'Aquaculture in small-scale farmer-managed irrigation systems'

Project 7064 Inception Report
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Acronyms

ARP	Aquaculture Research Programme
ARS	Agricultural Research Scientists
ARTI	Agricultural Research and Training Institute
CD	Check Dam
CIFA	Central Institute for Freshwater Aquaculture
DFID	Department for International Development
DoF	Department of Fisheries
DS	Divisional Secretariat
FFDA	Fish Farmers Development Agencies
FIT	Farm Irrigation Tank
FO	Farmers' Organisation
FP	Farm Pond
GDP	Gross Domestic Product
GN	Grama Niladhari (administrative division, Sri Lanka)
GoSL	Government of Sri Lanka
GTZ	German Technical Co-operation
IADP	International Agricultural Development Programme
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
OBC	Other Backward Castes. Deprived castes not belonging to SCs or STs in receipt of special benefits.
OFC	Other Field Crops
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
SIDA	Swedish International Development Agency
SLCDF	Sri Lanka Canada Development Fund
SP	Surface Pond
SSI	Semi-Structured Interview
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

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Executive summary

1. This report presents an outline of activities to date in the project 'Aquaculture in small-scale farmer-managed irrigation systems' (DFID project R7064). The project focuses on the arid and semi-arid tropics, which as home to a large proportion of the world's poor face a future of scarcity of food and insufficient water for consumption and irrigation of crops. Both India and Sri Lanka have been predicted to face a fresh-water crisis in the near future (Nigam *et al.*, 1998), 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 (Redding, 1990). The majority of surface water bodies in India and Sri Lanka are used primarily for irrigation. Although large-scale irrigation systems cover more surface area and supply a greater area of farmland, most farmers are dependent on small-scale systems for their daily livelihood (Wolf, 1986). The project aims to investigate options for producing fish in such small water bodies in Sri Lanka and northern Karnataka State, India.

2. The Indian government currently spends some US$300 million on a variety of watershed development programmes in semi-arid areas (Barr, 1998). In Karnataka, as in the rest of India, watershed management is a relatively new activity, involving the construction of large numbers of small community or farmer-managed water bodies for rainfall harvesting, groundwater recharge and the prevention of soil erosion. These water bodies have become the focus of the research in Karnataka. In Sri Lanka, as in many parts of India, watershed management mainly exists in the form of the ancient community managed cascade tank systems. These tanks form the basis of the Sri Lankan research.

3. Potential local research partners were identified in the two areas, and situation appraisals, were carried out in 1998 (and are still ongoing in Sri Lanka). Findings from the Karnataka analysis and preliminary findings from Sri Lanka are presented in terms of the Sustainable Livelihoods framework. The analyses reveal a need for options appropriate to resource-poor farmers with seasonal waterbodies, as the current extension advice in the two countries focus on high-input strategies in perennial waterbodies. In the areas where watersheds are being developed in Karnataka poor farmers eat fish, and are interested in growing them in seasonal and perennial water bodies associated with watershed development, but currently have no knowledge of how to do so. In Sri Lanka cheap inland fish from capture fisheries in perennial reservoirs is a staple component of the diet of the rural poor. However, this fishery based on the exotic *Oreochromis mossambicus* is reaching it's maximum sustainable yield. Shallow seasonal tanks have extremely high natural productivity, and may represent unexploited potential for an enhanced capture fishery. In general, many farmers interested in participation are constrained by a lack aquaculture experience, highly limited seed availability, extremely high predation pressure, erratic water availability and an almost complete absence of extension capacity.

4. Stakeholder workshops were held in India and Sri Lanka, where representatives from aquaculture research and extension institutions, government offices and NGOs participated in identification of key research issues. Farmers' priorities were elicited from the situation analyses and a farmer workshop in Karnataka. A farmer-prioritised research agenda was formulated for Karnataka, and farmer participants identified. In Sri Lanka a situation analysis is still on going. Researchable issues relevant to poor people are being refined in the context of developing farmer-managed water bodies that tend to be community-based and located within complex watersheds. A preliminary research agenda is presented.

5. In Karnataka the main objective of the current trials is to identify aquaculture options, which are available and attractive to marginal farmers. The project aims to devise and test *livelihood strategies* which include aquaculture (based on a mixture of local traditional knowledge and contemporary scientific knowledge) against *livelihood outcomes* using

farmer and scientist derived indicator categories like more income, increased well-being, reduced vulnerability, improved food security and more sustainable use of the NR base. By using a participatory approach the project aims to test livelihood strategies which are appropriate for poor people. In the trials, the approaches and strategies used by the farmers are being monitored, as are the indicators by which farmers measure their success.

6. A baseline survey of participating farm families and community groups has now been completed in Karnataka, and fish seed have been stocked in four types of water bodies common to watershed development areas. A trial monitoring framework has been started, and a post-trial farmer workshop is planned when the trials are completed.

7. An Activity to Output table for the 'Aquaculture in small-scale farmer-managed irrigation systems' project is presented below.

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

Activity	***Progress to date***
1.1 Conduct an in-depth study of one location in Karnataka and one location in Sri Lanka selected to represent water scarce areas farmed by poor people.	Outputs: Situation analysis Karnataka completed. 10 Working Papers. produced: 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 7. An Investigation of Aquaculture Potential in Small-scale Farmer-managed Irrigation Systems of Raichur District, Karnataka, India 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 Sri Lanka Working papers. Project Summary Report 1. Puttalam and Kurunegala Districts; Site for study of aquaculture development in the lowland dry-zone of Sri Lanka and methodology for participatory information and analysis. 2. Inland fisheries resources and the current status of aquaculture in Sri Lanka, Puttalam and Kurunegala districts. 3. Fisheries marketing systems and consumer preferences in Puttalam and Kurunegala Districts of Sri Lanka. 4. The nature of small-scale farmer managed water resources in Sri Lanka, Puttalam and Kurunegala Districts. 5. An investigation of on-farm resources with relevance to aquaculture in farmer managed irrigation systems of Puttalam and Kurunegala Districts. 6. Socio-economic analysis of villages within cascading tank systems of Puttalam and Kurunegala districts. On-going situation analysis investigating seasonal livelihood patterns in villages of selected cascade systems within Puttalam and Kurunegala Districts of Sri Lanka is being carried out April to November 1999.

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

Activity	*Progress to date*
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 Nov 1998 and Kandy, Sri Lanka 26-27 Nov 1998.Key researchable constraints identified with farmers from Koppal and Raichur districts (India) and Puttalam and Kurunegala 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 Oct 1999.** Outputs: Proceedings of stakeholder workshops in 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	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 Oct 1999 a situation analysis. Outputs: Proceedings of stakeholder workshops in India and Sri Lanka and findings from situation analyses.
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 Nov 1998 and Kandy, Sri Lanka 26-27 Nov 1998: stakeholder analysis completed and major constraints to aquaculture identified. Workshop proceedings expected completed in Jul 1999. Farmer Workshop in Koppal, Karnataka, 20-21 April 1999: Farmers' research priorities identified. Workshop proceedings in Appendix 6. Sri Lanka: Activity to be included as part of a farmer workshop Oct 1999. Outputs: **Stakeholder workshop - Coimbatore Nov 98.** **1.** Position papers. (based on secondary data sets): • The nature and distribution of major irrigation systems in Tamil Nadu and their potential for aquaculture. • The nature and distribution of small-scale farmer managed irrigation systems in Karnataka and their potential for aquaculture. • Participatory technology development: perspectives from an NGO • The present status of aquaculture in Peninsular India 2. Notes on stakeholder analysis sessions 3. Notes on research agenda formulation with NARS. **Stakeholder workshop - Kandy Nov 98.** 1. Position papers. (based on secondary data sets): • The nature and distribution of major irrigation systems in Sri Lanka and their potential for aquaculture. • The nature and distribution of small-scale farmer managed irrigation systems in Sri Lanka and their potential for aquaculture. • The present status of inland fisheries in Sri Lanka • Socio-economic and gender issues in Sri Lanka and their relevance to aquaculture development. • Production of aquatic organisms in large and small scale irrigation systems. 3. Notes on stakeholder analysis sessions 4. Notes on research agenda formulation with NARS.

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

Activity	*Progress to date*
3.1 Investigate options for enhanced natural fish production, cultured fish, non-fish aquatic production	Preliminary trials initiated May 1999 with 33 farmer individuals / groups associated with Samuha watershed development projects in four different types of water body, Baseline information collection for participating farmers completed July 1999. Participatory trial monitoring forms and database developed in collaboration with Samuha in May 1999, monitoring of trials commenced after stocking of water bodies during July 1999. Outputs: Initial report of field trials (Nov 1999) Sri Lanka: Farmer trials to be initiated by Nov 1999 after formulation of farmer derived research agenda in Oct 1999.
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 by Cecile Brugere (IoA) March 1999. Post-trial Farmer Workshop in Dec 1999 will incorporate a thorough analysis of benefits and drawbacks of water-based compared to land-based production systems. Outputs: Working paper: 'An economic approach to the integration of aquaculture within small-scale irrigation systems'. Workshop report: Karnataka field trials
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 by Graham Taylor (IoA) Feb-March 1999. The potential of aquaculture in poverty alleviation investigated as a joint activity between the large scale and the small-scale projects by Mike Bruce & Lindsay Pollock (IoA) March 1999. Outputs (Working papers): - 'Sustainable Aquaculture for Developing Countries'. - 'A risk assessment of agrochemicals in integrated irrigation/ aquaculture systems in Northwest Province, Sri Lanka'.
3.4 Develop an index of water resource development potential.	India: Index of water resource development potential completed March 1999 (using information from situation analysis). Index presented to and modified with farmers and Samuha field staff April-May 1999. Index left as a working document, to be expanded as research yields new findings. Sri Lanka: Index based on farmer indicators and field measurements during situation analysis (inc. frequencies of spill and seasonality, ratios of catchment, command and water spread, farmer water usage ranking). To be developed further during current phase of situation analysis. Outputs: Occasional Paper: 'Waterbody specific aquaculture guidelines for Karnataka, Appendix 12'.
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 continues. Outputs: Video on options for and constraints to aquaculture development in small-scale farmer-managed irrigation systems recorded in field in Karnataka and Tamil Nadu April – May 1999, expected edited output Aug 1999.

1 Introduction

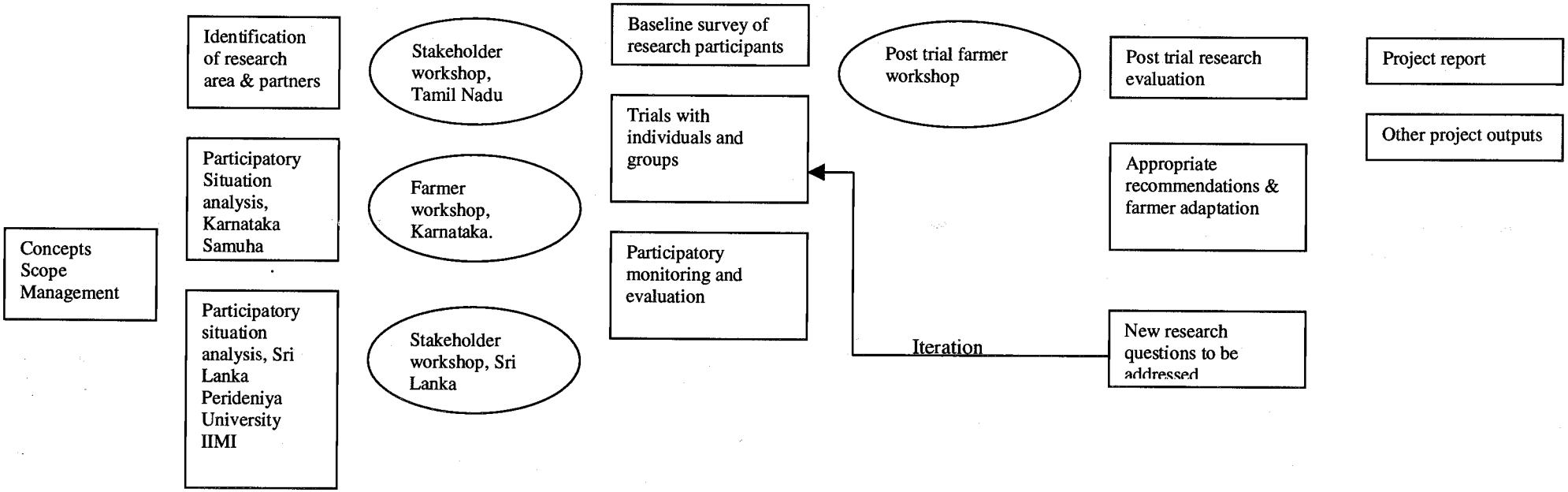
Aims of report

This report provides a description of the 'Aquaculture in Small-Scale Farmer-Managed Irrigation Systems' project. Specific components of the report include the following:

- A statement of progress against the logical framework.
- Justification for selection of targeted research areas.
- Evidence of willingness amongst local institutions to collaborate.
- Evidence of participation of local institutes and farmers in the formulation of a research agenda.
- Research activities and outputs to date.
- Plan for future research activities.

1.1 Project approach

The different stages of the project are shown in Figure 1. Activities at each stage are outlined in subsequent sections.



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:** Production of project outputs

Figure 1: Project stages.

2 Stage 1

2.1 Scope of project

Research focus

The arid and semi-arid tropics are areas in urgent need of development. As 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. The single most populous country within the arid and semi-arid tropics is India. India is one of the poorest countries of the world, and with an estimated 300 million of the total 950 million population living in absolute poverty (DFID, 1998). It has been predicted that India and Sri Lanka will face a fresh-water crisis in the near future (Nigam *et al.*, 1998), 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 (Redding, 1990).

The majority of surface water bodies in India and Sri Lanka are used primarily for irrigation. Although large-scale irrigation systems cover more surface area and supply a greater area of farmland, most farmers are dependent on small-scale systems for their daily livelihood (Wolf, 1986). Irrigation systems often have 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 small-scale irrigation (Harrison, 1996; Pretto, 1996). The focus of improved rainfed water management, both in South Asia and elsewhere in the arid and semi-arid tropics, is increasingly at the catchment level. The Indian government currently spends some US$300 million on a variety of watershed development programmes in semi-arid areas (Barr, 1998), and watershed development is a huge development initiative in Sub-Saharan Africa and other semi-arid areas of the world. In the south-western Indian State of Karnataka, as in the rest of India, sponsorship by Government and non-Government agencies has stimulated a new approach to watershed management. This involves the construction of large numbers of small community or farmer-managed water bodies for rainfall harvesting, groundwater recharge and the prevention of soil erosion. In Sri Lanka, as in many parts of India, watershed management mainly exists in the form of the ancient community managed cascade tank systems. Large-scale rehabilitation of tank systems has take place over recent decades in both countries.

Despite this potential, attempts to integrate fish production into these water bodies have been rare and based on conventional commercial semi-intensive pond aquaculture. Whilst the resource-rich have been able to adopt such an approach, it has proved inappropriate for poorer marginalised people. By investigating aquaculture options for both traditional and modern watershed development structures, the research results are likely to have broad applicability.

Two closely related DFID projects are looking at aquaculture in irrigation systems. The DFID ARP[1] project 'Small-scale farmer-managed aquaculture in engineered water systems' (project R7064) aims to identify social and bio-economic constraints to the introduction of aquaculture into farmer-managed irrigation systems and to develop and promote effective approaches to aquaculture. Intended beneficiaries include the rural poor, which in India belong to the Scheduled Castes (SCs)[2] and Scheduled Tribes (STs)[3]. Target groups in Sri Lanka include low caste, landless, youth and women's groups. A closely linked DFID Engineering Programme KAR[4] project is investigating the potential for integrating aquaculture into formally managed irrigation systems of semi-arid areas.

[1] ARP: Aquaculture Research Programme
[2] SCs: lower castes identified by the Indian government as a means of classifying castes for the allocation of benefits.
[3] 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.
[4] Knowledge And Research

Consistent with DFID guidelines, the project follows a participatory approach. A brief outline of the approaches used in the project is given in Appendix 1.

2.2 Preparatory work

A literature review of aquaculture and farmer-managed irrigation was carried at the project proposal stage. This revealed the need for integrated approaches to water management, a current under-utilisation of water used for irrigation purposes, and the magnitude of resource-poor farmers depending on such water bodies. Likely collaborators and target institutions were identified including the DFID KAWAD project, ICAR[5] Fisheries Institutes, KVKs[6], Panchayats[7], FFDAs[8], and NGOs such as Prarambha, Samuha, and ActionAid. In Sri Lanka the Agribusiness department of Peradeniya University was identified as the principal collaborator for the first phase of the project.

3 Stage 2

3.1 Selection of research area and partners

The geographical focus of the project is the regions of the semi-arid tropics where fish is of major dietary importance and an integrated approach to water management by farmers most needed. The water scarce regions of Karnataka, southern India, and dry zone of Sri Lanka were chosen as appropriate project focus areas. By investigating aquaculture options in both traditional and modern watershed development structures the research results are likely to have broad applicability. Furthermore the linked engineering project on aquaculture in large-scale irrigation systems also focuses on irrigation systems in southern India (the Bhavani System in Tamil Nadu) and Sri Lanka (Mahaweli H system). This provides excellent opportunities for linking the two projects to produce comprehensive guidelines, targeted at engineers, extension workers and policy makers, for integrating the production of fish and other aquatic animals into irrigation systems.

An inaugural project visit was made in February 1998 by Graham Haylor and Dave Little to Karnataka and Sri Lanka to establish links and plan activities with key collaborators. In Karnataka contact was made with the Peninsular Aquaculture Division (PAD) of the Central Institute for Freshwater Aquaculture (CIFA) and representatives from Samuha, an NGO active in watershed development. A visit was made to the northern drought-prone districts of Koppal and Raichur where Samuha carry out the majority of their watershed development. After it had been established that this area was fairly representative of other watershed development areas of India (dryland areas with poor infrastructure and a high concentration of STs and SCs) collaboration between the Institute of Aquaculture (IoA) and Samuha on a participatory situation analysis for aquaculture was established. For further information on Samuha, see Working Paper 9, 1998. In Sri Lanka a Memorandum of Understanding was established with the Agribusiness Department of Peradeniya University to collaborate in a participatory situation analysis and provision of logistical support. Contact was also established with the International Irrigation Management Institute (IIMI). Whereas in India the collaboration with Samuha determined the exact location of the research, in Sri Lanka a more in-depth situation analysis was needed to target area to focus research activities (see section 3.4).

