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FINAL TECHNICAL REPORT

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Small-scale farmer managed aquaculture in engineered water systems: critical design and management approaches

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Acronyms

ARP	Aquaculture Research Programme
ARS	Agricultural Research Scientists
CD	Check Dam
CIFA	Central Institute for Freshwater Aquaculture
DFID	Department for International Development
DoF	Department of Fisheries
FFDA	Fish Farmers Development Agencies
FIT	Farm Irrigation Tank
FP	Farm Pond
GDP	Gross Domestic Product
GTZ	German Technical Co-operation
ICAR	Indian Council of Agricultural Research
IFAD	International Fund for Agricultural Development
IPM	Integrated Pest Management
IIMI	International Irrigation Management Institute
KAR	Knowledge And Research
KAWAD	Karnataka
KCIFF	Karnataka Co-operative Inland Fisheries Federation
KVK	Krishi Vigyan Kendra (Farm Science Centres)
MOFARD	Ministry of Fisheries and Aquatic Resources Development
MT	Mini Tank
NARA	National Aquatic Research and Development Agency
NARS	National Agricultural Research Scientists
NDF	National Development foundation (NGO Sri Lanka)
NGO	Non Governmental Organisation
NR	Natural Resource
OW	Open Well
PAD	Peninsular Aquaculture Division
PRDP	Participatory Rural Development Programme (Tank rehabilitation -Sri Lanka)
PWDS	Pampanagar Women's Development Society (Devadasi group)
SC	Scheduled Caste. Lower castes identified by the Indian government as a means of classifying castes for the allocation of benefits
SLCDF	Sri Lanka Canada Development Fund
SP	Surface Pond
ST	Scheduled Tribe. 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
STC	Small Tank Cascade system

1. Executive Summary

The purpose of the project was to identify the major social and bioeconomic constraints to the introduction of aquaculture into farmer-managed irrigation systems and then to develop and promote effective approaches to aquaculture. The project focused on two areas of the Sub-Continent that suffer water stress and where aquaculture has little tradition, up-state Karnataka, India and Northwest province Sri Lanka. The project aimed to deliver an assessment of the potential for aquaculture within available farmer-managed irrigation systems through a series of situation assessment activities. This culminated in several physical systems (open wells and check dams) being identified for their potential in Raichur District, Karnataka and the small seasonal tanks that are numerous in the Dry Zone of Sri Lanka. A range of research methods and tools were also identified and tested for developing appropriate aquaculture interventions. These were based on participatory approaches that sought to understand the needs of, and resources accessible to, the poor. A series of activities with our partner institutions were then initiated to pilot potential ways for the poor to gain from integrating fish culture within their irrigation systems and to monitor the impact.

The project, working with an NGO partner actively involved in watershed development in the drier areas of Karnataka State, India identified most physical structures to have little potential for aquaculture. Demand for fish was identified with some of the poorest low caste and tribal people but consumption rates were very low as supplies had poor penetration into marginal rural areas. Most outputs from both fisheries and culture in the region tend to be exported to distant urban markets. On farm trials were conducted to assess the potential for using open wells, accessible by individual households, and check dams used by groups in the project area. Poor availability of nutrient inputs was a major constraint to increasing benefits from open wells. However, collaborating households appreciated the small amounts of fish for social and convenience reasons and at this level of integration there appeared to be few conflicts with other uses. In a series of trials, farmers participated and in the last phase interest had increased to the point where farmers purchased their own seed, which was the major input. The timing of seed availability of the carps stocked in check dams constrained interest and outputs among groups of poor women involved in the trial. The spatial separation between settlement and the check dam resource was also identified as a constraint. A lack of knowledge and experience in aquaculture within the private and NGO sector was a major constraint to carrying out field research in the area.

In Northwest province Sri Lanka, the project has identified and tested an approach that benefits poorer people located in upper watershed areas through fish culture in collaboration with CARE, who financially supported the work over a further season. Over an extended situation assessment period the risk of increasing conflicts through misguided promotion of community fish culture was established and alternative approaches developed. These were then piloted with communities over a two-year period in an adaptive process in which learning by the group was facilitated. Recommendations for enhancing livelihood outcomes for the poorest people were developed and are being used by CARE. They are based on using simple local transfer of fish for stocking and modifications to traditional practice that recognise social and technical constraints identified by the communities themselves. The research also assessed the value in combining low input enhancements with other micro-industrial uses of tanks (such as brick-making). This allowed the production of portfolios of options which are more attractive to landless and youth groups, thereby increasing the chance of their mobilisation.

The project focused on developing recommendations for an extensive but largely undocumented resource accessed by many of the most marginal groups, but which is currently entirely ignored in government policy. A major outcome are recommendations to agencies involved in tank rehabilitation of how to optimise fish migration and refuge potentials to improve overall watershed productivity, especially during drought years.

The project also identified that demand for freshwater fish was a critical driver of aquaculture development based on studies of marketing in both locations. Linking this with an assessment of current status led to an improved understanding of the potential role and benefits of fisheries and aquaculture production to the poor. The relationship between aquaculture development in areas of combined seasonal and perennial water availability has also been clarified. This has critical importance for determining the likely trajectory of aquaculture development and for informing change agents to more efficient and poverty-focused approaches to interventions.

2. Background

The relationship between water and poverty in rural Asia is stark. Inevitably the poorest people live in more marginalised and risk-prone environments, typically in rain-fed areas with less access to alternative sources of employment. A realisation that multiple use of scarce water resources is essential to stabilise or improve livelihoods is growing (World Resources Institute, 1996; FAO, 1995, UN, 1994; Gleick, 1993) and the potential for fish production to become an integrated activity has been identified as an important researchable issue (Haylor and Bhutta,1997). Most of the focus thus has centred on the use of larger irrigation systems. It is often assumed that an assured supply of water is required for fish culture to be viable but in practice aquaculture has often been readily adopted in rain-fed areas in Asia. This often occurs where water availability is seasonal, whilst physically more suitable sites in irrigated areas remain undeveloped (Little 2000). Moreover, only a minority of the worlds' farmers are served by large-scale irrigation schemes, a proportion that seems set to fall as many of the suitable sites for large-scale dam and irrigation development have already been utilized (Higgins, Dieleman and Abernethy, 1988). The growth of interest in improving farming systems in more diverse, risk-prone rain-fed areas (Jones et al.,1996) has been tempered with a realisation that poor peoples' livelihoods are impacted by a range of on-farm and off-farm factors (Ellis, 2000). Furthermore, impacts on the poor can be derived through the role of the poor as consumers or intermediaries in the production and marketing of fish, in addition to producers (Edwards, Little and Demaine 2002). Agro-ecosystems that can incorporate aquaculture may be based on small irrigation dams or associated with ground and surface water as well as rain and floods. Small dam irrigation has a very wide geographical application (approximately 84% of the world's total farmland) and only minor modifications, easily undertaken by farmers themselves, may be needed to incorporate and sustain fish production. In Sri Lanka ancient man-made reservoirs ('tanks') are believed to be critical to food production in rain-fed areas and to have potential for aquaculture (Fernando, 2001).Previous work by De Silva (1988) has identified viable technical approaches to the integration of aquaculture within such tanks but there has been little evidence of widespread adoption, despite freshwater fish being of major importance in rural diets (Jinadasa, 1998) Tanks are also an important part of the social and agricultural landscape in southern India and the rise of watershed development as a major focus of Government and Non-Government efforts has led to promotion of a range of other physical structures with potential for aquaculture. Reduction in run-off loss with resultant soil erosion is a major objective but the capture and storage of highly seasonal rainfall as surface or ground water may be prioritised. Rainfall in Karnataka occurs between April and October, the distribution is bi-modal, with the first peak in May and the second in September. In the dry zones of the state in the rain shadow of the Western Ghats, irrigation is vital to stabilise or increase farm production. The total area of large water bodies is more than 630,000 ha. Other small perennial and seasonal water bodies exist throughout the state as well as 6000 km of rivers. Although rainwater harvesting has been known for almost 4,000 years (Tapiador, 1983) the use of stored water for managed fish production or aquaculture is rare or a relatively recent innovation. For example, productive fish culture in small reservoirs began 40 years ago in Japan (Kafuku and Ikenoue, 1983), 30 years ago in China (Li, 1987) and within the last 15 years in Sri Lanka and Israel (De Silva,1988; Lieberman and

