An Evaluation of Floodplain Stock Enhancement

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1. Introduction

The UK Overseas Development Administration commissioned this report within its Fisheries Management Science Programme to evaluate floodplain stock enhancement. Floodplains fisheries are complex systems and the release of reared fish to augment natural production is a comparatively recent activity. This report aims to draw together relevant project experience and current understanding of floodplain systems in a bid to improve the capability of institutions enhancing floodplain fisheries.

1.1 Declining Fish Yields on Floodplains

River systems that flood are composed of a network of permanent aquatic habitats that can expand and link with the seasonally inundated land flanking the main channel during the monsoon. Nutrients from terrestrial sources enter the aquatic food chain as the land floods. Fish have evolved in response to this and move onto the floodplain to take advantage of the rise in productivity. As a result there is a seasonal increase in ichthyomass, from which people living on the floodplain have often derived considerable benefit.

In many floodplain systems, anthropogenic modifications of hydrology (dams, flood control measures and road and rail embankments etc.) and of natural wetland habitats (changed to agriculture) have blocked migration pathways and disturbed or destroyed fish breeding areas and dry season habitats. This, combined with over-fishing, has reduced recruitment to indigenous fish stocks and, so, the potential production that could be expected from the remaining floodplain[1].

The declining fish yields in an environment that provides an important livelihood for millions of people worldwide has prompted much attention from governments, international donors and non-governmental organisations (NGO's). Potentially, there are a variety of solutions that could be applied. For example, release of introduced or indigenous species, habitat rehabilitation or changes to exploitation patterns (banning of gears harvesting juvenile fish or introducing reserves to protect dry season habitats). Of these, the release of seed fish (primarily species of carp) onto the floodplain is the solution that has been applied most extensively.

1.2 Enhancement

Release of seed fish onto the floodplain results in a culture-based capture fishery as both resident species and farm-produced fish are harvested. Culture-based fisheries lie at the interface of aquaculture, when managed extensively, and capture fisheries, when managed intensively (MRAG, 1996). The premise is that the failure of natural recruitment to tap the full productivity of a water body is met by the addition of young fish. Improving yields is dependent

[1] Even when hydrological flows are blocked, inundation will often continue due to high seasonal rainfall. This may be protracted by blocked drainage.

on the correct selection of species for release. A successful species introduction will fill a vacant niche: the greater the competition with existing species the less the production increase is likely to be.

As floodplains are complex physical, biological, social and economic environments an activity such as stock enhancement will never be straightforward. In addition, the objectives of donors and governments involved in stock enhancement extend beyond increasing fish yields. Heavy emphasis is placed on beneficiaries and sustainability of enhancement programmes. This demands that enhancement programmes address the wider issues of resource management - not just the technical aspects of seed fish production and stocking. The challenge is to find an approach that succeeds technically and socially. The design of 'successful' floodplain stock enhancement programmes is the subject of this document.

1.3 Issues in Stocking Project Design

Stocking projects have taken a variety of forms. All, however, have to face a set of basic issues that are critical to the outcome of the project. These include technical, biological, social and economic questions, as to:

- what are the project's objectives;
- which water bodies to stock (where, what size, water quality criteria);
- how to stock (density, species composition, size/age, timing);
- where and by whom are seed fish to be reared;
- what are the objectives of fishery management;
- how is fisheries management to be enforced; and
- are costs to be recovered (and how).

Related to these are a series of institutional questions:

- what is the role of government;
- what is the role of NGOs;
- what is the role of fishers;
- what is the role of the community;
- how to monitor (what and by whom); and,
- how to assess impact.

The answers to these questions are both interrelated to each other and to the biophysical and socio-economic context of the project: what works well in one situation may fail in another.

1.4 Objectives of the Report

This report aims to evaluate these issues and how they are related by examining the experience of a number of projects. These include large-scale floodplain stock enhancement projects from Bangladesh, reservoir stocking projects from Asia and a habitat restoration project from Bangladesh.

This report aims to identify key issues that should be taken into account in the design of stock enhancement programmes. It is not designed to provide a generic package of measures that should be adopted on all stocking projects: design has to be sensitive to circumstances (bio-physical and socio-economic) and to the potential offered by existing institutions.

The approach taken in this review has been guided by the strategy defined for the Fisheries Management Science Programme of the ODA. Essentially the strategy emphasises the need for an integrated approach to fisheries management. This stems from recognition that the interests of people are often both the primary objective and a principal constraint for fisheries management. This evaluation therefore covers both technical and socio-economic issues.

The original project document for this evaluation of floodplain enhancement defined three main outputs:-

- increased capacity of national agencies to maintain or improve the level of capture fishery yields through stock enhancement;
- increased capacity of donors and national agencies to introduce more forward planning for enhancement of capture fisheries' sector; and,
- the distribution of benefits better understood and equitable distribution mechanisms promoted.

The need to consider both technical and socio-economic aspects of floodplain fisheries is acknowledged. To this end, the strategy defined for the FMSP provided useful guidance for this review. The emphasis given to integrated approaches to fisheries management is reflected in the approach taken to meeting the outputs as defined.

Stock enhancement is considered within a wider context of 'resource management' which then raises issues such as the nature of the resource, its users and managers. Despite some degree of private landownership within the floodplain, large components of the fishery are a shared resource for the community of users. As a result floodplain fisheries can be regarded as a special case of common-pool resources[2].

1.5 Report Outline

Chapter 2 begins with an overview of activities required to enhance a floodplain. Three phases are identified and discussed; development of a stocking strategy, fingerling supply and post release. The common-pool nature of the floodplain fisheries is critical to enhancement of the resource. As a result the remainder of Chapter 2 reviews the key principles of managing common-pool resources and applies a framework developed for analysis of these resources to floodplain enhancement. Chapter 3 describes the characteristics of floodplain fisheries and discuses the influence these have on enhancement. This provides a background to floodplain fisheries enhancement from which the experience of past projects can be reviewed. Chapter 4 is the first of two chapters which review enhancement projects: it is devoted to the Third Fisheries Project. The remaining projects are reviewed in Chapter 5. Finally project experience is synthesised in Chapter 6 and key themes which are instructive for design of future enhancement projects are drawn out.

[2] Note that the term 'common-pool' is used in preference to 'common property' throughout this document. A rationale for this is available in Bromley (1992) and Ostrom (1992).

2. A Framework for Evaluation of Floodplain Stock Enhancement

2.1 Introduction

Stock enhancement of floodplain fisheries faces two sets of problems:

i. The development of a stocking strategy appropriate to the floodplain system (i.e. choice of floodplains with greatest potential, species mix, size at first stocking, stocking density, fingerling supply, floodplain management etc.); and,

ii. The development of appropriate institutional arrangements for managing both the stocking programme and the enhanced floodplain: a key component of this is cost recovery.