3.2 Sustainable Livelihoods framework

An appreciation of the importance of participation in development, along with increased understanding of the role of the environment and an emphasis on sustainability, has led to the formulation of a Sustainable Livelihoods framework. A recent change in policy concerning

[5] ICAR: Indian Council of Agricultural Research
[6] Krishi Vigyan Kendra (Farm Science Centres), run by ICAR these centres carry out agricultural extension activities, including some aquaculture.
[7] Panchayat: local governing body
[8] FFDA: Fish Farmers Development Agencies under the DoF

development assistance from the UK was signalled with the publication of a White Paper[9] that commit the Department for International Development (DFID) to promoting "Sustainable Livelihoods" while both protecting and improving the management of the natural and physical environment. These objectives are expected to contribute to an overall goal of poverty eradication (Carney, 1998). Livelihoods comprise capabilities, assets (material and social) and activities required for a means of living. They are sustainable when they can withstand stresses and shocks and maintain or enhance capabilities and assets, both now and in the future, whilst not undermining the natural resource base.

A conceptual framework for sustainable livelihoods has been developed by the Institute for Development Studies (Scoones, 1998). Livelihoods are described as built upon *Natural, Social, Human, Physical* and *Financial* capital assets vulnerable to trends, shocks and local cultural practices. Livelihoods are defined by *transforming structures* (e.g. institutions, government) and *processes* (e.g. laws/incentives) which determine who gains access to which type of asset, its effective value and thus which strategies and activities are attractive to whom. Management of living aquatic resources, that includes aquaculture, is a livelihood option that may contribute to the robustness of, and increase the opportunities available to, people by building up their *asset* base.

The sustainable livelihood framework is shown in Figure 2.

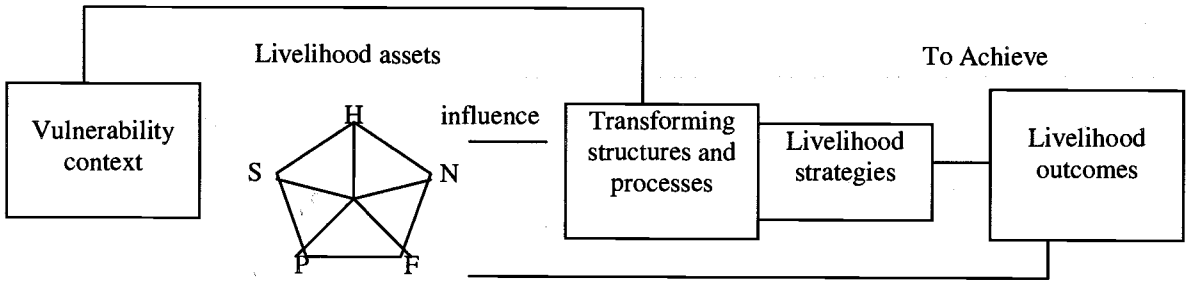


Figure 2: Sustainable livelihoods framework. Key: H = Human Capital, N = Natural Capital, F = Financial Capital, S = Social Capital, P = Physical Capital. Adapted from Carney (1998).

3.3 Participatory situation analysis Karnataka

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 two Districts 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 farm families, 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. A full description of the research is contained in Working Papers.

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.

Below the findings from the situation analysis are briefly outlined within the context of sustainable livelihoods.

[9]Eliminating World Poverty; A Challenge for the 21st Century. White Paper on International Development Presented to Parliament by the Secretary of State for International Development by Command of Her Majesty November 1997.

Livelihood assets

Asset analysis can form a useful basis for identifying and prioritising development interventions that will improve livelihoods of poor people. It should allow researchers to assess if current assets are adequate to support aquaculture adoption, and what impact aquaculture might have on gains or losses of assets. The asset pentagon (see Figure 2) indicates the relative access to different capital assets. The centre of the pentagon, where the lines meet, represents zero access to assets, the outer perimeter maximum access. The overall shape of the pentagon may be established for generalised communities, social groups or individual households In research projects it is useful to ask how the outcomes of the research may change the shape of the asset pentagon. Below is a generalised description of the relative access to capital assets for marginal farmers belonging to SCs or STs in northern Karnataka, as established from the participatory situation analysis.

Human capital

The skills and knowledge base of poor communities in northern Karnataka varies a lot from village to village, between sub-groups within villages and even between members of households. The low status of women in India and the practice of dowry has led to a preference for, and favouritism of male children, with a consequent restricted access to education and information for women (Mosse, 1993). Literacy levels are very low, especially for women. In poor households, children constitute an important farm labour resource and many children are therefore not sent to school. Boys are always educated in preference to girls. Whether educated or not, farmers in the area are skilled at dryland agriculture, and are well aware of irrigation techniques suitable for drought-prone uplands. In areas where the NGO Samuha is working farmers have some knowledge of the principles of watershed management (farmers' groups, pers. com.).

Infant mortality is low (in a medium sized village of 200 households an average of 0-2 children die each year), but higher among girls than boys (village midwives, pers. com.). The nutrition and general health of boys is better than that of girls (local health clinic, pers. com.). Both men and women undertake fieldwork on their own holdings and, in poor households, also work as farm labourers for others. Women's total workload is appreciably higher than men's as they additionally perform all household and child-minding duties. Because women have the sole responsibility for looking after children their ability to take on off-farm work can be restricted if no other female members of the family can look after young children.

Knowledge about water management in the context of dry-land farming is highly developed, especially by men. The ability to combine their own knowledge with external information from Samuha suggested high potential for increasing this type of asset. Indigenous knowledge about aquaculture or fish production techniques (e.g. suitable species, feed, fertilisers, husbandry procedures) is very limited in the area. In villages near rivers or tanks stocked with fish some members of the community (fishermen and poachers) know about fish capture techniques, but in other areas fish are very rarely seen (here villagers stated that they had never eaten fish simply because it is not available). Prospects for aquaculture development in the region are limited by the low access of villagers to existing information on fish production techniques provided in different media (e.g. written word, TV) as well as the relative lack of information relevant to these farmers' specific circumstances.

Poverty and cultural norms make general human capital highly undeveloped in the target area. The currently low literacy rates and large differences within and between communities suggest the most marginal groups should be targeted and, given appropriate support, could gain assets of this type rapidly.

Natural capital

In the region there is little natural vegetation, poor soil quality, little and erratic rainfall, a topography prone to erosion, and high seasonal temperatures. Water rather than land

constrains agriculture. Water resources are scarce and farming activities limited to dryland agriculture (typically 0-4 ha per household) and small irrigated areas (typically 0-1 ha per household).

Commonly cultured crops include many that are potentially suitable for use as supplementary feed in aquaculture. All crop by-products are used for a multitude of purposes (human and livestock consumption, marketing, fire, house construction etc.). Livestock kept in the villages include cows, buffaloes, oxen, goats, sheep and chicken. Cows, buffaloes and goats provide milk, and goats, sheep and chicken are eaten. Oxen are used for draft work and organic fertiliser is obtained from cows, buffaloes, oxen and also to a minor extent goats. Furthermore all livestock provide a realisable financial asset for farm families in an emergency.

Men own all the land, livestock, and water resources. Local wealth rankings carried out as part of the situation analysis showed wealth to be directly related to land holdings (especially irrigated). Landless people constitute the poorest, most marginal part of society.

Increased availability of water could result in enhanced natural capital elsewhere in the farming system or, if aquaculture becomes competitive for seasonally scarce water, cause a deterioration.

Financial capital

Big differences were found between the villages surveyed in terms of availability and uptake of credit. In the better-off villages very few farmers borrowed money, whereas in the poorer villages the majority of villagers were in debt for certain parts of the year. Most farmers borrow money during June, July and August for seed and fertiliser, and repay their loans after the harvest in September-October. Greatest indebtedness thus occurs at a time when water bodies need to be stocked with fish seed and credit for aquaculture is most likely to be required.

Farmers borrow money from banks (12% p.a.), private village lenders (36% p.a.) or from savings and credit groups started by NGOs, e.g. Samuha (36% p.a.). Most money is spent on agriculture (seed, fertiliser, pesticides and farm labourers) but some households borrow money for food. All families interviewed managed to pay back these smaller loans within 2 to 6 months after taking them out. Bigger loans such as for houses, wells or pumps generally took longer to pay off. The total amount of money borrowed per year varies from Rs. 1,000-20,000 (~£17 - £333)[10]. Private moneylenders are mainly used for emergency credit and by illiterate farmers, who stated that they 'did not know how to' access banks. Very few farmers use banks for saving. Land, livestock and gold jewellery are kept as liquid assets and sold in times of hardship.

Given the restrictions in access to credit and the risky nature of a new activity such as aquaculture, strategies to lower the cost of entry and cover risk will be required.

Physical capital

Water storage: farmers have always generated physical capital in order to increase the production of their land. Indigenous structures potentially useful for aquaculture include large government-owned tanks, farmer managed open wells, and, as part of more recent watershed development initiatives, other farmer-managed water bodies. These are described in Table 1. Each water body has multiple functions, and the integration of aquaculture may conflict with existing water uses such as human and livestock drinking.

[10] These figures may not be accurate estimates as there was a general feeling amongst the researchers that farmers would exaggerate their poverty because they were hoping to obtain support from the research team.

Table 1: Small-scale farmer-managed water bodies in northern Karnataka. Of the water bodies listed, only open wells are traditional structures, whereas the rest are part of watershed development initiatives supported by external funding.

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
Farm irrigation tank	Farmer managed	Ground water (pumped)	Irrigation (livestock, domestic)	Owned by farmer, used by farmer
Open well	Mostly perennial	Ground water	Irrigation (livestock, domestic)	Owned by farmer, used by farmer

Source: situation analysis from Karnataka, March-May 1998.

Infrastructure: good access to villages often reflects their proximity to larger towns. Most villages are only accessible by dirt road, and are only infrequently serviced by public transport. Usually there are only one or two telephones in a village, a couple of radios and often no television. Electricity supply for SC and ST households are subsidised by the state government, so some villages have electricity but power cuts are commonplace. Markets are normally held in bigger towns nearby, where farmers can also buy newspapers, and access banks and government offices. Women are normally not allowed to leave the village without travelling in pairs or (preferably) accompanied by a male member of the family. Interestingly women of more marginal status, such as many tribals and the former Devadasis[11], enjoy more freedom than higher caste women. Many villages have village wells but sanitation / sewage facilities are rare.

Adoption of aquaculture may lead to improved physical assets that benefit other parts of livelihood development. Improved water availability could result in a range of positive livelihood outcomes

[11] Devadasis: temple 'dancing girls' traditionally donated by poor, low-caste families to the temple to act as temple prostitutes for male visitors to the temples.

Social capital

Table 2: List of groups in villages where the NGO Samuha operates. Akanksha and Kanakanala refer to Samuha projects.

Institution	Description
Women's self help groups	Responsible for tree nursery projects as well as acting as village savings groups. One or more groups per village. Group quality varies from village to village. Most have successfully increased the power of women in the villages by making them responsible for financial matters.
Woni gumpu (street group)	Each household in a street select a female representative and these together form the woni gumpu. The group operates as a credit and savings group, with each household donating a set amount of money every week. Group members can borrow money at 3% interest per month.
Grama Samuha (village organisation)	All woni gumpu members in a village.
Grama samiti (village committee)	Each woni gumpu elects one representative into the grama samiti. Each grama samiti represents one street or 5 to 15 households if the street has more than 15 households. The grama samiti makes decisions regarding funds (i.e. who can borrow how much).
Jana samuha (people's organisation)	All farms in the village are represented by one male each in the jana samuha.
Jana samiti (people's committee)	Each group of 5 to 15 farmers selects one representative in the jana samiti. The committee makes decisions regarding crops and farming.
Watershed Implementation Committee (WIC)	Elected members from the grama and jana samitis. Numbers from each vary from village to village, but generally the ratio is about 3:8 (grama:jana Samiti).
Community Economic Asset Committee (CEAC)	Two elected members from each of the grama and jana samitis. The CEAC is responsible for the collection of money from the villagers and using them for agricultural items.
Village health committee	Elected representatives from the grama and the jana samitis (normally in the ratio of 9:2 grama:jana samitis).
Village animators	Individuals selected by the Watershed Management Committee in Kanakanala villages. Duties include note-taking and reporting to Samuha on the meetings of the grama and jana samitis.
Team leader and team secretary	Samuha staff in charge of Samuha activities in Akanksha project villages.
Village volunteers	Similar function to village animators above, but for Akanksha villages.

Source: semi-structured interviews with Samuha staff.

A number of NGOs adopt an entering strategy of increasing social capital in villages, with additional support to development of other forms of natural, human and physical capital (through watershed development, nursery activities, sanitation programmes, etc.). The formal village structures established in all villages where the NGO Samuha operates are shown in Table 2. Through these groups villagers are responsible for planning their own development and managing their own funds.

Kinship relations are very important in villages, and family is important for emotional and financial support during times of crisis. Three to four generations commonly live under one roof, and marriages often provide a link between families with adjacent land holdings. In villages with several different castes, families of the same caste live on the same street creating greater cohesion within caste-groups than between them (Samuha staff, pers. com.). Links with the government varies between villages, often depending on the activities of local

government officials. In some villages families are well aware of government benefits that they are entitled to, whereas in others access to government is limited.
Community-based aquaculture development could either strengthen or weaken social cohesion, depending on approach and outcomes. Individually-owned enterprise could also have either negative or positive effects on social assets.

Vulnerability context

The sustainability of livelihood strategies is strongly affected by the wider environment in which people live, over which they often have little or no control. The vulnerability context seeks to sum up these outside influences on people's lives, and includes trends, shocks and seasonality.

Trends

There is evidence for a decline in natural capital (such as groundwater levels and wild fish stocks), which together with rapid population growth (2.9 % p.a. in Karnataka 1991 (Government of Karnataka, 1996)) makes communities and individual households likely to benefit less from chosen livelihood strategies. Although land is considered the most valuable asset, land accumulation rarely occurs, on the contrary land fragmentation continues to decrease land-holdings.

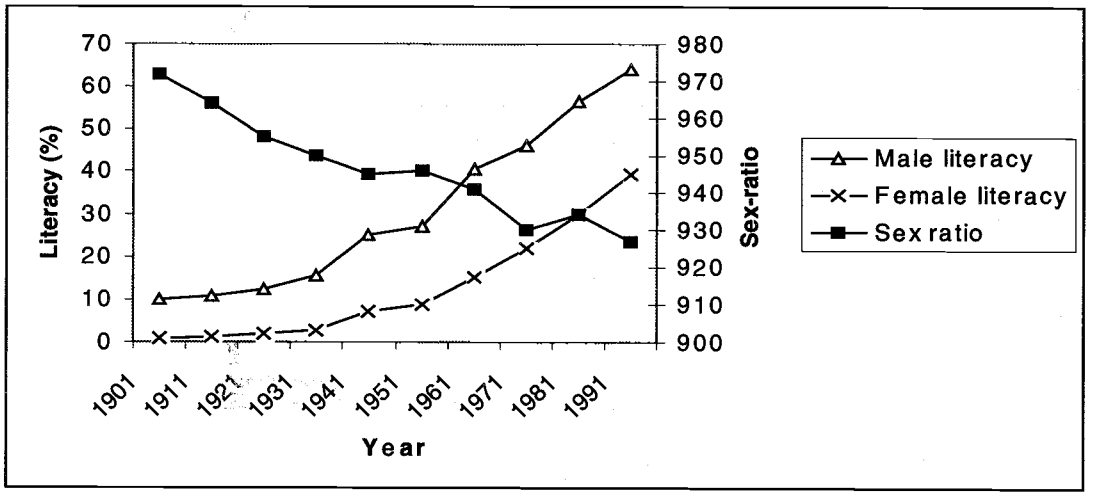


Figure 3: Male and female literacy levels and sex-ratio of India from 1901-1991. Source: Government of India (1991).

Educational levels have been steadily increasing in India over the last 70 years. As a result literacy levels are increasing for both men and women (see Figure 3). In the villages of the situation analysis most children had some years of schooling. The current sex-ratio of the villages investigated varied between 868 and 956 women per 1000 men. Dowry values are continually rising and have been predicted to continue to rise in the future (Jayalakshmi, 1994), a trend likely to increase already high vulnerability of women, and depress the falling sex-ratios even further (see Figure 3).

Shocks

Climate constitutes a major shock to livelihoods in the area, especially drought. Prolonged dry spells during the crop-growing period results in occasional crop failure, with ensuing human and livestock health consequences. Because poorer households commonly have members migrating to large-scale irrigation systems for work during the paddy harvest, changes in the agricultural systems of the irrigated belt of Raichur and Koppal districts could have profound importance in the northern dryland districts.

Diversification, through aquaculture, might reduce the risks associated with shocks to the terms of trade (input/output prices) that disproportionately affect the poor.

Seasonality

The dominant Southwest monsoon is active from June through to September (*kharif* growing season) and the less intensive Northwest monsoon from October to December (*rabi* growing season). Dryland farmers only have one crop a year, in the *kharif* season, and food availability is greatest just after this crop harvest (September – November). Because dryland farmers rely on only one harvest for their annual food production, they are particularly vulnerable to the crop failures caused by drought spells which occur approximately once every three years in many districts of northern Karnataka (Government of Karnataka, 1996). Farm families with irrigation (from a tank, open well, farm irrigation tank or farm pond) can obtain an additional crop in the *rabi* season, and thus have greater food security. Farmers are busiest in the main harvest season (September – November), where, in addition to harvesting their own crops, most households have members migrating for work harvesting paddy in the irrigated regions of the state as well. At this time of year many poorer households have only one or two adults remaining in the village.

The major sources of income in the region are from crop and livestock sales and payment for work as agricultural labourers or migration work. Farm labourer wages vary throughout the year according to demand, and peak during the main harvest season. Prices of food crops vary throughout the year according to availability, are lowest just after harvest time (September – November) and highest just before crops are harvested (August) (Samuha staff, pers. com.). The major expenditures are seed, fertilisers, pesticides and events such as treatment for illness or marriage. Most families borrow money once or twice a year from banks or local village lenders, and pay back loans after harvest. During the dry summer months food availability decreases, and many families in the area only just manage to get three meals a day.