Shilo, 1989). However the integration of fish production into the rural agro-economy is being encouraged in many parts of the world (Tapiador, 1983; De Silva, 1988; ICLARM and GTZ, 1991) and this type of aquaculture could become increasingly important as world water resources become limiting and their use is increasingly optimised

In terms of water-use efficiency integrated aquaculture *best practice* is perhaps currently most well developed in Israel. Israel uses some 1,770 million m^3 of water annually, of which 72.8% is used for agricultural production (Dill and Ben-Tuvia, 1988). Many farms have improved efficiency of water use by shifting fish culture from shallow ponds to on-farm irrigation reservoirs integrated within a larger water management system. By 1989, more than sixty percent of the fish cultured was from dual-purpose reservoirs (Lieberman and Shilo, 1989). In development contexts as varied as Southern Africa (Prein and Pullin, Brummett and Noble) and Latin America (Lovshin *et al*. 2000) fishponds have also evolved to meet irrigation needs on-farm rather than to produce large quantities of fish, often to the surprise of promoters of aquaculture. Undoubtedly developing strategies whereby aquaculture can be integrated within farmer-manage irrigation systems will require a better understanding of current livelihoods and constraints. Aquaculture in managed water systems is reviewed in detail by Haylor (1994). The approach of using small-scale irrigation systems for aquaculture is likely to hold particular value for the semi-humid tropics including parts of India, Pakistan, Sri Lanka, the Sahel, Southern Africa, parts of the Middle East, Bangladesh, South East Asia and Southern China. Two thirds of the predicted shortfall in world fish production (20-30 million tonnes by 2000) will occur in these regions. Population growth will be amongst the fastest in the world and the need to make the most efficient and productive sustainable use of renewable natural resources, particularly water, will be critical. The demand for the project was identified through previous field work by Haylor (Haylor, Perry & Monan, 1993) in the Sub-Continent and the experiences of DFID-funded work in SE Asia through AIT Outreach. Additionally the NR and engineering advisors within DFID had identified the issue of multipurpose use of irrigation systems in relation to aquaculture as a priority researchable issue following the UNCED summit in Rio de Janeiro in 1992.

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3. Project Purpose

Aquaculture was not practised locally at either project site at inception despite the widespread occurrence of irrigation systems. The purpose of the project was to identify the social and bio-economic constraints to the introduction of aquaculture into farmer-managed irrigation systems and to develop and promote effective approaches that enhance livelihoods of the poor.

4. Outputs

The first major output of the project was the assessment of potential for the integration of aquaculture in farmer-managed irrigation systems. The results from participatory exercises with groups of primary stakeholders at both sites led to the identification of systems with potential, target communities for follow up research and an analysis of the potential of aquaculture from a livelihoods perspective.

Output 1:**The potential of aquaculture in small-scale farmer-managed water resources assessed.**

Summary of systems with potential in India and Sri Lanka

A variety of water resource systems was identified at each location (Tables 4.1 and 4.2) with variable potential for integration with aquaculture. Key issues are the impacts of seasonality, often linked to the principal water source, the primary uses and ownership and access by different groups and individual households. Generally poorer, more vulnerable people, have less access to water and are more dependent on more highly seasonal water resources. The production of aquatic resources within every type of resource identified is currently low, non-existent or subject to brief seasonal harvest at both sites although reliance on and levels of consumption of fish are very different. Freshwater fish is far more important to poor peoples' livelihoods, as producers, intermediaries and consumers at the project sites in Sri Lanka than India.
An assessment of the livelihoods context for both sites is given in the ARP Inception report.

Table 4.1 : Small-scale farmer-managed water bodies in northern Karnataka.

Type	Seasonality (post rains)	Principal water source	Primary uses (other uses)	Ownership and access
Check dam	3 months to perennial	Rainfall	Silt and water harvesting (livestock, pumped irrigation)	Owned by community or government (occasionally farmer), used by community or farmer
Farm pond	3-4 months (most) to perennial	Rainfall	Ground water recharge, small –scale irrigation (domestic)	Owned by farmer, used by farmer
Agro wells	Mostly perennial	Ground water	Irrigation (livestock, domestic)	Owned by farmer, used by farmer
Farm irrigation pond	Farmer managed	Ground water (pumped)	Irrigation (livestock, domestic)	Owned by farmer, used by farmer

Table 4.2 Small-scale farmer-managed water bodies in Northwest Province, Sri Lanka

Type	Seasonality (post rains)	Principal water source	Primary uses (other uses)	Ownership and access	Notes
Rice fields	Short season and shallow water	Rainfall and seasonal tanks	Rice	Individual households	Would require change in management practices for fingerling production Low potential in dry zone
Agro-wells	Mainly perennial	Groundwater, often recharge from seasonal tanks	Crops and domestic use	Individual, better-off households	Low potential: fingerling production subject to harvesting constraint
Borrow pits	Variable, site dependent	Rainfall/run-off-associated with tank construction	Livestock watering	Common, generally accessible by the landless	Potential for advanced fingerling production and refuges for wild fish stocks
Quarries	Little retention of water	Rainfall/runoff	Removal of materials for construction	Typically open access	Little potential
Seasonal tanks	Variable-defined in terms of irrigation; usually more seasonal at top of watershed	Rainfall/runoff; tanks further up watershed	Many-depending on type (see below)	Complex, but tends to be accessible by the poor for non-consumptive use such as fishing	Very numerous, high potential

