COMPOSITE FISH CULTURE IN WATER HARVESTING STRUCTURES

CENTRAL SOIL & WATER CONSERVATION RESEARCH & TRAINING INSTITUTE

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Published by

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Central Soil & Water Conservation
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218, Kaulagarh Road, Dehradun-248 195 (Uttarakhand)

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Printed at

Allied Printers
84, Nehar Wali Gali, Near Kotwali,
Dehradun-248 001 (Uttarakhand)
Phone : 2654505, 3290845

FOREWORD

Agriculture in north-western Himalayas is mostly rain-fed. Majority of farmers practice routine crop cycles using traditional varieties, which are low yielding. The farming systems in the region therefore, require amendments and product diversification with the introduction of fish based integrated farming component. Interestingly, watershed management programmes provide scope to integrate fisheries interventions. A large number of Water Harvesting Structures (WHS), ponds and extensive network of *ghuls* have been established, especially under various developmental schemes or farmers' own initiatives to tackle the widespread water scarcity problems in the region, which provides immense scope for fish farming in them.

Fish farming in WHS and watershed ponds would enhance water productivity, agricultural yield, fish availability and fish consumption at watershed scale. Nonetheless, appropriate design of WHS in terms of depth, inlet-outlet features, size, shape etc. and appropriate farming calendar, techniques and pond management strategies are important for successful fish farming. Thus, a package of practices on subsistence carp culture refined for the foothill and mid-hill Himalayan regions at the research farm of the Institute and in adopted watersheds as briefed in this brochure would be very helpful for farmers, extension specialists, land use planners and other end-users of natural research such as soil and water.

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INTRODUCTION

- Fish (carp) farming provides livelihood and nutritional security to improve socio-economic conditions of resource-poor farmers by providing protein rich food and income, especially in the face of declining fish availability from wild environments and increasing demand- supply gap.

- The huge financial and physical targets given nationally for Integrated Watershed Management (IWM) and rural development towards water harvesting and creation of water resources including Water Harvesting Structures (WHS) to help flood moderation, groundwater recharge, conservative water use etc. provide opportunity for composite fish culture.

- Integration of fish farming in ponds and harvested water helps in recycling of nutrient-rich pond water and mud to cultivate vegetables and diversify crops on dykes and adjacent fields.

- For successful fish farming, the ill-effects of over stocking and importance of pond water quality management and fish healthcare measures need to be understood.

- Fish farming techniques suitable for exclusive fishponds and plain regions may not hold good for watershed ponds or WHS, especially in north-western Himalayas since rainfall runoff is the main water source and water level fluctuates according to rainfall, evaporation and seepage.

- Suitable culture techniques evolved by the Institute along with an appropriate farming calendar changing the existing calendar of fish seeds supply, stocking, culture and harvesting are given in this brochure to promote fish farming through IWM.

WATER SOURCE AND REQUIREMENTS OF WHS OR PONDS

- Primary source of water for WHS and watershed ponds is rainfall-runoff from the area surrounding the ponds or impoundments.
- The WHS and watershed ponds should preferably be medium size (100-200 m^2 in hills and 0.1-1.0 ha in plains), rectangular-trapezoidal in shape with maximum area or long axis facing towards sunshine (north-south orientation) and wind direction and 1.5-2 m deep for easy management of fish production.
- Avoid construction of deep ponds since excessive water depth beyond 4 m, especially during monsoon causes feeding and stratification (temperature, oxygen, nutrients, light) related problems.
- Series (cluster) of WHS can be constructed instead of a large pond, if runoff potential is higher.
- Divert excessive runoff, if possible, instead of allowing through pond to avoid siltation, dilution or flushing out of applied feeds, fertilizers & nutrients and developed natural fish foods such as phytoplanktons, zooplanktons and other small aquatic organisms in ponds.
- Maintain a minimum of 1 m water depth (dead storage) throughout the culture. For this, 3500-4000 $m^3\ ha^{-1}\ yr^{-1}$ groundwater or irrigation canal water may be needed in foothill Himalayas for conjunctive use during summer or low rainfall period.
- Provide net filter or screen at inlet and outlet (Photo 1) to prevent entry of wild fishes (Photo 2) and unwanted materials and escape of stocked fishes. Keep the size of the outlet proportionate to pond size so as to empty the pond within 1-2 hours on need.