Wealthier farmers with access to ground water and storage facilities can produce cash crops for niche markets and avoid seasonal gluts. If aquaculture extends seasonal availability of water and home-produced food, this may reduce the amount of time spent and cost accessing food. Rural families are particularly vulnerable in years of water shortage, where high food crop prices coincide with lower farm production levels and reduced options for off-farm work.

In the rainy season, waterborne diseases such as malaria are commonplace. Stocking of seasonal water bodies with fish is likely to reduce the suitability of these habitats for mosquitoes through their direct control and modification of habitat.

Transforming structures and processes

The key structures supporting aquaculture development are national and local line agencies; the Departments of Fisheries (DoF); the Indian Council for Agriculture Research (ICAR) fisheries institutes; and a number of academic departments and NGOs. Currently in India there is little incentive or support for aquaculture initiatives appropriate to resource-poor farmers. Research focuses on perennial water bodies and high-input systems, with the result that most of the government extension support in Karnataka result in aquaculture options, which are unavailable or unattractive to poor farmers (Appaji, 1991; Sivasankar *et al.*, 1991; Suresh and Selvaraj, 1991). Access to farmer-managed water bodies is increasing for most farm households because of the watershed development activities in the area, but because of the lack of recommendations for aquaculture in these water bodies their potential for fish production remains unexploited.

Farmers from rural villages have been excluded from the mainstream political processes but constitutional amendments[12] provide a basis for elected village representatives (*Gram Panchayats*) and give additional powers to the combined assembly of all voters in a village including executive rights over natural resources. Village development falls under the formal leadership of elected Panchayat leaders whereas the settlement of disputes (marriages, religion and culture) come under the guidance of unelected traditional leadership. Both men and women vote, but women stated that they do not know anything about politics, have no interest in it, and that they follow the advice of their husband when voting. Illiterate villagers are generally less aware of their rights than people who can read and write, and in some areas farmers who clearly qualify for the 'green card' (the Indian Government ration card given to farmers below the poverty line) are unable to obtain it.

A few powerful merchants control the bulk of commercial fisheries production in the region. In West Raichur, one family has a wholesale monopoly and exported nearly one third of the entire district's 1997 production; they also control all significant retail activity within Raichur City except for dry fish. Although both men and women work on the farm and look after the livestock, women generally have no decision-making powers relating to the management of land or water resources. Furthermore social taboos restrict the access of women to the farm and livestock at certain times. Farmers derive income from the crops and livestock, and as migratory workers or local farm labourers. Men are in charge of finances, and for all work, men are paid up to three times more than women (Rs 10-50 per day ~ £0.17 - 0.83).

Most farmers in the area are eligible for 'green cards', which are ration cards provided from the Indian government to the people below the poverty line. SC and ST farmers are also entitled to a variety of government subsidies, including those relating to watershed development. However, in reality, many farmers have difficulty accessing these benefits. In Akanksha[13] villages ST and SC farmers are eligible for 95% and 90% subsidy respectively on the construction of farm ponds (total cost Rs 3000), with uptake facilitated by the NGO Samuha.

Livelihood strategies and outcomes

Farming is a major component of many livelihood strategies of the area. Most farmers own dryland, but some have a small holding of irrigated land as well. Significant sources of income also come from selling labour locally and migration. Assets accumulated at times of wealth is mainly livestock and jewellery, although a number of farmers are starting to invest in the construction of on-farm water bodies for irrigation, tubewells or pumps.

In poor households, livelihood strategies include dedicating young women to temples[14] and avoiding dowry obligations. These Devadasis are one of the most marginal groups of society, with no access to land or water, mainly subsisting as prostitutes or labourers. Interestingly, perhaps because of their very low status, Devadasi women are generally not bound by all the taboos facing higher-status women in Indian society, and are thus quite outspoken and unrestricted in their movement. They are also the recipients of various government and non-

[12] The 1996 Constitutional Amendment extended Panchayat Raj Act to Scheduled Areas.

[13] Akanksha: Samuha watershed development project operating in 50 villages.

[14] In many parts of India low-caste girls are traditionally dedicated to Hindu temples as 'Devadasis', married to God Sahoo, B. B. (1997). Revival of the Devadasi system. *Indian Journal of Social Work* **58**, 361-370.. The Devadasis perform rituals and collect money for the temple Shankar, J. (1994). "Devadasi cult: a sociological analysis," 2nd/Ed. Vedams Books International, Delhi., and used to be experts in music and dance, but as centuries passed, their services shifted from gods to wealthy landlords, and they effectively became prostitutes with a religious sanction. Devadasis are not allowed to marry, but are kept by wealthy patrons from the local community. Whereas they used to occupy quite a high position in Indian society because of their role as 'sacred servants', by the beginning of last century British influence led to substantial criticism of the practise, and a consequent devaluation of Devadasis in the eyes of society. Since the early 1900s Devadasis have been regarded as nothing more than temple prostitutes, accessible to all temple goers for a small donation to the temple, and in 1947 temple prostitution was made illegal Datar, C. (1992). Reform or new form of patriarchy - devadasis in the border region of Maharashtra and Karnataka. *Indian Journal of Social Work* **53**, 81-91.. Despite the abolition the system still continues on a smaller scale, and it has been estimated that Devadasis in temples in Maharashtra-Karnataka border areas number about 250,000 Shankar, J. (1994). "Devadasi cult: a sociological analysis," 2nd/Ed. Vedams Books International, Delhi..

government schemes, often involving land and water rights, encouraging self-development. They represent a potential for researching options for aquaculture suitable for women because of their special status.

3.4 Participatory situation appraisal Sri Lanka

Community-based water and land management at the wider watershed level can lead to increased options for on-farm water management at the individual level (Pretty, 1995). Hence the meso-watershed containing hydrologically connected series of tanks draining to a common point (see Figure 4) was selected as the fundamental unit of research. Detail of the screening process is given below.

In Sri Lanka an agro-ecological zone covering some 75% of the lowland dry zone (below 300m msl) and nearly 50% of the total island area was identified as the area for primary research (see Appendix 3). This agro-ecological zone is suitable for the project focus because of the:

- low and erratic water availability with heavy dependence on traditional rain-fed tank irrigation-based crop production.
- predominance of small-scale seasonal crop production and marked seasonalities in food availability, income and employment opportunities.
- high levels of rural poverty as evidenced by high and rising levels of chronic protein malnutrition.

Four districts (Puttalam, Kurunegala, Matale and Anuradhapura) within North Central and North Western Provinces were selected for detailed screening (areas within conflict zones to the North and East were excluded, as were areas to the south for logistical reasons)[15]. Secondary data including poverty indicators, water availability and relevant institutions were overlaid to identify seven Divisional Secretariats[16] for the final phase of screening. Subsequently 14 suitable cascading systems of small seasonal tanks were rapidly screened using site visits, mapping exercises and key informant interviews. Based on poverty criteria and suitable water availability, two of these systems in Puttalam and Kurunegala districts (incorporating a total of 21 tanks and 9 villages) were selected for a detailed participatory livelihood analysis. This also included an assessment of local fish production, marketing systems and consumer preferences. This work was undertaken in collaboration with field staff from the NGOs CARE and IFAD and the Government Samurdhi Welfare Programme. Summary results of this situation analysis are presented below. Because of the physical and socio-economic complexity found in these systems, two further cascade systems identified during the screening process are the subject of an ongoing analysis (see section 4.4). This is taking place in collaboration with staff of Peradeniya University with logistical support from the Mahaweli H authority. A map showing the location of all the cascade systems covered in the screening process is shown in Appendix 3.

Livelihood assets

The following information was collected in a participatory situation appraisal around two cascade systems of Puttalam and Kurunegala districts, carried out in December 1998.

Human capital

Sri Lanka's distinctive pattern of development with its emphasis on human capital has resulted in the establishment of an expanding network of education and health institutions

[15] Straddling North Central Province is the Mahaweli H irrigation system, part of the Mahaweli development programme (initiated in 1975 to relieve population pressure in the West). This is the project area selected for the linked large-scale (KAR) engineering programme. This proximity will facilitate investigation of potential synergies between communities managing large and small-scale irrigation systems.

[16] The second lowest administrative tier typically encompassing 90-150 villages.

with good access to both urban and rural communities. For this reason Sri Lanka has long held middle Human Development status (HDR 1998) despite a poor record of economic development. An estimated 30% of the country's household continue to live in absolute poverty (ESCAP 1997) and such poverty remains largely a rural phenomenon (Datt, 1997). Rural households tend to have fewer years of schooling, lowest literacy levels, higher dependency ratios, lower rates of participation in the labour force and significantly higher rates of unemployment and malnutrition (Datt, 1997; and pers. obs.). Most disadvantaged of all are low caste groups and farmers settled in rain-fed upper watershed areas.

Farmers have a good appreciation of sustainable land and water management techniques based on a 2,000-year heritage of watershed management for irrigation. This is centred on the division of watersheds around their village tanks into different sections for specific purposes [17] and the practice of a participatory irrigation management system known as Bethma[18]. However, adherence to these practices is diminishing due a variety of trends discussed below (see section on trends). Traditional slash and burn cultivation continues to be widely practiced in dry-land areas despite ever-shorter rotation cycles making this practice highly unsustainable. Farmers have good knowledge of rain-fed cropping systems suitable for various soil conditions and growing seasons of variable duration[19]. Little diversification exists within irrigated cultivation under rain-fed systems most farmers cultivating paddy alone. Although farmers are familiar with a range of methods they were found to rely exclusively on the wet broadcasting technique[20]. Knowledge of more modern biological and mechanical soil and water conservation techniques amongst farmers is low, though many rural development programmes are now extending these techniques. In low land areas these include; inter-cropping, agro-forestry and mulching supplemented with contour bunding and planting, graded or bench terracing though no construction of the water and silt harvesting devices of watershed development programmes in Karnataka identified as having potential for aquaculture.

The country had no tradition of aquaculture or an organised freshwater fishery until recently, although there is evidence that a minor subsistence fishery existed from the historical times (Ulluwishewa, 1995; Siriweera, 1986). Many farmers interviewed near small seasonal tanks were found to have a rich knowledge of fish species, habits and indigenous fishing techniques. However the sustainable low-output subsistence fisheries, which brought benefits to the whole community, has eroded with the village institutions responsible for regulating them. Lack of knowledge of basic aquaculture techniques was in large part responsible for the failure of one observed tank-stocking effort. Many farmers expressed great interest in participating in trials to gain knowledge.

Many aspects of human capital (including nutrition) are subject to modifying *trends* and are considered below under this heading.

Natural capital

Sri Lanka has almost no natural lakes, yet it has 3ha of inland water per km^2 of land (almost 2% of the land surface). Most of this vast acreage is a man-made legacy of ancient irrigation systems. These resources (in particular the small tank cascade systems (STCs) used to manage

[17] People located their houses and home gardens close to the tanks, land adjoining the village was used for shifting dryland cultivation, whilst forests in the catchment above the village tank were left undisturbed.

[18] Bethma is a traditional system of distributing the limited extent of land available for irrigated cultivation, with the available water equitably amongst all the farmers of the command.

[19] In the maha season, maize is the leading rainfed crop, followed by major millet (Kurakkan), cowpea upland paddy, vegetables and chilies. In the Yala season short duration crops including sesame, minor millet (meneri) and manyok are grown. Rice varieties of 2.5 to 4.5 month duration are also used to adapt to variable growing seasons.

[20] A water intensive and relatively low yielding, though labour saving method, where most of the applied water is consumed for farmer convenience rather than specific crop requirements.

the smaller meso-watersheds which cover much of the land area) have played a determining role in shaping livelihoods within the low-land dry zone.[21]

The landform is gently undulating with isolated hills and rocky outcrops. Thin, nutrient poor reddish brown earths (covering nearly 80 % of the dry-zone) occupy the higher aspects, whilst more fertile and deeper black, low humic gleys occupy lower depositional areas. Low rainfall coupled with high potential-evapotranspiration in the dry zone (averaging 2,100 mm/year - Gamige 1996) limits the rain-fed growing period to less than 150 days per year.

Farming activities in the rain-fed areas under study, are limited to dryland agriculture (typically 0-1ha) and smaller irrigated areas (90% of plots less than 0.4ha). Table 3 shows the relative importance of these rain-fed cultivation practices in terms of total land usage within the agricultural sector. Based around small-scale irrigation tanks these systems occupy nearly two thirds of cultivated land area and comprise of some of the smallest and least productive land holdings.

Water availability is highly variable between tanks (ranging from 4-12 months) and years, due to climatic and geological factors and this is one of the major constraints to livelihoods. Water retention time, volume, and size tend to be lowest in upper catchment areas, which then become home to the most resource-poor and impoverished communities. Often only supplementary irrigation is possible in these areas, which consequently achieve lower yields.

An estimated 70% of protein intake in Sri Lanka comes from fish consumption, 80% of which currently comes from local production (De Silva, 1991). In the dry interior the rural poor prefer cheaper, fresh, locally available inland fish, whereas more affluent urban populations prefer marine fish available through a cold chain. An estimated 90% of inland fish production originates from capture fisheries in only 74 major perennial reservoirs (De Silva, 1991). Due to the institutional situation (see 'vulnerability context' below) no accurate up-to-date national production statistics are available, though it is suggested that production levels have still to recover to pre -1990 levels (estimated at a maximum of 40,000 tonnes in 1989).

Table 3: Land utilisation within agricultural holdings in Sri Lanka (Gamage (1997), ESCAP 1997).

Type of agricultural landuse	**Area**	
	Total (million ha)	**Percentage[1]**
Total land area	6.5	
Natural forest cover[2]	1.5	
Total area under agricultural production	**3.2**	**100**
A. Permanent cultivation	**2.07**	**65.8**
• Plantation (tea, rubber, coconut)	0.94	29.4
• [3]Mixed upland crops and home-gardens	0.6	18.8
• Total irrigated paddy	0.6	18.8
[3]Irrigated paddy under seasonal tanks (<80ha)	0.23	7.4
Irrigated paddy under seasonal tanks (80-600ha)	0.05	1.6
Irrigated paddy under major irrigation (>600ha)	0.25 (0.13[4])	7.8 (4.1)
B. [3]Shifting – slash and burn	**0.95 (0.2[5])**	**29.7 (6.3)**
C. Pasture	**0.02**	**0.63**
D. Uncultivated cultivable area	**0.092**	**2.9**

[1] Expressed as % of total area under agricultural production.
[2] More than four fifths of this total are located in the lowland dry zone.
[3] Principal forms of cultivation practised by farmers in rain-fed areas
[4] Area under entire Mahaweli Irrigation Scheme.
[5] Total area annually cultivated under slash and burn cultivation.

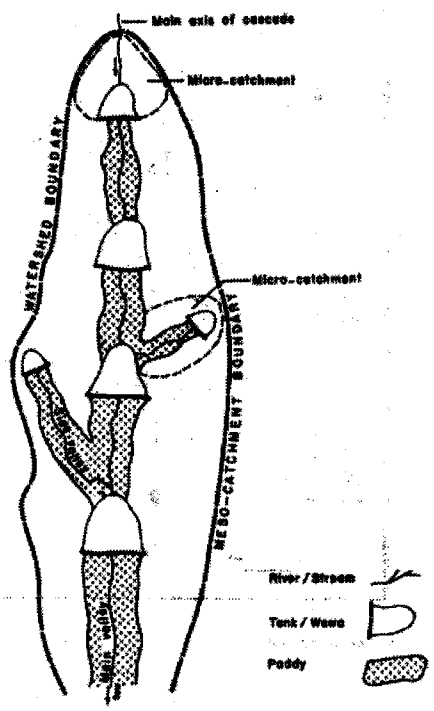
[21] Most of these watersheds drain into the one hundred and three river basins which radiate from the wet central highland area. Flowing nearly 200km to Trincomalee in the NE, the Mahaweli river is by far the largest and most important of these resources for major irrigation.

Financial capital

Nationally it is estimated that nearly one third of the population fall below the official government poverty line[22], most of whom live in rural areas (Datt 1997). CARE (pers. com.) reports that approximately 52% of all inhabitants in Putallam District survive under this level and are eligible for state welfare benefits. In the upper watershed villages investigated (in both Kurunegala and Putallam) welfare levels ranged from 65% to 88% (key informant interviews with welfare animators). Wealth ranking exercises[23] also demonstrated higher poverty levels amongst upper watershed communities. Two welfare schemes initiated by successive political regimes (Janasaviya and Samurdhi) operate and there appears to be a correlation between political affiliation and the scheme under which payments are likely to be made. The many families receiving remittances from family members who work abroad are ineligible for welfare. Farmers generally take little advantage of formal savings and credit institutions[24], and coping strategies (including borrowing) focus primarily on mutual support within kinship groups. Many poorer farmers rely on credit for food items from village boutiques and credit is also available from village moneylenders (15-20% per month interest). Village-level government development staff (Samurdhi) are responsible for the establishment of small credit and savings groups (5-6 members). Although livestock holdings are generally low, amongst poorer groups they are held primarily as a liquid savings asset which can be readily converted to cash, particularly during drought seasons.

Physical capital

Figure 4. Schematic diagram of a small tank cascade system (Scale 1:50,000)



Life in villages of lowland Sri Lanka has traditionally revolved around rainfed village tanks, the heritage of an ancient hydraulic civilisation. An estimated 18,000 tanks are clustered into 3500 to 4000 small tank cascade systems (see Figure 4) with greatest concentrations in the selected project areas of the North West and North Central Provinces. Slightly over half of these tanks are operational[25], 80% of which are 25ha or less. All but the smallest tanks (<5ha) are state owned and community managed. Primary use is for paddy irrigation (rice being the staple food along with fish). Secondary priorities include bathing, domestic and livestock purposes[26] (but no human consumption).

In addition to their highly seasonal tanks, communities located in remote upper-watershed areas are also most likely to have the poorest access to surfaced roads, mains electricity, permanent housing, sanitation and adequate protected water supplies. Low caste groups are more likely to be settled in these areas, where they have the poorest access to land and water resources and the poorest housing standards (see Figure 5).

[22] Household income less than Rs 1,500 or £13 per month

[23] Based on household criteria of food security, housing quality and area of paddy land held.