Table 4.3 Farmers' prioritisation of uses of tanks in terms of use of stored water and physical infrastructure

Priority	Resource use	Natural capital: Stored rain water	Physical capital Tank infrastructure
1*****	***Irrigation & drainage*** **-** Irrigation - Silt harvesting - Flood protection	- Distribution to command area [Principle consumer] - Seepage to adjacent home garden areas	- [Drawdown v dead storage] - Trapped silt – formally used as field fertiliser. - Prevents damage to soils and physical infrastructure
2****	***Domestic uses*** -Bathing & washing clothes …- Toilet, dish washing …- Drinking - Vehicle washing (bikes, vans, tractors)	- *In-situ* [quality modifier] - *Ex-situ* Home use - *Ex-situ* Groundwater recharge - *In-situ* [quality modifier]	- Bund steps facilitate access - Agro & tube wells below bund - Roads built across bunds facilitate access
3***	***Livestock*** **-** Watering - Grazing	- In littoral areas	- Tank bed: rainy and dry season - Command area: dry season
4**	**Biomass gathering** **-** Fisheries - Wild game - Aquatic plants	- [Indirect quality modifier] - Dry season watering	- [Trophic status & productivity] - Hides constructed around water - Macrophytes in littoral areas, tubers from tank beds.
5**	**Micro-industries** - Brick / pottery making - Cajun retting - Construction - Illicit distilling - Washing / soaking crops	- For fabrication - [Quality modifier] - Water for cement/mud - [Quality modifier]	- Excavation of clay kilns ranged around tank bed[1] - Residual dry-season storage - Sand and gravel extraction - Stills located in immediate catchment[1]
6*	**Environmental** **…**Habitat		Direct and indirect provision of habitats for a wide range aquatic terrestrial, and avian fauna
7*	**Consumption**	**Only poorest farmers in remotest sites – often where ground water salinity problems experienced**	

Note: Impacts are distinguished from uses by square brackets [ ].
[1] Location of these functions is determined by proximity to water resources in the tank and fuel wood resources in adjacent catchment areas.

Output 2: **Identification and testing of research methods / tools**

A variety of participatory tools and approaches at both farmer and institutional level were piloted at both sites. These included workshops at both primary and secondary stakeholder levels. In India the partner NGO had well developed practices with regard to their watershed development programmes that were adapted to the skills and interest of peoples institutions and individual farmers. In Sri Lanka these skills were largely absent and were developed and adapted mainly around an indigenous institution (Death Donation Societies). A range of methods was used to stimulate and monitor individual household and group research including focus group meetings, farmer-to-farmer exchange, community meetings and activities. Participatory monitoring of technical and livelihood outcomes were monitored at a variety of levels over the course of on-farm research at both sites.

Table 4.4 Output 2 components

Activity	***Description***
2.1 Characterise with farmers and NARS the researchable social, technical and economic issues relating to development of fish production in farmer-managed water resources from case study areas in Southern India and Sri Lanka	Key researchable constraints identified with NARS at Stakeholder Workshop in Coimbatore, Tamil Nadu, 19-20 November 1998 and Kandy, Sri Lanka 26-27 November 1998.Key researchable constraints identified with farmers from Koppal and Raichur districts (India) and Puttalam and Kurunegale Districts (Sri Lanka) during participatory situation analysis Karnataka. Elaboration on Indian farmers constraints identified during Farmer Workshop in Koppal, Karnataka, 20-21 April 1999. Sri Lanka farmer workshop to take place in October 1999.
2.2 Develop in conjunction with farmers and ARS a farmer ranked research agenda for the development of fish production in these systems	Farmer derived research agenda formulated at Farmer Workshop Koppal, Karnataka 20-21 April 1999 (facilitated by the NGO SAMUHA). Ranking being carried out as part of current baseline survey. Sri-Lanka: preliminary research hypotheses formulated as component of participatory situation analyses. Further definition and ranking to be undertaken during farmer workshop to be held October 1999 and longitudinal situation analysis.
2.3 Hold regional workshop on use of small-scale farmer-managed water resources for production of fish and other aquatic products.	Stakeholder Workshop in Coimbatore, Tamil Nadu, 19-20 November 1998 and Kandy, Sri Lanka 26-27 November 1998: stakeholder analysis completed and major constraints to aquaculture identified. Workshop proceedings expected completed in July 1999. Farmer Workshop in Koppal, Karnataka, 20-21 April 1999: Farmers' research priorities identified. Workshop proceedings in Appendix 3. Sri Lanka: Activity to be included as part of a farmer workshop October 1999.
2.4 Develop and test social and physical mapping techniques with different stakeholder groups and apply to watershed development in Sri Lanka	In 14 watersheds in three clusters located in Puttalam and Kurunegala Districts between 1999 and 2001. Subsequently used to inform adaptive learning approaches (2.5)
2.5 Develop and test group adaptive learning approaches to improved management of seasonal water bodies in Sri Lanka	In four communities (5 tanks) over two years concurrently with multi-level participatory impact monitoring over second year of trials. Involved regularising management within local community institution (DDS)
2.6 Action research techniques introduced to poor groups for household managed aquaculture systems and monitoring systems for partner NGO in India	Over three phases of trials with carps and catfish in three physical systems in households and groups in three communities.

An important additional output not covered here is the development of a relational data base that improved the management, validity and utility of large longitudinal and horizontal multi-disciplinary data sets. The basic structure can be exported and adapted for similar research contexts. Common ranking and scoring procedures were also adapted to better capture farmer perceptions.

Output 3: Approaches to key engineering and management options investigated and promoted.