Neither set can be determined independently and their joint solution must produce outcomes that best resolve the often competing claims of fisheries and/or development policy objectives: economic growth, employment, poverty alleviation, maintenance of biodiversity and economic sustainability.

One of the principle characteristics of floodplain fisheries is that they are a common-pool resource: resource units (i.e. the fish) are subtractable (i.e. what is taken by one fisher is no longer available to another) and users (i.e. fishers) are difficult/costly to exclude[3]. This contrasts with both: *public resources,* which any number of users can share (for example street lighting); and *private resources*, which are limited and restricted in their availability to particular individuals (e.g., fish from a private aquaculture pond). With unconstrained individual consumption/use (fishing), the shared resource (floodplain fish stock) can be depleted. Hardin (1968) characterized this problem as the “tragedy of the commons”. Management of common-pool resources seeks to avoid such ‘tragedy’ through restraint of individual effort, often by some collectively agreed mechanism.

The fact that individual fishers exploit a common resource is fundamental to any management intervention, such as the release of fingerlings. Therefore, the approach taken in this review is to consider floodplain enhancement as a special case of common-pool resource management (CPRM).

The next section provides an overview of the activities required for floodplain stock enhancement and introduces the issues of institutional arrangements, including cost recovery. Subsequent sections explore some of the issues of institutional design for CPRM before looking

[3] See Ostrom (1992) and Bromley (1992).

at its application to fisheries and their enhancement. The framework outlined is then used to structure the remainder of this report.

2.2 Stock Enhancement Activities

The sequence of activities required to enhance a floodplain through release of fingerlings is summarised in Figure 2.1. The activities have been separated into three phases: *development of the stocking strategy* involving assessment of the floodplain and making technical stocking decisions; *fingerling supply* with activities of production and transportation; and finally, *post-release* including management of the floodplain, harvesting and consumption, selling or processing of catch. A brief overview of each of the activities is given below: the review of stocking projects in a subsequent chapter provides more detailed discussion.

■ **Development of Stocking Strategy**

The first activity of the sequence is selection of a suitable floodplain for stock enhancement. Projects may take a range of factors into account to assess a floodplain: the objectives of individual projects will determine which factors are chosen. The following list provides examples of factors which may be assessed:

- Physical (e.g. hydrology, seasonality of the flood, morphology, flood control structures, transport links etc.);
- Biological (e.g. coverage of weed, current productivity and production trends, existing species in the fishery, seasonality etc.);
- Socioeconomic (e.g. history and current status of fishery, makeup of fisher communities, marketing arrangements etc.); and,
- Institutional (e.g. current floodplain management, groups or organisations currently involved in the fishery, level of government involvement, attitudes of potential participants to stocking etc.).

Once accepted for the stocking programme, projects have to decide on which species will be stocked. Selection will be based on, among other things, issues such as the available fingerling production technology, biological characteristics of individual species in reference to the floodplain environment, catch composition of the existing fishery, consumer preference, market value, and costs of production.

Decisions on stocking density, fingerling size, timing of release and effective release points will be determined by a mixture of biological assessment, logistic planning, hydrological attributes and consultation with the intended beneficiaries.

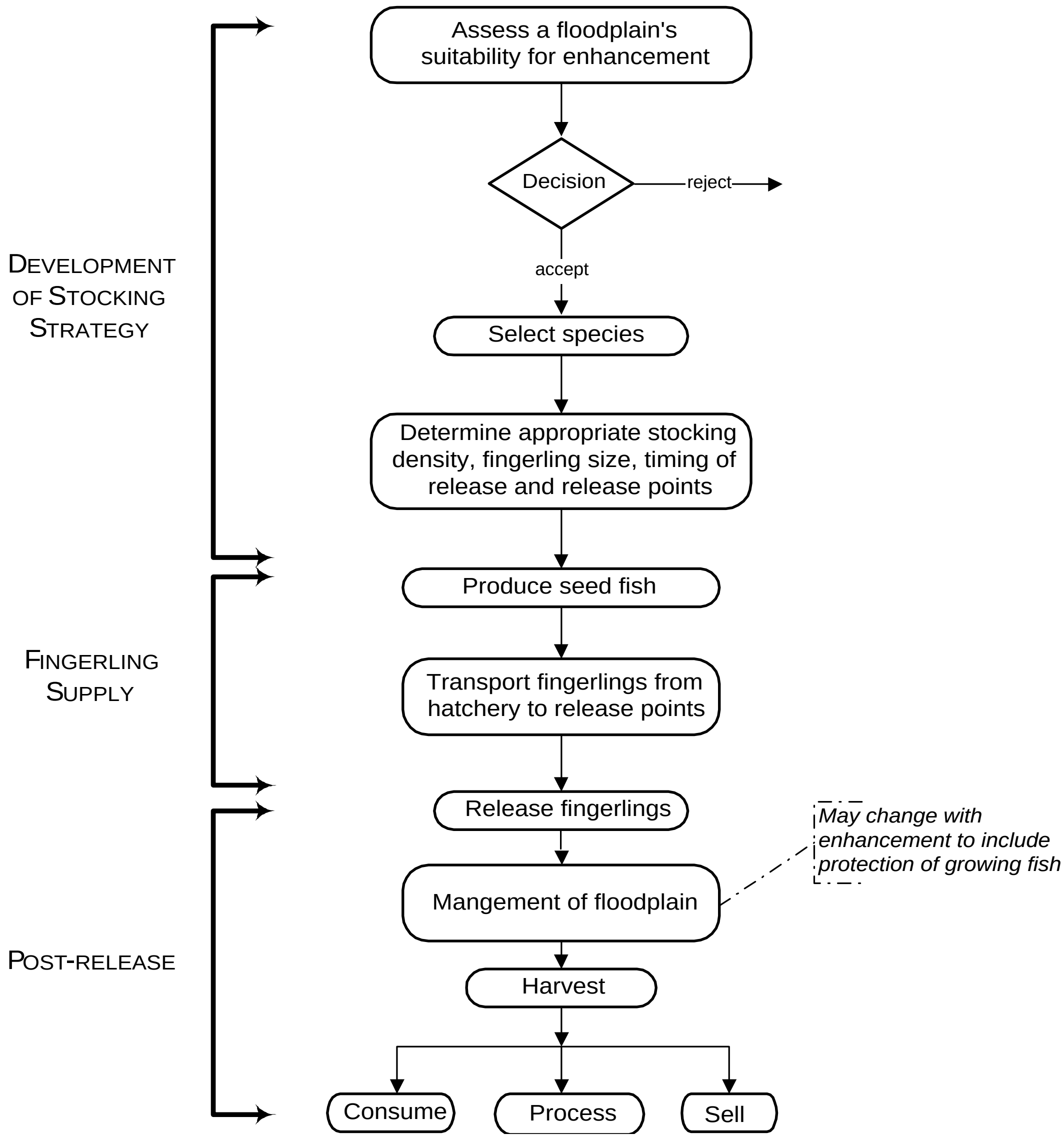


Figure 2.1: Sequence of activities undertaken in stock enhancement of a floodplain

