest is decreasing at the rate of 2% annually (Wallace, 1988) (Table 6).

Table 6. Area covered by Forest (Area in hectare)

Year	Area	Percentage	Source
1954	6478000	47.6	FAO, 1954
1964	6402000	45.5	HMG/USAID, 1967 &1973
1977	6284629	42.7	CRMP, 1986
1977/78	6211038	42.2	Master Plan, 1988
1985/86	5828368	39.6	DFRS,1999k

Siltation

Conversion of steep slope into agricultural land, urbanization, road construction etc are responsible for heavy erosion during monsoon increasing sediment loads in rivers. Siltation is an acute problem of all the rivers, lakes, reservoirs like Phewa, Rupa in Pokhara and Indrasarobar reservoir in Kulekhani. The intensive potato farming in the surrounding hills of Indrasarobar has further intensified the problem with adverse effect upon reservoir fisheries and power generation in the past. A sudden burst of heavy rainfall in August 1993 around Indrasarobar reservoir had added water level up to 22.0m within a night totally destroying public and private fish cages.

The direct and primary effect of soil erosion is soil loss and nutrient leaching. A study in the mid hills of Nepal revealed a soil loss of 20 ton/ha/year from rain fed marginal land and nutrient loss accounts for 300 kg of organic matter, 15 kg of nitrogen, 20 kg of phosphorus and 40.0 kg of potash (Carson, 1985 and 1992). More than 50.0% of losses occurred during pre-monsoon (May-June) when ground covers were absent and loss is mainly through leaching than surface run off. The nutrient accumulation and increased sediment loads in river systems has affected the fish population and their breeding grounds adversely.

Table 7. Suspended load of some of the rivers of Nepal (Sharma, 1997)

Rivers	Annual suspended sediment load (million tons)
Karnali River at Asaararghat	16.6
Seti River at Banganga	20.9
Sarada River at Daredhunga	0.41
Karnali River at Chisapani	86.2
Rapti River at Bagasoti	16.0
Kali Gandali at Setibeni	14.4
Seti River at Phoolbari	3.1
Trisuli River at Betrawati	4.0
Narayani River at Narayanghat	176.8
Lothar River at Piplet	0.6
Bagmati River at Chobhar	0.86
Kulekhani Khola at Kulekhani	0.02
Tamor River at Mulghat	57.6
Kankai Mai at Maina Chuli	5.5

Pollution

Pollution is another factor responsible for adverse alterations of natural environment and loss of indigenous fishes. An extensive study of water quality of different river systems of Nepal done based upon physical water quality criteria (Table 8), showed Koshi River least polluted while Bagmati river most polluted (Table 9).

Table 8. Water Quality Classification of the rivers of Nepal (Sharma, 1999).

Water Quality Classes	Mapping colour	Pollution Level	Water uses
I	Blue	None to very slightly Polluted	Multipurpose
I-II	Blue-green	Slightly polluted	Restricted uses (drinking restricted for locals)
II	Green	moderately polluted	Restricted uses (drinking possible after treatment for locals
II-III	Green-yellow	Critically polluted	Restricted uses (drinking possible after treatment for locals)
III	Yellow	Heavily polluted	Hazardous
III-IV	Yellow-red	very heavily polluted	extremely hazardous, unsuitable for any kinds of human uses
IV	Red	extremely polluted	unsuitable for human uses

Table 9. Pollution level in different major rivers of Nepal (Sharma, 1999).

Pollution Level	Koshi River	Gandaki River	Karnali River	Bagmati River
	48 sites	43 sites	9 sites	49 sites
None to very slightly polluted	26	2	2	-
Slightly polluted	5	14	2	3
Moderately polluted	5	23	3	14
Critically polluted	2	3	-	6
Heavily polluted	-	1	2	14
Extreme polluted	-	-	-	12

Chemical toxicity

With the intensification of agricultural productivity, use of chemical fertilizers and pesticides had also increased. Chemical toxicity is one of the important factors for the degradation of aquatic ecosystems and the loss of fish fauna.

