Chapter 3

A Framework for Research into the Potential for Integration of Fish Production in Irrigation Systems

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Abstract

Water is a critically important but increasingly scarce resource in much of the developing world. Increases in overall productivity in relation to water use are desirable in the context of rising pressure to utilise water more efficiently. This highlights the need for improved integration amongst water use systems. Thus paper presents a framework for research towards integrating fish production and irrigation systems, focusing on opportunities for poor people as beneficiaries. Any assessment of farming systems in Asia quickly recognises that `irrigated' and `rainfed' zones are far more complex with respect to water availability than such simple terms suggest. The constraints and opportunities for the poor to benefit from integration of fish production into large, institutionally-managed systems are likely to be very different for farmers managing various forms of micro-irrigation. We categorise irrigation as being under the control of (i) the household or inunediate community. or (ii) an outside institution, typically' an irrigation authority or department, as the basis of a framework leading to the development of improved systems integrated with fish production for both. We outline approaches that use technical and social methodologies both to understand current systems and to develop innovative approaches in participation with stakeholders. Engineering and management options are examined in an interdisciplinary mode in which action research with local conurnunities follows situation analysis. Projects are being undertaken in India,

Pakistan and Sri Lanka but technical and management guidelines, and the wider policy issues developed will have broader relevance in developing countries.

Background

It is estimated that almost half the world's poorest people, nearly 500 million, live in drought prone areas and depend on irrigated agriculture to provide them with much of their food supply (HDR, 1997). This will rise to 20% of the world's population by 2050 (Engleman and LeRoy, 1993). The area irrigated by major systems has increased by an order of magnitude during the 20th century; however, recent estimates (Yudelman, 1994) suggest that scope for further increases of the area irrigated in Asia may be exhausted in the next 20-30 years. Population pressure, competition with urban and industrial users, and increased frequency of drought will combine to make water a dwindling per caput resource in these areas.

Agriculture is responsible for some 70°0 of global water use (FAO, 1995) and Postel (1993) estimates average irrigation efficiency (defined as the ratio of the quantity of water delivered to that actually consumed by crops during their growth cycle) to be as low as 37% world-wide, indicating enormous potential for water savings in these[3] systems. Improved design and management will continue to be a major response to these problems. However, a new development priority has also emerged, following a recent paradigm shift: the impacts of irrigation systems are being reassessed at the wider watershed level in contrast to the 'on-farm soil and water management' priorities of earlier strategies. This approach recognises the importance of collective action in sustainable management of natural resources and thus offers greater options for individual on-farm management of water. Molden (1997) observed that increases in irrigation efficiency do not always coincide with increases in overall basin level productivity of water, which may be more readily achieved through the simultaneous multiple use and high concurrent re-use of water (Wolters and Bos, 1990).

Although the development of water resources for irrigation has often had a negative effect on natural fisheries, there has been little research into the production potential of extensive culture-based fisheries, and intensive cage culture in irrigation storage systems and little development focus on appropriate systems to benefit the resource-poor. Two thirds of the predicted shortfall in world fish production (20-30 million t by the year 2000 according to FAO, 1995) will occur in the semi-arid tropics, an extensive bio-climatic zone, home to large numbers of the world's poor, further underlining the need for such research effort.

Project Purpose

The purpose of this Project is to investigate the potential for integrated

production of all aquatic species, plant and animal, of nutritional or other economic value within large and small-scale irrigation systems; and the potential for this production to benefit the poor. Principal collaborators in India are the NGO Samuha and Tamil Nadu Agricultural University; in Pakistan the Department of Fisheries and the International Irrigation Management Institute (IIMI); and in Sri Lanka the Agribusiness Centre, Peradeniya University, and the Mahaweli Development Authority. A number of categories of irrigation systems representative of a wide range of `water stressed' areas will be studied in each of these countries.