■ **Fingerling Supply**

The large scale enhancement requires the production of millions of fingerlings requiring a cost effective means of mass fry production. For example, at a stocking density of 20kg/ha and mean fingerling size of 7g, a floodplain of 1,000 ha requires 2.8 million fingerlings. Government hatcheries offer one solution for large scale production. But 'back-yard' hatchery techniques can also be used. In Bangladesh, one technique for rearing carp fingerlings devised by a Hungarian specialist as part of a development project over a decade ago, has resulted in a rapidly expanding hatchery industry to support aquaculture development.

Transportation of fingerlings becomes an important issue when hatcheries are remote from release points in the floodplain. Temperature and oxygen are the critical variables to be managed: in general, fingerling survival will be inversely proportional to the distance travelled.

- **Post-release**

The significance of the moment of release depends on the objectives of the programme and the arrangements for funding. If there is external funding available and there is no need for immediate control harvesting, the point of release signifies a change in monitoring strategy. As the fingerlings disperse, grow and are caught by different groups, the outcome of the stocking programme can be assessed only by monitoring its - necessarily - wide-ranging impact.

If, on the other hand, there is a need for control of harvesting, either to protect fingerlings during the initial growth period or to encourage cost recovery, the release of fingerlings marks the point when the common-pool nature of floodplain fisheries resource asserts itself. Prior to this, all the activities could in principle have been taken by either government, or by private enterprise or by local community initiatives.

After release, the management of the resource becomes prone to the difficulties of either controlling fishing effort at all or of doing so without jeopardising the interests of existing - and often vulnerable - stakeholders in the fishery. In this case, much will depend on finding institutional structures and use rules that will permit development of the fishery that promotes outcomes consistent with societal/project objectives.

2.3 Institutional Arrangements for Enhancement

The previous section reviewed the components of stocking and emphasised the common-pool nature of the resource after fingerling release and the corresponding need for appropriate institutional structures to define use rules and encourage their observance. This section looks at the principles that can be used to inform institutional design for enhancement, drawing on insights for the local management of common-pool resources in general and fisheries in particular.

The sequencing of these two sections should not be allowed to obscure the first point made in the introduction of this Chapter: the technical measures of enhancement and the institutional arrangements to support them must be determined simultaneously.

2.3.1 Institutional Analysis and Design (IAD)

In recent years, the management of common-pool resource systems have received considerable attention within the academic literature (Oakerson 1992; Ostrom 1990; Bromley 1992). Particular attention has been paid to factors of management systems that allow sustainable use of renewable resources at levels exceeding those achieved when access is effectively unrestricted. In this, the work of Oakerson has been seminal, providing a focus for the elaboration of theory and a framework for many of the subsequent case studies.

Fisheries management lends itself particularly well to this type of analysis. One recent volume on the management of common-pool resources (Berkes 1989), had four single-resource case studies, three of which were devoted to fisheries. This approach has also been adopted by international research organisations: ICLARM use the Oakerson framework for the analysis of fisheries management systems, using RRA/PRA techniques (Pido *et al.,* 1996). It has been applied directly to problems arising from fish stocking, in Indian reservoirs (Hartmann, 1995), Laotian communal fish ponds (Garaway, PhD in progress) and Bangladeshi ox-bow lakes (DANIDA, 1995).

Figure 2.2 illustrates Oakerson's approach to understanding how a common-pool resource management (CPRM) system works - or how it should be developed. The model identifies four key attributes and the relationships between them. In the context of this report, the *physical, biological and technical attributes of the resource system* refer to the floodplain, the fishery (gears, fishing grounds), markets etc. While the *decision-making arrangements* are the rules (formal and informal) that govern who can fish, where on the floodplain, when and how. The *patterns of interaction* are the collective actions resulting from individual fishers making decisions to co-operate or compete in the fishery. The *outcomes* are resource flows to and from different groups of stakeholders, i.e. the costs and benefits associated with floodplain fishing. Two obvious examples of outcomes include the catch per unit effort or the amount of fish consumed. The objectives of the stocking programme are effectively the desired outcomes for the enhanced floodplain system.

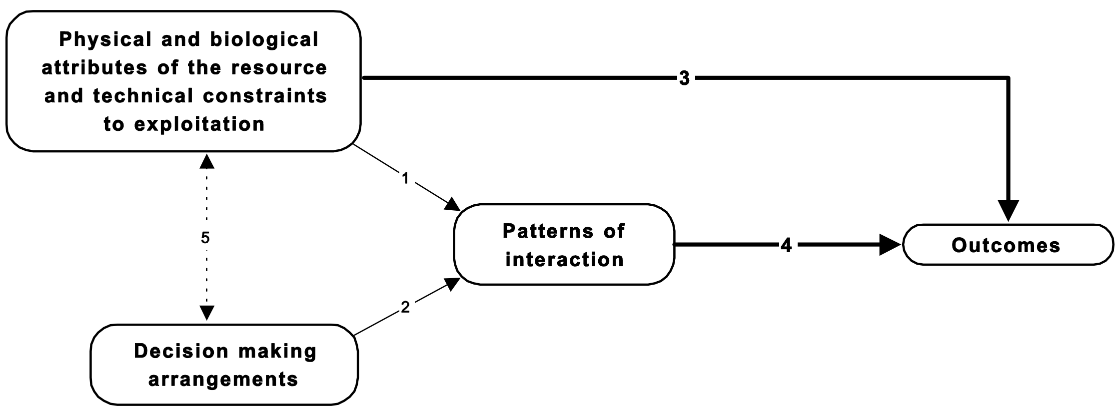


Figure 2.2 : Framework for analysis of common-pool resource management (Adapted from Oakerson, 1992)

The arrows within Figure 2.2 represent the relationship between the components of the CPR system, as identified in the boxes. Outcomes are determined through two pathways: first, arrow 3 represents a direct constraint on outcomes as the characteristics of the resource place the fundamental limit on what is possible in any CPRM system. This direct constraint is independent of human behaviour. The second path can be viewed as indirect as it incorporates human behaviour, this path involves the remaining arrows. An individual (fisher) makes decisions on the basis of the resource, i.e. arrow 1 and the rules governing its exploitation, arrow 2, the resulting collective action of all fishers affects the outcome of resource use, arrow 4. The dashed arrow 5 represents a non-causal relationship that exists, if at all, by human design.