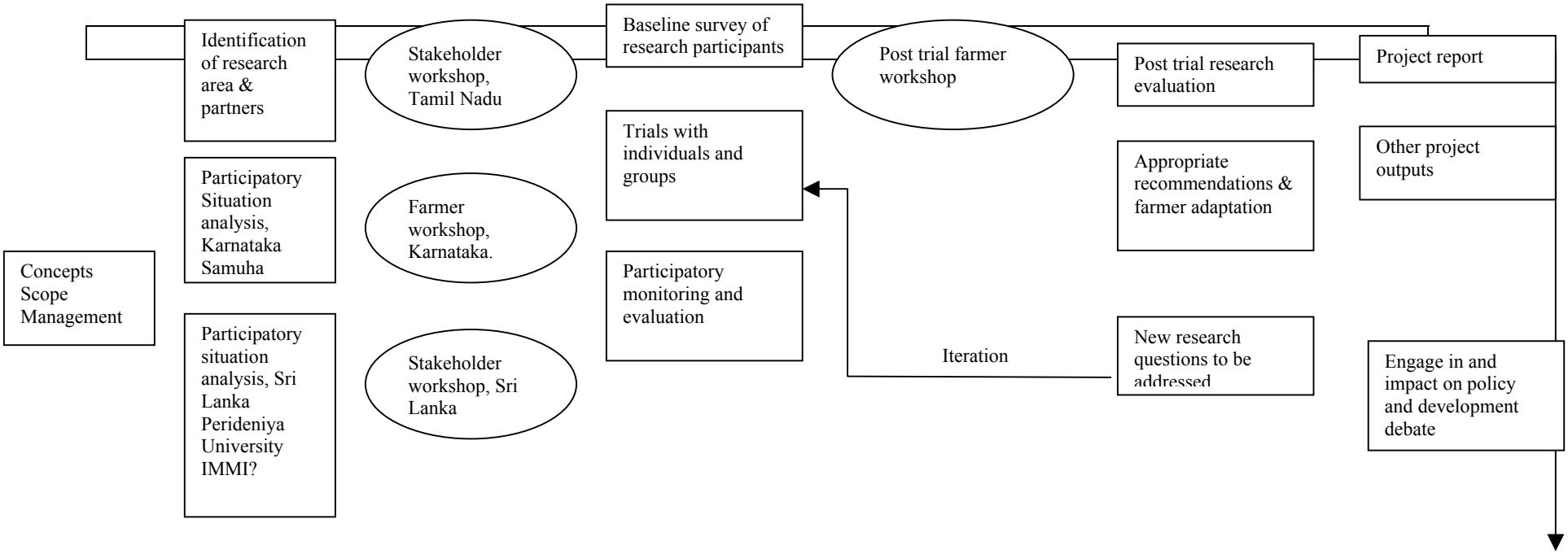
A major constraint to the development of aquaculture within farmer-managed systems was hypothesised to be a lack of appropriate technical options. Aquaculture has developed fast in India among better-off entrepreneurs and service providers have yet to target the poor despite rhetoric to the contrary. A major part of the problem, that is normally associated with identifying and working with poor people to improve their livelihoods, is the constraints of the service providers themselves in terms of attitudes and capacity. The development of appropriate 'improved' technical options therefore pre-requires use of a different process (Outputs 1and 2)

Table 4.5 Components of Output 3

Activity	***Outcomes***
3.1 Investigate options for enhanced natural fish production, cultured fish, non-fish aquatic production	India: Preliminary trials with groups 33 Farmers associated with Samuha Akanksha and Kanakanala watershed development projects in four different types of water body, using carp combinations, initiated May 1999. Participatory trial monitoring forms and database developed in collaboration with local NGO Samuha in May 1999. A further three series of trials focusing on use of agro-wells, backyard pits and check dams with *Clarias* catfish carried out. Sri Lanka: Farmer trials initiated in November 1999 after formulation of farmer derived research agenda. Two consecutive years of interventions with communities identified risks, potentials, benefits and constraints of aquaculture. Characteristics of success identified and mainly related to community structure, relative well-being and social status and the applicability of simple stocking and harvest regimes for self-recruiting species. Assessment of water plants and their role in livelihoods implemented identified important contributions to well-being
3.2 Define / compare draw down / water use of the land and water based production systems.	Economic impacts of the integration of aquaculture in irrigation systems investigated. Sri Lanka specific analysis based on quantitative monitoring of tank hydrology and management in progress. Qualitative assessment in India suggests that fish culture resulted in improved irrigation management through maintenance of higher levels of dead storage.
3.3 Investigate health and welfare implications.	Impacts of pesticide use in large and small scale irrigated areas investigated as a joint activity between the large scale and the small-scale projects in Sri Lanka. Poorer groups spending a higher proportion of income on health care, especially during the rainy season
3.4 Develop an index of water resource development potential.	India: Provisional assessment of water resource development potential completed Sri Lanka: Index based on farmer indicators and field measurements during situation analysis (inc. farmer water usage ranking, frequencies of spill and seasonality, ratios of catchment, command and water spread, construction of seasonal discharge curves to investigate relationships between water area, volume and fish yields). Final analysis in progress
3.5 Produce guidelines, information and other dissemination / promotion materials.	Written extension materials with farmers. Written policy guidelines with NARS and farmers. Project reports, peer-reviewed articles based on findings from farmer-trials in Karnataka and Sri Lanka. Iterative process of information resource update as research cycles continued. Lessons learnt summarised and used by partner institutions and more widely afield.

5. Research Activities

The project design aimed to identity and work with grassroots organisations at both sites. The secondary stakeholder workshops allowed some assessment of potential partners with MOU's subsequently signed with Samuha in India and CARE in Sri Lanka. CARE subsequently agreed to financially support much of the Stirling/ABC work in the Northwest Province field sites. Preliminary field work during Phase 1 was used to understand the situation enough to define the scope of the subsequent phase (Figure 5.1). Participatory field trials were planned and modified as an iterative process at both sites, based on knowledge gaps and geared towards meeting the needs expressed by primary stakeholders. The capacity of the local partner and characteristics of the wider environment was also an issue that affected the workplan in each case.



Stage 1: Scope of project, Preparatory work	**Stage 2:** Selection of area and partners, participatory situation appraisal	**Stage 3:** Stakeholder workshops, identification of constraints, identification of farmer researchers & hypotheses Longitudinal situation appraisal (Sri Lanka)	**Stage 4:** Baseline survey of research participants, farmer trials, PM&E,	**Stage 5:** Workshops, sharing of research findings, research planning	**Stage 6:** Post-trial farmer workshop Information dissemination Cycle of continuing research	**Stage 7:** Change in policy and development actions

Figure 1: Research approach and project stages

5.1 Situation appraisal

Karnataka, India

A participatory situation analysis investigating the economic and technical feasibility and the social acceptability of the production of fish in farmer-managed irrigation systems in arid and semi-arid regions of Karnataka was carried out. Field research took place from 6 April to 21 May 1998 and included a 'Rapid Rural Appraisal' of four villages in Koppal and Raichur Districts, Karnataka, and semi-structured interviews with representatives from the Government Department of Fisheries, marketing organisations, academics and other relevant institutional sectors within the state. Villages were selected on the basis of the frequency of small-scale farmer-managed irrigation water bodies as well as on socio-economic characteristics such as caste-composition and literacy levels.
The draft outputs of the situation analysis were shared with, and feedback encouraged from project collaborators and organisations involved with the uptake of project outputs in Karnataka in a field visit in August 1998. An assessment of the target area in terms of livelihoods status is given in the Inception Report

Northwest Province, Sri Lanka

A three tier screening process was used to select areas for detailed field research. Secondary information (from Governmental and NGO sources) was used to define the first two tiers based on administrative boundaries, and subsequently field level investigation used to resolve to the final meso-watershed i.e that containing hydrologically connected series of tanks draining to a common point, was justified as the fundamental unit of research.
Districts within North Central and North Western Provinces were selected for detailed screening. Secondary data including poverty indicators, water availability and potentially enabling institutional presence were over-laid to identify seven administrative areas for the final phase of screening. Within the targeted districts 14 cascading systems of small seasonal tanks were rapidly screened using site visits, mapping exercises and key informant interviews. Two of these systems (incorporating a total of 21 tanks and 9 villages) were the subject of detailed participatory livelihood analysis, which also included comprehensive assessment of fish production, marketing systems and consumer preferences. Selection of marketing research sites also reflected a broad division in consumer preference and availability between urban and rural inland areas.

