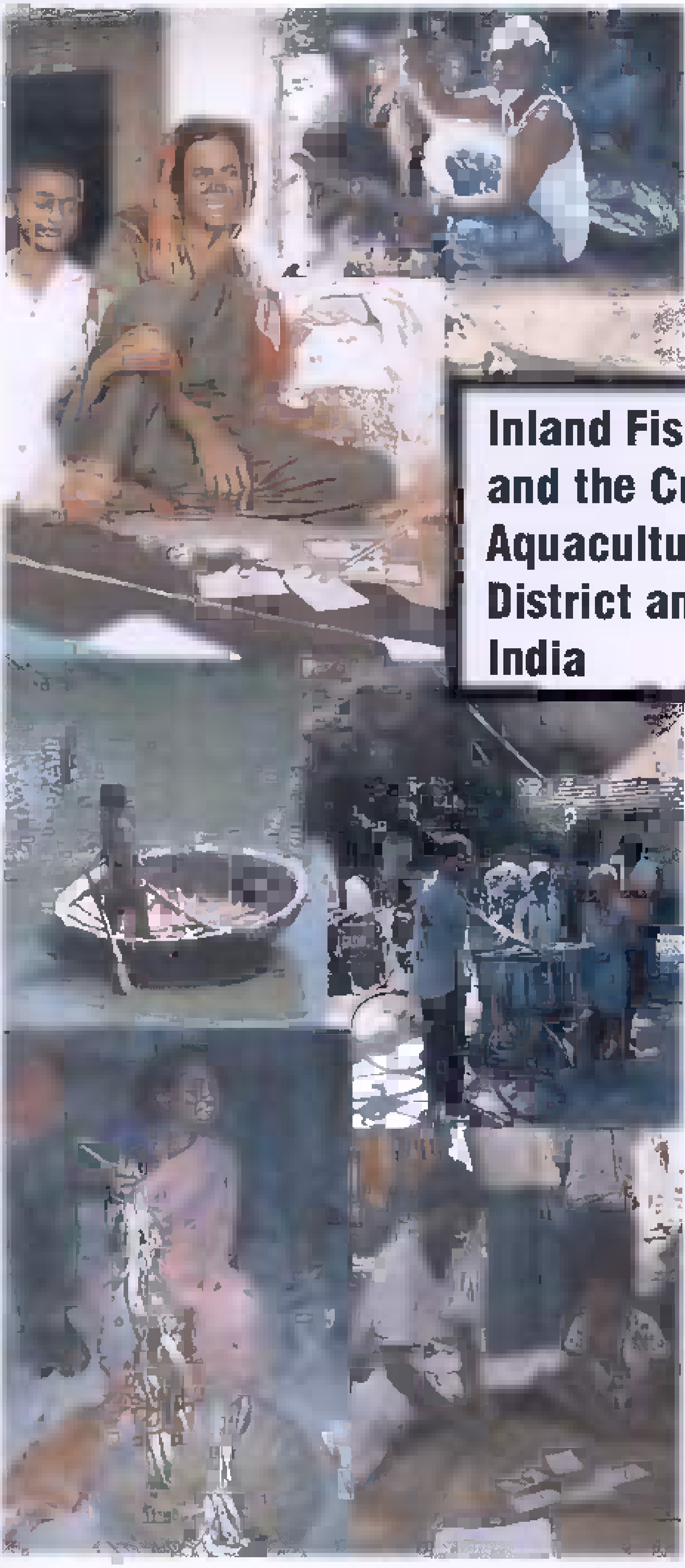

Working Paper No. 6
(July 1998)

Inland Fisheries Resources and the Current Status of Aquaculture in Raichur District and Karnataka State, India

Aquaculture in Small-scale Farmer-managed Irrigation Systems Funded by DFID Aquaculture Research Programme

Institute of Aquaculture
University of Stirling
Scotland, UK

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List of Working Papers

Project Summary Report
1. Raichur District: Site for a Study of Aquaculture Development in the Semi-arid Tropics
2. Methods for Participatory Information Gathering and Analysis
3. Socio-economic Analysis of Villages in Relation to Aquaculture Potential in Raichur District, Karnataka, India
4. Investigation of Gender Issues in Relation to Aquaculture Potential in Raichur District, Karnataka, India
5. On-farm Resources for Small-scale Farmer-managed Aquaculture in Raichur District, Karnataka, India
6. Inland Fisheries Resources and the Current Status of Aquaculture in Raichur District and Karnataka State, India
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8. Indigenous Freshwater Fish Resources of Karnataka State and their Potential for Aquaculture
9. Institutional Linkages of Relevance to Small-scale Aquaculture Development in Karnataka State, India
10. Fisheries Marketing, Demand and Credit in Raichur District, Karnataka, India

Project background

The arid and semi-arid tropics are areas in urgent need of development. As a home to a large proportion of the world's poor these regions face a future of scarcity of food and insufficient water for consumption and irrigation of crops. It has been predicted that India and Sri Lanka will face a fresh-water crisis in the near future, and as much water is currently wasted due to inadequate management and conservation practices there is a need for more integrated approaches to water management. The majority of India's surface water bodies are used primarily for irrigation. Although large-scale irrigation systems cover more surface area and supply a greater area of farmland, more farmers are dependent on small-scale systems for their daily livelihood. Irrigation systems are often very inefficient water distribution systems, and studies suggest that the efficiency of water use could be improved. The integration of aquaculture (which can be non-consumptive in terms of water use) has the potential to increase food production and improve the efficiency of the use of small-scale irrigation water resource.

These Working Papers are the first stage of the research project 'Small-scale farmer-managed aquaculture in engineered water systems' (DFID project R7064). The project aims to investigate the potential for integration of aquaculture into small-scale farmer-managed irrigation systems in arid and semi-arid regions of India and Sri Lanka. Intended beneficiaries include the rural poor, which in India belong to the Scheduled Castes (SCs)[1] and Scheduled Tribes (STs)[2]. This part of the project focuses on Karnataka State on the south west of the Indian peninsular.