It is argued that, for CPRM in general, the physical and biological attributes of the resource and the technical constraints to its exploitation or enhancement will determine which are the most appropriate decision rules to adopt: those that produce - through the pattern of interaction that they encourage - the desired outcome. Specifically, rules must discourage *free-riding*, whereby resource users allow others to bear the costs of developing or maintaining the resource, as this erodes commitment to the support of common aims and increases the chances of arriving at the sub-optimal outcome produced by open-access.

2.3.2 Application of IAD Insights to Enhancement Fisheries

The application of Oakerson's framework to the design of enhancement projects produces a number of insights. The most important of these is that impact of the project - its effect on outcomes - can not be predicted simply from changes in the size and composition of catch due to stocking (Lorenzen and Garaway, 1997). Changes in these variables can affect outcomes directly but they also affect the incentives of different stakeholders to co-operate and compete within the fishery. The consequent interactions also affects who benefits and to what degree. Use rules can influence these outcomes by changing incentives. Choice of institutional structure is therefore central to ensuring that use rules can be adapted to produce project outcomes in line with project objectives (Ostrom, 1990).

Enhancement projects typically involve at least two groups of actors - the local fishers and an outside agency, which can be government or an NGO. In many cases all three can be involved. In this context, the first stage of institutional design is the choice of which of these institutions are involved and their respective roles in determining technical interventions and changes in use rules to support them. The second stage is the determination of use rules themselves, their adaptation in the light of experience and the mechanisms for their enforcement. The process is not, however, unidirectional -the sort of use rules needed may influence the choice of institutions and the allocation of responsibility between them.

Institutions involved and their respective roles
The current trend in common-pool resource management is towards a greater involvement of the community of users. This is largely in response to the perceived failures of the so-called 'top-down' approach, dominated by centralised planning and decision-making. The inclusion of people who are interacting closely with their resource is widely thought to result in management that is more appropriate and sustainable (Pomeroy, 1991). Arguments for the potential of local control include: use of local knowledge, empowerment of poor, adaptation of technical inputs to local conditions, tighter control on costs, and sense of project ownership by the community.

Where the resource system is complex, variable and large, conflicts are likely between adjacent communities exploiting different components of the same stock. Mechanisms should be in place with suitable arenas (informal and/or formal) for discussion and access to conflict resolution should be rapid and low-cost. All activities should take place in a nested management structure so that support and recognition is provided at many levels from the community through to the government (Pinkerton, 1989). The role of outside agencies is therefore necessary.

NGOs may have a critical role, as - in many countries - they have extensive experience of both promoting groups and mediating in conflicts. Their experience of forming groups for enterprise development would have additional benefits in managing the initial stages of fingerling supply. Government has an important role in facilitating change, by providing enabling legislation and technical support, particularly in the early stages.

Where the benefits of stocking are unproven and local communities may be unwilling take on the financial risk entailed. In this case there may be an argument for government providing initial financial assistance, followed by a gradual transfer of responsibility to communities and NGO's as uncertainties (hence risks) are reduced.

2.4 Use rules required

What rules are appropriate can only be determined in the light of the outcomes that will satisfy the objectives of each project and the local character of the resource. In many cases multiple objectives are assigned, all of which may influence the rules adopted to some degree.

The objective that will most profoundly influence the structure of rules required, however, is that of financial sustainability. Collection of revenue to fund enhancement in the subsequent season requires that harvesting is controlled. In principle, this can be done directly, by managing operations and deducting costs from sales revenues, or indirectly, through a system of gear/catch levies or by sub-leasing portions of the fishery. All imply that access to the fishery must be restricted for some gears and/or in some seasons, raising the possibility that some groups may lose out from enhancement.

Ideally, the outcome of enhancement would result in a balance between costs and benefits for all stakeholders. This is achieved most easily if there is homogeneity in gear use and dependence on the fishery (Pinkerton, 1989). But, even where all stakeholders would stand to benefit from the proposed intervention, this does not guarantee they will not try to free-ride - obtain the benefits without bearing their share of the costs. In enhancement programmes this could take a number of forms: failing to contribute to communal labour, fishing in a closed period or area or with a prescribed gear, non-payment of fees owed etc.

Avoiding this problem is often done best by a system of mutual monitoring. Rather than rely on an outside agency to enforce regulations, they can be enforced by fishers themselves within a framework that is sanctioned or at least accepted by the state. This provides an additional and powerful argument for providing a central management role to local organisations in which fishers participate. These are then well placed to encourage collective modifications in behaviour appropriate to the condition of the fishery, impose social sanctions on rule breakers and act as arbitrators in disputes. For this to be possible, two main conditions have to be met.

The first, which is emphasised strongly by both Ostrom (1990) and Pinkerton (1989), is that the boundaries of the system and the membership of the group entitled to use it must be clear. Without mutual recognition of resource users, there can be no mutual monitoring. A corollary of this is that this form of management works best the smaller the area of the resource system and the fewer the number of communities/fishers involved.

The second condition for local enforcement of regulations is that there is an accepted schedule of sanctions, graduated in severity, that can be applied to rule breakers. If resource users are linked by kinship, then simple social sanction can be powerful. A shared ethnicity may also serve in this regard, though to a lesser degree. But more than this is often necessary: ideally there should be the ability to levy fines and, ultimately, to exclude rule breakers from the fishery altogether.

2.5 Framework for Evaluation of Enhancement Fisheries

Enhancement is usually proposed as a solution to declining yields, particularly of major carps, on the floodplain. Figure 2.3 adapts Oakerson's framework to illustrate the process by which floodplain fisheries are enhanced. The top box represents floodplain fishery being considered for enhancement. The shaded box represents the enhanced floodplain fishery. This includes management (enhancement) objectives and strategies that change the characteristics of the fishery and the arrangements governing its management to improve the outcomes of resource use.