Table 10. Application of chemical fertilizers in Nepal 1964 – 2000 (nutrients in metric tons)

Year	Nitrogen	Phosphorus (P_20_5)	Potash (K_2O)	Total
1964/65	370	180	42	592
1974/75	14488	3895	3375	21758
1981/82	17976	5489	775	24232
1990/91	51929	19256	1533	72718
1991/92	60008	29440	1602	84443
1992/93	60447	21596	1290	73810
1993/93	55385	17149	1278	90263
1994/95	64385	24300	1578	70154
1995/96	46448	21306	2400	70154
1996/97	43242	19283	1635	46160
1997/98	32629	13124	1442	47195
1998/99	32314	12097	1258	45669
1999/2000	25034	12031	185	37250

Irrigation and hydropower projects

Irrigation

Water resource development projects like irrigation and hydropower are increasingly implemented for overall development of the nation. Master plan for irrigation was developed in 1990 with following status of irrigation schemes in Nepal.

Table 11. Irrigation situation with respect to total land area and net irrigable area (in ha)

Ecological Belt	Total Land area (ha)	Net Agriculture area (ha)	Irrigable area (ha)
Terai	3,409,863	1,359,165	1,337,581
Hill	6,152,353	1,054,272	368,577
Mountain	5,186,183	227,198	59,918
Total	14,748,399	2,640,635	1,766,076

Hydropower projects

Hydropower development started as early as 1911, but due to poor planning less than 1.0% of total nation capacity is exploited so far (Table 12). The theoretical hydropower potential (riverwise and basinwise) estimated on the basin of average flow method and existing hydroelectric plants are outlined below (Table 13) (Sharma, 1997 and Shrestha, 1999):

Table 12. Existing Hydroelectric Plants

Plants	Firm capacity (MW)	Plants	Firm capacity (MW)
Pharping	-	Kulekhani II	32.0
Sundarijal	0.64	Pokhara	-
Chisang Khola	-	Marsyangdi	66.0
Panauti	2.4	Andhi Khola	5.1
Trishuli	12.5	Jhimruk	81.8 (GHW)
Tinau	1.25	Tatopani Myagdi	8.8 (GHW)
Phewa	1.0	Kali Gandaki	144.0
Sunkoshi	5.1	Bhote Koshi	36.0
Gandaki	10.8 (Private)	Upper Marsyangdi	44.0
Kulekhani I	60.1	Seti	1.5
Devighat	10.89 (Private)	Kulekhani III	38.0
Upper Modi	14.0	Middle Marsyangdi	42.0

Table 13. The theoretical hydropower potential (riverwise and basinwise)

Main energetic divisions	Area under count (in km^2)	Hydropower potential (in million kw)	
		Riverwise	Basinwise
Sapta Koshi	27,300	22.35	32.40
Sapta Gandaki	31,600	20.65	29.00
Karnali & Mahakali	47,300	36.17	56.50
Southern rivers	39,300	4.11	8.50
Total		83.28	126.40

Impacts of irrigation and hydropower projects

Water quality and ecological changes: Irrigation/Hydropower project will alter aquatic ecology forming an impoundment upstream of weir, a dry zone will be formed between headwork and power house or total dry zone below dam of diversion irrigation canal affecting downstream ecology. Dam will affect water quality, quantity and isolate upstream areas from downstream with adverse affect upon breeding grounds and fish migration. Artificial type of aquatic environment will be created forming a dry stretch and decreased water volume will rise water temperature in daytime with a sharp decline in temperature at night. Rooted plants, moss may develop with an increase in dissolved oxygen (DO) at daytime and decrease DO at night.

Impact on fishes: Decrease water flow will adversely affect the spawning and over all development of fishes. Upstream of the headwork, some fish may be caught by the intake structure and find their way to the tunnel and lost. Distribution of fish food like planktons and zoobenthos will be reduced with adverse affect upon fishes like stunted growth, disease- parasitic infestation and morbid body change.

Impact on fish migration: Dam will fragment and isolate upstream of weir from downstream obstructing the migratory route of fish like long distant and short distant migrants. The remaining resident fishes will be isolated also; however, they can adapt and congregate at upstream, dry zone and tail water. Fishes from upstream will occasionally sweep downstream during monsoon to become the part of lower zones.