During the research, the economic and technical feasibility and the social acceptability of the production of fish in such systems of arid and semi-arid regions of Karnataka were investigated. Field research took place from 6 April to 21 May 1998 and included a 'Rapid Rural Appraisal' of four villages in Raichur District, Karnataka, and semi-structured interviews with representatives from the Government Department of Fisheries, marketing organisations, academics and other relevant institutional sectors within the state.

All fieldwork was undertaken in collaboration with the NGO Samuha, an organisation undertaking wide-ranging activities in the arid and semi-arid areas of Karnataka State. Samuha has extensive experience within participatory development and its initiatives range across health, disabilities, women's development, HIV/AIDS, education, animal husbandry, drinking water and sanitation, irrigation and watershed development (Pradeep, 1994). The majority of the work of Samuha is carried out in the districts of Koppal and Raichur with a smaller project in Bangalore. The activities of Samuha are supported by a number of bodies: ActionAid; OXFAM; the Swiss Development Cooperation; the Government of Karnataka and the Government of India as well as individual donors.

The results and analysis are presented in the ten Working Papers listed above. For an overview of the content of each of the Working Papers, see the Summary Report. This series of working papers have been produced principally as a resource for a stakeholder workshop to be held in Coimbatore, 19th - 20th November 1998. Conclusions and the research agenda are therefore preliminary.

[1] SCs: lower castes identified by the Indian government as a means of classifying castes for the allocation of benefits.
[2] STs: all tribals. SCs and STs together constitute the 'socially and educationally backward classes of citizens'. The terms form the basis for policies of protection and positive discrimination.

Glossary

CIFA	Central Institute for Freshwater Aquaculture
DFID	Department for International Development (formerly ODA).
EUS	Epizootic Ulcerative Syndrome.
FFDA	Fish Farmers Development Agency
IMC	Indian Major Carp
KCIFF	Karnataka Co-operative Inland Fisheries Federation
Myrada	Mysore Rural Agri-cultural Development Agency
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
Rs	Indian unit of currency
Taluk	Sub-administrative region
TB	Tungabhadra
UAS	University of Agricultural Sciences. Bangalore.
1ha	2.4 acres

Summary

1. Karnataka State ranks 5th amongst Indian states in terms of freshwater area, yet only 10th in terms of freshwater fisheries production, suggesting an unfulfilled potential. Raichur District is situated between two major irrigation systems, the Tungabhadra reservoir to the south and the Upper Krishna Project to the north, and a great proportion of the district is under irrigation. Water resources of Karnataka State and Raichur District include major and minor tanks, reservoirs and smaller water bodies. Tanks have historically been a very important community resource, but in recent years many tanks have fallen into disrepair or have silted up. The two major reservoirs in the state are the Naryanapur (upper Krishna) and Tungabhadra, the latter of which supplies three regions of Raichur. A new irrigation scheme, the Upper Krishna Project is planned to supply irrigation to two additional regions of Raichur in year 2000. The existence of small-scale farmer managed irrigation systems is a resource about which statistics are not collected.

2. The majority of the inland fish production of Karnataka is from capture fisheries in stocked Government owned water bodies, with a smaller production from aquaculture. Karnataka currently produces 3.3% of India's total freshwater fish production (total production in 1997 was 103,500mt), with an estimated 5.6% from the aquaculture sector. The low fish production is in part due to the bad state of repair of many tanks, and partly caused by low seed quality and availability.

3. Raichur district currently ranks 11th in Karnataka in terms of total inland fish production and 15th in terms of its total freshwater area. In Raichur district fisheries production grew at an average annual rate of 22% during the 1980's, subsequently slowing to 12.6% between 1989 and 1997 (total production is currently 3,578mt). It is estimated that aquaculture currently accounts for approximately 10-15% of this production in Raichur district. Increasing ground water salinity associated with heavy irrigation has reduced the productivity of many crops and aquaculture may offer an alternative livelihood strategy to many farmers.

4. Karnataka ranks 9th amongst Indian states in order of fish seed production. This is less than 50% of its regional neighbour, Andhra Pradesh with a similar water surface area, again suggesting substantial unfulfilled potential. In attempt to improve efficiency and overcome a 50 million fish seed deficit, the Department of Fisheries is trying to decentralise production by encouraging private sector investment. This has met with some success in the 'rearing production' (on-growing fingerlings for subsequent stocking), but little private activity has occurred in the 'seed production' sector (spawning and fry production). Nearly 75% of state seed production still comes from three government hatcheries. Almost half of Karnataka's private rearing farms have been established in Raichur district. Although the district still records a 700,000 fish seed deficit, seed is available from neighbouring Andhra Pradesh and the large TB dam hatchery, and farmers in the district do not perceive availability of seed to be a major constraint to production. A history of inbreeding has reduced the performance of commercially available major carp stock and a collaborative selective breeding programme is currently trying to address this problem. The heavily centralised nature of seed production means that prices are effectively fixed by the government with little regional disparity.

5. Major carps (catla, rohu and mrigal) are the most important commercial species stocked. Fry availability for these species is greatest between August and November. This is a key constraint for short season fish production from seasonal small-scale water bodies. Options to overcome this limitation are suggested including the introduction of small-scale transportable hatchery technology.

Inland fisheries resources and the current status of aquaculture in Raichur District and Karnataka State, India

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1 Introduction

A comprehensive knowledge of existing fish production is useful when assessing the feasibility of integrating aquaculture into existing farming systems. In this paper the water resources currently used for fish production in the state of Karnataka are outlined, and inland fisheries production is described, first at state level and then in more detail for Raichur District. The seed production and rearing facilities for the state and district are outlined and the fish species used for commercial production detailed. In this paper the inland fisheries resources and the current status of aquaculture in Raichur District and Karnataka State is outlined.

2 Water resources of Karnataka State and Raichur District

Irrigation systems can be divided into
- large-scale: large tanks and reservoirs managed by the state, irrigating large areas of land, and
- small-scale: small-scale water resources owned and managed by individual farmers (for further details of the characteristics of small and large-scale irrigation systems, see Working Paper 1).

At present most inland fish production in Karnataka takes place in large water bodies such as tanks and reservoirs owned and managed by the government. Below is an outline of the water resources presently used for aquaculture within the project area.

