Renewed Justification for the Promotion of Carp Aquaculture in Seasonal Minor Irrigation tanks in Sri Lanka

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Abstract

New data reaffirms the ability of carp to effectively utilize the naturally high productivity of seasonal minor irrigation tanks in Sri Lanka. Stocked fish attained average weights ranging from 0.98 kg to 2.3 kg. Productivity ranged from 8 to 675 kg ha⁻¹ using stocking densities of less than 1000 fingerlings ha⁻¹. Fish were sold in the village locally and nationally negating concerns about consumer preference for carps and their marketability. Aquaculture management committees (AMC) were formed, four of which successfully negotiated their social right to manage and harvest fish. It is recommended that an AMC obtains an aquaculture management license to consolidate this negotiated agreement. Economic analyses indicate that carp aquaculture in seasonal tanks with a water spread area (WSA) less than 3 ha is not economically viable. Arguments are advanced to suggest that carp aquaculture in seasonal tanks with a WSA less than 4 is unlikely to be socially sustainable. No evidence is found to suggest that the same constraints do not apply equally or more so to the culture of tilapia in seasonal tanks. It is argued that the recent *a priori* claims made for the culture of tilapia require substantiation in contrast to the promotion of carp aquaculture in seasonal tanks.

Introduction

There are at least 13,302 minor irrigation tanks in Sri Lanka (Anon. 2000), the majority of which are located in the country's dry zone lowland areas to the north and to the east (Manchanayake & Madduma Bandara 1999). Many minor irrigation tanks dry out completely once every three to five years and are known locally as seasonal tanks. Characteristically these

non-perennial village tanks are highly productive water bodies (Chandrasoma 1986). Estimates of the potential annual production from aquaculture in seasonal tanks range from 25,000 mt (Anon. 1980) to 36,000 (Oglesby 1981).

Thayaparan (1982) described the characteristics of seasonal tanks that make them suitable for aquaculture and the results of initial stocking trials by the Ministry of Fisheries under the Aquaculture Development and Training Project (FAO/UNDP) which began in March 1981. A summary of the stocking trials undertaken by the Ministry of Fisheries between 1979 and 1982 was provided by Chakrabarty & Samaranayake (1983). Chandrasoma & Kumarasiri (1986) presented the results from 23 tanks stocked with assorted carp in 1983/84. The results of these trials demonstrated that a polyculture of carps was well suited to exploit the natural productivity of seasonal tanks and was capable of regularly generating yields of over 1500 kg ha⁻¹.

Nationwide civil unrest in the country between 1987 and 1989 (Gunaratna 1995) and the then Government's decisions to withdraw state assistance to the freshwater fisheries and aquaculture in 1989 (De Silva 1991; Amarasinghe 1998) caused the development of the sector to stall between 1990 and 1994. A change of government's policy decision in 1994 brought with it a renewed commitment to the development of freshwater fisheries and aquaculture. Emphasis was again placed on the potential for fish production through the promotion of aquaculture in seasonal tanks (Anon. 1995). This paper documents the promotion of carp polyculture in five seasonal tanks in Hambantota district in the south and Ampara district in the east of Sri Lanka.

Materials and methods

Five seasonal tanks (three in Hambantota district and two in Ampara district) were stocked with carp fingerlings between December 1999 and February 2000. Three varieties of carp fingerlings, i.e., rohu (*Labeo rohita*), bighead carp (*Aristichthys nobilis*) and common carp (*Cyprinus carpio*) were obtained from the Aquaculture Development Centres of the National Aquaculture Development Authority at Udawalawe and Inginiyagala. Fingerlings were counted by hand and released into the tank to ascertain the exact number of fingerlings stocked.

The five tanks were hitherto unexploited for commercial fisheries although some villagers were engaged in subsistence fishing for tilapia. Before stocking the tanks, aquaculture management committees (AMC) were formed to manage, harvest and market the stocked and non-stocked fish in the tank. The AMCs comprises interested local villagers, the majority of whom were members of the village farmers' organizations.

The water spread area (WSA) of the tanks at the time of stocking ranged from 1 ha to 8 ha. Stocking densities ranged from 186 to 1510 fingerlings ha⁻¹. The list of tanks that were stocked together with the WSA, variety and number of fingerlings stocked and the stocking densities is given in Table 1.