Conservation and Management

Conservation

Legislation: Conservation of aquatic life is addressed by the Aquatic Animal Protection Act (AAPA) 2017 (1961); which prohibits the use of explosive or poisonous substances in any body of water where the intention is to catch or kill aquatic life. This act has been revised by the parliament and consolidated in 1999 AD HMG/Nepal has formulated aquatic life protection regulation and the procedure of its implementation. It regulates fishing gears, size of the fish and season. Study on the effects of development projects on fishery resources and implementation of mitigative measures has been made mandatory under this regulation. AAPA is the basic legislation developed for fish conservation in the interest of fishery professionals. Besides, there is certain other scattered legislation such as

- National Parks and Wild Life Conservation Act (1973)
- Chitwan National Park Regulation (1974)
- Wildlife Reserves Regulation (1975)
- Himalayan Mountain National Park (1979)
- Khaptad National Park Regulation
- Soil and Watershed Conservation Act

All these acts are concerned for the conservation of wild fisheries inside National Parks and Wildlife reserves only but not for the fish resources outside them. There is controversies regarding the implementation of acts due to absence of well defined legal definition, strategy programs and policy, limited technical capabilities and infra-structures, multiple ownership and conflict between NEA and related government agencies etc.

Environmental Impact Assessment (EIA): After the implementation of the Nepal Environmental Policy and Action Plan (NEPAP), Nepal has introduced a legal and institutional mechanism for the application of EIA for the thorough assessment of impact of development projects on aquatic life along with mitigation measures.

Management

Regular monitoring: Extensive studies on water quality, changes in water temperature, aquatic vegetation, fish feed distribution and local fish fauna distribution of major rivers are required with an objective to develop database. Study of genetic composition of indigenous fishes of different river systems necessary to keep the records of fish genetics associated with different habitats and region's of the country.

Participatory Social Mobilization: The socioeconomic of fisher community in particular and other farmers in general will be affected and the critical issue is to provide adequate emphasis on the aspects of participatory social mobilization of the fisher communities. The role and responsibilities of the fishermen groups have to be clearly identified establishing adequate linkages with other developmental organizations to draw support in technical and economic activities. A 'Code of Conduct' should be developed for the implementation of participatory conservation plan in association with local elites, government agencies, district agriculture development officer/junior technical assistant officer to provide assistance/training to carry out the various fish conservation and economic activities of the groups.

i) Formation of fisher/farmer groups:

- Representatives of affected families and water user families should be involved in the farmers/fisher group.
- Each group may consist of 10 or more members with at least 25% female as far as possible
- Each groups should also be encouraged in income generating activities like agricultural (vegetable farming and vegetable seed production), livestock farming (goat, chicken, pig and dairy cattle etc) and industrial activities (medicinal herb farming and cottage industry etc.) to generate local funds for establishing self reliant groups.

ii) Training:

Based on the need of the group members various types of training should be organized primarily in fisheries and other allied aspects. Fisheries training would familiarize about the breeding biology, nursery rearing techniques along with the migratory behavior of the fishes. Fish sanctuary and closed fishing season would be declared to protect the brood fishes.

iii) Modality for group operation

- Follow up the riparian compensation flow of water, which is at least 10 percent of the total discharge.
- To recuperate the fish stock in the river, hatchery reared fish seed.
- Concerned agency should provide some funds for logistic support to each group under mitigation measure for an effective mobilization of fish conservation and income generating activities.
- Group should develop their own procedural regulation document in which the objectives, role and responsibilities of the members and other legal aspects such as imposition of fine on illegal fishing and planning of income generating activities of the group etc. are clearly spelled with the consultation of the group members.

iv) Linkage with different government and developmental agencies

Fish ladder: Fish ladder is one of the most important remedies for assisting natural fish migration. It had been proved satisfactory for salmon in north temperate rivers, for cyprinids in Tigris and Euphrates, and for *Tor* sp and Indian major carps in Ganga. Hydropower projects of Nepal are generally established in the areas of fish migration (mid-distance and long distance) and fish ladder is recommended to overcome the barrier effect of dam. Fish ladder should meet following criteria:

- it should be adapted to the requirements of the species concerned
- it should be pool and weir type, rocky ramp type or a vertical slot
- flow velocities must not exceed swimming capacity of fishes
- it should provide passage for all fish size - small and large
- it should be provided with proper fencing with total ban on fishing

The more natural type of pass, e.g. rocky ramps or artificial rivers (bypass channels), can even enhance the beauty of the landscape.