2.1 Water resources and irrigation

Karnataka has 300km of coastline with 25,000km^2 of continental shelf, 8000ha of brackish water, and over 450,000ha of freshwater resources. The aquaculture resources of the Indian peninsular states represent 50% of the total pond and tank area, 25% of reservoirs and 38% of swamp and derelict water areas of the country, yet contribute only 20% of the total inland fish production (CIFA, 1996). The potential of these water resources is, therefore, far from fully exploited.

Situated between the two command areas of the Upper Krishna and the Tungabhadra (TB) reservoirs, Raichur has tremendous potential for aquaculture integrated with irrigation systems. An area of 230,000ha of land (14.2% of total area) in Raichur was under irrigation in 1995. However, this area has dropped slightly over the last few years due to the deteriorating condition of the TB Left Bank canal feeding the Raichur command area. Of the irrigated area in Raichur, 44% is canal-fed, 18.6% is from open wells, 16% from bore wells and 10% from tanks (with the balance from assorted other sources) (Government of Karnataka, 1996).

Table 1 shows the distribution of water bodies in the study areas compared to that of the State. For administrative purposes, tanks with greater than 40ha surface area are known as major tanks and those smaller than 40ha as minor tanks.

Tanks

Figure 1 shows a map of Raichur. As can be seen the district is bordered by the Tungabhadra River to the south and by the Krishna River on the north. The different administrative regions (taluks[3]) of the district are also shown. Table 2 shows the distribution of major and minor tanks within the taluks of Raichur District.

Tanks have been a traditional means of irrigation in India and a focus for community development. However following independence individual tank property rights were abolished, and with the advent of pumping technology (which could be individually controlled), came reluctance to increase water rates (Haylor, 1997). Many tanks, therefore, fell into disrepair. Efficient maintenance of these resources is beyond the capacity of the Minor and Major Irrigation Departments, and many tanks have become

[3] Taluk: sub-administrative region

Figure 1: Map of Raichur District (source: Government of India, 1981)

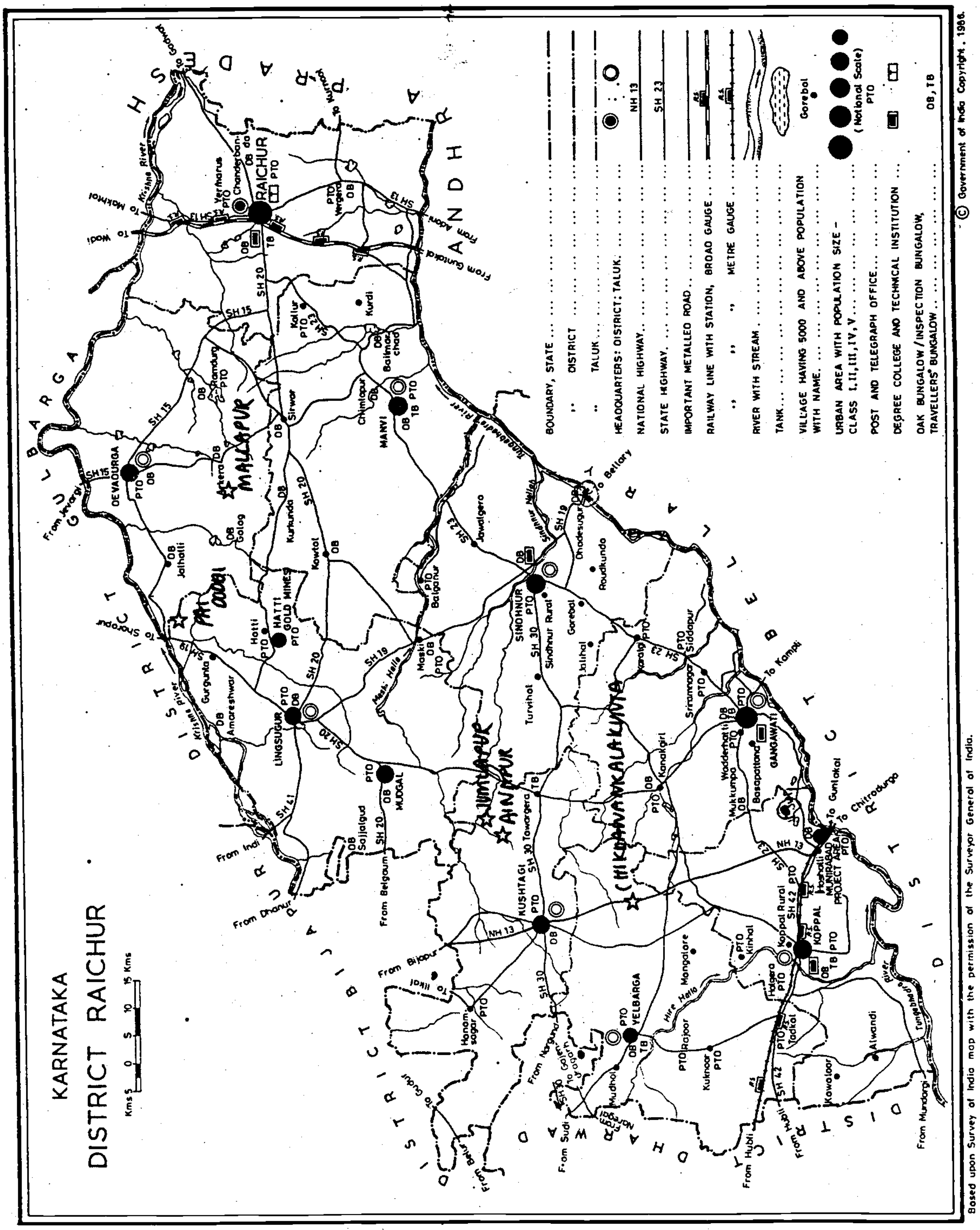


Table 1: Inland fisheries resources in Karnataka and the northern districts of Koppal and Raichur.