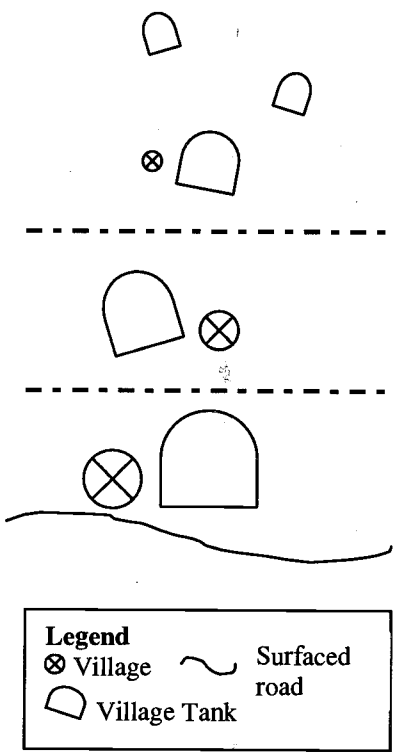
[24] It is estimated over 90% of farmers in Sri Lanka resort to informal methods of credit (IIMI 1998).

[25] Supporting a local village or community.

[26] Livestock holdings are generally low reflecting a culture of permissiveness to fish but not other meat consumption in a predominantly Buddhist Society.

Public transport, although regular, is overcrowded and generally only available on surfaced roads. These factors compromise the access of the poorest people to services such as banks, health care, education, extension services and markets located in nearby towns. With the exception of a few village boutiques (grocery stores) and occasionally primary schools, few such services are present in these study villages. However healthcare networks are well developed with regular visits by health workers to villages and less than 10% of women now give birth at home (village midwife – pers. com.). Weekly markets held in larger towns or at major road junctions are venues for the sale of cash crops (vegetables, fruits, spices) and dried fish by both small and large-scale vendors.

Figure 5. Schematic diagram showing spatial trends in physical and caste characteristics of different watershed areas in a small tank cascade system (source: PRA 1998).



Cascade level	Caste and Physical Characteristics
Upper (Steepest Gradient)	- Lower or Higher Caste - Poorest access to utilities[1] - Temporary housing[2] - Poorest sanitation - Unsurfaced tracks - Smallest seasonal tanks[3] - Least fertile land and lowest yields
Mid	-Lower or higher Caste - Poor access to utilities - Permanent & temporary housing - Unsurfaced or surfaced roads - Semi-seasonal tanks
Lower (Lowest Gradient)	- Mostly higher Caste - Good access to utilities - Permanent housing - Metalled roads & public transport - Sealed latrines - Largest perennial tanks - Most fertile lands and highest yields

[1] Mains electricity, piped water supply.
[2] Clay floors and walls with cajun roof.
[3] These tanks are ineligible for rehabilitation assistance under several government rural development tanks when they support less than 25 households

Social capital

The institutional capacity of the great majority of villages visited during the situation analysis was weak. Community participation in village-based institutions is low, with a general lack of co-ordination between groups addressing common issues. The only active and truly indigenous organisations are dealing with distress rather than bringing about social and economic development (e.g. death benefit groups). The effectiveness and activity of other organisations is dependent on levels of outside intervention by NGOs or governmental development agencies. Farmers' organisations that are also responsible for the management of tank fisheries often meet only a few times per year to co-ordinate irrigation calendars. Women's participation (in all but death benefit societies) is negligible. In this context, the family becomes the most important source of reliable mutual support.

Women still face discrimination in local labour markets (receiving an average of £0.85 - £1.25 per day, roughly 2/3 of male pay for unskilled farm labour), land ownership and participation in institutional decision making. They work longer hours than men, combining productive and reproductive tasks. Social taboos restrict the range of agricultural, marketing and other activities women participate in. Women challenging these constraints were typically

from lower caste or wealth groups, single or widowed. Both men and women take an interest in politics, but women tend to follow their husbands lead in voting. The female-headed households encountered arose exclusively as a result of male bereavement. As men inherit most land, women are most likely to migrate from their home villages after marriage.

The decline of caste demarcations amongst the Singhalese population has undoubtedly improved the status of women (dowries are now rarely exchanged, especially amongst the poorest groups). However inter-caste marriage is still extremely rare and in rural areas caste remains a potent indicator of social status, access to capital assets and often a barrier to wider co-operation.

Fish substitutes (beef, mutton and chicken) are rarely consumed by villagers (and never by 38% percent of villagers interviewed). This can be attributed in large part to the higher cost of these substitutes, but also to traditional Buddhist beliefs. Such beliefs are most firmly held by older and wealthier farmers who expressed greatest reluctance to participate in the culture and harvesting of fish. This taboo has less impact on fish consumption, with over 90% of villagers interviewed consuming fish at least once per week.

Vulnerability context

Trends

Amongst South Asian states Sri Lanka is widely recognised as a welfare model, yet government policies emphasising survival (resulting in spectacular reductions in infant mortality[27] and increased longevity), belie a persisting state of malnutrition amongst large sections of the rural community. Sri Lanka records the fourth highest rate of underweight births (20%) in the world (UNDP, 1997), whilst 36% of pre-school children are stunted (an indicator of chronic malnutrition). These levels are increasing once again, after food based government welfare was recently replaced with income based relief (UNICEF, 1997; quoted in Gunasekara, 1996). De Silva (1991) estimates mean individual daily protein intake is only about 28g compared to a recommended intake of 45g. Chronic malnutrition compromises the mental and physical capabilities of those affected throughout life.

Women's status is generally superior to that of women in India. Both men and women have high literacy rates (>70% in study villages, with highest rates amongst younger age groups), access to primary health care, and increased longevity. Both longevity and the sex ratio have recently moved slightly in favour of women. However, although female participation in the labour-force participation has increased significantly over recent decades, it is still only 51% of male levels (ESCAP 1998). In the rural sector female labour tends to be concentrated in casual, low-paid, low skill and low-status jobs and a higher proportion of women continue to work as unpaid family workers. Levels of long-term labour-migration amongst women have significantly outstripped male levels since the early 1990s[28], taking women away from their homes for extended periods. A perception amongst administrators and policy makers that women are dependent housewives or secondary earners is reported to be a major constraint to improving women's disadvantaged situation in the labour market (ESCAP 1998). Within the household, domestic violence against women and female children, incest levels and male alcoholism are all reported to be rising (Bohle *et al.*, 1998, ESCAP 1997). These trends impact negatively on child education and nutrition and threaten the integrity of the basic family unit.

[27] 18 mortalities per 1,000 live births (IADP 1997)

[28] Since the mid 1980s women's participation in agriculture has dropped by 9.8% and increased by 7% in manufacturing Rasanayagam, Y. (1998). "Globalisation and flexibility of female labour,". Centre for Society and Religion, Colombo.. This is associated primarily with opportunities in a burgeoning garment industry in free trade zones around Colombo and secondarily overseas employment in the Middle East as housemaids.

Sri Lanka is in the 16th year of an ethnic conflict between a secessionist Tamil population and the majority nationalist Singhalese Buddhist population. National development indicators do not take into account the conflict areas to the North and East, where 16% of the population live and from where more than 800,000 people have been displaced and the socio-economic infrastructure severely disrupted. Although the war is a major drain on the country's economy[29], many families in the predominantly Singhalese project areas now rely on remittances from family members employed in the armed services or security positions. Within the Singhalese community two violent youth insurrections have resulted in even greater loss of life than the long running ethnic conflict. Many of the female-headed households encountered in the situation analysis are a consequence of these insurrections.

With emphasis on quantity rather than quality, increased access to education has done little to secure sustainable economic growth, whilst human development has not been served by the mismatch between formation and use of acquired skills (Narapalasingam, 1999). Frustration arising from this mismatch was instrumental in triggering the two youth insurrections, whilst education policies perceived as inequitable have promoted ethnic division and played a significant role in initiating the current conflict (Marga Institute, 1985).

Although population growth is currently relatively low (around 1.1% p.a.) Sri Lanka is already the 21st most densely populated country in the world (UNDP, 1997). Land holdings have declined from an average of 2.7 ha/head to 0.38 ha/head over the last 100 years (Gamage, 1997). Watersheds around traditional tank systems were originally managed in a highly sustainable manner involving demarcation of different watershed areas for specific purposes (Ulluwishewa, 1995). Difficulties in collective water management associated with widespread land fragmentation have contributed to the deterioration of such good practice. Forest cover has decreased from 84% to 23% of total land area over the last 100 years (Gamage, 1997)[30]. Within many villages encroachment of forested catchment areas above tanks has accelerated rates of tank siltation whilst reducing inputs of useful organic materials.

Over the last 20 years 95% of farmers have switched to modern high-yielding / high-input varieties of rice, leading to losses in indigenous bio-diversity[31] (Koziell, 1998), soil fertility (Wolf, 1986) and farmer dependency on expensive pesticide and inorganic fertilisers in place of on-farm organic additions and traditional pest management techniques (Ulluwishewa, 1991). Soil erosion arising from this combination of environmental pressures, has been cited as one of the most serious land degradation problems facing all agro-ecological regions of Sri Lanka (IIMI, 1996). Many farmers interviewed during the situation analysis report falling profits as soils become exhausted accompanied by falling yields and rapidly increasing agrochemical costs[32]. This trend along with reduced water availability (see section on seasonality) has decreased the primacy of irrigated paddy in farmer livelihoods. Similarly the already low livestock holdings have decreased with reducing availability of pasture and increased farm mechanisation.

Following the shift to high-input agriculture, the highest use of pesticides occurs in irrigated areas. Over two thirds of rice now cultivated in Sri Lanka has had herbicide applied and rice consumes over 70% of the total application (though OFCs[33] receive a higher input per acre) (Steele *et al.*, 1997). This has replaced a tradition of hand weeding, a task formerly undertaken predominantly by women. Most farmers obtain advice directly from traders and

[29] Annual military spending is equivalent to approx. $30 per head, or nearly 5.5% of average per capita income ($540 in 1997) Narapalasingam, S. (1999). Economic growth and human development in Sri Lanka. *In* "The Island", pp. 8, Colombo..

[30] Much of this deforestation has been sponsored and almost all acquiesced to by the state, rather than as a consequence of population increase per se Rudran, R. (1990). "Problems and prospects for wildlife conservation in Sri Lanka,". Wildlife Heritage Trust, Colombo..

[31] The number of rice varieties has dropped from 2,000 in 1958 to less than 100 today.

[32] Average costs for inorganic fertilisers have increased by 70% and pesticide costs by over 90% the last 5 years (inflation averaging 11% p.a. over the same period) (IADP, pers. com.).

[33] OFCs: other field crops. typically grown for income generation (i.e. chilli, vegetables).

over-application is a major problem. Integrated Pest Management (IPM) extension services (operated by the Department of Agriculture and the FAO) are underway in 13 districts in an attempt reduce demand for pesticides, and many NGOs are increasing their activities in this area. Human levels of acute and intentional poisoning are all increasing. Pesticide poisoning is now the main cause of death in several agricultural districts (Fernando and Fernando, 1995). Chronic effects are less well documented as are longer term effects on the ecosystem through bio-accumulation of toxic substances in the food chain. Concentration effects in seasonal tanks are expected to be high due to the relative lack of dilution in rain fed systems. This is the focus a separate ecotoxicology study currently being undertaken within the project.

Privatisation of extensive areas of formerly state owned land has accompanied the transition from centrally planned to a free market economy over the last two decades. However this process is impeded by difficulties in demonstrating provenance and it is estimated that over 1 million acres of land is currently illegally encroached by over half a million persons (Government of Sri Lanka (1997), in Jayawardene *et al.* (1998)). The greatest incidence occurs along stream and canal reservations and ecologically marginal lands including upper watershed areas (Jayawardene *et al.*, 1998)[34]. Widespread encroachment of forestlands has also brought increased conflict with marauding wild animals (Rudran, 1990, pers obs). Associated crop (and occasionally life) losses were observed to have forced widespread abandonment of upland plots in many of the remoter villages visited during the cascade screening process.

The many tank rehabilitation programs focused on the individual tank level have created further problems. Often water deficits have simply been moved further down the cascade or upper command areas inundated when tank capacity has been increased without proper hydrological assessment of the whole cascade. In addition, an unregulated proliferation of private agro-well construction (following removal of import restrictions and increased availability of diesel pumps) has resulted in a dramatic reduction of the ground water table in many areas and availability of water in community tanks. Despite a series of Government policies that recognise the urgent need to manage water, and soil conservation at the watershed level[35], on-going projects comparable to those currently underway in India are as yet confined to a few geographical areas and limited in scale (IIMI, 1996).

Rehabilitation of small tank cascade systems has been accompanied by extensive re-colonisation of the dry-zone over the last 60 years (Siriweera, 1986). In 1958 all but the very smallest tanks were taken into state possession bringing an end to a tradition of community ownership and maintenance (only operation continued to be communally managed) (Jayawardene *et al.*, 1998). From the early 1970s the government began to engage in large-scale tank rehabilitation under a series of bilateral development programmes. At the same time it began to adopt policies aimed at revitalising full community participation in operation and maintenance[36], realising it lacked the ability to generate sufficient resources to effectively maintain an increasing stock of operational tanks (Brewer, 1998). Despite significant physical impacts less was achieved in the way of farmer mobilisation until more effective participatory styles of intervention were adopted. Later programmes have realised the importance of diversifying production options away from increased paddy production alone, and the need to include farmers with no access to irrigated land (Dayaratne, 1991). More recently many development organisations have become interested in the potential of integrated aquaculture

[34] Continued state regularisation of encroached lands (to elicit political support) has normalised this process as a means of laying claim to land. Encroached farmers continue to have good access to credit, land-transferability, technology and are eligible for subsidies through a variety of widely practised informal mechanisms, illegal land transactions are a common phenomenon and NGOs provide many extension services Jayawardene, K., Rajasekera, P., Wijayaratna, and Batuwitage, G. (1998). "Tenurial security and natural resources management in a watershed context,". International Irrigation Management Institute..

[35] Especially the National Environment Act (1980) & the ADB USAID funded National Environment Action Plan (1992 -1996)

[36] Key elements included the formation of farmer organisations (charged with managing water distribution and tertiary maintenance) and Project Management Committees (to co-ordinate government agency inputs with both farmer and official representation).

options to generate the financial capital required by community based organisations to offset the increasing costs of tank management and decreases in agricultural productivity (Ministry of Fisheries, 1995; and pers. com. from SLCDF 1998, Sewa Lanka 1998, GTZ-FCDRMP 1998, IFAD 1998, CARE 1998, PRDP[37] 1999). Within the study area, integrated aquaculture options have become a focus of the recently initiated Participatory Rural Development Programme (GoSL[38] and SIDA[39] funded). This integrated programme will operate at the watershed level in over 200 locations within Anuradhapura District (Jaywardene (PRDP), pers. com.)

A trend impacting most heavily on marginal resource-poor farmers is the increasingly erratic nature of seasonal rainfall patterns. Over two recent 30-year normal periods[40] flood and drought events have increased in frequency (now occurring on average once every 3-4 years) and mean annual rainfall levels have fallen by 12.5%. Abeywickrema *et al.* (1991) report the decline to be as high as 25% over the last century. Under seasonal tank systems, this has resulted in a reduction of cultivation effort during the more vulnerable secondary growing season, and consequently greater retention of stored water during this time than in the past (Sakthividel (IIMI), pers. com.).

Fragmentation of paddy holdings, weak institutional capacity and poor farmer discipline have increased difficulties in resource management resulting in water wastage due to lack of adherence to synchronized pre-season cultivation calendars.

Very low yields owing to the lack of truly lacustrine species appears to be the main reason for the neglect of the reservoir fishery prior to the introduction of exotic tilapias from the 1950s (De Silva, 1991). Daily catch data collected for one major reservoir confirms the primacy that *Oreochromis mossambicus* has achieved in the fishery today (averaging 95% of all landings by weight) and also the loss of indigenous bio-diversity. In the dry zone this loss has been attributed in large part to the degradation of riverine habitats on which the great majority of indigenous species depend for breeding (Pethiyagoda, 1994)[41]. It is recognised that both inland and marine capture fisheries are reaching their maximal sustainable yield levels under current systems of management, whilst demand for fish is increasing (NARA, 1997). Most fishermen report a decrease in mean catch size over recent years. The importance of realising the hitherto un-exploited potential of fisheries in seasonal tanks is evident in this context and is also consistent with government policy outlined in its current strategic fisheries development plan (MOFARD, 1995).

Sri Lanka's share of the world freshwater ornamental fisheries market has been increasing since the industry became established in the early 1980s. The industry has enjoyed good price stability over this period. In addition to a portfolio of 50 culturable exotics, 58 indigenous species constitute an ornamental capture fishery (Mee, 1993). Mee (1993) reports approximately 100 agro-farmers engaged in production ranging from back-yard enterprises to over 12ha ponds with six major breeders dominating production. Larger breeders are increasingly contracting out-growing functions to smaller producers to meet unfulfilled demand from exporters. Several NGOs and development organisations including the Small Fisheries Federation, SLCDF and the PDRP are looking at the potential for ornamental fisheries as an income generation activity for women's groups.

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[37] PRDP: Participatory Rural Development Programme

[38] Government of Sri Lanka.

[39] Swedish International Development Agency

[40] Monthly and annual rainfall averaged over two 30 year periods: 1951-1980 and 1961-1990 (Tirappane Station GoSL meteorological office).

[41] Of 62 indigenous species (26 endemic) 8 are considered as endangered and 5 as vulnerable, however all these species and 95% of the total are confined to areas of high natural bio-diversity in the upland wet zone Pethiyagoda, R. (1994). Threats to the indigenous freshwater fishes of Sri Lanka and remarks on their conservation. *Hydrobiologia* **285**, 189-201., IUCN (1990). IUCN Red list of endangered and threatened animals. , xxiv + 192..

Agriculture continues to be the mainstay of the national economy though it's contribution to GDP continues to decline as the manufacturing sector grows (it's share rising from 14.8% in 1985 to 19.7% in 1994). Without state intervention, many labour intensive agricultural products (including paddy) compete poorly in price with imported varieties due to relatively high wage rates in the agricultural sector compared to neighbouring states.