Fish trapping and hauling: It involves the trapping of fishes below dam and transporting them to reservoir or upstream to maintain fish diversity and gene pool. But it is labor intensive, prone to poaching by handlers and stressful to fish which increases their mortality.

Compensation riparian flow: There may be a dewatering effect downstream during dry season due to the flow diversion and damming of river. The effect is local and can be overcome to some extent by releasing compensation flow downstream. Compensation flow for the conservation of microflora, aquatic insects and fishes in dewatering zone should be within 10-20% of regular flow. However, the standard can not be used everywhere globally. While compensation flow release is present in the plan, negligence in commitment was noted as in the Marsyangdi Hydropower Project.

Habitat management and spawning area improvement: Some resident fishes such as stone roller (*Garra gotyla*), stone loaches (*Nemacheilus beavani*), catfish (*Glyptothorax pectinopterus*) and murrel (*Channa punctatus*) utilize the gravel bed area for spawning. Considerable loss of spawning ground of these fishes has occurred immediately below the dam. Adequate attention must be given to the protection of spawning and nursery gravel beds. Where needed, additional measures should be taken:

- depositing gravel to increase spawning habitat.
- manipulating angular and large boulders to create pool areas for spawning and as an escape cover for resident fishes during low water phase.
- using large boulders to alter flow pattern of downstream.
- keeping gravel and boulders together to create spawning riffles to attract resident stock in mass along the swift run rapids.
- releasing flushing discharge to rewater exposed gravel bed to maintain spawning gravel quality.
- enhancing habitat by tree planting to increase shelter cover, shade and drift food.

Fish Hatchery: A reservoir associated hatchery should produce seed of important native fish such as mahaseer, copper mahaseer, snow trout, jalkapoor, freshwater eel etc which are most affected by the dam projects. Stocking at the reservoir and tail water will replenish the losses resulting from the disappearance of the natural spawning grounds and from disturbance of migration. The fishers should be provided seed from government hatchery to grow fish in ponds to market size. This provides alternative means of subsistence and incomes thus reducing pressure of the capture fishery on native stocks.

Reservoir Fishery: While regular fish stocking is one way of enhancing reservoir fish stocks, reservoir-based aquaculture is also a useful enhancement practice. Beveridge and Phillips (1988) reviewed the cage, pen and enclosure practices in reservoirs. In Nepal also, practices of cage culture is being practiced in Trishuli and Kulekhani Reservoirs where it provides income to the local fisher community.

Rehabilitation of depleted fishes: The fish rehabilitation can be defined as the release of artificially reared fingerlings with a view to restock and replenish depleted fish resources. Rehabilitation has two main objectives:

- rehabilitation to mitigate or compensate for adverse effects of some activity within the river system
- rehabilitation to maintain and increase production in the face of intensive exploitation through extensive aquaculture or restocking

The channel so created has to be maintained as fish sanctuary or buffer zone. Some important conservation measures have to be undertaken to control the recruited fishes. Involvement of local fisher-folks in conservation practices and controlled harvesting with the complete restriction of illegal fishing methods will employ cooperative management implying a sharing of management responsibility between resource users and government. Here, Government should play a role in enhancement initiatives arrangement and research striking a balance between facilitating initiatives and regulating environmental impact on and from enhancement.

Establishment Fish Sanctuaries and Eish Ranching Centers: The majority of fish inhabiting rivers are extremely sensitive to modifications and environmental changes. An extensive network of protected areas has now been established in Nepal consisting six National Parks, four Wildlife Reserves and one hunting reserve with fishing being strictly restricted in water bodies situated inside their territory. Ranching is a potential conservation management method in rivers/artificial channels of Nepal for rehabilitating depleted fish stocks and enhances them to a sustainable level.