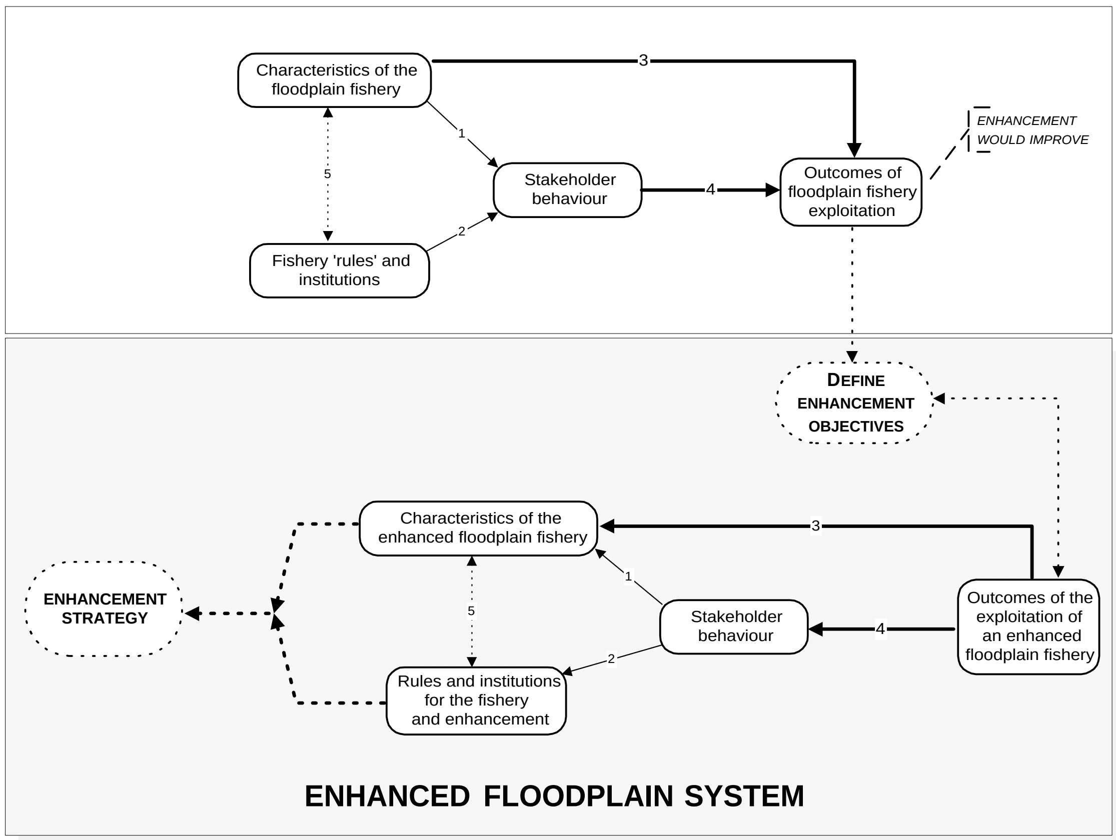


Figure 2.3 : Process of floodplain enhancement (Adapted from Oakerson, 1992)

In overview, the particular characteristics of floodplains directly determine what range of outcomes are possible when the fishery is exploited. Individual stakeholders respond to the opportunities presented within a framework of restrictions provided by the rules - formal and informal - which govern fishing activities, access regimes and marketing of catches. The aggregate pattern of behaviour which results determines the pattern of outcomes.

The outcomes of management interventions, such as enhancement, will only be 'successful' if the strategy adopted is appropriate to local conditions. This implies that the behavioural responses of different stakeholders to changes in resource characteristics must be anticipated and, where necessary, guided by appropriate modifications in rules of use. Failure in this regard can lead to seriously sub-optimal outcomes, even when technical stocking targets are met.

2.6 Summary

This chapter has introduced the stocking process and briefly discussed the issues facing stock enhancement. Given floodplain fisheries are common-pool resources (CPR), we reviewed the key characteristics of CPR's to provide background to the discussion in subsequent chapters. As stock enhancement is a management intervention in a CPR, we introduce Oakerson's framework as a tool used extensively in this evaluation. Oakerson developed the framework in a bid to find a systematic approach to common-pool resource issues. It allows the integrated description and analysis of commons management. We have adapted the framework to illustrate the particular resource management situation under review, i.e. floodplain enhancement.

3. Characteristics of Floodplain Fisheries and their Influence on Enhancement

3.1 Introduction

The seasonal inundation of low lying land creates a complex environment, the floodplain. This has been divided into two components: the plain which will be dry for at least some of the year and the permanent water bodies (Welcomme, 1985). Its main source of nutrients is from the decay of terrestrial vegetation during the seasonal inundation. A multiplicity of species have evolved to take advantage of the resulting rise in productivity, leading to a rapid expansion in biomass during the high water period. In unmodified systems this is broadly proportionate to the flooded area[4], which varies from year to year.

As the floodwaters recede, the fish become concentrated as they migrate back to the rivers through the connecting channels or in the permanent water bodies, leading to a sharp increase in their catchability. The seasonal improvement in the catch to effort ratio corresponds to a leap in the potential economic surplus. In the richer fisheries, competition for this surplus can result in conflict unless there are socially accepted mechanisms for allocating fishing opportunities.

This variability in biomass, catchability and potential economic surplus produce complex patterns of stakeholding in the fishery. Seasonal variability means that there can only be limited permanent employment but much scope for seasonal fishing. There are also often established claims to fishing rights on (the parts of) water bodies where the fish become most concentrated during and after the drawdown.

These characteristics pose a number of problems for agencies seeking to enhance the fishery. Where this exercise is funded externally, the main problems relate to the choice of species, means of rearing and delivery to the point of release and the subsequent management measures adopted. In this, technical decisions must be conditioned by their influence on the possible outcomes for different groups of potential beneficiaries. A further level of complexity is added where enhancement has to be self-funding, as the rules that govern harvesting in one season must generate the resources necessary for stocking in the next.

This chapter uses the Oakerson framework outlined in the last chapter to look in greater detail at the characteristics of floodplain fisheries and the problems they create for enhancement. Each section concludes with a discussion of their implications for enhancement.

[4] Temple and Payne (1995)

3.2 Physical and Biological Characteristics of the Resource and Technical Constraints

The physical characteristics of the resource and means by which it may be exploited constitute the first component of the Oakerson framework. Their features place important constraints on the potential for enhancement and the degree of uncertainty attached to it. The relationship between different elements of a floodplain system is represented in Figure 3.1.