Prior to 1977, farmers benefited from assured markets and high production subsidies under a centrally planned economy, which stressed self-sufficiency in food production (Weragoda, 1998) but stifled economic growth. These benefits along with protectionist exchange controls and import quota restrictions were gradually abolished as part of a liberalisation process, which aimed to encourage greater market orientation and efficiencies amongst producers (Kodithuwaku, 1997) and export orientated economic growth (Kelegama, 1999). Although these policies have resulted in a steady rise in GDP[42], the majority of poor farmers with small production surpluses have poor access to the new markets (Sinathamby and Noguchi, 1997; Narapalasingam, 1999) and have received few benefits. Consequently poorer farmers continue to adopt a production orientation aimed at sustaining household food security (eschewing cultivation of potentially more lucrative and less water consumptive cash crops – (Gunewardena, Peradeniya University Extension Specialist, pers. com.). A new sector of middlemen has emerged and a minority of wealthy farmers continues to amass and control the bulk of means production and exchange in the rural sector (Kodithuwaku, 1997).

A populist government rural re-construction programme pursued earlier in the decade has fuelled a home-building trend whereby many farmers invest any profits or savings they accrue into stockpiling materials for construction of permanent housing rather than increasing or sustaining agricultural production.

Shocks

Although superficially displaying a successful democratic tradition with seven changes of government since independence, the system of patronage and highly communal nature of party politics is one of the main causes of conflict in the country, especially during election periods. This divisiveness reduces the potential for collective community action, increases dependency on government intervention and leads to short-termism in development planning (Chandaratana, 1999).

Between 1989 and 1994 a catastrophic politically motivated withdrawal of all state patronage for the inland fisheries sector led to an almost complete loss of trained (extension, monitoring and regulatory) personnel, institutional memory and seed production capacity for food fish. Little has been achieved to reverse these losses which continue to handicap current development efforts.

Seasonality

Although mean annual rainfall and temperature levels are less extreme than in Karnataka, rainfall is highly seasonal and erratic, farmers experience water deficits for much of the year, and extensive habitation is only made possible where water storage takes place. Dry zone precipitation ranges from 750-2000 mm p.a., unevenly distributed over two growing seasons, with 60-70% falling during the Northeast monsoon (November to February). Tirappane Divisional Secretariat, located centrally within the research area (see Appendix 3), receives a mean 1230mm (1961-1990) rainfall per year. Consequently livelihoods here are predominated by small-scale crop production, subject to marked seasonalities in food availability, prices, income, employment opportunities, credit requirements and health (through water borne diseases and seasonal food deficits). Overlap of these factors results in periods of greatest vulnerability occurring from July to September.

[42] Growth in GDP rose to 6.4% in 1997 with exports contributing 31% of this total compared to only 14.9% in 1970 Kelegama, J. B. (1999). Future of Sri Lankas trade: Keynote address at the annual sessions of the Sri Lanka Association of Economists 24/4/99. *In* "The Island", pp. 7, Colombo.

Most children within lower wealth ranks attended school only irregularly as a consequence of participation in seasonal labour activities.

During the main rainy season the mobility of remote upper watershed communities is restricted, a factor compounded by a trend of reductions in holdings of draught animals (often the only means of negotiating flooded tracks). This also results in reductions of fresh fish (transported by 2-wheeler vendors) reaching such villages at this time.

The main requirement for credit is for agricultural inputs during August to September. Traders often supply this credit for guarantees of sales at the time of harvest (when prices are lowest). The high interest associated with these informal credit systems ties many poor families into a circle of debt, but their flexibility and ease of access (i.e. low collateral requirements) ensure their continued use. Consistent with the weak institutional capacity in most villages, small savings and credit activities are few or reserved for distress payments.

Transforming structures and processes

The core of the absolute poor[43] in Sri Lanka has remained at around 25% of the total population since the early 1970's, whilst relative poverty has grown sharply (Sinathamby 1998). This reflects a failure of all policies, including those implemented under economic reforms to reduce poverty levels.

As no indigenous tradition of aquaculture exists in Sri Lanka, initiation of suitable transforming structures and processes to facilitate adoption are critical. Today most perennial (and many seasonal) fisheries effectively remain open access with resulting problems of over-exploitation. Limited training facilities exist at the two remaining government seed production facilities, and two universities offer postgraduate courses in fisheries management and aquaculture. No effective extension service exists to provide knowledge on aquaculture techniques and fisheries management. Current MOFARD policy for developing seasonal tanks focuses on community based common carp and tilapia fingerling production programmes in collaboration with NGOs. As no private sector seed market currently exists, the plan incorporates a seed supply and buy-back scheme to be phased out when the envisaged markets develop (Ministry of Fisheries, 1995). Collaborating NGOs (programmes mostly in the planning stage) include GTZ, Sewa Lanka, SLCDF, the Small Fisheries Federation and the PRDP. In the NW Province a government agency, the Wayamba Development Authority, is implementing a similar programme. Watching briefs have been established with these and other institutions who participated in the regional workshop (see section 4.1).

Institutional strengthening and enhanced community participation are key objectives of the NGOs CARE and IFAD and the Government Welfare Programme Samurdhi, whose collaboration facilitated participatory information gathering in villages investigated during the preliminary situation analysis. In 1995 nine Provincial Councils were created resulting in extensive devolution of decision-making powers to provincial and district level, including dispersion of development budgets.

In Sri Lanka, land tenure directly effects the right to use water and security in tenure (in degree and period of control) and is widely recognised to be a major impact on the productive use of land and water resources. Twelve major tenurial forms have evolved in Sri Lankan watersheds, ranging from extremes of perfect free title to encroachment and various intermediate leasehold forms (Jayawardene *et al.*, 1998). Most paddy lands under seasonal tanks are still held under secure tenancies created under the Agrarian Services Act of 1958 (Government of Sri Lanka, 1958), which also protected the rights of traditional

[43] Households that spend more than 90% of their earnings on food (Sinathamby, 1998).

sharecroppers[44]. No such rights are extended to dryland farmers. The remains of once extensive temple estates managed by Buddhist clergy are now concentrated in upper watershed areas (temples typically being constructed on or around natural prominences). Many smaller tanks in these areas are leased to farmers by the clergy, who have the option to prescribe the culture of fish[45].

Livelihood strategies and outcomes

Absolute poverty in Sri Lanka is a rural, rather an urban problem. It is estimated that nearly half those below the poverty line depend on agriculture for livelihood and another 30% on non-agricultural rural activities (Datt, 1997, Sinathamby & Noguchi, 1988). Although reliance on waged labour is increasing, within study villages almost 70% of villagers continue to derive their primary source of household income from farming activities. Rice (the staple food along with fish) is the principal irrigated crop. Dryland crops are grown under a traditional pattern of (highly erosive) 'slash and burn', shifting, or fixed highland cultivation, whilst vegetables and other cash crops are also grown in smaller home-gardens. Already low livestock holdings are declining further due reduced pasture availability and the mechanisation of tasks formerly undertaken by draught animals.

Wealthier farmers with access to ground water resources and storage facilities, and the ability to negotiate good terms of trade can produce cash crops for niche markets avoiding seasonal gluts. Most asset-poor farmers, with small seasonal surpluses and poor access to emerging free markets, still adhere to traditional subsistence orientated production strategies emphasising household food security (Sinathamby and Noguchi, 1997). Most families supplement household income through seasonal labour migration or remittances from family members engaged in formal employment. Local opportunities for waged labour are low due several factors; low demand in domestic agriculture[46], peak demand in the rainy season when farmers have to cultivate their own crops, and lack of transport facilities. Access to local off-farm employment is almost non-existent. Farmers also resort to a number of illicit activities including logging, poaching wild game, crop stealing, brewing liquor and the leasing or sharecropping of land allocated to farmers settled under major irrigation developments (Jayawardene *et al.*, 1998). Wilson (1998) estimates that 80% of seasonal jobs are in the agricultural sector, whilst the fishing industry engages another 8%. Formal employment opportunities are predominantly within urban areas.

Poorer farmers are often tied into a debt cycle where the future price of their crops is fixed by traders who supply them with agricultural inputs, and have little opportunity to realise fair prices for their produce (Sinathamby and Noguchi, 1997). Although agriculture still provides the base for local food security, many farmers express a desire to move away from increasingly marginal and high-risk farming activities to the security of waged labour. High unemployment amongst well-educated youth (who record the highest suicide rates in a society, which already records one of the highest levels in the world (HDR, 1997) is recognised as a critical problem. This group has rightly become a focus for development efforts amongst state and non-governmental organisations.

Fisheries are currently a low priority for most farmers because of a variety of bio-technical and socio-economic constraints (see section 4.3). However, in the 1980s trials undertaken as components of two strategic inland fisheries development plans, demonstrated good production potential in seasonal tanks, though for various reasons resulted in little community

[44] The Paddy Lands Act of 1958 provided permanent and heritable rights of tenancy to operators of rice lands including sharecroppers and limited the rents payable by tenants to a maximum 25% of production.
[45] Although Buddhist philosophy explicitly forbids the taking of life, it's teaching on livestock husbandry and consumption is equivocal and subject to wide interpretation. Attitudes to the practice of aquaculture will often be site specific.
[46] Greatest opportunity exists under recently developed major irrigation schemes which generally enjoy higher yields and larger individual land holdings.

adoption[47] (Chandrasoma and Kumarasiri, 1986). Assessments of nutrient flows around village tanks indicate extremely high natural productivity, which increases with tank seasonality (due to their shallow depth, intensive grazing on extensive drawdown areas and nutrient-rich drainage inflows). This brings a rare comparative advantage to communities in upper watersheds. Thus low-input / low-risk enhanced fisheries options, which rely only on seed inputs and low-cost environmental modifications are highly suitable options for these systems (see section 4.3). Villages in upper catchments are also likely to be the most recently settled and consequently demonstrated the strongest kinship linkages and potential for integrated aquaculture options at the wider watershed level. Such options will offer increased potential for household consumption particularly during the driest, leanest periods of the year. As community managed resources, tank based options offer potential for the participation of the most disadvantaged groups in society, including landless, low caste, women and youth. Potential was identified for the participation of women's groups in production, processing, dry fish marketing, and small-scale ornamental fish production for income generation on their homesteads.

Although no taboo exists on part-time fishing activities within seasonal tanks, professional full-time fishing, processing and distribution is still regarded as the preserve of low caste groups. This can be viewed as a positive factor where it reduces the likelihood of elites moving into livelihood opportunities associated with increased fish production. Lower wealth groups and younger farmers were also found to have less entrenched beliefs about the participation in aquaculture on religious grounds.

Privately owned agro-wells, which extract ground water for small-scale irrigation, were also identified to have aquaculture potential.

In the past, many aquaculture development initiatives, which included improved income generation as an objective, have failed to give proper consideration to the potential for profitable marketing of production outputs. Key areas include potentials for value addition, seasonal production strategies, processing and preservation, and access to different levels of market networks by marginal groups. Suitable options in seasonal tanks incorporate staggered harvesting and processing components to overcome price depression associated with seasonal gluts. It is estimated that dried fish constitutes over 50% of the protein intake of low-income groups (Subasinghe, 1982). Only 10-15% of local freshwater fish is converted to dried fish (Subasinghe, 1982), the bulk of this demand being met by low cost imports (pers. obs.). Amongst poorer farmers greatest demand was identified for smaller fish (<150g) which retail at the lowest prices. Little demand was identified for exotic carp varieties. Fresh water fish prices are on average lower and have demonstrated greater seasonal and historic stability than those for marine fish. Most production from the reservoir capture fishery is distributed locally in fresh form by an extensive network of two-wheeler vendors who take fish to sell in villages or at road junctions. Little demand for freshwater fish exists in coastal or urban areas. Because of these extensive local markets, unlike the market for seasonally harvested agricultural produce (much of which is exported to urban areas), exploitative wholesale transactions with middlemen are the exception (pers. obs.). Although individual profits are low, benefits are equitably distributed to consumers, vendors and producers alike (pers. obs.)[48]. Although women are excluded from fresh fish sales, they participate in processing activities (drying and curing) and the small-scale turnover of dried fish (and cash crops) in weekly markets. Men and women's participation in these activities is confined mostly to the dry seasons, when on-farm labour requirements and labour migration opportunities are lowest and fish production levels from perennial reservoirs are highest. This potential also coincides

[47] Reasons include lack of access to an assured seed supply, highly variable production results due to a series of severe drought years and extremely high predation pressure on stocked seed of to small a size.

[48] This is in contrast to the situation found in Raichur District (India). With poor knowledge and access to consumer markets producers often unwittingly operate under exploitative tied credit relationships, where monopolistic wholesalers export the bulk of production to distant urban markets.

with the periods of greatest food insecurity. In addition to full time vendors, such seasonal strategies were found to be widely adopted by landless, marginal farmers and unemployed youth as a means of livelihood diversification. Further investigation of the marketing situation is a major component of the on-going longitudinal situation analysis.

Few aquaculture recommendations currently exist to support development. Research on intensive cage culture options and rice fish options are currently being undertaken by NARA, however these options may have little relevance to seasonal tank producers. Preliminary research hypotheses investigating aquaculture strategies compatible with existing livelihood strategies and outcomes are detailed in section 4.3. Although not explicitly identified as an outcome by farmers, these strategies are also compatible with more sustainable use of the natural resource base (Thayaparan, 1982). Further livelihood outcome indicators will be elicited during the longitudinal situation analysis and farmer meetings later in the year. Potential exists for collaboration with the institutions participating in the situation analysis (CARE, IFAD and Samurdhi) for establishing farmer trials in the next phase of the research. Other linkages (most notably with NDF[49] and the PRDP) continue to be explored in the ongoing longitudinal situation analysis.

4 Stage 3

4.1 Stakeholder workshops

Stakeholder analysis

Development activities can bring both benefits and losses, intended and unintended to the various individuals, groups, communities and institutions involved in a project. These 'stakeholders' are present at various levels. *Primary stakeholders* tend to live in close proximity to the project location and are likely to be directly affected by the project impacts. Further removed are *secondary stakeholders* who have an interest in the resources affected by the project, or are involved in the delivery or decision-making processes associated with project activities. Within this second group are those who affect and those who are affected by change. Losses are likely to impact most seriously on the poorest primary stakeholders.

When researching any new development initiative it is necessary to understand how people involved in it are likely to be affected. This can be achieved in a *stakeholder analysis*, in which the potential interactions, conflicts and trade-offs associated with a particular course of action can be recognised. Stakeholder analysis is also an important first step in developing a shared idea of the work to be done and how to go about it, to improve the way work is designed and carried out. In the present context stakeholder analysis was carried out to determine participants' priorities for the formulation of a research agenda, to clarify differences in contribution, expectations and priorities, and to negotiate acceptance of these.

As it proved difficult to bring primary and secondary stakeholders together within a single forum, these workshops focused mainly on the institutions working in development. Workshops were followed up by village-level consultations using a variety of participatory techniques. In India this has taken the form of a village level stakeholder workshop.

India

A combined Stakeholder Workshop for the 'Aquaculture in Small-Scale Farmer-Managed Irrigation Water Bodies' and the linked large-scale irrigation project was held in Coimbatore, Tamil Nadu on the 19th and 20th of November 1998. A total of 35 participants represented government development and research organisations, university agricultural, fisheries and irrigation research, NGOs, farmers and fishermen's co-operatives. Participants came from the Tamil Nadu, Karnataka and the UK. Full proceedings are reported in a separate working paper.

[49] NDF: National Development Foundation

The workshop began with a series of presentations based on available secondary data to provide context for the following discussions. Commissioned from six of the participating institutions, the presentations reported on the nature of the inland water resource including major and small-scale irrigation systems, the current status of aquaculture in Karnataka and Tamil Nadu, and an economic analysis of aquaculture. Production from inland fisheries over recent years was reported to have stagnated in both states. The bulk of existing production depends on enhancing capture fisheries for Indian major and exotic common carps in reservoirs, rivers and seasonal village tanks through government sponsored stocking programmes. Karnataka State is an area of high natural bio-diversity. However both here and in Tamil Nadu, catches of indigenous species are reported to have declined dramatically due to over-exploitation and increased environmental pressure. This included negative impacts of large-scale water resource development on natural fisheries. Subsequent papers. identified hitherto unexploited opportunities for low input, poverty-focused aquaculture options in small, seasonal water-bodies and niche environments within the command areas of large-scale irrigation systems. Existing policy on the management of large-scale systems was perceived to be focused predominantly on irrigation and hydropower.

The stakeholder analysis was based on three sessions.

Session 1: Participants were grouped into small stakeholder groups, including government development organisations, NGOs and farmers' representatives, government fishery staff, university irrigation, agricultural and fisheries research. Individual and consensus opinion was canvassed on three questions relating to the stakeholders' view on (1) their individual gain from the project (2) their potential inputs to the project and (3) constraints to participation in the project. The response of the different groups is shown in appendix 4.

Session 2: Participants were divided into four heterogeneous groups and were asked to consider potential issues of conflict and how best to address the poverty focus. Two main issues identified were a lack of multiple-use management approach in large-scale irrigation systems and the lack of a poverty focus in research. The need for research into integration of irrigation and fish production was agreed and the current lack of suitable management and technology recommendations was noted. Finally the role of the project in improving dissemination of information and improving co-ordination and collaboration was suggested.

Session 3: Formulation of research agenda. Participants were divided into four heterogeneous groups and asked to consider where knowledge gaps existed for aquaculture in large-scale and small-scale systems and generally. Most of the outputs generated were common to large and small-scale systems. Representatives of the DoF, ICAR institutes and an NGO with watershed management experience focused on farmer-managed irrigation systems.

Freshwater fish production in Karnataka is currently reported to be approximately 90,000 thousand tonnes annually, or one third of the estimated capacity of the State water resource base (Kumaraiah, pers. com.). Poor and mismatched seasonal seed availability continues to be a major constraint. State sponsored development interventions have focused on encouraging private sector seed production, the establishment of an intensive pond aquaculture sector and formation and strengthening of co-operative fishermen's organisations within the established capture fishery sector. Over-optimistic projected internal rates of return, which did not accurately reflect the risks involved in intensive aquaculture ventures, were reported to have weakened investment enthusiasm in the private sector over recent years and growth has been slow. There is a need for research into sustainable strategies for the further development of freshwater resources and fisheries aimed at poorer people.

Farmer-managed irrigation systems: It was agreed that although small-scale water bodies are highly accessible to the poor, no policy initiatives or recommendations currently exist for integrating aquaculture into such resources. Participants generated a list of different types of small water-bodies having potential for aquaculture. The results were ranked for research importance (Table 4) and their relative abundance in Karnataka State (Table 5). Perceived as being most abundant were surface ponds, followed by farm irrigation tanks and check dams. Results of research ranking were more equivocal. Farm irrigation tanks and mini tanks achieved markedly lower rankings than the other water-bodies.

Table 4: Small-scale water-body types ranked by research importance.