Direct beneficiaries could include the poorest marginal, landless and women's groups, all of whom have traditionally derived least benefit from irrigation developments. A key objective is to identify options to diversify the existing livelihood strategies of such groups through low-risk aquatic food production. Indirect benefits could accrue to fish processors and the wider population in the irrigated area through potential control of aquatic weeds, disease vectors, generation of subsidiary income generating activities and increased provision of a cheap, high quality protein source.

The Project seeks to promote a participator approach to the design and implementation of research with individual households and communities. Stakeholder workshops and situation analyses will be used to guide initial selection of research areas, institutional collaboration and prioritising of key researchable constraints. Situation analyses are currently under way in India (Karnataka, Tamil Nadu), Pakistan (the Punjab) and Sri Lanka (North West Province). Research outputs will include technical guidance to engineers, policy guidance to planners and donors, research guidance to scientists, and extension guidance to producers.

The Relevance of Research Areas to Wider Development Needs

Research outputs from case studies in India, Pakistan and Sri Lanka will be relevant to extensive areas of 'rainfed drylands' located in broad sub-equatorial belts north and south of the equator. Large sections of the population in these regions have less than the WHO recommended daily intake of 2,800 calories due mainly to the erratic and short duration of rainfed growing seasons and nutrient poor soils which reduce the productivity of local agriculture (Myrada and IIRR, 1997). Yet because of their wide extent. rainfed drylands support large populations and produce a large proportion of national food requirements in many developing countries. Rainfed drylands are home to one sixth of the world's population and represent one of the largest bio-climatic zones within the semi-arid tropics (ICRISAT, 1997). Rainfed drylands in India provide almost 44% of the country's food and support nearly 40% of the population (Myrada and IIRR, 1997). Irrigation systems are widely used to increase the cropping potential or simply to reduce the risk of crop losses in these impoverished areas.

Other Project Objectives

Gender Focus

Our approach will consider gender in targeting beneficiaries, in addition to marginal and landless groups. Although rural women contribute over half the labour used to produce the food required in Asia (SPPRGA, 1997), they come last in the distribution of productive resources and social services and often form the poorest and most vulnerable sub-sector of marginal communities (Engle, 1987, Mehendale, 1991). Only 3% of extension time and resources are allocated to women in Asia compared to a global average of 5% (UN, 1997). The tendency to ignore women (who may have different inputs, ideas and needs than men) in development planning, renders many development projects unsustainable (Fatima, 1991; Agarwal, 1997). Many developing country development projects have actually marginalised women further by depriving them of their control over productive resources and authority within the household, whilst failing to lighten their traditional workloads (Afshar, 1991; Momsen, 1991). Since the UN Decade of Women 1975-1985, women have been increasingly singled out for special attention in development. Yet despite the increasing provision of favourable policy and legal reforms, awareness of gender issues and wider adoption of participatory techniques within development programmes, women continue to have little opportunity to participate in the planning of development projects. Moser (1989) suggested that there remains a widespread reluctance by development planning authorities to consider gender as an important planning issue. In addition, the preoccupation of feminist writers with describing the complexity of gender relations makes it difficult to translate gender awareness into a practical gender-planning framework. Amongst research priorities, the adoption of analytical frameworks that facilitate better understanding of gender relations in rural areas is required.

Although recommendations on how to incorporate gender concerns into aquaculture development planning are virtually non-existent, two main approaches do exist with respect to women's involvement within the wider development arena. The first, known as the 'women in development' approach, focuses on special, women-only projects considering `traditional' women's roles related to domestic activities. The more recent 'gender in development' approach concentrates on efforts to promote women's empowerment by involving men and women alike (Moser, 1989; Humble, 1998). King (1989) identified areas for the training of women in aquaculture, which included pond management (preparation, stocking, feeding, fertilisation and Harvesting), and handling, transport and marketing of fish. Our approach involves a gender impact assessment to evaluate existing gender roles, workloads, access to resources and the potential negative and positive impacts of aquaculture interventions on both sexes. Although many barriers exist, there are also reasons to expect good potential for women's participation in aquaculture initiatives. Firstly, where fish production is adopted as a new activity, men will not already dominate it. Secondly, there is good evidence to suggest that poorer women do

take on non-traditional roles, even in conservative cultures. Woman may also utilise other aquatic products for income generating household activities such as reeds harvested for basket making.