Selective harvesting of stocked fish began five to six months after stocking using 11.4 cm and 14 cm mesh gillnets. Harvesting of fish using 6.4 cm mesh seine nets, ranging from 100 m to 400 m in length, commenced 6 months after stocking. Subsistence fishing for tilapia by non-AMC members using hook and line only was permitted by the AMC five months after stocking and continued throughout the harvesting period. Restrictions on access and fishing gear were lifted immediately after the AMC agreed that the harvests were complete.

AMC members were provided with training to collect daily catch, sales and consumption data. Data were tabulated using a simple data collection format.

Table 1. Stocking data for five tanks in Ampara (A) and Hambantota (H) districts. BH – Bighead carp; RH – Rohu; CC – Common carp; SD – Stocking density (fingerlings ha⁻¹).

Tank	WSA Ha	Fingerlings stocked				SD
		BH	RH	CC	Total	
Polwattewewa (A)	8	400	50	1035	1485	186
3B wewa (A)	1	400	60	1050	1510	1510
Ihala Kumbukwewa (H)	12	984	-	2036	3020	251
Maha Indiwewa (H)	8	2926	1878	1390	6194	774
Wewagama (H)	6	1196	1313	858	3367	561
Totals	35				15576	445

Results

Although the water levels in all 5 tanks decreased throughout the year, none dried out completely. AMC members carried out incomplete harvests of fish at four of the five stocked tanks. Overall recapture rates for all stocked fish were 50%, 37%, 4% and 4% for Maha Indiwewa, Wewagama, Ihala Kumbukwewa and 3B wewa respectively. Total fish production in the four tanks harvested ranged from 8 to 701 kg ha⁻¹ (see Table 2).

The highest individual recapture rate for stocked fish (52%) was achieved for rohu at Maha Indiwewa. Bighead carp attained the heaviest mean weight for stocked fish (2.3 kg) at both Maha Indiwewa and Wewagama. The growth performance of rohu was the highest at Maha

Indiwewa (mean weight of 1.6 kg) and that for common carp was observed at 3B wewa (mean weight of 1.8 kg) (Table 3).

Non-stocked varieties of fish, predominantly tilapia (*Oreochromis niloticus* and *O. mossambicus*) contributed 4%, 0% and 4% of the catch by weight at Maha Indiwewa, Wewagama and Ihala Kumbukwewa respectively. Only at 3B wewa, where tilapia contributed 84% and snakeheads a further 4% of the catch by weight, did non-stocked varieties make a significant contribution to fish production and income.

Table 2. Recapture rates, production and productivity for four partially harvested tanks stocked in Ampara and Hambantota districts.

Tank	Recapture rate (%)	Stocked carps		Others		Totals	
		Kg	Kg ha ⁻¹	Kg	Kg ha ⁻¹	Kg	Kg ha ⁻¹
3B wewa	4	104	104	442	442	546	546
Maha Indiwewa	50	5400	675	210	26	5610	701
Wewagama	37	2090	374	-	-	2090	374
Ihala Kumbukwewa	4	96	8	3.5	0.29	99.5	8.3

Consumer preference and marketing strategies created a strong price differences between varieties of fish and between tanks. The higher average price per kg for rohu (Rs. 29 to Rs. 54 per kg) and for common carp (Rs. 26 to Rs. 53 per kg) reflected strong consumer preference for these two species. The converse holds true for the lower average price paid for bighead carp (Rs. 21 to Rs. 33 per kg). Tilapias were sold for between Rs. 25 and Rs. 42 per kg whilst snakeheads commanded the highest average price at Rs. 100 per kg (Table 3).

Highest prices for all types of fish were obtained by AMCs selling fish directly to villagers. Vendors paid the same or lower prices than villagers and wholesalers negotiated the lowest price per kg. At Maha Indiwewa, Ihala Kumbukwewa and 3B wewa, the majority of fish were sold to villagers or through vendors. This was reflected in the higher average price paid for carp irrespective of species (Rs. 31, Rs. 35 and Rs. 50 per kg in Maha Indiwewa, Ihala Kumbukwewa and 3B wewa respectively). The lower average price per kg for carp at Wewagama (Rs. 25 per kg) reflects the AMCs decision to market the majority of the catch through a single wholesaler.