Resource	Karnataka	Koppal (a)	Raichur (b)
Major tanks **Water spread area (ha)** **Tanks with fishery**	4,695 17,378 1,643	49 28	40 5,283 (total a and b) 35
Minor tanks **Water spread area (ha)** **Tanks with fishery**	21,801 17,378 1,776	22 16	174 728 (total a and b) 118
Reservoirs **Water spread area (ha)**	62 136,491	2 (Kushtagi)	1 (Vinakamala) 360 (total a and b)
Max water spread all tanks (ha)	415,000	2,130	2,089
Rivers (km)	6,000	70	86
Canals (km)	3,000	80	95
Fish seed production and rearing centres **- Government** **- Private**	 40 12	 2 (Shivapur/Munirabad) 1 (Battarahalli)	 0 1
Private rearing farms	41	1	20

Source: Government of Karnataka Statistical Bulletin of Fisheries (1997) and Sivasankar (1991).

Table 2: Number of major and minor tanks in Raichur District.

Taluk	Major	Minor
Deodurg	8	18
Gangawati	8	
Koppal	5	
Kushtagi	13	1
Lingsugur	10	1
Manvi	3	5
Raichur	3	382
Sindhnur	1	
Yelbarga	8	
Total	89	406

Source Sivasankar (1991).

silted, breached or overgrown (Myrada & IIRR, 1997). Von Oppen & Subba Rao (1987) mention inadequate maintenance and failure of effective management as some of the important reasons why tank irrigation has been steadily declining over the last 30 years. Formerly tanks used to be a community resource, and de-silting of tanks a community activity where every villager contributed labour and shared the silt harvest (to use as manure for fields) (Myrada & IIRR, 1997). Now, most tanks depend upon government agencies for repair and maintenance, but within government agencies administration structures for dealing with these issues are insufficient (von Oppen & Subba Rao, 1987). However, because of their lack of ownership, individual farmers or community groups are unlikely to take action to improve the state of these resources.

Reservoirs

The Naryanapur (upper Krishna) and Tungabhadra (TB) reservoirs are the two largest reservoirs in the state, (13,000 and 37,700 ha surface area respectively). The TB reservoir is over twice the size of any other freshwater body in the state. Three of the nine taluks (Gangawati, Sindhnur and Manvi), known as the wet or irrigated belt, receive waters from the Left-Hand (LH) canal of the TB reservoir. The projected completion of a second irrigation scheme, the Upper Krishna Project (UKP), in the year 2000 will bring supplemental irrigation to the dry northern taluks of Lingsugur and Deodurg.

Small-scale water bodies

The small-scale water bodies of farmer-managed irrigation systems (the focus of the present project) is an aquaculture resource that has yet to be assessed. Small-scale farmer-managed irrigation water resources of Raichur District were classified as shown in Table 3.

Table 3: Small-scale farmer managed irrigation water bodies.

Type	Construction	Position in watershed	Primary uses	Seasonality (post rains)	Principal water source	Max water surface area (ha)
Ravine reclamation structure	Boulder and silt check across ravines 10-20m	Upper	Silt harvesting	Max. 3 months	Rainfall	0.1-1.5
Check dam	Concrete and stone. Occasionally vented.	Upper to middle	Silt and water harvesting	3 months to perennial	Rainfall	0.1-1.5
Nala bund	Earth possibly with stone facing.	Middle to lower	Ground water recharge.	3 months to perennial	Rainfall	10
Farm pond	Terraced excavation (10x10x3m)	On farm	Ground water recharge. Small –scale irrigation.	3-4 months (most) to perennial	Rainfall	0.1
Open well	Square or circular excavation. Usually 10x10m, up to 20m deep. Occasionally stone lined.	On farm	Irrigation	Mostly perennial	Ground water	0.1
Farm irrigation pond	Surface tank impounded by rectangular bund. Earth or concrete. Max. 10x20x0.7m	On farm	Irrigation	Farmer managed	Ground water (pumped)	0.1-0.15

Source: semi-structured interviews with farmers.

3 Fish production in Karnataka State and Raichur District

The majority of the fish production of Karnataka is from the sea. Of inland fish production the major part is from capture fisheries in stocked Government owned water bodies, with a smaller production from aquaculture. The following is an outline of fish production in the project area. Firstly the marine fish production is briefly outlined. Then inland fish production at state level is considered, after which the inland fisheries of Raichur District is described in more detail. Lastly the contribution of aquaculture to the fisheries production of the area is estimated.

3.1 Marine fisheries

Karnataka State is the fifth largest producer of marine fish in India, consistent with its resource base. Production in 1996-97 was approximately 223,000mt (over twice the level of inland production). This represented a drop of nearly thirty thousand mt on the previous year, largely due to restrictions placed on the operation of mechanised purse seiners who were exploiting the inshore fishery to the detriment of poor artisanal fishermen. However the general trend shown in official statistics is increasing production. A monsoon-closed season from June to the middle of August makes the availability of marine fish highly seasonal. Much of the harvest is exported to cities within and outside the state, and consumption in Karnataka is limited to areas within 100km of the coast, thereby excluding much of the dry inland area (DoF, 1997).

3.2 Inland fish production

Karnataka is ranked 5th amongst Indian States in terms of its total freshwater area, yet only 10th in terms of freshwater fish production (3.3% of India's total freshwater fish production). There are several reasons for this relative lack of productivity. Firstly, 29,588 of the tanks in the state are seasonal, whilst only 2,187 are the more productive perennial tanks (Shanmuka and Kulkarni, 1985). Only 3,419 of the total tanks are stocked by Government agencies. In addition to the derelict state of many tanks (mainly caused by silting), quantity and quality of seed supply constrains further increases in production (see section 3.4.1).

Most of the inland fish production (fisheries and aquaculture) comes from minor and major tanks, reservoirs and rivers. Fish farming in Karnataka began to expand in the mid-eighties and there are now 350 fish farms in the state. Table 4 shows the district-wise trends in production within Karnataka over the last decade.

Table 4: Karnataka district-wise metric tonnes inland fish production (fisheries and aquaculture) 1990-97.