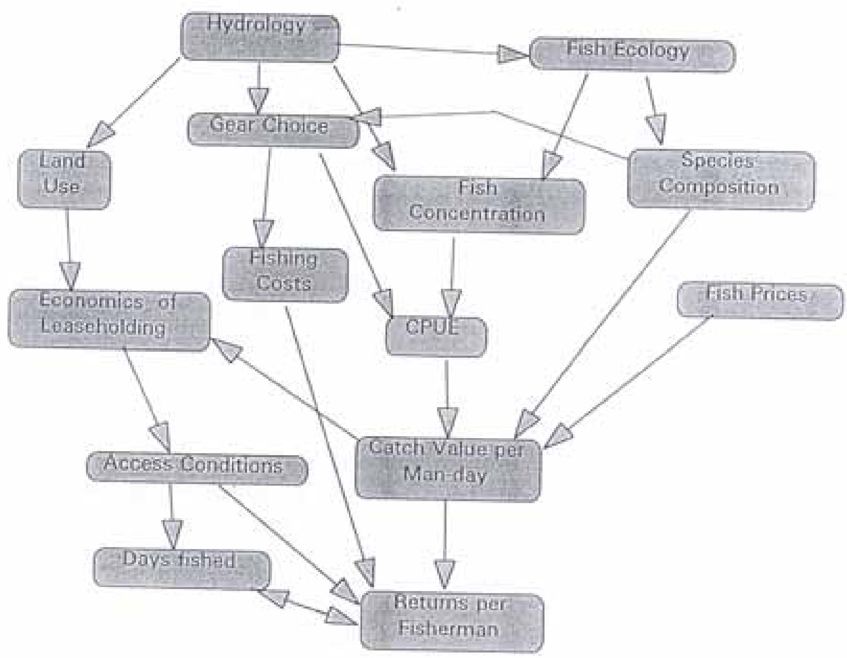


Figure 3.1 Floodplain characteristics and their influence on fishing incomes

The main components of the floodplain system are examined below. It starts with a brief discussion of fish ecology before moving on to the other elements of the system that will influence the outcomes of enhancement: the size, composition and value of catch, and the distribution of the benefits these bring between different stakeholders.

3.2.1 Fish Ecology

The species that make up the floodplain fishery can be divided broadly into two groups, based on the form of their adaptation to the harsh, deoxygenated conditions of the low water period. Using the terminology originally developed for the Mekong and adopted by Welcomme (1979, 1985), *whitefish* avoid the severe conditions of the floodplain - high temperatures, deoxygenation - by migrating to the river channels or into the deeper permanent water bodies. *Blackfish* have become adapted to these conditions using a variety of mechanisms. Many are capable of breathing air to so some degree; others make use of the more highly oxygenated water in the surface layer; a few are able to withstand the desiccation of the water bodies.

Spawning is timed so that the hatchlings can take advantage of the massive increase in primary productivity caused by nutrients entering the aquatic system as the floods expand (Cross, 1992) and entails considerable lateral migration from the rivers for lentic species (Temple and Payne, 1995). But floods, particularly on the smaller streams, can be erratic. In response to this uncertainty, a variety of strategies have evolved, such as multiple spawning or eggs that may pause in their development in response to environmental conditions (Welcomme, 1979).

The complexity of the floodplain habitat - in terms of substrates, vegetation types, water conditions etc. - provides a multitude of ecological niches. This is reflected in the numbers of species present. Rahman (1989) has described over 240 species of freshwater fish in Bangladesh. Size tends to vary by around three orders of magnitude - 1.5 to 1500 cm. But the majority of species are small, allowing them to reach spawning size within one season (Welcomme, 1979).

The adaptation of *blackfish* species to the natural uncertainties and stresses of the floodplain means that floodplain fisheries are highly resilient to environmental perturbation, even if some species are lost. Enhancement of the fishery usually augments the number hatchlings of the migratory species, particularly carps, that are more vulnerable to change. In some cases new species have been introduced. But replacement of the existing species is not an objective. The enhanced stocks are often, therefore, only a minor component of the fishery that results. The continued existence of the “wild fish” fishery poses problems for the development of rules to moderate fishing activity to benefit the enhanced stocks or to collect revenue to pay for stocking.

3.2.2 Hydrology

The existence of a relationship between hydrology and fish production is well established. Analysis of data from Asia and South America showed significant correlation between fish catches and river discharge rates (Payne, Crombie, Halls and Temple, 1993). But the hydrology of floodplains differ significantly in ways that affect the potential outcomes from enhancement.

The seasonal fluctuations in the areal extent of water, and the effect of this on floodplain nutrient recycling, are the principal driving force of fish ecology. The spatial variability in hydrological characteristics determines which areas have the greatest potential catch. The year to year variability in flooding is correlated with the year to year variation in production from wild stocks and is a major influence on the risks of enhancement. Modifications to hydrology, either intended (flood control) or unplanned (roads and rail embankments), influence wild stocks and the opportunities for enhancement.

- **Seasonal Pattern**

The seasonal pattern of flooding depends on the timing and distribution of rainfall within the river catchment. In the tropics, it is usually closely linked to the monsoon. The timing of overspill from the river channels is determined largely by the amount of rainfall in the upper catchment, sometimes hundreds of kilometres distant. Rainwater flooding is influenced by the local level of precipitation, by local topographical features and by the height of rivers into which this water will drain - if the rivers are high, impeded drainage can produce or prolong flooding.

The seasonal cycle can be divided into four phases: the rising flood, the peak flood, the falling flood and the low water period (or dry season). Catch levels are strongly influenced by flood phase. Figure 3.2 shows catch rates (per month) on two sites studied by FAP17. In the *beel* site, which included the main floodplain depression, catches peaked in October, during the falling flood. The adjacent floodplain site, NC04, which was on a slightly higher elevation, also peaked in the same month.