Gross income ranged from Rs. 12,000 at Ihala Kumbukwewa to Rs. 169,165 at Maha Indiwewa. Income per ha for each AMC ranged from Rs. 290 to Rs. 21,145. Only the AMC at Maha Indiwewa realized a sufficient net income (= gross income minus operating costs and contributions) to

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provide a dividend commensurate with members' efforts over the preceding seven months. At Maha Indiwewa, AMC members received shares equal to Rs. 11,431. A summary of the financial performance of the four partially harvested tanks is given in Table 4.

Non-AMC members successfully disputed the legal right of the Polwattewewa AMC to harvest and market the fish in the tank. Violent clashes led to intervene the Police to resolve disputes by prohibiting harvesting of fish.

Table 3. Catch statistics for stocked and non-stocked fish from four partially harvested tanks. In July 2002, Rs. 89 = US\$ 1.

	3B wewa	Ihala Kumbukwewa	Maha Indiwewa	Wewagama
Bighead				
% recaptured	6	4	42	62
Mean weight (kg)	1.7	0.95	2.3	2.3
Av. price/kg (Rs.)	28	33	27	21
% Gross income	7	37	46	78
Rohu				
% recaptured	30		57	16
Mean weight (kg)	1.0		1.6	0.7
Av. price/kg (Rs.)	54		33	29
% Gross income	6		34	10
Common carp				
% recaptured	2	4	56	34
Mean weight (kg)	1.8	0.8	1.0	0.8
Av. price/kg (Rs.)	53	37	34	26
% Gross income	16	61	16	12
Tilapia				
Mean weight (kg)	0.135	0.07	0.1	
Av. price/kg (Rs.)	25	42	35	
% Gross income	67	4	4	
Snakehead				
Mean weight (kg)	1.13			
Av. price/kg (Rs.)	100			
% Gross income	11			

Discussion

The mean weights of fish harvested from four tanks reaffirm the ability of carp to utilize the natural productivity of seasonal tanks. The current data compares favourable with average fish weights for bighead carps, rohu and common carp (0.71 kg, 0.65 kg and 0.98 kg respectively) recorded by Chandrasoma & Kumarasiri (1986).

The performance of the highest yielding tank, Maha Indiwewa was an improvement on the year-wise average productivity (155 to 614 kg ha⁻¹) achieved by Chakrabarty & Samaranayake (1983) and only slightly lower than the average production (891 kg ha⁻¹ inclusive of tilapia) reported by Chandrasoma & Kumarasiri (1986). The complete failure of stocking in two tanks stocked in the present study (i.e., Ihala Kumbukwewa and 3B wewa) is also comparable with earlier trials (Chakrabarty & Samaranayake 1983). These results highlight the importance of the correct selection of seasonal tanks to the ultimate success of any stocking programme.

Table 4. Financial analyses for four partially harvested tanks.

	3B wewa	Ihala Kumbukwewa	Maha Indiwewa	Wewagama
Income from sales (Rs.)	10,500	3,480	140,609	42,861
Value of fish consumed (Rs.)	5,373	-	28,200	4,040
Gross income (Rs.)	15,873	3,480	169,166	46,901
Income (Rs/ha)	15,873	290	21,145	7,816
Expenses (Rs.)	-	-	18,485	1,542
Community contribution (Rs.)	-	-	7,500	3,000
Savings (Rs.)	-	-	6,000	4,000
Net income (Rs.)	15,873	3,480	137,181	38,359
No. of members	5	10	12	11
Member's share (Rs.)	3,175	348	11,431	3,490

The failure of the stocking programme in these tanks is attributed to existing high densities of competitors (tilapia) and predators (snakeheads) at 3B wewa and the dense growth of aquatic vegetation at Ihala Kumbukwewa. Thayaparan's (1982) eight criteria for the selection of suitable seasonal tanks for aquaculture remain a valuable point of departure in the quest for the selection of suitable tanks for carp aquaculture.

Chakrabarty & Samaranayake (1983) drew attention to the fact that lower stocking densities do not necessarily result in concomitantly lower production. The comparatively high production achieved at Maha Indiwewa and Wewagama using very low stocking densities further questions the need for stocking densities greater than 1500 fingerlings ha⁻¹ as used by

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Chandrasoma & Kumarasiri (1986). Hand counting of fingerlings prior to the release as was practiced in this study is strongly recommended to enable accurate assessment of stocking densities and recapture rates, as opposed to sub-sampling and estimates that were used in earlier studies. No clear indication of the correct composition for stocked species emerged from this study. The contention that the optimal utilization of natural productivity in a tank will best be achieved by stocking several carp species, which between them are able to exploit the range of food resources available in the tank, remains pertinent to future stocking programmes.