This work was undertaken in collaboration with field staff the NGO's CARE and IFAD and the Government Samurdhi Welfare programme in different villages.

A further phase of situation analysis was made at both community and household level in the same area. Participatory research with farmers based on a research agenda and indicators identified during secondary and primary stakeholder workshops was carried out on 118 village tanks and 23 associated villages comprising 14 cascade systems (including those sites in the preliminary and extended situation analysis – but not sites in post situation screening that weren't finally selected!). A detailed longitudinal

assessment of tank nutrient dynamics, hydrology (8 tanks) and fish yields (4 and 5 tanks where enhancement interventions had been implemented in 2 successive years) was also carried out over a 14 month period.

5.2 Participatory interventions

Karnataka

Identification of appropriate interventions was based on participatory workshops with farmers from which information was exchanged on the nature and potential of various types of approaches and the benefits obtained. After year 1 trials in which a range of interventions were piloted with over twenty households, the stocking of open wells, check dams and backyard pits was prioritised as having most potential and studied further. The latter included concurrent researcher managed trials on the Samuha campus as well as on-farm / farmer-managed trials.

Table 5.1 Major foci for research activities in Karnataka, India

System piloted	Researchable issue(s)	Main constraint identified	Lessons learnt
Farm ponds and farm irrigation tanks	• Can enough water be retained in these systems to permit returns from stocking fish that meet beneficiaries expectations?	• In farm ponds exceptionally low rainfall and poor water retention meant little potential • Farm irrigation tanks showed some potential, especially if kept filled and productive	• Fish culture possible in these systems • Small wild fish common and encouraged for a variety of reasons • Relatively few people are likely to benefit directly as systems are limited and mainly controlled by better-off
Carps in check dams	• Is cage culture an option? • Does stocking a range of available fish species meet beneficiaries expectations ? • What level of intensification is possible?	• Participants rejected cage culture on the basis of the higher risk and inputs costs • loss of fish during spill events • distance between peoples' homes and systems • poor availability of carp seed and constraints to local nursing • tilapias do not meet expectations	• pre-spill stocking too risky • post spill stocking has potential – optimal timing established from historic rainfall data • common carp and rohu have potential

Agricultural (open) wells	• do stocked carps grow in agricultural wells and what benefits does the activity bring? • What level of intensification is possible and sustainable? • What are the disadvantages/advantages of using indigenous fish compared to exotic catfish?	• Low input/output approaches were followed for a variety of reasons • Harvest of varieties requiring netting from wells can be problematic	• Performance of a variety of carps can meet farmer expectations when stocked in low numbers • Catfish and indigenous fish have most potential • Farmers appreciated for the fish as a social asset and for maintaining quality of water for domestic purposes • Stocking fry outwith the irrigation season when natural productivity is highest can increase net growth and yield
Catfish in backyard pits	• Does the construction and stocking of small pits have potential for the poor with little access to other water resources? • Can the production of catfish intensively in pits be integrated with backyard vegetable production?	• Poor quality of available materials to prevent loss of water by seepage • Lack of nutrients on-farm for feeding fish • Labour cost of exchanging water • Siting of pits under shading and leaf fall affecting water quality	• The construction of pits was improved using local materials and skills and technical constraints in terms of water availability and quality overcome • On-campus trials indicated the value of integration to produce vegetables • Major constraint was the lack of nutrients/high opportunity cost of available to farmers
Catfish in open wells	• Can catfish nutrient requirements be met through low density stocking in open wells -with and with out self-recruiting prey species. •	• Stocking fish at suitable size to prevent predation losses	• Advanced fingerlings can reach a consumable size in 3-4 months • Fish stocked at low density can grow rapidly scavenging naturally available feeds with little reliance on supplementary feed or prey species polyculture

Northwest Province

Identification of appropriate interventions to pilot with communities was an iterative process which overlapped with the an extended situation appraisal. Preliminary farmer-managed trials . took place in four communities (4 Tanks) in 1999/00. A second phase of modified trials took place with three new communities and one old (5 Tanks) in 2000/01. A fortnightly household livelihood monitoring survey, incorporating a participatory impact monitoring (PIM) component, was undertaken concurrently with the second phase of trials. This incorporated a total of 41 wealth-stratified households in four communities in different watershed locations. Other village level activities concurrent with the Phase 2 trials included a detailed longitudinal assessment of tank nutrient dynamics, hydrology (8 tanks) and fish yields (5 tanks). A detailed questionnaire assessing the outcome of the agricultural cropping strategies of the 40 monitored households and PIM questionnaire investigating the fisheries enhancement outcomes were also undertaken at the completion of the second trial phase.

Table 5.2 Major foci for research activities in Northwest province, Sri Lanka

	System piloted	Researchable issue	Main constraint identified	Lessons learnt
1	Promotion of interest through Shrimadana tradition[1]	• Can community-based traditional activities be used to motivate interest in improving fish productivity of tanks?	• Expectations of tangible commercial benefits associated with dependency culture often unfulfilled • Sustainability and replicability • Dependent on established leadership • Coupling of shrimadana with welfare benefits modifying traditional value system.	• May be a relevant entry point • Needs prior understanding of community characteristics
2	Broodfish and seed transfer	• what is the feasibility of intensifying fish productivity through local transfer of brood and or seed fish?	• No major constraints identified	• High potential for increasing productivity in a sustainable way • Particularly for highly seasonal tanks • Mechanism for linkages with traders
3	Early stocking	• is early stocking adoptable by	• Belief by community that	• Important way to increase yields,

		communities as a mechanism to increase tank productivity? • What levels of productivity and benefit gains can be achieved using this approach?	fish would be lost during spills • Availability of seed	particularly of highly seasonal tanks
4	Continuous harvest	• will communities practice continuous and pre-spill harvest? • What levels of productivity and benefit gains can be achieved using this approach?	• Expectations that fishing increases percolation losses • Increase in conflicts between poorer fishers and non-fishers in community	• Hook and line fishing was shown to have clear advantages including improving fish availability and CPUE (especially in water bodies occluded with aquatic weeds)
6	Mutual learning workshops as part of Death donation societies	• can groups or communities change their management of seasonal tanks to enhance fish productivity and benefits?	• Appropriate institutional home inclusive of all groups, including the poor	• especially in smaller and more cohesive communities, the process of facilitating changed management resulted in net improvements in water management and fish availability

[1]A tradition whereby public works were undertaken in order to gain social and religious merit.