District	Year		
	1990–1991	1993-1994	1996-97
Bangalore (rural, urban)	6,551	11,243	8,928
Belgaum	1,923	2,612	1,894
Bellary	8,531	6,787	11,599
Bidar	821	602	1,156
Bijapur	643	1,274	2,848
Chickmagalur	679	1,440	4,739
Chitradurga	3,686	4,862	6,502
Dakinsha Kannada	150	149	228
Dharwad	1,714	3,671	4,291
Gulbarga	1,830	862	1,500
Hassan	4,134	4,773	7,184
Kodagu	453	262	634
Kolar	2,223	7,423	7,736
Mandya	3,641	6,448	5,631
Mysore	7,559	7,435	15,196
Raichur	1,410	2,824	3,578
Shimoga	3,010	4,635	7,131
Tumkur	3,578	6,798	10,502
Uttara Kannada	55	532	777
Total mt	52,063	74,631	103,553

Source: DoF (1997).

Raichur district currently ranks 11th in Karnataka in terms of total inland fish production and 15th in terms of its total freshwater area (however this does not consider river resources). Unfortunately there are no official statistics about the contribution of aquaculture to the total fish production for Karnataka or Raichur/Koppal. However, in total 3,137 ha are used for freshwater aquaculture in the state and average cultured fish production is 1.56 tonnes ha^{-1} (mostly major carps) (Haylor 1998). Using this figure a current production of 4,894mt or only 5.6% of the total inland production for 1996 (87,354) can be calculated.

Sivisankar & Umesh (1993) reviewed taluk-wise fish production patterns over a twelve-year period from 1977-1989, during which time annual fish production in Raichur increased nearly seven-fold. Table 5 shows compound growth rates calculated over this time interval.

Table 5: Production and growth rates of inland fish production in Raichur District 1977-89. Source Sivasankar & Umesh (1993). Compound growth rate p.a. calculated from $Y_t = ab^t$ Where Y = production in metric tonnes and t = time period (years).

Taluk	1977-78 (mt)	1988-89 (mt)	% Change	Compound growth rate (%)	Mean yield 1977-89 (mt)
Deodurg	25	200	700	23.2	76.1
Gangawati	25	125	257	18.8	126.6
Koppal	25	112	348	18	74.9
Kushtagi	10	100	900	29.5	75.8
Lingsugur	55	50	-9	10	122.8
Manvi	20	100	400	11.8	50.3
Raichur	45	800	1,687	29.8	284.3
Sindhnur	15	100	367	20.3	71.3
Yelbarga	20	105	425	22	69.5
Total /Mean	250	1,692	577	22.9	952

Increased output in nearly all the taluks in the district have contributed to a high overall growth rate over the period. Raichur taluk has recorded the highest growth but Kushtagi, Deodurg and Yelbarga taluks have also shown impressive increases. This can be attributed in part to increased government stocking of the high numbers of major and minor tanks within these taluks (see Table 2). Only Lingsugur shows a decrease in production between the first and last year of the period but still shows 10.2% compound growth over the whole period. This reflects the variable nature of the fish production within the overall upward trend (mean yield co-efficient of variance: 84.5%). Although one might expect this to correspond with a high variability in annual rainfall and consequent variation in water spread over the 12-year period, rainfall data show the coefficient of variance (CoV) of district rainfall to be relatively low for the period (19.1%). Between 1989 and 1996 the compound growth rate in production has dropped to 12.6%. During this time the CoV of rainfall rose by almost one third, to 28.5%, something which may in part explain the slowing of growth. Table 1 shows that there is still a substantial number of major and minor tanks without fishery within the district. However, as outlined in section 2, there are considerable problems with the management and maintenance of tanks, which perhaps is why these water bodies are not being used to their full potential. Other constraints include rising pollution and the seasonality of water bodies being further pronounced by increased irrigation demands.

Aquaculture development in Raichur district

As noted above independent statistics for the aquaculture sector are not available in Karnataka. The Department of Fisheries, Shimoga District, estimates that 85-90% of production in Raichur is from stocked capture fisheries in Government water bodies (tanks, reservoirs and rivers) (T. Venkarteshappa, DoF, pers.com.). Total production in Raichur for 1997 was 3,578mt, which suggests an output of between 358 and 537mt from the aquaculture sector in the same year. Most of this production occurs in the southern taluks within the command area of the TB dam.

Fish farming began to expand significantly in Raichur in the mid-eighties, four to five years after the Left Bank Canal supplying TB Dam irrigation waters started to breach (mainly because of lack of capital available to carry out required maintenance). Farmers responded by building surface bund tanks of 1-2ha for emergency irrigation. In addition the predominantly black soils of the irrigated belt are poorly suited to heavy irrigation. This has resulted in increased salination and alkalinity and reduced crop performance. For these reasons fisheries extension workers recommend the integrated culture of carp as a diversification strategy (Dr Shanmuka, DoF Bangalore, pers. com.). Major and common carp can tolerate salinities up to 15ppt (Jinghran, 1982). The FFDA recommends construction to a 3 - 3.6m depth to allow a minimal draw down for integrated usage (originally irrigation tanks were built with surface bunds only (no excavation), allowing complete drainage of the tank for irrigation purposes.

There is now over 2,500ha of such emergency water spread owned by approximately 1,500 farmers (Mr Ramacharya, DoF Raichur, pers. com.). Approximately 5% of the farmers in the irrigated belt are immigrants from Andhra Pradesh. In addition a large Bengali rehabilitation camp was established in Sindhnur in 1972. Both of these ethnic groups have a history of fish cultivation and consumption and were ready innovators when the opportunity arose. Entrepreneurial 'Andhra' farmers tend to farm on a larger and more intensive scale (water area 1-20ha) than relatively less affluent Bengali farmers (water spreads 0.5-3ha). Uptake of aquaculture by the indigenous population so far remains very limited.

Fish farmers in the region have problems with increasing salinity levels, which is blamed for stunted fish growth (as a response to slow growth rates, farmers are currently extending the grow-out period). It is unlikely that salination is the major cause of slower growth, and other potential problems include the introduction of leached pesticides into the water supply or elevated ground arsenic levels (Baird, IoA, pers. com.) and partially inbred hatchery stocks (Penman, IoA, pers. com.). Fish farmers report record harvests of only 550kg ha^{-1} p.a., but on average they attain less than half this level. Because of the increased frequency of canal breaching and the uncertainty over repair time, farmers have to calculate the risk of using their water for potentially limited emergency irrigation or conserving it for aquaculture.