The contention that the carps are unpopular with consumers (Fernando 2000) is refuted by this study in which carps demanded a price per kg at least equal to and frequently more than that of tilapia. At no time were AMC members, vendors or wholesalers unable to sell any of the three stocked varieties of carp, a scenario suggested by Fernando (2000). Further, wholesalers stressed that strong markets exist for rohu, catla and common carp in the towns and villages among the tea estates in the central highlands and any surplus production of carp is readily bought for processing into dried fish in Negombo on the west coast.

Where consumers did express a strong negative preference for particular carp, as in the case of bighead carp, the lower sale price per kg was offset by the higher mean weight per fish; each bighead carp was sold for Rs. 90. Chandrasoma (1988) recommended replacing bighead carp with catla (*Catla catla*) to obviate this problem. However, the potential negative impact on both production and thus on income should be first explored. Catla's higher value may be offset by its lower mean weight (Chandrasoma & Kumarasiri 1986).

Analyses of the potential production from seasonal tanks have focused almost exclusively on the stocked fish with limited consideration of social factors and tank management *per se* (De Silva 1988), which are likely to strongly influence its sustainability. Eleven of the twenty two tanks stocked in 1980/81 were partially poached before fish were harvested (Thayaparan 1982). Thayaparan (1982) and Charkabarty & Samaranayake (1983) stressed the need for active community organizations to manage stocking programme in seasonal tanks.

In these trials, AMCs were formed comprising interested villagers prior to stocking the tanks to address social issues such as poaching. Through negotiation with the government-appointed head members of the village, farmers' organization and other villagers, four out of five AMCs successfully negotiated their social right to stock, manage and harvest fish in the tank. The four AMCs effectively transformed the village tank from an *open access* resource, where access to the fish in the tank is free and open to all to a *communal property* resource held by an identifiable community of users, i.e., AMC, with rights to exclude others (Berkes et al. 1989). Each AMC then devised a management plan, which covered stocking, security

and fisheries management. All AMCs permitted the continuation of subsistence fishing for non-stocked fish in the tank, such as tilapia by non-AMC members, but restricted the types of gear permitted to hook-and-line only.

Only in Polwattewewa was the AMC unable to negotiate its social right to stock, manage and harvest fish in the tank. In this tank, a violent clash over the right to harvest fish between the AMC members and villagers who were not members of AMC, was an indication of the inability of this AMC to negotiate resource use rights. This incident highlights the need for AMCs to obtain a second layer of consent, confirming and AMC's legal right to stock, manage and harvest fish in the tank. The first level, i.e., the AMC's social right, is negotiable between villagers, members of the farmers' organization, village based government officials and staff at the divisional level government offices. It may involve payment of a mutually agreed rent to the village to manage the fish resources in the tank. The second level is a non-negotiable legal contract wherein the state transfers its ultimate custodial right to stock, manage and harvest fish resources in the tank to the AMC for a specified period. Provision for the AMC's legal right can be provided for under the Aquaculture Management Regulations of 1996, which have been imposed under the Fisheries and Aquatic Resources Act No. 2 of 1996. It is strongly argued that securing both the social right and legal right of the AMC to manage fish resources in a tank is fundamental to ensuring both the short-term success and long-term sustainability of stocking activities in seasonal tanks.

Even the most rudimentary economic analysis of stocking programmes in seasonal tanks has hitherto not been considered, notwithstanding its importance to sustainability. In the present study, only the AMC at Maha Indiwewa paid its members a sufficient dividend, Rs. 11, 431 upon the completion of the harvest. The income generated at Maha Indiwewa was equivalent to Rs. 1,700 per member per month creating an increase in the annual income for AMC members of approximately 20%. Cost-benefit ratios (CBRs) for carp aquaculture in seasonal tanks, assuming costs for stocking, tank management, security, harvesting equipment, re-investment and rent are shown in Table 5. These data indicate that stocking seasonal tanks with carp, which have a WSA of less than 2 ha, is uneconomic and thus unsustainable, even if the opportunity cost of fishing (OCF) is zero. If the OCF is set by the AMC at Rs. 50 per fisherman per day, the CBRs for a 3 ha tank and a 4 ha tank are 1.74 and 2.23 respectively. It is argued herein that the minimum WSA requirement for carp aquaculture in seasonal tanks is 4 ha.