Photo 1: A watershed pond at Selakui research farm showing net lined inlet and outlet at right side

Photo 2: Weed fish species that compete with stocked fishes

- If watershed contributes more sediment, provide sediment detention structures or grass barriers in the watercourse and pond inlets.

- Establish a small pond or tank near the main WHS or ponds for acclimatization of fish seeds and/or soaking of fertilizers to be applied in fish culture ponds uniformly . A water ramp or trough outside the pond dyke may be very useful for providing drinking water to form animals since WHS are often designed for multipurpose.

- Fence the pond to 1 feet height using iron mesh to prevent entry of snakes, if the pond is small in size or feasible to fence.

POND PREPARATION AND WATER QUALITY MANAGEMENT

- Use minimum fertilizers & pesticides and do limited soil working in catchments to minimize soil, nutrients & chemicals reaching WHS or ponds.

- Prepare the pond by applying lime and fertilizers (Table 1) as per soil-water conditions to improve soil and water quality parameters (Table 2), maintain natural fish foods and fish biomass and enhance pond productivity. Pond preparation should start by end of February so as to release fish seedlings or fingerlings by March-April for culture.

- Maintain preferred pond water colour to have natural fish foods (planktons) in ponds, particularly during initial stages of culture.

- Check the fertility and turbidity of pond water by dipping arm into it. If palm disappears before water reaches the elbow indicates dense algal bloom or higher turbidity. Alternatively, it can be determined by the visibility or disappearance level of Secchi disc (the depth (cm) at which a thin iron plate of 15 cm dia, painted black and white alternatively, disappears).

- Lime and fertilizers need to be dissolved with water and sprayed all over pond uniformly to facilitate complete dissolution and equal distribution for better results.

Table 1: Liming and fertilization guidelines

Pond soil-water conditions	Name of input (kg ha^{-1})	Initial dose (kg ha^{-1})	Regular dose on need (kg ha^{-1})
If soil is acidic (pH 4.5-6.8)	Calcium carbonate ($CaCO_3$) or Calcium oxide (CaO) lime	300-500	100-125
If alkaline soil (pH 7.5-8.5)		100-150	50-75
If soil is low in organic carbon (< 1.0%)	Animal dung or wastes	2000-4000	300-500
If rich in organic carbon (1-2%)		300-1000	200-300
If water is low in nutrients (NPK) & productivity as observed from the plankton bloom in water	Urea	100-200	50-75
	Single Super Phosphate	50-100	20-40
	Murate of Potash	25-40	10-15

- Avoid excessive application of animal wastes if a supplementary water source is not available and stop application if disease occurred, to reduce loading of organic materials and problem of oxygen depletion in ponds and WHS.

- Exchange (add 10-20% of water after taking out equal quantity of water from pond) or simply add 10-20% water if water quality deteriorates and water for supplementation is available.

- Agitation of pond water using a wooden pole or re-circulation of pond water using a small *tullu* pump, if electric supply is available, would improve dissolved oxygen (O_2) concentration in pond water.

- Drag a long stretched rope with series of stones tied intermittently to it, across pond bottom with the help of two persons periodically to release obnoxious gases and the process is called as "raking".

- Remove planktons from pond water manually using a fine net or cloth or kill them by applying diluted mild dose of formalin (0.01-0.05 ppm) to reduce water turbidity and dark water colour due to planktons.

Table 2: Preferred water quality parameters for carp culture

	Critical parameters	Preferred range	Limiting level	Possible correction measures
	Dissolved oxygen (ppm)	5-10	< 3.5	Reduce fish density, exchange or add water and agitate water
	Free CO_2 (ppm)	< 3	> 20	Exchange or add water, do raking
	pH	6.7-9.0	< 6.5	Apply lime
			> 10	Apply gypsum or exchange water
	Temperature (°C)	25-32	< 15 or > 40	Reduce stress factors, maintain on minimum feeds and harvest fishes
	Water hardness (ppm)	30-180	< 20	Apply lime
			> 500	Exchange or add water
	Transparency or turbidity (cm)	20-40	< 15	Harvest planktons, exchange or add water
			> 120	Apply lime and fertilizers
	Color	Clear with greenish hue, light greenish to greenish, light brownish green	Dark, brownish, intense greenish	Remove planktons, exchange or add water
			Colourless	Apply lime and fertilizers

FISH SPECIES AND CULTURE GUIDELINES

- Indian Major Carps (IMC) and exotic carps are suitable species (Table 3; Photo 3) for culture.