Sustainability

The fragile ecosystems characteristic of rainfed dry lands typically suffer accelerated degradation where poor resource management accompanies increasing population pressure (HDR, 1997). Improved understanding of wholefarm systems gained in participation with farmers may aid in the development of sustainable strategies involving lower-input, integrated crop and aquatic production rather than high-input, monocropping. Although it is recognised that resource-poor farmers' short-term needs may not readily correspond with those which promote sustainability, greater efficiency of' water management gained through closer integration could reduce the costs of producing both terrestrial and aquatic crops. Aquaculture extension in many developing countries currently focuses on high-yielding technologies dependent on off-farm inputs (Haylor *e1 al.,* 1997). Such approaches exclude the majority of poorer farmers who possess only limited resources which must be managed with minimal risk. We expect that suitable technologies would include semi-intensive production of herb herbivorous/omnivorous species low in the food chain.

Biodiversity

Both south-west India and Sri Lanka have been recognised as bio-diversity `hotspots': areas where high concentrations of endemic fish species are experiencing unusually high rates of habitat modification or loss (Kottelat and Whitten, 1996). This has specific ecological impacts as well as negative longterm impacts on wild capture fisheries. The potential of indigenous species and indigenous farming practices to enhance sustainable development will be evaluated.

Methods

A participatory research approach with the following components will be adopted:

- A wide-ranging situation analysis (Box 3.1) to determine relevant initiatives which impact the poor. Situation analysis progresses from regional to local level, using secondary information and key informant interviews as well as other participatory rural appraisal (PRA) approaches in villages. Validity of PRA results may be enhanced by use of triangulation techniques, and in some cases non-parametric statistical tests, to determine whether different stakeholders hold E significantly different viewpoints.

• Beneficiaries, institutional collaborators, opportunities for, and researchable constraints to, fish production can be identified using methods such as stakeholder workshops. Mechanisms including stakeholder analysis (Lawrence et al., 1999) can be used in conflict management and resolution leading to a multi-perspective, participatory approach involving irrigation, aquaculture, socio-economic and development specialists.

Farmers who wish to research these opportunities on their farms can be supported to monitor and evaluate such research. Such village level activities can be established through community based organisations.

Methodologies need to be constantly reassessed and adapted to both understand current systems and develop innovative systems in participation with stakeholders, which are relevant to a wider range of situations.

Box 3.1. Major components of a situation analysis for aquaculture-related development (adapted from Haylor et al., 1997).

Regional situation analysis:

- institutional support (governmental, non-governmental organisation, research and training, credit)
- fisheries production, including history, production by sector, seed production
- market analysis, including consumer preferences, infrastructure, wholesale and retail systems
- relevant political and economic situation, i.e. demography, social disintegration

Local situation analysis (includes village PRA):

An aquaculture situation analysis contains information about:

- the economy, landholdings, social structure and priorities of the local community
- farming systems and the role of women in these systems (seasonal patterns, workloads)
- physical nature of the area (temperature range, rainfall, soil types, water resources)
- relevant indigenous knowledge and perceptions and demand for fish and aquaculture

Aquaculture Potential and Poverty Focus in Large and Small scale Irrigation Systems

Irrigation systems comprise the following functional sub-sections: water collection, water delivery, on-farm application and wastewater removal. Potential exists to incorporate aquatic production in each of these components (Haylor, 1994). Important differences exist in water delivery policy and control structures. The impact of these differences on aquaculture potential has not been considered. This is in large part due to past failures to value the multiple uses of water (Gowing, 1998).