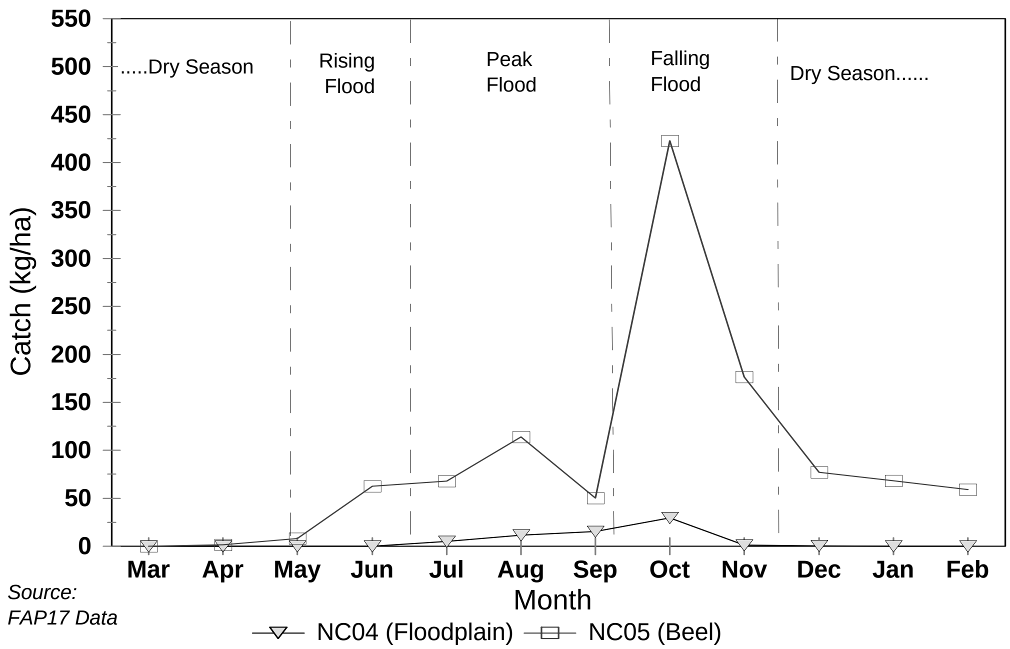


Figure 3.2 : Monthly catch rates at two sites in Bangladesh (FAP17 data)

■ **Spatial Variability**

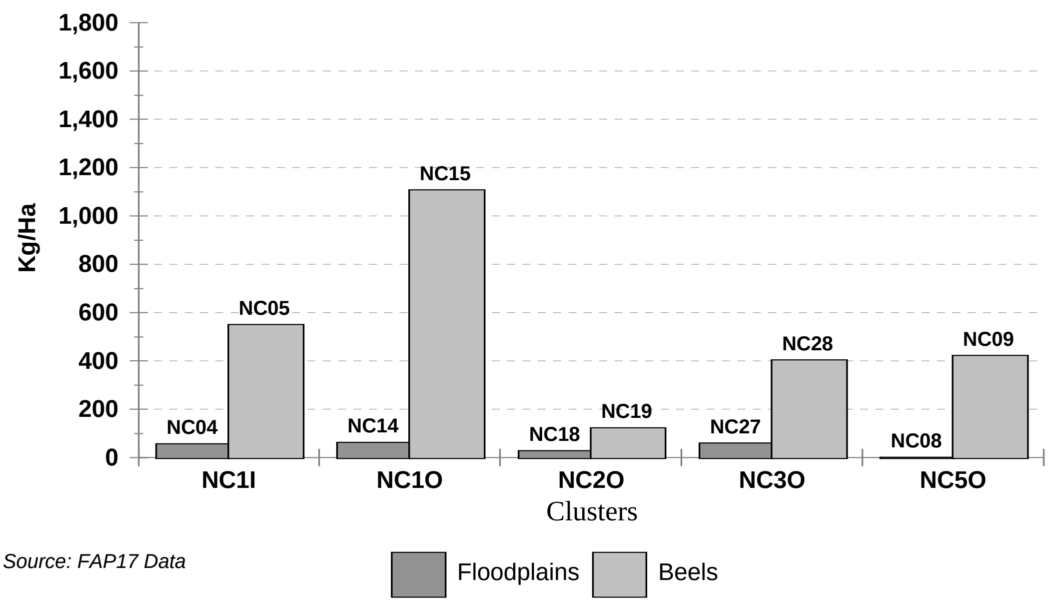
There can be important differences between floodplains, even within the same catchment. Attention has been drawn to the influence on fisheries production of both the proportion of the area covered by permanent water, which influences levels of the breeding stock mortality (fishing and natural), and the average length of flooding, which influences the level of nutrient recycling, (Welcomme and Hagborg, 1977). Depth of flooding influences the type of gears that can be used, and the groups able to fish, at different stages of the season.

Micro level variations are also important. Cut-off channels (ox bows), which result from meander development associated with lateral river channel migration, provide significantly deeper areas that can promote the survival of breeding stocks during the dry season.

Even where two floodplains have similar hydrological characteristics and floodplain features, differences in scale can significantly affect the problems of fisheries management or enhancement. The area of a floodplain and the number of people who may have access to its fishery is likely to be a geometric function of the diameter of the basin. In the north-east of

Bangladesh floodplains are sometimes 5 km from ridge-crest to ridge-crest, in the south-west they may be only 1-2 km.

Variations within floodplains are also critical. The concentration of fish in the lower parts of the floodplain during the drawdown results in fishing hot spots. The difference in the relative catch per unit area on a floodplain depression (*beel)* and its adjoining floodplain, illustrated in Figure 3.2, was by no means exceptional. Results from other pairs of sites surveyed in the North Central region of Bangladesh by FAP17 are presented in Figure 3.3.



Source: FAP17 Data

Figure 3.3 : Annual CPUA for beels and adjoining floodplains in NC Bangladesh

The degree of contrast is affected by floodplain characteristics - the extremely high CPUAs were on small oxbow lakes, NC15 and NC05. But site pairs in other regions surveyed by FAP17 also demonstrated contrasts. The extent of the differences found varied with local topographical features and management regime. In the South West, where floodplains tend to be smaller and relatively shallow, CPUAs on depressions sites were typically 2-3 times larger than on the higher part of the floodplain. In the North East, which had larger deeper depressions where the fisheries were more tightly controlled, the ratio was in the range 5-10 times.

This spatial variability has important consequences for enhancement. Stocking will increase the value of controlling areas where production tends to become concentrated. This can disproportionately benefit those with existing claims to access rights to these areas, see Section 3.3.1, whether this be particular communities, groups or individuals. Even where prior claims either do not exist or are not being exercised, there is a danger that landowners or local elites may attempt to capture the benefits for themselves. Attempting to (re)negotiate access rules is likely to be easier before stocking than after, when vested interests have been established.

But local concentration of catch also brings opportunity, as it reduces the costs of harvest control. This may enable the capture of a sufficiently large fraction of the economic surplus generated to fund future stocking.

■ **Year to Year Variability**

Welcomme notes the relationship between the flood regime and fish abundance. The 'general conclusion that the fisheries production of the Danube is directly proportional to the extent and duration of floods has proved equally applicable in all other rivers investigated' (Welcomme, 1979).

Even in the humid tropics, year to year variability in rainfall is significant. But the inundated area is an amplification of this, as flooding is a function of the river height relative to the point where the banks are overtopped. The significant year to year variations in the area flooded in Bangladesh are given in Figure 3.4.