Participant	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**Mean rank**
Nala bund	7	4	6	4	5	7	3	4	4	4.9
Farm pond	4	3	2	7	4	3	7	7	7	4.8
Surface pond	5	6		5	1	6	5	5	5	4.5
Open well	3	1	5	6	6	1	6	6	6	4.4
Check dam	6	2	4	3	7	5	4	3	3	4.1
Farm irrigation tank	2	5	1	2	3	2	2	2	2	2.3
Mini tank	1	7	3	1	2	4	1	1	1	2.3

A-I = Different respondents. 7 = most important, 1 = least important

Table 5: Small-scale water-body types ranked relative abundance within Karnataka State.

Participant	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**Mean rank**
Surface pond	6	7	4	5	1	6			5	5
Farm irrigation tank	7	6	7	3	2	3	3	3.5	3	4.2
Nala bund	4	4	6	7	4	6			4	4
Farm pond	5	2	3	4	6	4		3.5	4	3.6
Check dam	3	3	5	6	5	5			3	3
Open well	2	1	1	1	7	1	1	1	6	2.3
Mini tank	1	5	2	2	3	2	2	2	1	2.2

Aquaculture technology: Issues of poor seed availability and species choice were raised. Common carp was suggested as the species with greatest potential in terms of seed availability, tolerance of a wide range of water quality and appropriate feeding and fast growth characteristics. Tilapia was considered to have similarly good characteristics and also good potential for *in-situ* breeding, but doubts were raised over the legal status of transfers within Karnataka. Although occupying a strategic feeding niche, grass carp was considered to have less tolerance of poor water quality. Stunted Indian Major carps were considered to be widely available and have good potential for stocking the most seasonal water-bodies. Several indigenous carp species; *Labeo fimbriatus, L. calabasu, and Puntius pulchellus* were considered worthy of investigation, but are relatively slow growing compared to major and exotic carps.

The Farmer Workshop for the 'Aquaculture in Small-Scale Farmer-Managed Irrigation Systems' project was held in a local village in Koppal, Karnataka, 20-21 April 1999. Participants included IoA staff, the NGO Samuha staff, farmers from Samuha project villages (most of whom had participated in the situation analysis) and representatives and farmers from the NGO The Dhan Foundation in Tamil Nadu.

The workshop had four components: the feedback of situation analysis results to farmers, the sharing of information about aquaculture between IoA staff and farmers, the identification of key constraints to aquaculture for the different water bodies and the formulation of a research agenda.

Session one: feedback from participatory situation analysis. The key findings from the participatory situation analysis were presented back to farmers by IoA staff.

Session two: information sharing. Prior to the workshop (March 1999) general aquaculture guidelines were produced and distributed to Samuha and the Dhan Foundation, and in April 1999 teaching sessions were held to further acquaint Samuha staff with these. On the first day of the workshop these 'aquaculture basics' were presented to farmers, after which farmers with experience of fish farming or fisheries shared their knowledge with the rest of the forum.

Session three: identification of key research topics. Farmers were divided into water body specific stakeholder groups (farm ponds, open wells, check dams and tanks) and asked the following questions:

- What would you need to try aquaculture?
- How do you think it could be done?
- What do you think the positive impacts of aquaculture may be?
- What do you think the negative impacts of aquaculture may be?

The needs were broadly categorised into building human (knowledge), social (group formation, institutional support from Samuha) and financial (assistance to obtain fish seed) capital assets. Table 6 in section 4.2 shows this classification. From the identification of farmer priorities, combined with the research interests of Samuha and the IoA, the research agenda was loosely formulated. Farmer identified research topics can be seen in Table 10. Table 6 shows farmers' positive and negative expectations to aquaculture for the different water bodies.

Table 6: Potential positive and negative impacts of aquaculture as perceived by Karnataka farmers present at the April farmer workshop in Karnataka.

Water body	Positive impacts	Negative impacts
Check dam	Increased income from selling fish. Increased social status because of increased income. Increased nutrition from eating fish. Increased prosperity of village leading to increased social cohesion. Increased crop production caused by irrigation with water fertilised for and by aquaculture.	Inability to drink check dam water if fertilisers are added. Because of community ownership of check dam aquaculture may lead to user conflicts.
Open well	Increased income from selling fish. Increased nutrition from eating fish. Increased wealth in the village will create more social equity. Increased crop production caused by irrigation with water fertilised for and by aquaculture. Dried fish meal can be used for chicken fodder. Diversification of farming systems will reduce risk, and because aquaculture is not dependent on frequent regular rainfalls like crops it is a less risky activity than most agriculture. Fish can provide a liquid asset - because they don't have to be harvested at a particular time like terrestrial crops they are more flexible.	Inability to drink well water if fertilisers are added. Risk of killing fish if water needs to be used for emergency irrigation. Risk of saturating local markets with fish if everybody in the village starts aquaculture.
Farm pond	Increased income from selling fish. Increased nutrition from eating fish. Fish can clean the water in our pond by consuming plankton. Fish can replace chicken or goat as food for social events. Diversification of farming systems for little extra investment (if we feed fish resources available from the farm) will reduce risk.	Introducing farmed species may adversely affect the local fish species naturally present in the pond. Inability to drink pond water if fertilisers are added.
Tank	Increased income from selling fish. Increased nutrition from eating fish. Increased crop production caused by irrigation with water fertilised for and by aquaculture. Diversification of farming systems will reduce risk. Aquaculture can generate employment amongst people who cannot get work in nearby cities and who don't want to work as agricultural labourers and amongst landless people.	Inability of livestock to drink tank water if fertilisers are added.

Session four: identification of farmers interested in participating in research. After the research priorities had been formulated, farmers who were interested in a visit from the project team (IoA and Samuha staff) were identified, and a visit schedule was planned.

Unfortunately not all farmers who participated in the situation analysis could be present at the workshop, and it proved especially difficult to ensure the attendance of women, mainly because of the overnight stay involved. The participation of the women present was limited, mainly because they were inadequately represented and facilitated[50].

The workshop was documented on video by the Stirling video team.

[50] Despite initial agreements that women should constitute 50% of the approximately 50 workshop participants, only 16 women were invited to the workshop by the male-dominated NGO Samuha. Unfortunately a funeral in one village prevented eight of the invited women from attending the workshop, with a resulting representation of eight women out of a total of 58 participants. Because Indian women traditionally do not speak up in mixed assemblies, especially not on 'male' issues such as agriculture, with so few female participants extra encouragement and facilitation was required to elicit their opinions, a point not picked up on by workshop facilitators.

Sri Lanka

A workshop was held in Kandy on the 26th - 27th November 1998. Attending were 34 participants, representing a variety of institutions, including local and central government, NGOs, donors, banks and research organisations (see Appendix 11A). The workshop was hosted by the Agribusiness Department of Peradeniya University and aimed to canvass opinion on aquaculture options in both large and small-scale irrigation systems. Proceedings of the workshop are reported in a separate working paper (Little and Murray, 1998).

The workshop began with a series of presentations based on available secondary data to provide context for the following discussions. Commissioned by the Agribusiness Centre and IIMI, the presentations considered the following areas: the nature of the inland water resource including large and small-scale irrigation systems, aquaculture options learned from elsewhere and socio-economic and gender issues.

These outputs clearly demonstrated the variation in reporting of agencies involved in irrigation and fisheries. Inconsistent definitions for large and small-scale, perennial and seasonal systems made interpretation difficult. The source and quality of fish production data was also impaired by the weak institutional situation that persists following withdrawal of all government support to the inland fisheries sector between 1989-1994 (see section 3.4). The primacy of crop production, particularly paddy, both historically and in modern times for the design and management of irrigation structures and water became evident from presentations on both large and small-scale systems. During discussion after the presentations, participants with a fisheries background raised the negative impacts of irrigation development. The lack of an aquaculture tradition contrasted with the recent boom in coastal shrimp culture and a traditional dependence on inland and marine fisheries (papers 3 and 4). The socio-economic and gender issue paper stimulated lively discussion especially regarding the importance of poverty and gender. The subsequent stakeholder analysis was based on three sessions.

Session 1: Participants were grouped into seven stakeholder groups; donors, government development organisations, NGOs, government research organisations, university irrigation research, university agricultural/fisheries, and one group of women (see Appendix 11B). Most participants were from research and university backgrounds. The workshop was held in English, and some of the field-based NGO participants may have been prevented from fully active participation because of language difficulties. Individual and consensus opinion was canvassed on 3 questions relating to the stakeholders view on (1) their individual gain from the project (2) their potential inputs to the project and (3) constraints to participation in the project (the results are presented in Appendix 8). The main benefit was seen by the dominantly research-orientated group as an opportunity to collect data and gain knowledge in a new area of study. The main constraints to their participation in the project were the shortage of time and other resources.

Session 2: This session focused on reactions to the project objectives and developmental impact, particularly on the poor. Participants were divided into four mixed groups (see Appendix 11C). There was wide agreement between different groups. The need for research that improves the knowledge base for integration of irrigation and fish production was agreed. The current lack of suitable management approaches and technology was raised. The role of the project in improving dissemination of information, improving co-ordination and collaboration was suggested. There was broad agreement that the project objectives did meet Sri Lanka's needs and that a participatory, grass roots approach was vital to developing appropriate solutions. Co-ordination of the various stakeholders was raised as vital to improving dissemination of results to the target groups. Improved awareness among decision-makers, exchange of published data between scientists and field workers, and farmer participation in field schools and village meetings were recommended.

Session 3: Formulation of research agenda. The same four stakeholder groups who had participated in session 2 were asked summarise the research priorities for small-scale and large-scale irrigation systems (see Appendix 12) within four categories. Technical, socio-economic, institutional and biological foci revealed both common and specific issues. A variety of knowledge gaps were identified. The technical issues of fish seed availability, species choice, and management strategies were raised. The matrix does little justice to the complexity of constraints identified. For instance, predation pressure on stocked fish and encroachment of aquatic weeds in small-scale systems were identified as biological issues but clearly also have institutional, social and economic bases. Similarly the technical problem of siltation can be linked to socio-economic factors such as land use practices around the tanks and population pressure. The constraints to fish production of seasonality of water availability and primacy of water for crops were raised as technical rather than institutional or socio-economic issues. Technology options based on fish culture in canals, in cages in water bodies and in rice fields were identified as priority knowledge gaps to overcome. The current lack of extension and research services towards improving fish production in irrigation systems was linked to conflicts of interest between agencies, or at least communication gaps. Very limited capacity to implement change, especially for the numerous small-scale tanks, and enforce laws was identified as a major constraint.

During the course of formulating a research agenda, the stakeholders identified many of their own weaknesses in facilitating communities to improve fish production in irrigation systems. Even field-based NGOs mainly concentrate on tank rehabilitation and the improvement of fish production through stocking with hatchery produced seed is constrained by the scarcity of government fish seed supplies, and lack of technologies for local fish seed production. Two major questions are, if fish seed were available at the right size and time, would they lead to measurable impacts on production, given the importance of self-breeding and recruiting of exotic tilapias? In turn would these benefits accrue to poorer people within communities?

In both large and small group sessions, academics were challenged by field researchers and development workers as to the relevance of their research foci and knowledge of real issues facing poor communities.

4.2 Key researchable constraints

The major constraints to aquaculture as identified in the farmer workshop in Karnataka were categorised under the different types of capital assets. These can be found in Table 7. Work in Sri Lanka is in a less advanced phase. Constraints to aquaculture in cascades of seasonal tanks as identified during the participatory situation analyses in Sri Lanka are listed in table 8.

India

Table 7: Farmer-identified needs for aquaculture categorised into capital assets in the sustainable livelihoods framework. Outputs from the Farmer Workshop for 'Aquaculture in Small-Scale Irrigation Systems' in Koppal Karnataka, 20-21 April 1999.

Capital assets	Aquaculture needs
Social	Formation of groups for using common water bodies, buying seed and marketing activities. Field visits to farmers already fish farming.
Human	Knowledge about aquaculture practices, specifically: suitable species, feeds & fertilisers, stocking & harvesting practices, how to obtain seed.
Financial	Credit for the purchase of seed and cage / hapa materials if needed.

Sri Lanka

Table 8: Summary of constraints to uptake of culture based fisheries in STCs, categorised into capital asset types based on participatory situation analysis in Puttalam and Kurunegale districts, Sri Lanka Dec 1998.

Constraint	Research options:
Natural capital	
Smallest seasonal tanks often owned by religious estates or privately owned.	Site specific constraint. Investigate attitude of religious authorities and different tenure potentials (leasehold, kinship linkages, sharecropping).
High turbidity during rainy season reduces productivity, fingerling growth and survival and flooding brings risk of escape and entry of predators.	• Construct low diversion bund around tank to redirect surplus inflows. • Strategic use of lime to enhance solids settlement.
High predation pressure from rich indigenous fauna, especially the snakehead (Ophiocephalus striata) can dramatically reduce fingerling survival.	• Undertake fingerling production to predator -resistant size in smallest seasonal tanks (which as they dry out completely during the dry season, lack predators). • Install screens on spillways to prevent upstream migration during rains. • Mechanical protection from avian predators (e.g. refuge placements, lines stretched across tank)
Encroachment of aquatic macrophytes (Salvenia and Hyrdilla) reduces tank productivity and impedes harvest (especially in shallow, semi-seasonal tanks, less in highly seasonal tanks)	Physical clearance or biological control (potential for using fish species).
Over-application of pesticides and concentration effects in seasonal tank cascade systems leads to chronic toxicity problems in lower tanks (or where tank bed cultivation is practised).	Focus of preliminary research project undertaken by Graham Taylor (IoA) March/April 1999.
Human capital	
Lack of indigenous or introduced knowledge of aquaculture practices among the target group.	Produce recommendations on choice of species, seed procurement, stocking and management options.
Religious attitudes may restrict participation and predator eradication (e.g. where air breathers survive in residual muddy areas).	Non researchable (such attitudes are less entrenched with younger farmers)
Social capital	
Lack of social cohesion required for community participation in aquaculture options in shared water resources.	Formation of fisheries groups within existing institutions and kinship groups around small tanks, for purpose of seed procurement, production, processing and marketing activities.
Conflict with primary usage of water for irrigation (e.g. where farmers pump out dead storage for emergency irrigation).	Conflict resolution through integration of fisheries groups within existing water user groups (farmers' organisations). Selection of tanks based on cost benefit and risk analyses.
Poaching (threat especially great in smaller isolated tanks)	Potential for community policing as component of group activities.
Financial capital	
Lack of group micro-credit or savings activity.	Potential for such activity within fisheries groups.
Potential for marketing gluts and reduced profitability during driest months.	Investigate potential for staggered production programmes. Investigate potential for value addition and enhanced storage (e.g. smoking and curing options).

4.3 Identification of farmer researchers and research hypotheses

India

Following a post-workshop meeting with the NGO Samuha and a further two-day exposure field visit by IoA staff, the research focus was determined. It was agreed that research activities should be limited to about 35 farmers representing four different types of water body (farm pond, check dam, farm irrigation tank, and open well). Villages in the taluks[51]. Lingsugur and Deodurg were selected as a focus for the open well, farm pond and farm irrigation tank research, since these water bodies are present in great numbers in these more northern taluks. This enabled the research to be focused to just a few villages, thus providing a reasonable control on climate variations as well as easy access for field staff. Villages in Kustagi taluk were selected as focus for the check dam research because this is where the Pampanagar Women's Development Society is based, providing a women's group interested in participating in the research. Because the DoF already stocks major and medium tanks, it was decided to omit these systems from the research. It was also agreed during the workshop that all farmers expressing an interest would be provided seed on credit (to be repaid within a year when profits from aquaculture were realised) if they so wished. Visits were subsequently made to individual farmers to confirm their interest and their potential to participate (based on an assessment of water availability and other constraints). Where possible simple physical modifications, which should be completed prior to stocking, were recommended (e.g. to reduce the likelihood of flooding or drying, silt loads, well collapse, removal of toxic plants etc.). Stocking recommendations (species[52] and numbers) were also produced for each farmer. Shortlisted farmers were invited to attend a second one day workshop (1 June 1999) where feedback on the site visits were presented to farmers, information on basic aquaculture options were again reviewed and further farmer derived indicators for assessing aquaculture impact were elicited. For logistical reasons participants in the monitored trial were finally restricted to five village clusters. The location of these sites are shown in Appendix 2 (also shown are the location of the four villages participating in the preliminary situation analysis).

Table 9: Summary of participants in monitored farmer trials categorised by water body type and village (individuals or groups attending farmer workshop 1 June 99).

Water body type	Mallapur	Janmardi	Malladevergud / Pilligunde	Pai Doddi	Tawagera / Nandapur
Open wells	5	4	1	4	1 (Tawagera Campus)
Farm ponds	1	1	0	3	0
Check dams	0	1	0	2	5 (inc. 3 PWDS groups)
Farm irrigation tanks	0	0	5	0	0
Total	6	6	6	9	6

Note: OW = Open Well, FP = Farm Pond, CD = Check Dam, FIT = Farm Irrigation Tank.
PWDS = Pampanagar Women's Development Society (these are rehabilitated members of the Devadasi cult).

Table 9 shows a summary of participants in the monitored trials. For open wells, farm ponds and farm irrigation tanks numbers refer to individual farmers, for check dams they refer to groups of 3-5 farmers. Included are three 'Pampanagar' women's groups each with five members (no women with individual access to water resources were recruited). One of the check dams listed (Tawagera Campus) will be managed by staff of the NGO Samuha. This represents a provisional total of 33 water bodies in the monitored trial and a total of 49 participating farmers. With the exception of one higher caste farmer all participants belong to

[51] Taluk: sub-administrative region

[52] Stunted (1yr old) rohu and mrigal and advanced common carp fingerlings are seed options available from local government and private hatcheries during the pre-monsoon season. Samuha staff were instructed in transport and maintenance techniques and the first fish were moved to two designated distribution points ready to supply to farmers.

non-vegetarian ST, SC or OBC[53] groups. The results of other farmers out-with the monitored trials will be briefly assessed at the end of the project.

Farmers participating in the workshop formulated a number of research interests for each water body. These are shown in Table 10.

Table 10: Research topics identified by farmers at the April Karnataka workshop.