Government and commercial seed production in Karnataka State and Raichur District

Karnataka ranks 9th amongst Indian states in order of seed production. The annual fry production, area of water spread and the fry:water ratio can be seen in Table 6.

The fry production of Karnataka is less than 50% of its regional neighbour, Andhra Pradesh, a state with a similar water surface area. This suggests that there may be substantial unfulfilled production potential within the state. There was a seed deficit of 50 million seed in 1997 and this is a major constraint to increased fish production. In addition to this deficit, seed quality has also deteriorated. Induced breeding programmes carried out over the last 3-4 decades have led to heavy inbreeding and reduced performance (Dr. Kumariah, CIFA, pers. com.). An improved breeding programme is currently the focus of a collaboration between the University of Agricultural Sciences (UAS), Bangalore and the Institute of Aquaculture (IoA), Stirling. Population genetic analysis of the existing hatchery broodstock of catla showed it to be highly inbred compared to wild stocks. Subsequent trials showed a significant increase in the yield from crosses between two main hatchery stocks when compared to parental stocks. This led to the recommendation that hatcheries should exchange broodstock and produce F1 crosses in order to improve the performance (Penman, IoA, pers. com.)

Table 6: Relative freshwater fry capacity of Indian States (1997), Department of Fisheries (DoF) seed requirements in millions (1997) and taluk-wise breakdown of seed production in millions in Karnataka State 1996-97.

State	Annual fry production (x 10^6)	Area of water spread (x 10^3ha)	Fry:water (ha) ratio
West Bengal	8,126	545	14,910
Assam	322	160	2,007
Bihar	700	815	859
Uttar Pradesh	2,387	186	12,833
Andhra Pradesh	479	445	1,007
Karnataka	208	571	415

Karnataka DoF seed requirements and sources (x 10^6)		Karnataka current fry and fingerling production (x 10^6)	
Target spawn	460	DoF farms	110
Target fry	230	FFDA	12.3
Target fingerling	120	TB Board	24
Total requirement 1997	250	Private	25
No. govt. seed farms	10	Total production.	200
No. private seed farms	15 (mostly < 10 million)	Deficit	50

District in Karnataka	Seed production (x 10^6)		Comments	Total seed stocked (x 10^6)
	Govt.	Private		
Bangalore (rural & urban)	3.425			10.94
Belgaum		0.5		4.31
Bellary	29.58	32.2	28.3 from TB Dam	16.52
Bidar				2.475
Bijapur				6.76
Chickmagalur	1.6			8.41
Chitradurga	2			9.02
Dakinsha Kannada				0.24
Dharwad				5.01
Gulbarga				2.5
Hassan				10.65
Kodagu	1.6			1.33
Kolar	4.175			7.77
Mandya	1.05			13.75
Mysore	13.25	17.4	11.3 from KCIFF	14.2
Raichur	4.6			5.29
Shimoga	93		6 from FFDA	17.56
Tumkur	2.98			13.64
Uttara Kannada				1.26
Total	157.26	50.1		151.635

Sources: Haylor (1997); Dr. Shanmuka, DoF Bangalore, pers. com.; Government of Karnataka, 1997. DoF = Department of Fisheries, KCIFF = Karnataka co-operative inland fisheries federation, FFDA = Fish farmers development agency.

To increase seed output the government has in the past made substantial investment in large-scale regional seed production units (Sivisankar & Umesh, 1993). Many of these programmes carried out by the Public Works Department were of a lamentable standard, and substantially reduced the productivity of hatcheries (Shanmukha, DoF, pers. com.). Consequently, the DoF has tried to encourage seed production initiatives in the private sector by offering production subsidies and guaranteed sales of outputs (an initiative that has been aided by expanding markets). This policy has been most successful in encouraging the establishment of rearing farms[4]. There are now 41 private rearing farms in Karnataka State, half of which are in Raichur District. To date only 12 private seed production farms have been established in Karnataka. However seed production in the state is still highly centralised with 75% of all production taking place in three government hatcheries (in Bellary, Shimoga and Mysore). Table 6 shows the regional breakdown of fry production within Karnataka State. Shimoga is the largest producer, concomitant with its status as the wettest district with the greatest land area under irrigation in the state, followed by Bellary with its TB Dam facility. Although Raichur's fry production is relatively small (showing a 690,000 deficit on a 5.29 million DoF stocking requirement last year), it is bordered by major seed producers in Bellary and Andhra Pradesh. Within Raichur, the culturists interviewed considered seed quality more of a constraint than seed availability unless the monsoon was delayed (this concentrated demand in November last year).

Within Raichur there were 21 private rearing farms, 2 private seed production farms and 2 Government rearing farms in 1997. Distribution and production characteristics are shown in Table 7. Seed production sites are almost exclusively located in the wetter southern taluks with concentrations in Raichur (private) and Koppal taluk (DoF and TB Dam). To the North only the Naryanapur Dam (DoF) facility is present on the Lingsugur / Gulbarga border.

Table 7: Taluk-wise distribution of seed production and rearing farms in Raichur area, 1998. IMC: Indian Major Carps; A.P.: Andhra Pradesh; TB: Tungabhadra.

	No.	Capacity if known	Comments
Private seed production			
Raichur taluk	1	30 million fingerlings	A second farm had closed down this year with the operator preferring to import seed from A.P. Produces IMC, common carp and this year grass and silver carp under DoF subsidy.
Private rearing			
Raichur taluk	14		
Manvi taluk	2	8 million fingerlings 1.5 million seed	Largest farm belongs to an A.P. farmer / wholesaler who has recently taken over the remaining private seed production farm. Produces IMC, grass and silver carp. Experimented with hybrid catfish.
Sindnur taluk	2		
Gangawati taluk	1		
Government seed production / rearing			
Koppal taluk	2	7 million IMC 1.5-2 million common carp spawn	DoF hatcheries in Munirabad and Shivapur: Munirabad broodstock (900 IMC) transferred to Shivapur 1998 because of construction defects and water supply problems at Munirabad. 1997 Munirabad figures shown.
Koppal/Bellary – TB Dam		25 million IMC and common carp (capacity 150 million) fry	Controlled by TB dam board. Located on Raichur border near Hospet. Second largest seed producer in the state. Broodstock: 1,500 catla, 2,000 rohu, 2,000 mrigal, 1,500 common carp. Priority is for reservoir stocking. Spawn supplied to rearing farms and fingerlings to culture farms.
Lingsugur/Gulbarga – NP Dam		2-2.5 million IMC 2-250,000 common carp fingerlings	Located by Naryanapur Dam on the River Krishna, administered by Gulbarga DoF. 76 acre farm largely derelict due to poor construction practices. Small number of common carp broodstock. IMC seed from Shimoga, Shivapur and Munirabad. Most seed supplied to Belgaum and Bijapur co-ops.