Uncorroborated support for this contention can be derived iteratively from a consideration of both social and technical constraints, which impinge on the composition of an AMC. First, an AMC must be able to accommodate a significant number of individuals in a village who wish

to be engaged in aquaculture in the tank. This is seldom less than 10 (pers. obs.). Second, an AMC must be sufficiently representative of the village to be able to negotiate its social right to manage the tank. An AMC comprising only 2 or 3 individuals will face challenges from other groups of individuals disputing this social right. Thirdly, an AMC must have sufficient members (e.g., eight to ten) to enable it to harvest the tank. The involvement of non-AMC members in harvesting undermines the purpose of the AMC, creates the potential for social conflict and would reduce the AMC's net income.

Table 5. Cost benefit ratio (CBR) for carp aquaculture in seasonal tanks in two scenarios. Scenario 1 - Without an opportunity cost for fishing (OCF); Scenario 2 - With an OCF of Rs. 50. WSA - Water spread area.

	WSA (ha)							
	1	2	3	4	5	6	7	8
Scenario 1	0.89	1.67	2.37	2.99	3.55	4.05	4.51	4.93
Scenario 2	0.63	1.21	1.74	2.23	2.68	3.09	3.48	3.84

<i>Assumptions:</i>	1. Stocking density	- 1,500 fingerlings/ha
	2. Recapture rate	- 50%
	3. Mean weight	- 1.4 kg
	4. Average selling price	- Rs. 30/kg
	5. Discount rate	- 12% per annum over 5 years

If one accepts that 1 ha of carp aquaculture in a seasonal tank is sufficient to generate an income for two AMC members (assuming net present value of Rs. 25,500 on the basis of productivity of 850 kg ha⁻¹) then the following is true. An AMC with 12 members requires a tank with a WSA of 6 ha to be economically viable. A seasonal tank of 1 ha can support an AMC of 2 members but the AMC is unlikely to be socially viable. To harvest a tank an AMC requires a minimum of 8-10 members thus the WSA of the tank must exceed 4 ha. This also reiterates socially, economically and technically that 4 ha emerges as the minimum WSA capable of sustaining carp aquaculture.

Do the same economic, social and technical constraints apply to stocking programmes in seasonal tanks which utilize tilapia as opposed to carp as advocated recently by Fernando (2000) and by Murray & Little (2000)? Neither paper presents evidence to indicate otherwise. The productivity achieved by unstocked tilapia at 3B wewa in the present study (424 kg ha⁻¹) is indicative of the potential of tilapia in seasonal tanks. Chakrabarty & Samaranayake (1983) indicated that annual productivity for stocked tilapia ranged from 9 to 547 kg ha⁻¹ in 1979/80. To achieve these yields, concomitant stocking densities ranged from 750 to over 10,000 fingerlings ha⁻¹ and the total number of fingerlings stocked ranged from 3,000 to over 57,000 (Chakrabarty & Samaranayake 1983). Assuming that

stocked tilapias average 135 g at the time of harvest and that each tilapia has a value of Rs. 3.50 (see Table 3), an AMC would need to harvest over 7,000 tilapia per ha to achieve an income comparable with that of carp (see above). If the recapture rate was 50%, an AMC would need to stock 15,000 tilapia fingerlings ha⁻¹ to achieve the equivalent annual productivity from a seasonal tank. Although the cost of tilapia fingerlings is currently less than for carps (Rs. 1.00 versus Rs. 1.50), the stocking costs per ha appear to be considerably greater than those for carp. The costs for management, security, harvesting and the recurrent costs are likely to be the same for aquaculture involving either tilapia or carp. It is therefore possible that the economic viability for tilapia-based aquaculture in seasonal tanks may actually be less than that for carp.

Stocking tilapia in seasonal tanks may also create an additional social constraint, wherein unlike for carp, the AMC will be unable to ban subsistence fishing for non-stocked fish, predominantly tilapia, in the tank. The easy differentiation between stocked carp and non-stocked fish facilitated the AMC's negotiation of its social right to manage and harvest stocked fish. The continuation of, albeit restricted, subsistence fishing for non-stocked fish appeased many non-AMC members who were accustomed to occasionally fishing for tilapia in the tanks. Until such time as data exists to substantiate the *a priori* argument in favour of tilapia aquaculture advanced by Fernando (2000) and by Murray & Little (2000), the data that is available strongly supports the continued promotion of carp polyculture in seasonal tanks.

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