Group	Research suggested by farmers
Check dam	Group formation for aquaculture (small groups of farmers with land close to check dams or women groups with access to check dam). Extensive fish culture for 6 months. Semi-intensive fish culture in (inputs: organic fertiliser and terrestrial vegetation).
Open well groups	Experiment with aquaculture in brackish open wells. Semi-extensive fish culture for at least 6 months (input: rice and sorghum when fish are small, leaves, manure and ricebran when fish grow bigger). Extensive fish culture in wells. Investigations on how to protect fish against frogs and snakes. Deepening of wells to increase the time of water availability.
Farm irrigation tank	On farms where open well is used for drinking water, construction of farm irrigation tank supplied by tubewell for aquaculture. Use of land near farm irrigation tanks to grow inexpensive fodder for fish.
Farm pond	Experimentation with different types of feed. Experimentation with different stocking densities. Experimentation with use of nets to screen pump intake to avoid fish being pumped out. Investigations of fish tolerance to high turbidity during rainy season. Investigation into the feasibility of growing fish in only 3-4 months in very seasonal ponds.
Tank	Group formation of interested farmers / landless, renting access to tank from village or government. Experimentation with the use of hapas in tank. Experimentation with different means of protecting against theft. Semi-intensive fish culture in small tanks (inputs: organic and inorganic fertiliser and terrestrial vegetation).

Because of the great variation in functions and uses of the different water bodies as well as within each water body category, a loose research framework was thought most suitable.

4.4 The project approach to farmer research

The framework is *exploratory*[54] and this project approach has been used with success in Laos (DFID project R6380CB).

The research is addressing needs identified by farmers as shown in Table 7. Knowledge about specific aquaculture options for the different water bodies and credit for seed is made available to an informal association formed by all participating farmers. A monitoring scheme is designed to enable the detailed follow-up of the approaches taken by each individual farmer and the evaluation of the relative success of each venture as measured by indicators identified by the farmers, Samuha and the IoA.

[53] OBC: Other Backward Castes: deprived castes not belonging to SCs or STs in receipt of special benefits.

[54] See e.g. Lightfoot, C. (1987). Indigenous Research and On-farm Trials. *Agric. Admin. & Extension* **24**, 79-89., Gosling, L., and Edwards, M. (1995). "Toolkits: A practical guide to assessment, monitoring, review and evaluation," Save the Children, London, UK.) and Lawrence, A., Haylor, G., Barahona, C., and Meusch, E. (1997). Participatory indicators for farming systems change: matrices for learning in farmer-managed trials in Bolivia and Laos. *In* "International Workshop on Participatory Monitoring and Evaluation", pp. 18. AERDD Agricultural Extension and Rural Development Department, IRR, Philippines..

The research will provide:

- Indirect support to social capital via the formation of informal association (horizontal network) for the management of loans to farmers for purchase of seed. Because of the uncertainty associated with experiments, any risks associated with the aquaculture trials must be underwritten by the project. Samuha will therefore facilitate the establishment of a farmer informal association, of which all groups and individuals participating in the research will be members. The money required for the purchase of seed will be provided to the association, and the lending out of these funds to individuals or groups managed by farmers themselves.
- Direct support to human capital by making information available to individual households on which basis farmers can select technical / management options and learn by doing. Training will be carried out on a group basis.

Research questions addressed by the trials are as follows:

- Can increasing the versatility of the water resource use help reducing the vulnerability of groups and individuals, by cushioning users against shocks? An attempt to identify suitable indicators to measure this impact is part of the current baseline survey in India.
- Is it better to use large fingerlings to stock the ponds? This will involve some farmers stocking large fingerlings and adding the inputs they can, and others stocking small fingerlings and adding what they can. Tested by analysing the benefits of the two different treatments (large fingerlings cost more but larger fish would sell for more, they may also show better survival), measure farmer satisfaction (would he/she do it again if he did not receive support for inputs?) etc.
- Which of the four water bodies (farm ponds, open wells, check dams, farm irrigation tanks) are most suited for fish culture in the project area? Tested by comparisons of fish yield, return on farmer investment and farmer satisfaction (measured by quantification of farmer indicators as well as in-depth interviews) for different water bodies.
- Can aquaculture in community check dams provide an option for marginalised women's groups (subgroups of the Pampanagar Women's Development Society (PWDS)) to generate income? Tested by financial analysis of trials and monitoring of participant indicators of success as well as comparison of livelihood strategies before and after the introduction of aquaculture.

Water body-specific aquaculture guidelines can be found in Appendix 12. These are intended to constitute a working document for Samuha and IoA staff into which further knowledge and recommendations can be included once farmers and researchers learn more about possible options for aquaculture in these systems.

Sri Lanka

The following researchable hypotheses are based on results of the participatory situation analysis undertaken in December 1998 together with knowledge gaps identified from a literature review. Hypotheses are presented after brief statement of relevant background knowledge.

In Sri Lanka, the following conditions are commonly found around seasonal tanks:

- There is a traditional seasonal subsistence fishery, but no indigenous tradition of aquaculture.
- In the most seasonal tanks regular disruption of natural fish recruitment occurs, necessitating periodic restocking.
- High yields are possible from culture-based enhanced fisheries in seasonal tanks, with no requirement for additional fertilisers or supplementary feeds. Early trials using polycultures of tilapias, and exotic carps yielded 120kg to 2.3t/ha (mean 820kg/ha) in a single growing season (Chakrabarty, 1982). This compares to mean production levels of 256kg in perennial tanks (De Silva, 1991)

- Highly erratic water availability and high predation pressure were attributed as the main causes of the wide yield fluctuations between successive crops, observed in early trials.
- Limited technical, extension, private and public seed production capacity in Sri Lanka continues to be major constraints to uptake of culture based fisheries in seasonal tanks.
- Conventional hatchery based restocking programmes (devolved to community level) continue to be the favoured approach of development institutions in Sri Lanka. Although such programs can work technically, they have not been shown to be sustainable, and their impacts on poor local people have not been demonstrated.

In this context, greater emphasis should be placed on low cost enhancement systems, which aim to increase or sustain existing production levels in the face of increasing environmental pressure. Stock enhancement requires a cost-effective means for mass production of young fish. Ideally suited to this role are naturally recruiting and locally available tilapia species. Tilapias have the ability to grow rapidly in short seasonal growing periods and are tolerant of extreme water quality fluctuations common in seasonal tanks. A simple method of ensuring adequate seed is to stock breeding tilapia and control predation pressure early in the season (e.g. using tanks that dry out and where densities of predatory fish such as snakehead are consequently low). Subsequently, fingerlings of a suitable size can be used to stock less seasonal tanks where predation will be concentrated on their offspring (this will also enhance the by-catch of higher value predatory species, especially the snakehead *Channa striatus*). Previous studies in Sri Lanka have demonstrated that greater natural productivity is associated with decreasing surface area (Amarasinghe, 1998). Thus accelerated growth could be achieved by producing advanced fingerling in the smallest tanks. Communities in the mid to upper watershed may have access to both small and intermediate sized tanks suitable for *in situ* fingerling production and on-growing respectively. The following research hypotheses (which should be read with reference to Figure 6) are consistent with these observations[55]. Hypotheses will be assessed through the comparison of farmer defined indicators before and after trials, overall farmer satisfaction using in-depth interviews, biological indicators (survival, yield and growth rate) and cost benefit analyses.

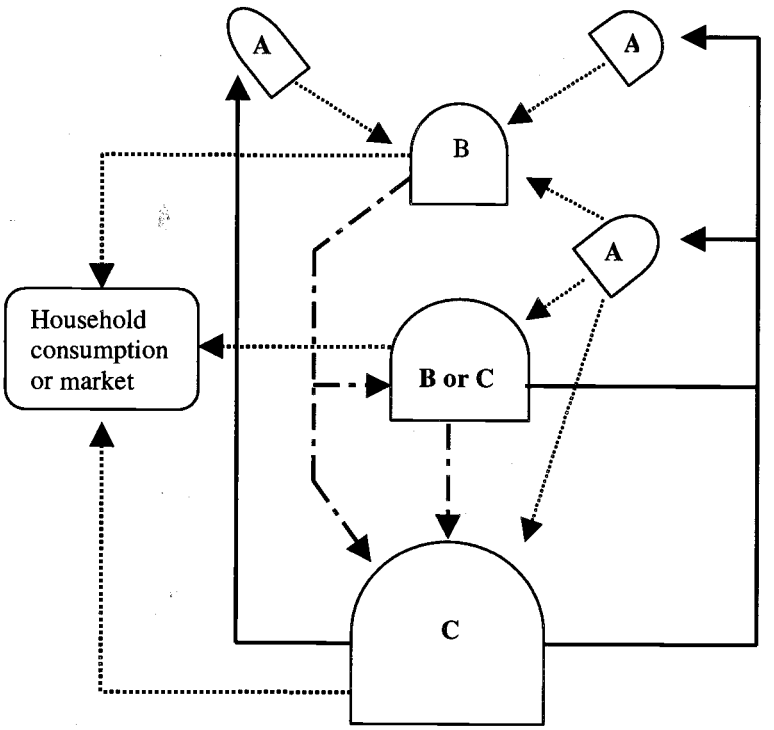
- (I) Could aquaculture options, which demarcate seed, broodstock and out-growing components, enhance social capital, cohesion and water management at the village and wider watershed level?
- (I) Could advanced fingerlings be grown in small highly seasonal tanks kept free of predators, if mature tilapia broodstock sourced from larger perennial tanks are stocked at the onset of the NW monsoon?
- (I) Could stocking of seasonal tanks with advanced fingerlings overcome the problems of poor survival and erratic water availability experienced in early trials?
- (I) Could broodfish be produced in perennial tanks within the same cascade and what are the most sustainable production systems (e.g. cage culture or simple recapture)?
- (I) Could communities with access to perennial tanks be encouraged to trade broodfish to those with seasonal tanks requiring them early in the season?
- (II) Could the system be enhanced by communities around seasonal tanks selling small food fish to those around perennial tanks for fattening in cages, for subsequent 'buy-back' and use as broodfish?

In addition to seed inputs, low cost fisheries enhancements can incorporate simple habitat modifications to favour the production of useful species. Elevated turbidity levels during the rainy season can impact directly on fish health and reduce primary productivity when it is most critical for fingerling advancement. Turbidity levels are likely to have increased as a result of the widespread encroachment of forested catchment areas for cultivation purposes.

[55] Hypotheses are prefixed as first (I) or second (II) order hypothesis. First order hypothesis represent the most extensive, simple and lowest risk interventions which should be tested before or independently of second order hypotheses, which seek to further enhance production systems and marketing networks.

- (I) Could turbidity levels, potential for stock escape, and entry of predators be controlled by constructing low bunds around seasonal tanks to divert runoff waters after the tank has filled to a suitable level?
- (II) Could liming prior to inundation (which accelerates precipitation of suspended material and ensures removal of residual predators) improve productivity?

Figure 6. Envisaged fish movements in a tilapia based, low input, enhanced fishery with seed, grow-out and broodstock components demarcated at the watershed level (based on situation analysis in Pahala Diulwewa & Danduwellewa cascade systems of Putallam & Kurunegala districts, NW Province)



Legend

Symbol	Key
A	Highly seasonal small tank; CPR[1] or private (Temple/farmer)
B	Semi-Seasonal village tank; CPR
C	Perennial village tanks (rain fed or system[2]): CPR
·····→	Advanced fingerling movements from seasonal tanks
·····→	Staggered food-fish production (to markets)
— · →	Dry season broodstock movements (maintenance)
——→	Rainy season broodstock movements (in situ fingerling production)

[1] Communal Property Resource.

[2] Lower tanks may also receive water from medium or major irrigation systems.

Note: The water shed level at which culture components are demarcated will depend on site specific constraints, in particular the seasonal characteristics of the various water bodies accessible to different communities.

Production in seasonal tanks is typically concentrated into two months at the end of the dry season (July – August) when supplies from the major reservoir fishery are also at a maximum and prices are at their lowest seasonal level. Poorer farmers are more likely to purchase smaller tilapias (as little as 50g), being less costly than larger 'table-size' fish. The smallest

specimens (<120g) are more likely to be sold as dried fish. Dried fish is relatively more important to the protein intake of poorer groups.

- (I) Could staggered harvesting strategies sustain greater yields, higher market prices and hence increase profitability?
- (I) Could staggered harvesting strategies bring indirect benefits to poorer consumers through increased production of smaller, more affordable fish through much of the year?
- (I) Could the production window be widened further if end of season surpluses were dried either for home consumption or marketing when prices have recovered?
- (I) Could the processing and marketing of smaller dried fish (between 50-150g) provide sustainable means of diversifying the livelihood of women's groups?

As most former government hatcheries have switched from food fish to more lucrative ornamental production, ornamental seed availability is good. Small-scale growers are beginning to undertake grow-out production on a contract basis. Such production is easy to initiate and requires relatively low start-up capital, production inputs, or water resources and production can take place throughout the year. Constraints identified by consumers and producers include poor flow of information along marketing channels, lack of species variety, poor quality standards and unreliability in supply (Gunasekara, 1998).

- (I) Could the small-scale production of ornamental fish in ponds created on homesteads or cages in village tanks provide sustainable means of diversifying the livelihood of women's or youth groups?
- (II) Could culture of indigenous species improve profitability (through enlargement of species portfolios) and help sustain ecological bio-diversity?

4.5 Extended situation analysis Sri Lanka.

Preliminary work in Sri Lanka revealed a much more complex bio-technical and socio-economic situation than that found in India. Access to water resources is determined by a complex of hydrological inter-linkages and communal management of tanks, whilst liberalisation of the economy is bringing rapid and often negative impacts on the livelihoods of the rural poor. Consequently an extended situation analysis undertaken by staff from Peradeniya University and the Institute of Aquaculture was initiated in April. This will further characterise the marketing and production potential for aquaculture outputs based on the low input enhanced fishery system and other research hypotheses proposed above, by monitoring seasonal changes in relevant criteria (e.g. water availability. This six-month phase will reach completion in September after which workshops will be held to share information and elicit a farmer determined research agenda and monitoring indicators. Initiation of on-farm trials will then commence with the onset of the major rainy season in October/November.

Fieldwork will be focused around three cascade systems identified in the initial screening process the locations of which are shown in Appendix 3. Marketing components will also consider regional (urban) markets in Kandy and Anuradhapura.

Characterising demand for freshwater fish

Available information on fisheries marketing in Sri Lanka is heavily biased towards urban markets, predominantly for marine fish. Further research is required to characterise the nature of demand for inland fish in poorer rural areas. The specific aims of this study are as follows:

- To further characterise existing seasonal patterns and trends in demand and supply for inland fish species with potential for culture fisheries in seasonal tanks (principally carps and tilapias), substitutes (marine fish and meat products), different forms (dried, cured, smoked, large and small) and differences between different socio-economic groups.
- To further characterise fish processing systems and potentials for value addition, targeting niche markets, seasonal and daily risk avoidance/salvage strategies.

- Characterisation of marketing networks and participant perspectives at the regional (urban) and sub-regional levels and potential entry points for lower socio-economic groups (inc. landless, women and unemployed youth).
- Potential for fresh and processed inland products to penetrate urban markets and niche markets (e.g. Tamil Plantation communities).
- Ornamental fisheries: Whereas good basic knowledge on small-scale production technologies exist, there is little insight into the potential for low-income groups to market their products in a profitable and sustainable manner. Case studies will be used to assess the stability and accessibility of future markets.

Characterisation of production potentials

To further define the potentials, benefits and constraints for the practice of aquaculture production by low-income groups in cascading seasonal tank systems. Biophysical and socio-economic factors will be assessed over a six-month time frame to see how aquaculture options could fit with other livelihood components.

Bio-physical

Agro-ecology: Seasonal availability of water, quantity, quality and current uses. Access, ownership (who makes decisions) of tanks and ground-water systems and current uses, winners and losers. Observation of seasonal characteristics of water bodies (encroachment, productivity, turbidity, fish production etc.). Mapping of cascade systems. Land access and ownership, cropping systems and seasonal patterns.

Socio-economic

Range of income generating activities and seasonal patterns (cropping systems, livestock, labour). Potential for community participation within villages (especially by farmers, women's and fishers institutions) and at the wider cascade level.

Details of research activities designed to achieve these aims are included in Appendix 17. Data recording sheets are shown in Appendices 18-24 and a timetable for this phase of research in Appendix 25.

5 Stage 4 - India

5.1 Participatory monitoring and evaluation

Farmers who manage complex systems are continually developing their farming systems and livelihood strategies via their own experiments, by slightly modifying their farms or crops and evaluating the outcome, and adopting practices that seem beneficial. In order to evaluate what is beneficial, farmers informally monitor their own experiments, making mental notes on approaches that seem to work well. This informal research is not always consistent with the scientific paradigm, farmers do not necessarily separate their treatments or record the results. Traditionally the information needs for farmers and scientists are different. Scientists are interested in research yielding unequivocal 'hard data' results that can be replicated elsewhere, and therefore normally monitor biological or economic parameters such as fish growth, return on investment etc. However, farmers make decisions on the viability of new technology on the basis of not only biological or economic parameters, but also factors such as social esteem, risk diversification, opportunities gained, increased utility, accumulation of liquid assets and many more (see e.g. Lightfoot, 1987; Gosling and Edwards, 1995). Many aquaculture technologies extended to farmers are not adopted, mainly because they do not respond to the farmers' needs, because farmers have not been involved in the technology development process. For research to generate sustainable recommendations, it is important to evaluate technology as the end-users would, i.e. to monitor both farmers' and scientists' evaluation criteria.

To monitor farmers' evaluation criteria, Lawrence *et al.* (1997) recommend eliciting farmers' indicators[56] for a successful trial, and ranking or scoring these indicators with individual members of the farming household to establish the relative importance of parameters before, during and after the trials. New indicators should be added as they appear, and the ranks or scores supported by in-depth interviews recording why farmers' prioritise what they do. This can be combined with scientists' indicators on the research monitoring form.

5.2 Baseline survey

In co-operation with the NGO Samuha which allocated staff as field workers to the project, a preliminary baseline survey form was developed, tested in the field, modified as needed, and tested again, before the format was formalised. The final baseline data collection form (English version - field workers use a Kannada translation) were entered into a Microsoft Access database, and can be found in Appendix 13.