Source: semi-structured interviews.

[4] The Indian Department of Fisheries (DoF) use the following terms *'seed production'* and *'rearing production'* to describe the production of fry and fingerlings respectively. Farmers subsequently on-growing to harvest are known as *'culturists'*.

Seed production facilities in the Raichur area

The TB Dam is run by the TB Board. Seed production from the TB Dam dwarfs the total production in Raichur. However, priority is for stocking the TB Dam (9.1 million seed was stocked in 1997), and the balance of 25 million is supplied to culturists and co-operatives in 13 districts of Karnataka, and 4 in Andhra Pradesh. Because of constraints on catla production, this species is only allowed to constitute 50% of each purchase, which has deterred some farmers from exploiting this source. The TB Dam hatchery is currently running at 50% capacity (Dr Shanmuka, DoF, Bangalore, pers. com.). Due to recently installed new hatchery technology, fry output figures should be improved in the future, but there is evidence that production techniques in Karnataka are generally technically far behind those in West Bengal (Sivisankar & Umesh, 1993).

Naryanapur Dam seed production farm was meant to be the largest carp rearing and production farm in Asia, with a water spread of 76ha, and envisioned as a regional production centre. However, due to substandard construction on porous ground, the site is now largely abandoned, producing only 2.5 million fingerlings p.a. for Belgaum and Gulbarga.

Within Raichur there are two small government seed production centres at Munirabad and Shivapur. Each produces around 7 million p.a. In the private sector there is now only one farm in Raichur taluk producing 3 million fry. From here 'small sales' (less than 10,000 fingerlings) are made to neighbouring farmers.

The DoF estimates approximately 50% losses from spawn to fry, and the same again to fingerling (i.e. a total survival of 25%). Whilst most culturists purchase fingerlings, spawn and fry is sold to rearing farms for fingerling production.

Rearing production facilities in the Raichur area

The DoF contracts a high proportion of rearing production to the private sector. Start-up subsidies and spawn are provided in return for a five-year guarantee allocation of their stock for tank and reservoir stocking.

Unfortunately, no reliable production statistics for the 21 rearing farms of the private sector were available. Three quarters of these farms are located in Raichur taluk and the remaining are spread over the southern taluks of the irrigated belt (Table 7).

Seed prices

Table 8 shows current government and private sector seed prices respectively. Government prices are heavily subsidised and fixed at state level. Therefore private farmers can normally only sell for a slightly higher margin when in direct competition. However, this balance is heavily dependent on the time of onset of the monsoon. In a good monsoon year water bodies will be full by the end of July. In 1997, eight districts including Raichur did not receive significant rain until August-September (this affected the TB but not the Naryanpur Dam catchments). Thus demand was concentrated into a very short space of time and private farmers were able to sell at inflated rates (i.e. Rs 300 / 1,000 catla). This partially covered their extra expenses for on-growing their stocks for an extra month.

Table 8: Government seed prices (Indian Rs) per thousand fry (source: DoF), ( ):= private sector seed prices.

Species	Spawn (6-8mm)	Fry (8-25mm)	Advanced fry (26-50mm)	Fingerlings (55-100mm)
Catla	10 (20)	75 (80)	125	250 (258)
Rohu	10 (18)	56 (60)	90	225 (240)
Mrigal	10 (16)	50 (55)	75	190 (210)
Grass/silver carp	40	125	160	400 (400)
Common carp	10	50	N/A	200 (200)
DoF mortality allowance	10%	5%		

Notes:

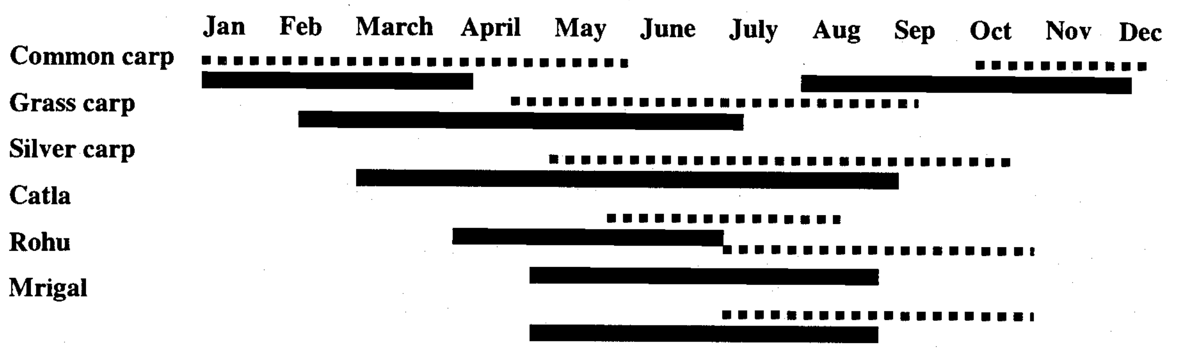
- The DoF encourage farmers to practice polyculture with silver and grass carp. As these have twice the production costs of carp, the DoF offers a 50% subsidy on their sale price.
- The Government undertake to transport fish up to 300km (or 18-20hrs) (reported mortalities: around 10%). Plastic bags and oxygen supplied at an additional Rs 4 per 5,000 fry.

Source: G Chandraekhara (Proprietor),Sri Balaji fish seed farm; M. Dodammi, TB Dam.