The majority of the world's poorest farmers in the most marginal regions continue to employ traditional minor and micro-irrigation systems (Table 3.1) to increase the productivity of their land such as village tanks, farm ponds (Fig. 3.1), open wells (Fig. 3.2), check dams (Fig. 3.3) and irrigation ponds (Fig. 3.4). Dryland development in India is increasingly being undertaken on a watershed basis on which the Indian government spends some USS300 million year ^{1} (Barr, 1998). Integrated components include the construction of farmer-managed soil and water-harvesting structures. Much of this substantial and expanding resource remains unquantified and there has been little exploration of the potential for integrated fish production into these water bodies.

Table 3.1. Administrative classification of irrigation systems in project nations.

1 = household or community managed, 2 = formally managed by outside institution

Criteria	Major (2)	Medium (1 or 2)	Minor (1)	Micro (1)
Description	Large dams and canals constructed on perennial rivers	Reservoirs fed by run-off (or cross basin diversions)	Reservoirs fed by ephemeral surface or ground water	Rain and silt harvesting devices or ground wells
Seasonality	Perennial	Perennial or seasonal	Mostly seasonal	Perennial only with ground supply
Water spread (command area)	> 200ha (> 600ha)	50-200ha (80-600ha)	1-50ha (< 80ha)	< 0.1-1 ha (< 1 ha)
Planning and management	State	State or Community	Community	Community or individual farmers
Construction	Outside contractors	State	Community using local materials	Community or individual farmers
Limnology	Natural productivity usually low. CPUE' for stocked species` is low	Higher natural productivity due to vast draw - down	Increasing natural productivity. Highest CPUE for stocked species	Manageable by farmer interventions

Catch per unit effort.

Where species are not naturally recruiting.

Contrary to popular perceptions of 'small-scale simplicity', because of their inherently less predictable nature, some aspects of small-scale irrigation systems (SSIs) are sometimes considered more difficult to manage than larger systems

(Carter, 1992). Smaller storage systems, which harvest surface nut-off waters, are most likely to be seasonal in nature (often holding water for less than 6 months). Such seasonality is a critical factor when considering aquaculture potential, bringing with it a range of constraints and benefits (Box 3.2). Smallscale water bodies which exploit ground water resources, are more likely to be perennial, but are often used as a source of drinking water.

Box 3.2. Benefits and constraints imposed on aquaculture by seasonality.

Constraints:

- **requirement for annual inputs of seed (often advanced fingerlings to take advantage of the shortened growing season)**
- **seasonal availability of large volumes of fish reduces prices and producers' returns**
- **increased potential for conflict with irrigation and other primary uses of water bodies**

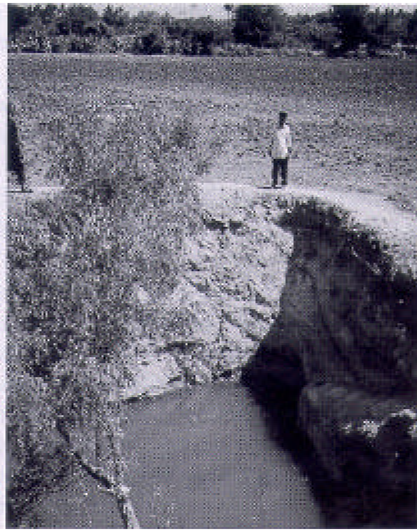
Benefits:

- **improved manageability, including ease of predator control and high catch per unit effort (fishing need not be a full-time occupation)**
- **draw-down areas used for pasture increasing natural productivity**