Table 3: Suitable fish species for culture and their niche in ponds

Species	Common name	Scientific name	Niche occupied in ponds
IMC	Catla	*Catla catla*	Surface feeder
	Rohu	*Labeo rohita*	Column feeder
	Mrigal or nain	*Cirrhinus mrigala*	Bottom feeder
Exotic carps	Silver carp	*Hypophthal-michthis molitrix*	Surface feeder
	Grass carp	*Ctenopharyngodon idella*	Column feeder
	Common carp	*Cyprinus carpio*	Bottom feeder

Photo 3 : Indian Major Carps (IMC) and exotic carp species

- Both composite carp culture towards table size fish production and or raising fish fingerlings or yearlings from fries depending on demands can be practiced in WHS.

- Fish growth rate is relatively higher in summer than winter and *vice versa* is for fish demand in the region. Hence, provide optimum feeds & fertilizers is ponds and WHS and harvest fishes during summer and winter, respectively.

FISH SEEDS AND STOCKING GUIDELINES

- Stock active, healthy and bigger size (20-50 gm) fish seeds collected from nearby hatchery or seed nursery at 1-2 m^{-2} for table size fish production alone or 5-10 small size fish seeds (1-5 gm) m^{-2} for both table size and fish fingerlings production together, in a pre-decided or source-mixed

ratios during March-April so as to harvest during Dec.-Feb. according to pond features, fish demand and management possibilities (Table 4).

- About 10-25% margin of fish seeds may be overstocked to compensate, if mortality by any means like predation and transport stress occurs. While stocking consider the expected water volume during ensuing summer or water scarce period and accordingly rationalize stocking density. If water scarcity exists, take up only production of fish fingerlings rather than grow-out culture for table size fish and/or resort to lower stocking density and/or minimum application of feeds and fertilizers.

FISH FEEDS AND FEEDING MANAGEMENT

- Apply supplementary feeds made of ground agricultural wastes such as poor-quality (broken) wheat, maize and rice, rice polish or bran, mustard oil cake, groundnut oil cake etc. as per availability. A mixture of rice polish or bran and mustard oil cake (Photo 4) at 1:1 ratio would suffice supplementary feeds.

Table 4: General guidelines for stocking to drive synergism from fish-fish and fish-environment relationships

Pond situation or ecosystem	Stocking principles to be followed
If the pond is eutrophicated (nutrient rich) and weed infested	Stock more of grass carps for weed control.
If the pond is deeper	Stock more of column feeders *i.e.* rohu and grass carps.
If the pond is managed more under external feeding	Stock more of fast growing and demanded species like catla and rohu.
If the region is colder	Stock more of exotic carps.
If the region is warmer and warmer water exists	Stock all carp species in suitable proportion according to demand.
If pond is located in remote areas and requires extensive travel or if water is turbid and polluted	Stock only common carps and air-breathing catfishes (*Clarius* spp.) instead of carps as they are hardy species.

Photo 4: Fish feed ingredients (rice polish, rice bran, mustard oilcake) and prepared feed dough

- Provide feeds daily @ 4% of fish biomass weight in the initial days and subsequently @ 3%, 2% and 1% towards the end of culture. Roughly, provide 2.0 kg feed day^{-1} initially and gradually increase up to 25 kg day^{-1} towards the end of culture (10th-12th months) for 10,000 fishes stocked in 1.0 ha pond depending on days of culture, fish size, fish biomass present in pond and feed consumption by fishes as observed.

- Prepare feeds in dough form and apply in tray at 1-3 fixed places inside pond for fish feeding and its easy monitoring. Apply chopped terrestrial green grasses like dhub-grass (*Dichanthium* spp.), para-grass (*Brachiaria mutica*) etc. for grass carps @ 0.5-1.0 kg per 20 fishes after a month of stocking.