6. Contribution of Outputs

The outputs of the projects allow a better definition of the likely scope and role(s) for aquaculture in arid areas where farmer-managed irrigation systems support livelihoods in variety of ways. They have described complex situations in which aquaculture interventions can, if implemented uncritically, increase social conflicts and undermine livelihoods or have the potential to increase community cohesion's and yield benefits beyond improved food security. A better understanding of the current status of aquatic resources and their use by the poor led to a research process that has focused on maintaining or improving these benefits for the poorest groups, which, in both locations, are of most interest to poorer people.

6.1 Groups impacted

The situation appraisal identified both areas and poor people, which were then targeted, initially as groups, and then as individuals for participating in research. To some extent this process was self-selecting as better off communities and individuals were typically less interested in involvement in fish production considered to be a low status activity. In India scheduled caste and tribal people predominated and in Sri Lanka low caste groups showed most interest and success. The number of individuals directly affected In India was limited but because the knowledge gained has been retained within an active NGO it is expected that this will have a strong multiplication affect and, in future, impact on watershed development throughout India. In Sri Lanka, involvement with a large range of institutions and actors planning future development is expected to have a major affect on how inland fisheries initiatives are implemented. The project has clearly made an important contribution to watershed development in general.

6.2 Uptake by research and development partners

The nature of collaboration, uptake, dissemination and impact are given in Tables 6.1-6.4.

Table 6.1 Collaboration

Institution/ address	Type	Key contact	Agreement	Functions
CARE International PO Box: 1024, No 134 Havelock Road. Colombo 5. Sri Lanka	NGO	Mr Steve Hollingworth Country Director Care@care.lanka.net	MoU	Village entry. In country financial, logistical and staff support. Output dissemination and follow-on research and programming collaboration
University of Peradeniya. Faculty of Agriculture Agribusiness Centre. Sri Lanka	Univ	Dr Sarath Kodithuwakku Executive Director Sarath@agecon.pdn.ac.lk	MoU	Logistical and data collection support. Hosted workshop.
British High Commission. 190 Galle Rd, Colombo 3 Sri Lanka	DFID	Mr Martin Dawson Second Secretary Colombo-bhc@dfid.gov.uk	Informal	Offer of in country funding. Output dissemination
Wayamba Development Authority. The Katcheri Kurunegala. Sri Lanka	Govt Dev	Mr Kanankage Aquaculture programme director	Informal	Provision of fingerlings and output dissemination
National Aquaculture Development Authority of Sri Lanka. 307 1/1 TB Jayah Mwt Colombo 15 Sri Lanka	Govt Dev	Mr AM Jayasekara Director Aqua1@eureka.lk	Informal	Workshop participation and dissemination pathway. Assistance procuring intervention materials.
Action Contre la Faim Batticaloa. Sri Lanka	NGO	Astrid Thierry Project Director	Informal	Output dissemination
Samuha, 268, 1st Main Defence Colony, HAL 2nd stage, Bangalore 560 038 India	NGO	Mr Pradeep - Secretary Ms Gita Srinivasan Programming Officer Samuha@samuha.org	MoU	Village entry. In country financial, logistical and staff support. Output Dissemination
CIFE Peninsular Aquaculture division. Hesseraghata lake Banglare. India	Govt Research	Mr Kumariah Chief Scientist	TOR	Participatory data collection. Technical advice.
Sewalanka Foundation No 128, Second floor, High level Rd, Nugegoda, Sri Lanka	NGO	Mr Steve Creech Aquaculture Expert oddfish@slt.lk	Informal	PRA collaboration Output Dissemination
International Water Management Institute	Interntional Research	Mr Ian Makin Research Leader	Informal	Output dissemination Post project staff placement

PO Box 2075 Sri Lanka		i.makin@cgiar.org		
IUCN 48 Vajira Road, Colombo 5, Sri Lanka	International Research/ conservation	Dr Nirmalie Pallewatta nirmalie@sltnet.lk Dr P Balakrishana pbala@sltnet.lk	Informal	Output dissemination
GTZ fisheries and community development resource management project, 249 Matara Rd, Tangalle, Sri Lanka	NGO	Berthold Schirm Team leader fcdrmp@mega.lk	Informal	Output dissemination
Deakin University Australia	Research	Prof Sena De Silva ACIAR fisheries project principle Investigator	Informal	Workshop collaboration & output dissemination
Department of Zoology, University of Kelaniya, Kelaniya 11600, Sri Lanka	Research	Prof. Upali Amerasinghe ACIAR fisheries project principle Investigator	Informal	Workshop collaboration & output dissemination
Asian Development Bank, Sri Lanka Resident Mission, 49/14-15 Galle Rd, Colombo 3	Donor	Mr Sanath Ranawa	Informal	Output dissemination – project design and policy
Dhan Foundation 18 Pillaiyar Koil, S.S Colony, Madurai, Tamilnadu, India	NGO	Mr MP Vasimalai Executive Director	MoU	Output dissemination and follow-on research collaboration

[1]One of the main purposes of this program is to improve the ability of those directly affected by the current ethnic conflict to deal with its consequences. This is also in accordance with DFIDs in-country development focus

Table 6. 2 Uptake pathways

Level	Institutions	Form of interaction
Primary	• Sri Lanka: Agribusiness Centre, Peradeniya University • Sri Lanka:CARE International NGO • India:Samuha NGO • India:Dhan Foundation, NGO	• Joint situation appraisal • Use of situation analysis working papers for formulation of grant applications. • In Sri Lanka: Viable outputs will be incorporated into a 6yr EU funded rainfed areas Integrated development programme commencing next year[1] • Capacity building *vis* training of staff in action research techniques. • In Sri Lanka: Outputs will be used to inform CARE international social mobilisation role in $30,000,000 ADB funded national inland fisheries 10 year development project commencing 2003 • In Sri Lanka: Based on research policy recommendations, ADB and GoSL will convene a regulatory NGO consortium to ensure equitable distribution of benefits associated with forthcoming national development programme. • In India: Findings of research will be adapted to requirements of partner NGO active in watershed development and tank rehabilitation, after a further period of research
Secondary	• Sri Lanka: National Aquaculture Development Authority of Sri Lanka • Sri Lanka: Wayamba Development Authority. The Katcheri Kurunegala. Sri Lanka • Sri Lanka: Sewalanka NGO • Sri Lanka: Action contre la Faim • Sri Lanka: Dept Zoology, Kelaniya University & Deakin University Australia • India: Samuha NGO	• Use of information from situation appraisal for improved farmer-orientated research, education and extension advice International workshop on aquaculture in community managed waterbodies to be co-hosted with Kelaniya University and Deakin University, Nov 2003
Tertiary	• Marginal farmers, low caste, women and disenfranchises youth groups, internally displaced persons	• Research partners, recipients of advice