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Status of the Indigenous Major Carps (IMC) Breeding, Cultivation and Commercial Aquaculture in Nepal

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Introduction

Nepal is very rich in water resources. The water is in the form of rivers and streams, lakes, reservoirs, flood plains and swamps, man made ponds, irrigation canals and irrigated paddy fields. Nepal has three distinct agro-climatic zones. Terai with sub-tropical warm climate lies in the south, Himalayas with cold temperate climate lies in the north and hills and mountain with intermittent climate is in the centre. The varied type of climate makes our country very rich in aquatic biodiversity. There are 182 species of indigenous fish identified so far in Nepal out of which 101 species are considered to be warm water inhabitants and 81 cold water inhabitants and 31 species of fish are considered to be economically important. Indigenous fish contributed 63% in national fish production in 2004/2005 (Table 1).

Table 1. Production contribution of indigenous fish in metric tons

	2001/02	**2002/03**	**2003/04**	**2004/05**	**Percent contribution**
Aquaculture	4965	5185	5870	6604	29.3
Pond	4676	4810	5417	6073	30.0
Marginal swamp	289	375	453	531	28.0
Fisheries	17900	18888	19947	19983	100.0 (nearly)
Total	22865	24073	25817	26587	65.0

Global production from aquaculture was 60 million metric tones in 2004 which is nearly half of the world fish production .Contribution of cyprinids in world aquaculture was 18 million metric tones in 2004 (FAO 2006). Carps and minnows are the major group of fish in Nepal. There are five species of carp considered to be very important in terms of their food value as well as sporting value and because of their size they can be considered major carps but only three species are commonly considered as indigenous major carps (IMC) namely Rohu, Mrigal and Catla. Annual fish production in Nepal reached 45425 m ton in 2005/2006 in which aquaculture contributed 56%. Pond culture, cage culture, pen culture, culture in marginal swamps, rice fish culture and raceway culture systems are commonly practiced in Nepal.

Production technology

Pond culture and culture in marginal swamps include IMC whereas other culture systems are dominated by exotic species. Pond culture contributes nearly 90% in aquaculture production and is mainly concentrated in the southern part of the country. Polyculture of carps is the technique adopted for pond culture. Indigenous major carps (IMC) share nearly 30% in stocking as well as production and Rohu is the dominant species amongst IMC in pond aquaculture system in Nepal. Commercial production of IMC is very popular in Andhra Pradesh state of India and lot of their production comes to Nepal. Nepal has also initiated commercial production of IMC by adopting the technique followed in India but it is on a very small scale (Table 2). A new trend has emerged particularly in Bara and Parsa districts to produce IMC of 50-100g in order to meet domestic demand of fish in the hills. Smoked and dried fish are marketed in the hilly regions.

Table 2. Technical variation in Nepal and Andra Pradesh, India for the production of IMC

Attributes	Nepal	Andra Pradesh, India
Productivity, tons	4-5	12.56 (maximum)
Stocking density, fry.ha^{-1}	7000	4000-10000
Stocking size, g	25	10-15 cm
Stocking ratio, %		
Catla catla	40	45
Labeo rohita	40	50
Cirrhunus mrigala	20	5
Recommended input		
Water depth, m	>1.5	>2.0
Lime, kg.ha^{-1}	500	200-500
Cattle dung, ton.ha^{-1}	3	10-15
Nitrogen, kg.ha^{-1}	220	(200 kg urea)
Phosphorous, kg.ha^{-1}	345	(250-500 kg SSP)
Feeding with oil cake + rice bran in 1:1, % of standing biomass	1	Ground nut oil cake + DORB in 1:3 ratio at 2-4 % of body weight twice daily

Breeding and seed production

Fish production through culture of IMC started by importing riverine collected seeds from India. Loss of seed during transportation led to the development of artificial propagation technique. Artificial breeding of Rohu and Naini was successful in 2033 BS and that of Bhakur in 2036 BS (Table 3). The technique of artificial propagation is well established in the country and adopted by farmers easily as a result nearly 71% of the required fish seed in the country is produced by private sector (Figure 1). Nepal is self dependent in IMC seed.