4 Commercial species and short season harvesting

The major carps; catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*), and common carp (*Cyprinus carpio*) are the major species stocked for commercial production, but the DoF also subsidises grass and silver carp production. The fast growing (exotic) Thai Silver barb (*Puntius gonionotus*) has been successfully used to stock seasonal waters across Asia. With induction of spawning and supplementary feeding, 3-4 annual crops can be produced (O'Riordan, 1993). Other recent exotic introductions include *Oreochromis mossambicus* and hybrid magur (*Clarias gariapenus* crossed with the indigenous *C. batrachus*). Both species have been banned by central government because of the threat they pose to wild fisheries, but the former was found to be widely established and thought to be responsible for decimating the productivity of at least one tank near Raichur City (Dodammi, DoF Raichur, pers. com.). The culture of the voracious and fast growing hybrid magur was only officially banned in May 1998, at the same time as production was beginning to take off in a Bengali refugee camp in Raichur.

Box 1: Spawning times (▬▬▬) and fingerling availability (▪▪▪▪▪▪▪▪▪) of major species used.
Source: Dr. Kumariah, P.A.D., pers. com.



As can be seen in Box 1, Indian Major and Chinese carps spawn at different times of the year. The net result of these staggered breeding seasons is that the fry availability of combined species in the area is greatest between August and November. Late spawning is not ideal for early harvesting of seasonal ponds, and induced spawning techniques can bring spawning times forward considerably.

Catla may be an ideal species because it spawns early and take only 45 days to reach fingerling size. However it has low fecundity relative to other species. Multiple spawning of common carp is possible, and because of the last late spawning there is commonly a surplus of common carp late in the season.

Last year the DoF stocked free surplus common carp seed in Karnataka (Dr Shanmuka DoF, pers. com.).

Perennial ponds may be stocked with major carps at the conventional time but advanced fingerlings are most suitable for seasonal ponds. Over-wintering, after the onset of the north east monsoon, may result in arrested or negative growth, and therefore short season strategies may be relevant to all water body types. A variety of possible short season strategies can be seen in Table 9.

Table 9: Short season strategies. IoA: Institute of Aquaculture, University of Stirling, Scotland.

Option	Studies
Small-scale transportable hatchery technology	DANIDA (the Danish development agency) used manual pumps in Mymensingh. This allows the stocking of small fingerlings in May, and the harvesting of marketable adults in November (Shaw, 1986). IoA project exploring the potential of similar technology has just been carried out in Bihar (see Tarazi 1998).
Replenishment of seasonal ponds	Seasonal ponds can be replenished with groundwater or water pumped from neighbouring perennial ponds. If the costs of running pipes are prohibitive the use of suitable transport facilities could be investigated.
Vertical integration seed production, nursery rearing and final on-growing	Vertical integration of mini-hatchery seed production, nursery rearing of fish and final on-growing could overcome many of the problems with seasonal water bodies, give more flexibility over choice of culture species and bring short-term profits in its own right. This is a highly technical solution, and the potential for a collaborative implementation by Samuha, interested farmers and research institutions such as Stirling IoA should be investigated. Other constraints to this technology are broodstock and pituitary availability, and credit levels.
Bonzai fish	Stunted one year old major carps – widely available in the rearing farms of Raichur taluk - might be suitable for short-season harvesting periods in bodies of water with greater than 0.5ha surface area. According to Mr. Ramachaya (DoF, Raichur) these would be made available through the DoF at Rs 1 per fish (typically 20g). This strategy may require higher start-up capital, and incur high transport costs, but is worthy of further investigation. The possibilities for using Bonzai fish are currently being investigated in DFID project R6759 in Eastern India.
Use of perennial water bodies as nursery holding tanks	Possibility of stocking perennial water bodies such (e.g. some tanks and reservoirs) and using them as nursery holding tanks for stocking of seasonal water bodies should be investigated.
Stocking with early spawners	All species under consideration can probably be spawned earlier. Pretto (1996) suggests that silver carp can be stocked in March and April and partially harvested in November. Grass carp are also early spawners.

The potential of indigenous species for short season harvesting options should also be investigated (see Working Paper 8).

The University of Agricultural Sciences (UAS) in Bangalore consider that stocking catla, common and silver carp in tanks with high inorganic turbidity would be the best option (K. Rao, UAS, pers. com.) as these species have been shown to perform better in turbid environments (growing from 500-750g per year). In such situations, plankton levels are low and zooplankton predominate. These species may be most suitable for stocking the silty waters found in farm ponds and checkdams. Exotic carps also have the advantage of growing twice as fast as native species, and major carp culture has already been successfully carried out in irrigation tanks.

No institutional provision exists for small-scale farmers to purchase small numbers of fingerlings. Private producers are reluctant to provide the small numbers of fish required by these farmers. Box 2 shows an estimated annual seed requirement for an individual well owner. The minimum quoted sale volume of 10,000 fry from private rearing farms equates to 6 times that required for one open well. Transport of 10,000 fry should be feasible by public transport in oxygenated bags, as journey times from project villages to the nearest seed production site would be no greater than 4-5 hours by public transport. Collective fry purchase options by farmers could be investigated. The short seasons harvesting options available by stocking indigenous species with potential for aquaculture are considered in Working Paper No. 8.

Box 2: Estimated fry requirements in an open well, assuming productivity of 3kg m^{-3} p.a.
Typical draw down volume = $50m^3$
Annual biomass production = 150kg
Typical harvest weight = 250g
(Advanced) fry requirement = 600 fingerlings
Allowing for 50% loss = 1,200 fingerlings
50% allowance for staged cropping of shooters = 600
Total requirement = 1,800 fingerlings per pond
Seed Cost (@ Rs 250/1,000) = Rs 450
Potential revenue p.a. (@ Rs 20/kg) = Rs 3,000

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Appendix 1: Visits to seed rearing facilities in Raichur District

N. Venkata (manager) Sri Ganesha (private) fish seed production/rearing farm, Dongere Ramapura Raichur taluk, Raichur.

G Chandraekhara (proprietor) Sri Balaji fish seed farm, Manikeri camp, Raichur.

B. Lamani (fisheries field man) Naryanapur Dam (DoF) Government Rearing farm. Naryanpur, Shorapur taluk, Gulbarga.

M.L Doddamani (Fisheries Development Officer) TB Dam (TB Board) Government rearing farm, Hospet, Bellary.

Fisheries field man, Shivapur production/rearing farm, Shivapur, Koppal taluk, Koppal.