Table 6.3 Dissemination strategy

Target group	Number	Messages	Means of dissemination	Type of uptake	Evidence of uptake
Consumers of cultured fish				Increased availability of low cost fish	Follow up workshops
Fisheries organisations	3 (pilot phase)	Enhancement or sustainable management of tank fisheries	• Partner organisations • Follow up workshops • Dissemination of outputs to national and provincial institutions.	Income generation and protein intake enhanced. Livelihoods diversified –reducing unsustainable exploitation of other natural resources	Participatory monitoring and evaluation including follow up workshops
Provincial and district administrative agencies	Agencies around 14 cascade systems	Co-ordination of indigenous institutions to improve integrated water management at the watershed level		Awareness raising and improvement of institutional capacity in target communities	
Food fish farmers	30	Low input sustainable aquaculture options		Positive impacts on ground water recharge, Income generation and quality food consumption	
Other users of the water resource		Equitable benefit sharing to enhance co-operation and reduce social conflicts.		Improved maintenance of water storage devices Social cohesion	

Table 6.4 Impact analysis

Impact expected	How created (Role of the project)	How impact measured
• **Indirect** • Improved relevance and quality of local research • Improved understanding of the current status of small-tank fisheries as an entry point for future projects. • Improved management, diversified and sustainable use of local resources • **Direct** • Basic food security of most marginal groups improved.	• Joint situation appraisal and collaborative implementation of farmer-managed trials. Assessment using farmer-derived indicators. • Facilitation of group-based learning and consensus building	• Change in policy and activities of research and development organisations • Follow up monitoring surveys and workshops in and around target villages

6.3 Follow-up action/research

A follow up project that will research improved strategies for seasonal water bodies has been approved to concept note stage and the development of a full proposal is currently underway. Our expected partners are active over a broad area of Southern India and work in Sri Lanka will focus on locations within the conflict zone. Preliminary field work and institutional analysis has already been carried out with prospective partners at both sites to scope the proposed collaborative work. In both cases the proposed research will be nested within development programming of local partners and geared towards producing outputs of with direct development impact but also contribute to the production of broader more generic guidelines.

7. Communication materials

7.1 Peer –reviewed

Little, D.C. 2000. **Fish in irrigation Systems.** Aquaculture News, 26:11-12.

Little, D.C and G.S Haylor 1999 Integrating water and waste management to support sustainable inland aquaculture, **WAS 1999. Sydney.**

Murray, F.J., S. Koddithuwakku and D.C.Little. 2001. **Fisheries marketing systems in Sri Lanka and their relevance to local reservoir fishery development**. P.287-308. In De Silva, S.S. Reservoir and Culture -based fisheries: biology and management. Proceedings of an International Workshop, Bangkok, Thailand 15-18 Feb 2000. ACIAR Proceedings No. 98. 384pp. Canberra.

Little, D.C., F.J. Murray and S.S. Kodithuwakku. 2001. **Understanding Demand - How the poor benefit from Tilapia production in the Northwest Dry Zone of Sri Lanka** E-conference proceedings: Aquatic Resources Management for Sustainable Livelihoods of Poor People (DFID/ICLARM).

Murray, F., D.C.Little, G. Haylor, M. Felsing, J. Gowing and S.S. Koodithuwakku. 2002. **A framework for research into the potential for integration of fish production in irrigation systems.** p.29-40. In Rural Aquaculture. CABI Publishing, Wallingford.

7.2 Internal Reports/Working papers.

SL1.1 The Lowland Dry Zone of Sri Lanka; Site for Study of Aquaculture Development in The Humid Tropics and Methodology for Participatory Situation Appraisal. 2000
SL1.2 Inland Fisheries Resources and The Current Status of Aquaculture in Sri Lanka and North West Province. 2000
SL1.3 The Nature of Small-Scale Farmer Managed Water Resources in North West Province, Sri Lanka and Their Potential for Aquaculture. 2000
SL1.4 Fisheries Marketing Systems and Consumer Preferences in Regional and Sub-Regional Markets of Sri-Lanka. 2000
SL1.5 Socio Cultural Analysis and On-farm Resources of Villages in North West Province in Relation to Small-Scale Aquaculture Potential (Draft).
SL1.6 Potential for aquaculture within farmer-managed irrigation systems – lesson learnt in Northwest Sri Lanka, 2002
I.1 Raichur District: Site for a Study of Aquaculture Development in the Semi Arid Tropics
I.2Methods for Participatory Information Gathering and Analysis
I.3Socio-economic Analysis of Villages in Relation to Aquaculture Potential in Raichur District, Karnataka, India
I.4Investigation of Gender Issues in Relation to Aquaculture Potential in Raichur District, Karnataka, India

I.5On-farm Resources for Small-scale Farmer-managed Aquaculture in Raichur District, Karnataka, India
I.6Inland Fisheries Resources and the Current Status of Aquaculture in Raichur District and Karnataka State, India
I.7An Investigation of Aquaculture Potential in Small-scale Farmer-managed Irrigation Systems of Raichur District, Karnataka, India
I.8Indigenous Freshwater Fish Resources of Karnataka State and their Potential for Aquaculture
I.9Institutional Linkages of Relevance to Small-scale Aquaculture Development in Karnataka State, India
I.10Fisheries Marketing, Demand and Credit in Raichur District, Karnataka, India

Aquaculture in small-scale farmer managed irrigation systems. Project R7064 Inception Report

Proceedings of FiRST stakeholder workshop. Hotel Topaz Kandy 1999
Proceedings of a Stakeholder workshop to identify opportuntities for integration of aquaculture within irrigation systems. Coimbatore, Tamil Nadu Nov 1998.

Towards improved management of living aquatic resources in watersheds of the Dry Zone, Sri Lanka (Draft)

Understanding the Role of Customary Water Rights in Sustainable Management of Small-scale Community Managed Fisheries in the Dry Zone, Sri Lanka. (Draft)

A Rapid Survey and Computer Mapping Technique for Estimating Seasonal Water Storage Profiles in Small Community Tanks of North West Province Sri Lanka (Draft)

Potential for poverty focussed integration of aquaculture into small-scale irrigation systems of the conflict affected areas of the Dry Zone of Sri Lanka: Batticaloa, Jaffna and the Wanni 1999-2001

Nutrient Dynamics of Seasonal Tanks in the Dry Zone of Sri Lanka in relation to their hydrological regimes, B.V.P.L. Jayakody ,Francis Murray, Dave Little[2,]M.I.M. Mowjood

Smith, J.K. 2000. Conceptualising conflict in natural resource development projects. University of Reading, MSc Dissertation.56 pp.

Yanes-Roca, C. 2001. Assessing productivity of free breeding fish species in farmer-managed tanks in Northwest Sri Lanka.University of Stirling, MSc Dissertation, 79pp.

Newton, R. 2000. Small-scale farmer-managed aquaculture trials in Raichur District, Karnataka State. India. Principles of backyard aquaculture., University of Stirling, BSc Project, 46pp.