Table 3. Breeding performance of indigenous major carps in public farms of Nepal (main breeding season range between the months June to September. Ovaprim is the common hormone applied to induce ovulation in IMC).

Fish species	Success %	Fertility %	Hatchability %	Hatchling.kg^{-1} female
Labeo rohita	80	78	79	58
Cirrhunus mrigala	83	83	75	56
Catla catla	60	70	75	34

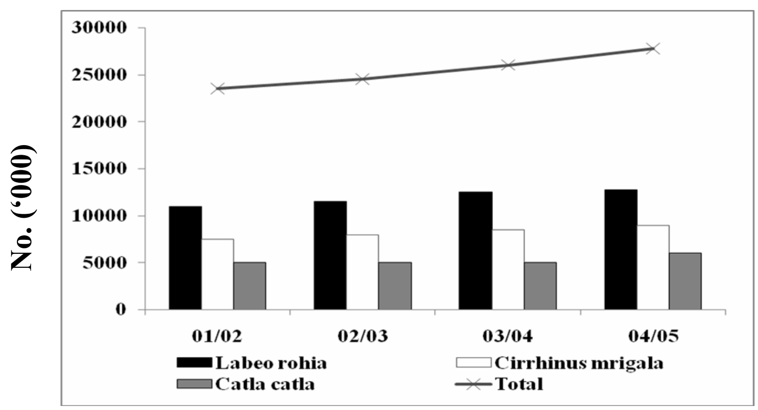

Figure 1. Seed production of Indigenous Major Carps

Even though IMC is found in our natural water bodies no attempt has been made to collect the brooders from natural sources and check for any phenotypic or genotypic variation and their importance. There has been no attempt made to search for the breeding ground of these species within the country. Therefore hatchery breeding is the only source of IMC seeds. Parental stocks of the hatcheries are progeny of reverine seed from the Ganges. Genetic degradation in existing stock is the general complain of the farmers, which is justified by the low fecundity, poor hatchability, poor seed survival and poor growth.

Limitations in fish breeding

- Limited recruit of brood fish from natural sources.
- Limited exchange of brood fish between hatcheries.
- Small number of brood used to spawn.
- Small number of new individual recruited as brood-stock.
- Inbreeding rate ranges from 1.6-27.6% per annum.

Issues

- Genetic degradation of farmed stock.
- Appreciation for high production technology.
- Attraction to private entrepreneur in commercial aquaculture.
- Lack of appropriate policy body for new direction of Aquaculture and Aquatic Resource Management.
- Illegal Fishing
- Increased import of fish

Therefore it is a high time to start genetic improvement program through selective breeding, stock replacement, stock manipulation etc. and at the same time searching for the breeding ground of IMC in the country and keeping their profiles updated.

Recommendation

- Determine the degree of inbreeding in cultured species and launch genetic improvement program.
- Formulate and enforce code of conduct for fish hatcheries.
- Ensure supply of healthy and quality fish to consumers at comparative price.
- Mechanization in production system.
- Formation of National Board for Aquaculture and Aquatic Resource Management.
- Activation and enforcement of Aquatic Animal Protection Act.
- Initiation of conservation of Aquatic ecology, fauna/flora, fish biodiversity through participatory management.
- A well-established genetic characterization record of indigenous species is necessary in order to monitor the long-term purity of the parental lines.
- The broods of IMC from our own natural water bodies be collected, reared and their natural breeding grounds to be identified.