The baseline survey records basic information about the farming systems and water resources. In addition the current pattern of meat (including fish) consumption is established, and the patterns of income and expenditure described. To obtain information on the impact of aquaculture on the farming system, field staff are asked to facilitate the drawing of livelihood strategy charts (farm resource flow diagrams) which shows the interrelationship between different income sources, resources, activities etc. Systems diagrams can be drawn again at the end of the trial, to show changes to the livelihood strategy occurring as a result of the experimentation, and can form a focus point for in-depth discussions with farmers of the impacts of the trials. Lastly on the form, male and female members of the household are asked to list and prioritise (by scoring[57]) their expectations (positive and negative) to aquaculture. This provides a set of farmer-derived indicators, which can be transferred to a monitoring form, for each household participating in the trials. Guidelines to field staff for data collection can be seen in Appendix 15. The baseline survey sheets, fish stocking records and trial monitoring forms were entered into an Access database, from where forms to be filled out in the field can be printed and into which all data collected will be entered.

5.3 Farmer trials

The current status of farmer trials (inc. water body types, ethnic and gender breakdown of participants etc.) is described in section 4.3. Small subsidies will be given to ensure these very poor farmers are not exposed to undue risk, but adoption and adaptation of fish culture will be carefully monitored to assess sustainability.

5.4 Trial monitoring

A trial monitoring form was developed with Samuha project field staff. An initial outline of the form was developed with field workers, tested in the field, modified and tested again until a user-friendly final product had been developed. The form (English version – field workers use Kannada version) can be seen in Appendix 14.

The monitoring form records in detail the inputs of feed, fertiliser and labour to the aquaculture activity. Mortalities and their causes are recorded, as are fish catches, and subsequent consumption or sales. Physical parameters (water area and indicators of water quality such as colour, temperature and smell) are measured, and farmer derived indicators (both those identified during previous field work with farmers and new ones) scored.

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[56] Indicators are specific, explicit measures of a situation brought about by changes in the environment, social actions or activities, which enable measurement of variance over time, space or social category Rennie, J. K., and Singh, N. C. (1996). "Participatory Research for Sustainable Livelihoods: A Guidebook for Field Projects," International Institute for Sustainable Development, Winnipeg, Manitoba, Canada..

[57] Scoring was chosen over ranking because scores contain more information than ranks Maxwell, S., and Bart, C. (1995). Beyond Ranking: Exploring relative preferences in P/RRA. , 28-34.. The scoring system used assigns an independent number (between 0 and 10) of scores to each parameter, thus allowing independent comparisons of indicators regardless of the total number scored.

A user-friendly Access database has been developed, into which all collected trial information will be entered by field staff (this package will also generate the record sheets required for data collection).

6 Stage 5

6.1 Post-trial farmer survey

After trials are completed, IoA and Samuha staff will carry out an in-depth survey of the farm households. The starting point for discussions with the household will be the baseline and monitoring forms for the trial. From these forms, the research team will ask for elaboration on farmer opinion about the experiment, reasons for changes of management / variation in the prioritisation of indicators etc. indicated on the form.

6.2 Post-trial farmer workshop

A post-trial farmer workshop has been planned for December/January 1999 for farmers to feed back on the research process and share their findings with other farmers, Samuha and the IoA. The aim of incorporating a forum for farmers to share their experiences in the project framework is to ensure a deeper understanding of the knowledge generated and to facilitate sharing.

6.3 Future research

The aim of the present project is to achieve a better understanding of the factors affecting small-scale farmer management of water resources, and to carry out research into aquaculture options over one water storage cycle. It is clear that results from just one cycle of research will enable only outline recommendations indicating the likely suitability of such water bodies for aquaculture and possible successful management approaches. To yield clear recommendations for diverse and complex areas, however, multiple cycles of research are normally needed. It is therefore intended that the research agenda developed with stakeholders to modify and improve outline options would be addressed in a follow-up phase of the project (phase two of the initial project logframe) investigating the options for a period of further two water storage seasons.

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Appendix 1: Participatory research

Participation

Early approaches to development were often top-down, target-driven and often not very successful (Rennie and Singh, 1996). The apparent failure of development to improve the lives of poor people is now believed to be related to the absence of stakeholder involvement of those "undergoing" development. In the early 1980s approaches incorporating people's participation started gaining foothold (Chambers, 1983). In the late 1980s, it was argued that participatory research methods and approaches could serve as a powerful tool for meeting farmers needs, especially those who manage complex, diverse and risk prone agriculture (Chambers *et al.*, 1989).

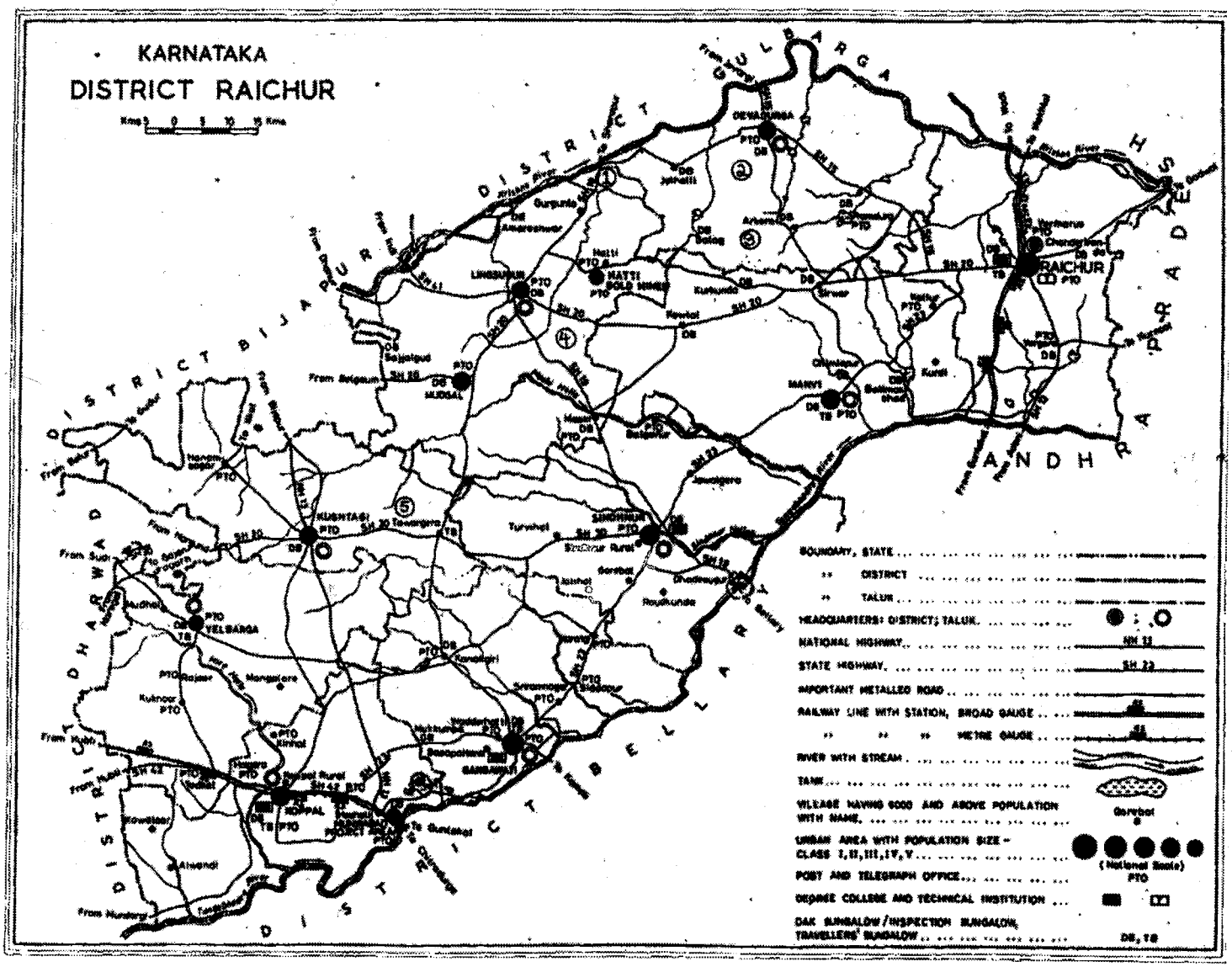
Farmer Participatory Research (FPR)

It has long been recognised that farmer participation is vital for agricultural research directed towards producing strategies for farmers in marginal areas. Low-income farmers most often operate in complex, diverse, risk-prone environments where farming strategies are unusually flexible and complex and therefore difficult to replicate in on-station trials (Marsh and Appendini, 1998). Where experiments on research stations have optimal levels of all inputs other than the experimental variable, the situation is quite different in the complex farming systems of poorer, more marginalised farmers (Shah *et al.*, 1991; Farrington, 1989; Okali *et al.*, 1994). The failure to elicit farmers' views in the technology development process is now widely regarded as a major reason for the low adoption by farmers of technologies generated on research stations (Farrington, 1989). On-station research most often does not take into account the interdependent social and economic activities of the farm, variables which are just as important as pure production figures for the viability of farming activities (Delince, 1998; Hodge *et al.*, 1998; Veach, 1996). Better suited for the special conditions of marginal areas is farmer participatory research, where on-farm trials are used in an attempt to develop technology in the environment in which it is to be used (Collinson, 1998; Farrington, 1996a; Jones, 1998; Lightfoot, 1987; Loevinsohn and Simpson, 1998; Tripp, 1991). Research should therefore not only take place in farmers' fields but farmers need to actively participate in the research needs assessment, and the planning and management of research (Leelapatra *et al.*, 1992).

Participatory approaches are well established and integrated into most rural agriculture and agroforestry research projects (e.g. Chambers *et al.*, 1989; Farrington, 1989, Lightfoot, 1987; Okali *et al.*, 1994; Farrington, 1996b; Loevinsohn and Simpson, 1998, Roling *et al.*, 1998)), but scientist-led, on-station research dominates in the field of aquaculture. Whereas this approach may be appropriate for resource-intensive, high-technology aquaculture research, it is clearly unsuitable for yielding suitable outputs for marginal farmers in risk-prone areas.

Presently in India research into options for resource-poor farmers is virtually non-existent and participatory research approaches not used.

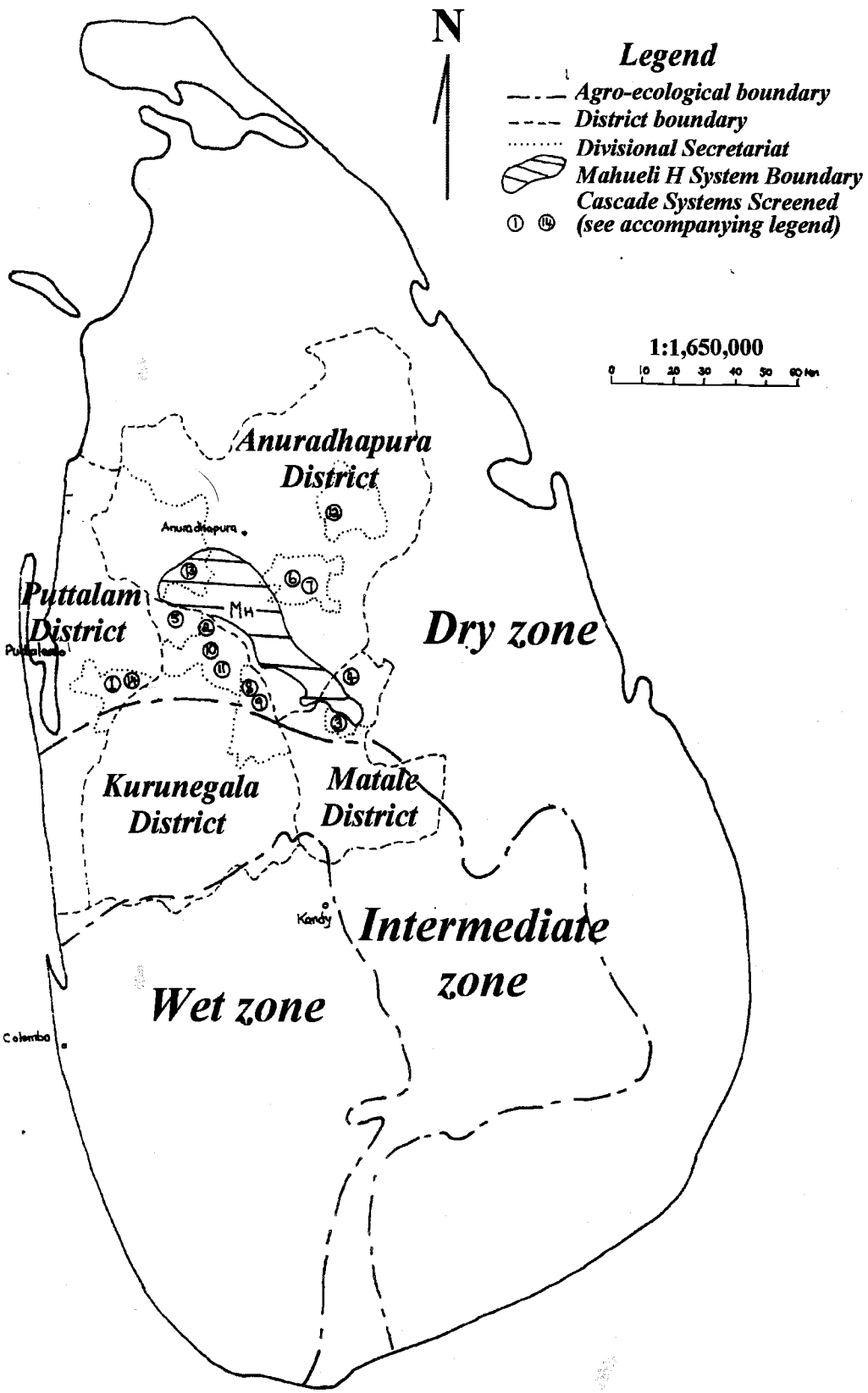
Appendix 2: Location of research areas in Karnataka State India.



Legend to site locations

1. *Pai Doddi*
2. *Malledevergud / Pilligunde*
3. *Mallapur*
4. *Jan Mardi*
5. *Towegera / Nandapur*

Appendix 3: Location of research areas in Sri Lanka.



Appendix 3 (continued).

Key to locations included in cascade screening process (See map on previous page).

District	Divisional Secretariat[1]	Grama Nilhadiri[2]	Cascade Name[3]	Principle Villages[4]	Ref no[5]
Puttalam	Anamaduwa	Paramakanda	Pahla Diulwewa	PDW, Pahal Sembugama, Uttura Paliagama	1*
Puttalam	Anamaduwa	Koiladigama	Andarawewa	Andarawewa	14**
Kurunegala	Galgamuwa	Kumbukwewa	Danduwellawe	Dandulawellawe Ainkenda, Kumbuk	2*
Kurunegala	Galgamuwa	Nitalawa	Nitalawa	Nitagama	10
Kurunegala	Galgamuwa	Timbiriyawa	Bedigama	Bedigame	11
Kurunegala	Giribawa	Ihala Marankadawela	Ihala Marankadawela	IMK, Madurugama	5**
Kurunegale	Polpitigama	Mamunugama	Mamunugama	Mamunugama, Ihala Timbiriyawa	8
Kurunegale	Polpitigama	Saliagama	Amunokole	Galkandegame, Aumunkole	9
Matale	Dambulla	Ethabendawewa	Ethabendawewa	Ethabendawewa, Manikdena	3
Matale	Dambulla	Digampatana	Digampatana	Digampatana	4
Anuradhapura	Tirappane		Mahakanamulla	Mahakanamulla	6
Anuradhapura	Tirappane		Pahala Ambathale	Phala Ambathale, Ihala Ambathale	7
Anuradhapura	Kahatagasdigiliya	Moraganawella	Moraganawella	Moraganawella	12
Anuradhapura	Nochchiyagama	Dambawelegama	Dambawele Gama	Dambawele Gama	13

[1] Administrative division covering 90 – 160 villages
[2] Lowest level administrative division covering 4 – 10 villages
[3] Name of cascade system based on principal village upper cascade.
[4] Villages visited during preliminary screening process.
[5] Cascade reference no. refers to map on previous page
* Cascades selected for detailed preliminary Participatory Rural Appraisal (PRA).
** Cascades selected for follow-up longitudinal PRA study.

Appendix 4: Results of stakeholder analysis sessions - Tamil Nadu workshop 19-20/11/98

Three questions were asked of each participant, the responses to which were to be written on three different coloured cards. The cards were then marked depending on the stakeholder group to which each participant belonged (A-G inclusive) The answers and groups are recorded below with responses divided as question 1A-G etc (answers in bold are not statements of personal gain and imply that participants misunderstood what was expected of them).

1. How could you benefit from participating in the project?

Group A
*increased understanding of how to help poor farmers identify their needs
*experience in poverty focused research
*increased understanding in the analysis of opinions & benefits
*increased research/publication opportunities that could also benefit the livelihoods of poor people

Group B
*learn new technologies for better livelihoods
*gain greater access to water over longer period of time
*achieve improved relationship with crop farmers

Group C
*relevant to my work within my department
*will improve my ability to transfer information to the public
*will enhance my ability to interact with other disciplines
*will gain an understanding of integrated aquaculture with irrigation systems
*will help with interacting with those from other disciplines
*will learn modern methodological study of aquaculture
*will gain a great deal of information and statistical data for extension work
***will be able to supply fish to those who want them**
*will gain knowledge that I can then use to influence people at the grass root level, policy makers and managers with the aim to improve nutrition
***will benefit aquaculture in irrigation systems if it is discussed more than the other subjects**
***will learn new ideas, technologies and solutions to existing problems in increasing fish production and how to utilise this through the fisheries department**
***will help improve the interaction between aquaculture within irrigation systems and thereby help increase fish production and thereby increase the protein content in local diets**

Group D
*will learn policy recommendations relevant to community
*will gain an insight into the perceptions and expectations of farmers who are or may be involved in aquaculture
*will learn appropriate methodologies that to supplement the nutrition of the poor
*will learn how to optimise resources
*gain opportunities to continue working with the community
*will learn by listening to the findings of this research and using the knowledge

Group E
*will benefit through the exposure to a new, novel project through improving my knowledge, which will serve me over the next few years
*will help perfect my analytical tools and skills
*will enable me to gain knowledge on small scale systems that I can then use to reorient my division programs in Bangalore
*will help my research project if it is widened to include small reservoirs
*will improve my knowledge of different methodologies

Group F
*through association with the project (Karnataka), I have learnt how backward the four taluks in Raichur are and I have learnt about RRA systems
*learn the perceptions of delegates from other institutions