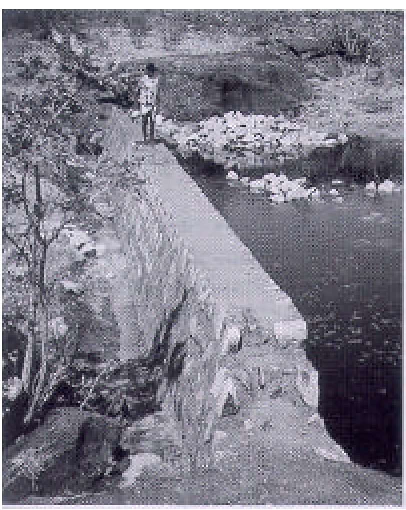
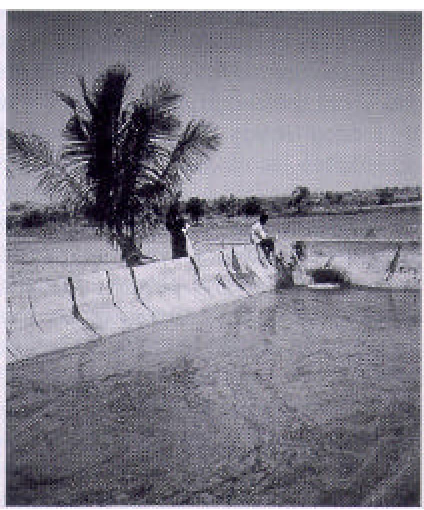
Large or small, the economic and em ironmental valuation of different water uses might be used to quantify the relative costs and benefits of aquaculture, particularly Nvith respect to the primary objective of each system, i.e. water comeyancing in irrigation supply canals, and analysis conducted to deternune who benefits. Other potentially competing uses of water include human and livestock consumption, domestic, industrial needs and bathing. The challenge is to find complementarities between integrated uses which may' improve both equity and productivity over single production outputs. Some of the principal factors that should be considered during site-specific evaluation are:

Cost and benefits of integration The scale of investment required Equity of benefits accruing from aquaculture production The degree of synergy or antagonism of multiple uses Production factors, i.e. access, water quality. quantity and availability of suitable species, of inputs and of markets. reliability,

The constraints to, and opportunities for, the poor to benefit from integration of fish production into large and small-scale irrigation systems are likely to be different as a consequence of both technical and socio-economic factors. With increasing system size, the potential of individual households to participate in water management is progressively replaced by larger groups, whole communities and ultimately outside institutions (Table 3.1). In many' instances reduced autonomy and participation of individual farmers accompanies this progression.

3.1 3.2

3.3 3.4

Figs. 3.1-3.4. Small-scale irrigation devices in Karnataka State, India with potential for aquaculture. Farm ponds are micro-irrigation and ground water recharge devices, open wells are traditional ground water harvesting devices. Fig. 3.1. Farm **pond (highly seasonal); Fig.** 3.2. Open well (perennial); Fig. 3.3. Check dam (seasonal); Fig. 3.4. Irrigation pond (perennial).

Where aquaculture is integrated into major systems and SSIs in close proximity, synergies can be expected to bring indirect benefits to poor people:

- Enclosed fingerling culture in perennial systems used to stock seasonal water bodies, or production of seed in seasonal water bodies to stock perennial systems
- Reduction in fish prices through increased supply
- Creation and strengthening of production, processing and trading networks.

The poorest farmers are often located at the 'tail-end' of large engineered systems and suffer particularly from unequitable and unreliable water allocation, and land degradation due to salinisation, seepage and liability to flooding, all of which compromise their ability to grow crops successfully. Production of fish in borrow-pits (resulting from excavation of soil for other purposes) of small onfarm reservoirs, seepage zones or emergency irrigation ponds may offer such farmers a means of using their limited resources more productively.

Common property resources (CPRs) within both large and small-scale systems may offer opportunities for the landless to participate, for instance through stocking village tanks or small-scale cage culture in reservoirs and canals. However, many issues surround the capacity of the poor to make productive use of CPRs without these being appropriated by more powerful individuals or groups. Legal issues will need to be investigated. Levies placed on production could contribute to the maintenance of communally owned water resources, potentially improving social cohesion. Women are often constrained by a need to stay close to their homes to attend to domestic tasks traditionally undertaken by women. Identification of suitably located CPRs or smaller onfarm water bodies could facilitate their participation.

However, traditional power structures may undennine attempts to utilise irrigation systems for novel uses. Changes may be required at a range of levels, including water and power authorities, local administration and communities themselves. Accommodating alternative users may therefore require new institutional as well as technical solutions.

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