Workshop Recommendation

I. Recommendation of Group A: Conservation strategy for the promotion of indigenous fish

1. Establish a bench mark data base of indigenous fish biodiversity and identify economically important indigenous fishes of Nepal.
2. Establish gene pool of economically important indigenous fishes - *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, *Tor tor, Tor putitora*, *Neolissocheilus hexagonolepis* and *Schizothorax* spp for educational, developmental and conservation perspectives.
3. Establish a national museum of indigenous fish for educational, recreational, tourism, conservation, biological, social perspectives.
4. Carry out socio-economic studies on native fishes and other aquatic organisms, both from hills and southern plain.
5. Establish "Aquaculture and Aquatic Resources Management Board" for commercial development and monitoring fish biodiversity, mitigation program, fisheries and aquaculture program of the country representing DoFD/ NARC-FRD/TU-Zoology Committee, IAAS-TU Aquaculture Department and Freelancer with executing rights to promote aquaculture production as well as to monitor fish conservation.
6. Emphasize studies on global warming aspect in respect to safeguard indigenous fishes in the affected water bodies.
7. In recognition of indigenous fish resources, make effort to organize a regional / international workshop / seminar in collaboration with regional/ international institutions at appropriate time.
8. Emphasize indigenous fishes and other weeds, water animal of southern terai for research and cultivation.
9. Establish a body to enforce the Aquatic Life Conservation Act-2017 (amend 2056) for hatchery or fish ladder as mentioned in all streams, rivers or lake wherever, dams for irrigation and power generation is constructed with bearing all expenses to primary stakeholders.
10. Establish a Fisheries and Aquaculture board to monitor fish conservation and increase production with legal rights.
11. Identify economically important indigenous fishes and bring consensus on the number of indigenous fish in Nepal using available technologies of taxonomic importance.
12. Empower the users group with informal property right for resource conservation.

13. Uplift the economic condition of fisher folk by involving them in community based program on aquatic resource conservation and promoting the culture/ recreational activities at suitable sites.
14. Effective implementation of EIA ($\geq$2 MW) recommended.
15. Alternative program for displaced group.

II. Recommendation of Group B: Domestication strategies for the promotion of indigenous fish

1. Study the commercial production methodologies of indigenous fishes especially those in mid and high lands
2. Intensify studies on *Tor putitora, Tor tor*, *Neolissocheilus hexagonolepis* (Katle), *Schizothorax* spp (Asala), and *Labeo dero* (Gardi) for developing culture practice for production and initiate preliminary studies on *Clupisoma garua* (Jalkapoor), *Bagarias yarelli* (Goch).
3. Develop methodologies to integrate indigenous fishes into ongoing fish farming system for capturing nutritive and micronutrients advantages and values of indigenous fishes.
4. Improve genetic bases of Rohu (*Labeo rohita*), Naini (*Cirrhinus mrigal*) and Bhakur (*Catla catla*) for improving the aquaculture productivity.
5. Emphasize Sahar (*Tor putitora, Tor tor*), Katle (*Neolissocheilus hexagonolepis*) and Asala (*Schizothorax* spp) for commercial production.
6. Prepare the data base of micro nutritive values of indigenous fishes
7. Research focus on the traditional and indigenous values of indigenous fishes
8. Domesticated population should represent gene pool of the wild population of native fish to represent fitness trait, to prevent possible gene introgression and to maintain genetic variability.
9. Promote agro-tourism with the exploitation of native fish.
10. Native fish species selection for aquaculture and stock enhancement should address the issues of food security and livelihood of rural area.
11. Enhance local government aacountability to distribute informal ownership of communal water bodies to the local community.

Annex 1. List of participants

	Name	Designation	Institution
1.	Dr. Nanda Prasad Shrestha	Executive Director	Nepal Agricultural Research Council (NARC)
2.	Dr. Tek Bahadur Gurung	Chief	Fisheries Research Division, Godawari
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15.	Mr. Resham Raj Dhital	Fish Expert	
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28.	Dr. Bharatendu Mishra	Chief	Outreach Research Division, NARC
29.	Dr. Ananda Gautam	Chief	Agricultural Environment Unit, NARC

30.	Dr. Devendra Gauchan	Chief	Socio- Economic Division, NARC
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48.	Mrs. Khagisara Majhi	Fisherman	
49.	Mr. Gyan Bahadur Jalari	Fisherman	
50.	Mr. Tek Bahadur Rijal	Fisherman	
51.	Mr. Prem Bahadur Majhi	Fisherman	
52.	Mr. Prabin Kumar KC	Journalist	
53.	Mr. Rameshwor Pande	Journalist	
54.	Mr. Giri Raj Bhandari	Journalist	
55.	Mr. Bishnu Kalpit	Cameraman	
56.	Mr Sanjaya Neupane	Reporter	
57.	Mr. Rajendra Bajracharya	Administration, A4	CPDD, NARC

Annex 2. Photographs of the Workshop