- Under-feeding is less harmful than over-feeding. Reduce feeding during winter and monsoon when minimum temperature and higher water depth prevails, respectively.

FISH HEALTH PROBLEMS AND SYMPTOMS

- Fishes not feeding, lethargic, resting near the dyke, not responding to stimuli, abnormally swimming, ulceration on the body, red colouration of eyes etc. indicate disease and health problems, needing healthcare timely.

- Fish surfacing (gasping) for oxygen, fowl smell of pond water and dark pond watercolor indicate O_2 related problems, requiring immediate appropriate action and healthcare measures, such as agitation of water or water addition and reduction of fish density by partial fish harvesting.

- Bacterial infections, *viz*; eye disease (reddening of eyes), dropsy (accumulation of water in body cavity or scale pockets), sloughing of scales; fungal diseases, *viz*., Epizootic Ulcerative Syndrome (EUS; Photo 5), saprolegniasis (cotton wool like growth on fishes), gill rot (gills becoming yellowish brown); and infestations by dead algae settling down from water column and insects on lethargic fishes are some of the major diseases or infections.

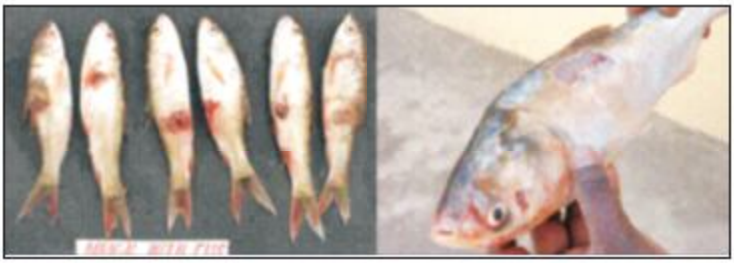

Photo 5: Infection of EUS in mrigal and silver carp

- Dermal ulcers or open sores on the body of fishes which increase in size gradually exposing muscles, tail rots and complete degeneration of epidermal tissues in ulcerated area of skin indicate the incidence of EUS.

- Fishes with high ulcerative lesions exhibit distinct abnormal swimming with frequent surfacing. In most of the advanced cases, fishes with ulceration start rotting even while alive and eventually die.

- The primary cause of EUS (*Aphanomyces invadens*, a fungal pathogen) could spread either vertically from the movement of runoff water with wild fish species or horizontally from fish seeds. The EUS occurs due to synergistic effect of disproportion between heavy

unscientific stocking (1.0-1.5 lakh fish seeds ha^{-1}) without any sequence and a mismanagement adopted by some farmers in the region that causes water quality deterioration.

- The EUS occurs more in bottom dwelling carps, mrigal (*Cirrhinus mrigala*), murrels (*Channa* spp.) and catfishes (*Clarius* spp.) especially in water with low alkalinity (20-40 mg l^{-1}), hardness (10-40 mg l^{-1}) and calcium and follows a specific seasonality of occurrence (mainly during winter and after rainy days).

- A wide size range of 10-1500 gm of fishes is variously affected by EUS. Maximum infection occurs in smaller size mrigal as compared the larger ones. Common carps (*Cyprinus carpio*), rohu (*Labeo rohita*) and catla (*Catla catla*) have good resistance and show minimum incidence. In grass carp (*Ctenopharyngodon idella*) and silver carp (*Hypophthalmichthis molitrix*) the incidence is low and occurs only when infection advances in fishes of the infected pond.

- Major health problems can be noticed through regular observations of feed trays after 2 hours of feeding, which allow periodic inspection of the pond premises and by nettings to know feed consumption status, fish behaviour and health status.

FISH HEALTH MANAGEMENT

- Avoid over-stocking and disturbance in pond water. Provide fish feeds regularly. Maintain good water quality and sanitary conditions in pond.

- Scare away migratory birds and remove their habitats from the pond premises by suitable bird scaring device like anti-bird nets and scare-crow techniques, especially during winter months. Remove snakes if noticed in ponds, especially during summer by suitable means to avoid predatory loss of stocked fish biomass.

- If disease or infection or ulceration is noticed, especially during winter, apply lime in pond @ 1.5-2 kg/100 m^2 and then industrial-quality $KMnO_4$ (@ 0.1-0.2 ppm) by dissolving in water.