An approach to valuing ponds within farming systems for aquaculture C.Brugere and D.C. Little 37pp.

Murray, F. 1999. Small-scale Farmer Managed Aquaculture Trials in Raichur District, Karnataka State India. Back to office report. September 1999 25pp.

Murray, F. 2000. Small-scale Farmer Managed Aquaculture Trials in Raichur District, Karnataka State India. Back to office report. July 2000 25pp.
Murray, F. 2000. Small-scale Farmer Managed Aquaculture Trials in Raichur District, Karnataka State India. Back to office report. October 2000 33pp.

Murray, F. 2000. Small-scale Farmer Managed Aquaculture Trials in Raichur District, Karnataka State India. Back to office report. December 2000 13 pp.

Murray, F. 2001. Small-scale Farmer Managed Aquaculture Trials in Raichur District, Karnataka State India. Back to office report. March 2001 41pp.

Patil, A.K. Third Phase Open well Trials.2002 4pp.

7.3. Extension and policy materials

Basics for aquaculture – helping farmers to develop their irrigation systems for fish production David Little and Malene Felsing. Guidelines for developing baskets of choices for farmer-managed research in Karnataka produced for Samuha.

Potential for aquaculture within farmer-managed irrigation systems – lessons learnt in Northwest Sri Lanka; Francis J. Murray and David C. Little.report of summary findings produced for CARE International

7.4 Workshop and conference presentations

Integrating water and waste management to support sustainable inland aquaculture David C. Little [1,2] and Graham S. Haylor . Invited paper at the World Aquaculture Symposium, Sydney 1999.

Managing Aquatic Resources to Benefit the Poor Where Water is Limiting - Lessons from India and Sri Lanka. Francis J. Murray and D.C.Little. Paper presented at World Aquaculture Conference, Beijing April 2002

Identified Opportunities for Inland Aquaculture Development in Dry Zone, Northwest Sri Lanka; David C. Little, Lindsay J. Pollock and Francis J. Murray Paper presented at World Aquaculture Conference, Beijing April 2002.

Farmer-managed irrigation systems and Aquaculture. Presentation to DFID, FGRP-3 and ARP Workshop on 'Practical Strategies For Poverty Targeted Research', David C. Little and Francis Murray. Hanoi 7-11th November 2000.

Why watersheds? Presentation to CARE international Dry-Zone Staff, Hotel Renuka, Kurunegala, Presented by Francis Murray 27-28 July 2000

7. Project logframe

NARRATIVE SUMMARY (NS)	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Goal			
Sustainable yields from small scale semi-intensive and extensive aquaculture systems increased through improved management.	By 2005, in target regions of four core/niche countries where demand exists: - No. of small scale fish farmers increased by 20%. - Real value of benefits from small scale fish production incr. against 1995 baseline by 20%. - Yield/hectare in one targeted extensive system increased by 100%. - Yield of fish from one irrigation system where demand exists increased by 50%. - Fish production from multiple-use ponds on small scale mixed farms in one targeted semi-arid area increased by 20%	- Reports of target institutions. - National production statistics. - Evaluation of aquaculture programme. - Research programme reports. - Monitoring against baseline data.	- Climatic condit. remain favourable. - Enabling environment (policies, institutions, markets, incentives) for the widespread adoption of new technologies and strategies exists.
Purpose			
1 Social and bioeconomic constraints to introduction of aquaculture into farmer-managed irrigation systems identified and effective approaches to aquaculture developed and promoted.	By 1998 , key locations/constraints identified re: productive resources and social factors; criteria defined for aquaculture in mixed farm/multi-use systems. By 1999, development strategies identified and promoted in selective locations/production systems.	Reports, peer review publications, extension materials and guide books, workshop proceedings, use in target locations/communities	- Target institutions support strategic planning initiative
Outputs			
1. The potential of aquaculture in small-scale farmer-managed water resources assessed. 2. Identification and testing of research methods/tools.	1.1 By 1998, comprehensive peer-reviewed farmer-managed water resource assessment produced for Asia. 1.2 By 1999, reviews of current knowledge completed and peer reviewed and disseminated to	Peer review publication. Edited workshop output. Research action plan	Planned research to alleviate constraints conducted and strategies effective. Funds forth coming

3. Approaches to key engineering and management options investigated and promoted.	all identified stakeholders. 2.1 By 1999, 80% of stakeholders agree researchable constraints and disseminated to all identified stakeholders. 2.2 By 1999, a well attended regional dissemination workshop conducted 3.1 By 1999, preliminary research in case study sites leads to production of farmer-centred research agenda in conjunction with National Government organisations /NGO's and farmers 3.2 By 2000, sustained improvement of resource use through integration with fish production being researched with farmers and support agencies.	Extension outputs Project Memorandum for phase II farmer-centred research Farmer-response Research reports	
Activities	**Inputs**		
1.1 Conduct an in-depth study and categorisation of farmer managed engineered water resources in Asia focusing on countries and regions facing critical water stress. 1.2 Information collection. A broad sweep documenting aquaculture activities in small-scale water resources by region, type, species, socio-economic group of operators, sources of funding, nature and level of support, production, markets, etc. This would be from secondary sources, key informants and survey co-ordinated by the IOA/CLUWRR. 1.3 Produce a review and other promotional outputs.	Staff 1997/98 1998/99 1999/00 UK staff 9705 21445 15031 Travel and Subsistence 7590 15735 7635 Overheads 2149 3248 2370 Capital Equipment 6463 Misc. 8250 8570 3910 TOTALS 34157 49530 28946 £112633	Quarterly, annual and final progress reports plus final report. Quarterly financial statements of expenditure	- visas, access and co-operation forthcoming from authorities , target institutions and end user groups. - social, economic and natural environment is conducive to the development of sustainable integrated aquaculture strategies.

2.1Characterise with farmers and NARS of the researchable social, technical and economic issues relating to development of fish production in farmer-managed water resources from case study areas in Southern India and Sri Lanka. 2.2 Develop in conjunction with farmers and NARS a farmer ranked research agenda for the development of fish production in these systems. 2.3 Hold regional workshop on use of small-scale farmer-managed water resources for production of fish and other aquatic products 2.4 Develop and test social and physical mapping techniques with different stakeholder groups and apply to watershed development in Sri Lanka 2.5 Develop and test group adaptive learning approaches to improved management of seasonal water bodies in Sri Lanka 2.6 Action research techniques introduced to poor groups for household managed aquaculture systems and monitoring systems for partner NGO in India 3.1 Investigate options for enhanced natural fish production,			

cultured fish, non-fish aquatic production 3.2 Define/compare draw down/water use of the land and water based production systems 3..3 Investigate health and welfare implications 3.4 Develop an index of water resource development potential 3.5 Produce guidelines, information and other dissemination/promotion materials			

8. Notes