- Partial harvesting of fishes and application of broad-spectrum antibiotic like Septron-500 (100 mg/kg fish feeds) protects fishes from infectious diseases. Pick out sick fishes when spotted to avoid further disease spread. Reduce or stop feeding during disease outbreaks till the condition improves by implementation of corrective measures and call a technical person for assistance during emergencies.

PRODUCTION AND ECONOMIC POTENTIALS

- Although growth rate largely depends on genetic potential, stocking density, feeding rate and health status, silver carps and catla grow faster, followed by common carps, rohu, grass carps and mrigal in the region.

- Low input composite carp culture in runoff-fed ponds yields about 3.5-5.0 ton (t) ha-m^{-1} yr^{-1} (Photo 6) in foothill and mid-hill Himalayas.

- Fish farming converts poor quality agricultural wastes into fish meat.

Photo 9: Harvested fishes ready for market

- The composite carp culture provides a net profit of about ₹ 90,000 to ₹ 1,00,000 ha^{-1} yr^{-1} with a Benefit Cost (B:C) ratio of up to 1.9:1 (Table 5).

Table 5: Fish production from culture of Indian major and exotic carps

Fish farming	Culture duration	Av. production (t ha^{-1} yr^{-1} of table fish or No. of yearlings)	Net profit (₹ ha^{-1}) yr^{-1}	B : C ratio
Table size alone	Continuous*, 12 months	4.5 table size fish	90,000 to 1,00,000	1.9:1
Table size + fish yearlings	-do-	2.8 table size fish & 32,000 yearlings	1,15,000	2.2:1
Fish yearlings alone #	6 months, Aug.-Feb.	1,00,000 yearlings	1,40,000	3.4:1

Tested in farmers' pond; * Needs supplemental water of 800 m3 for 0.2 ha during summer.

OTHER BENEFITS

- Besides tangible benefits of cash income, fish meat and employment potential, many intangible benefits like improvement of water quality, pond ecosystem (Table 6; Photo 7) and reduction of hunting & fishing from wild environments are possible out of carp culture either directly or indirectly as incentives for resource conservation.

Table 6: Fish farming improves water quality and aquatic ecosystems

Attributes	Occupants or features of ponds	After fish farming
	Before fish farming	
Aquatic plants	Profuse growth of vegetation: *Arundodonax nugundo*, *Ipomea* spp., *Eichornia* spp., lotus, *gurju* grass, wild *pudina* etc. with a progressive increase of coverage in pond area from 5% in Feb. to 40% in Mar. and 80% by April.	Negligible

Attributes	Occupants or features of ponds	After fish farming
	Before fish farming	
Aquatic animals	Excessive wild fishes (0.04-0.09 kg per m^2), tortoises 20-25 no. ha^{-1}, leeches 0.5-2 no. per m^2, snakes 4-5 no. ha^{-1} etc.	Nil to negligible
Water quality	Poor with obnoxious smell	Good with fishy smell
Aesthetics and approachability	Poor	Good

Photo 7: Fish farmers clearing unwanted aquatic weeds from ponds

OUTREACH AND SCOPE OF APPLICATION

- The technology is applicable in foothill and mid-hill Himalayas including Shiwaliks up to an average altitude of 1800 m average mean sea level with average annual rainfall of 1100-1700 mm.

- The refined composite carp farming technology is extended to State Government's Fisheries department and watershed management related organizations, NGOs and local farmers besides policy makers, technocrats and defence personnel (Photo 8).

Photo 8: Outreach demonstrations on fish farming in a WHS

- As a result of trainings and demonstrations, about 30 farmers could improve their fish yields, at least by 175-500% over earlier production (from mere 0.8-2 to 3.5-4 t ha^{-1} yr^{-1}) and about 20 new farmers have gone for fish farming afresh in the foothill and mid-hill Himalayan regions over 5 years span.

- However, the traditions and superstitions prevailing amongst local farmers and the nature of fish farming based technologies being new to the region, necessitates the need for basic trainings to farmers on water quality and fish biomass maintenance and support system to provide inputs (especially fish seeds) in order to promote widespread adoption of the technology in the region.

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