Figure 3.4 : Area flooded in Bangladesh, 1954 - 89

The contrast between years has been partially documented by FAP17, whose monitoring of sites in the North Central Region covered the drawdown of two seasons (1992/3 and 1993/4) with contrasting flood characteristics. Catches were 39%, 53% and 59% lower in rivers, canals and floodplains in the first year, which was less flooded (FAP 17, 1995).

■ **Modifications to Hydrology**

The hydrology of floodplains, particularly those in the more densely populated parts of Asia, has been subject to modification for millennia. But the pace of change has increased significantly over the last 50 years. Changes have been direct, both intentionally (flood control and drainage projects) and incidentally (roads and railway embankments or increased extraction of water for irrigation), and indirect (changes in land use causing siltation) (Naruzzaman, 1992). Their impact on fish production has been felt through changes in patterns of recruitment - if migration routes are blocked, overwintering habitats impaired, or lower water levels allow a more complete harvest.

In Bangladesh, where more than 40% of the floodplain can be considered modified (Temple and Payne, 1995), FAP17 demonstrated a significant impact in the composition of catch at sites where flooding had been controlled to some degree (FAP17, 1995). Interestingly, in many cases flood control served to reduce hydrological fluctuation during the peak flood, rather than eliminate flooding altogether. Catches in the protected areas were often not significantly lower in the weight per unit area, despite lower fish densities, because the intensity of fishing pressure was higher.

Where changes in hydrology are the prime cause for declines in wild stocks, enhancement may be achieved most cost effectively by moderation of these changes. For instance drainage can be improved or regulators managed to improve entry of hatchlings onto the floodplain. Roads and railway embankments can be built with culverts.

3.2.3 Fishers

The seasonality of fishing opportunities and the wide diversity of gears needed to exploit the fishery to the full, encourage significant heterogeneity in patterns of engagement. The FAO have a three tier classification of fishers: occasional, part-time and full-time.

Compared to other types of fishery, occasional fishers are more significant in floodplains, due to the bio-physical characteristics of the resource. Floodplain homesteads tend to be located on natural ridges or levees, sometimes on mounds raising them above the higher floods. The flood margins often reach up to or into the settlements, bringing with them the chance to catch fish using a variety of cheap, hand-held gears. The high floods are also the agricultural slack season. So, though catch per unit effort during this period is low, so too are the opportunity costs of fishing. Widespread participation in the fishery is also encouraged in many parts of Asia and Africa by the tradition of fish drives, when the depressions are fished out communally by members of the local communities (Welcomme, 1979). In Bangladesh, 50-70% of rural households engage in occasional subsistence fishing (FAP17, 1995).

Full-time fishers are limited in their numbers and can have a distinct social identity. Fluctuations in hydrology produce a changing mosaic of fishing opportunities through the year. Opportunities are most constrained during the dry season, when the areas of remaining water can be jealously guarded until fished out. Full-time employment in fishing is possible for some but requires mobility between aquatic sub-components of the floodplain system, particularly when stocks have longitudinal as well as lateral migrations. This mobility, together with the social taboos that limit engagement in professional fishing in many societies, often helps to give professional fishers a separate social identity. In most of Bangladesh, fishing for sale was traditionally considered demeaning by the largely Muslim agriculturalists and, as in India, full-time fishing was undertaken only by particular Hindu castes or distinct Muslim groups, such as the *maimols* in the North-East. (These restrictions have been gradually relaxing over the last three decades.)

Part-time fishing, the intermediate category, assumes a particular importance on floodplain fisheries because of the seasonality of catch opportunities. Its absolute significance varies with local hydrological conditions and the force of social custom. In Bangladesh, part-timers were the dominant category in the floodplains of the south-west.

The distribution of catch value between different categories for different floodplain habitats in different regions in Bangladesh is shown below in Table 3.1. In this table fishers are differentiated into four categories instead of the three used by FAO. There are important regional variations: subsistence fishers are significantly more important in NC than elsewhere; full-time professional fishers take a significantly larger proportion of the catch on the *beels* in some areas (NE and NW); the patterns of exploitation differ between habitats. Some of these differences can be explained by social custom or management practices. In the NE and NW, *beels* are more often intensively managed by leaseholders who require fees to be paid for access or who employ professional fishermen directly. In the NW, the higher catch taken on *khals* (the connecting channels) by subsistence fishers reflects the still significant taboo among many Moslem households against fishing practices that involve them getting wet. On *khals* it is possible to use small lift nets from the bank and much of the catch is taken in this way.

The most important feature of this table, however, is that it illustrates the range of participation in all habitats and all regions. Only in the *beels* of the NE and the NW is more than 50% of the value of the catch taken by a single group of fishers. Thus in many floodplains, fishers will tend to have neither a similar stake in the fishery nor a similar interest in its improvement.

Table 3.1 : Distribution of catch value between different fisher categories by habitat and region

Region	Habitat	% Value of Catch Taken by			
		Fishers for Whom Fishing as Source of Income is			Subsistence fishers
		Sole	Primary	Secondary	
NC	*Khal*	45.1	4.9	14.8	35.0
	Floodplain	18.5	4.1	15.4	61.2
	Beel	14.8	4.0	23.7	57.5
NE	*Khal*	30.8	6.8	41.1	21.2
	Floodplain	26.6	28.5	23.9	20.8
	Beel	74.5	9.1	7.7	8.7
NW	*Khal*	18.3	10.8	35.1	35.8
	Floodplain	26.5	19.9	39.2	14.5
	Beel	52.7	14.6	26.5	6.1
SW	*Khal*	9.9	28.9	30.6	30.6
	Floodplain	1.7	35.6	44.5	18.2
	Beel	2.6	32.0	51.1	14.3

Source: FAP17 Data

This heterogeneity of participation creates important problems for enhancement, as it complicates the trade-offs that may be involved. In some cases, the problems created by this could be moderated by targeting management interventions at gears associated with particular groups of users.

3.2.4 Fishing Gears

The complexity of the floodplain environment encourages a wide variety of fishing activities adapted to the conditions found in different periods of the flood cycle in different habitats. Many of these are targeted towards particular (groups of) species with particular behavioural or size characteristics. In Bangladesh, the FAP17 project, categorised over 100 different gears (FAP17, 1994). On one fishery on the Ogan-Komering floodplain in South Sumatra, there were 25 "main" fishing methods, many with minor variants on features such as mesh size (Hoggarth and Utomo, 1994). The methods and gears used, while having local names and design features, display striking similarities in form across floodplain systems. Seine nets, gill nets, cast nets, traps, hooks and lines, dewatering, fish drives and barriers are all common, though their relative significance varies with hydro-morphology and season.

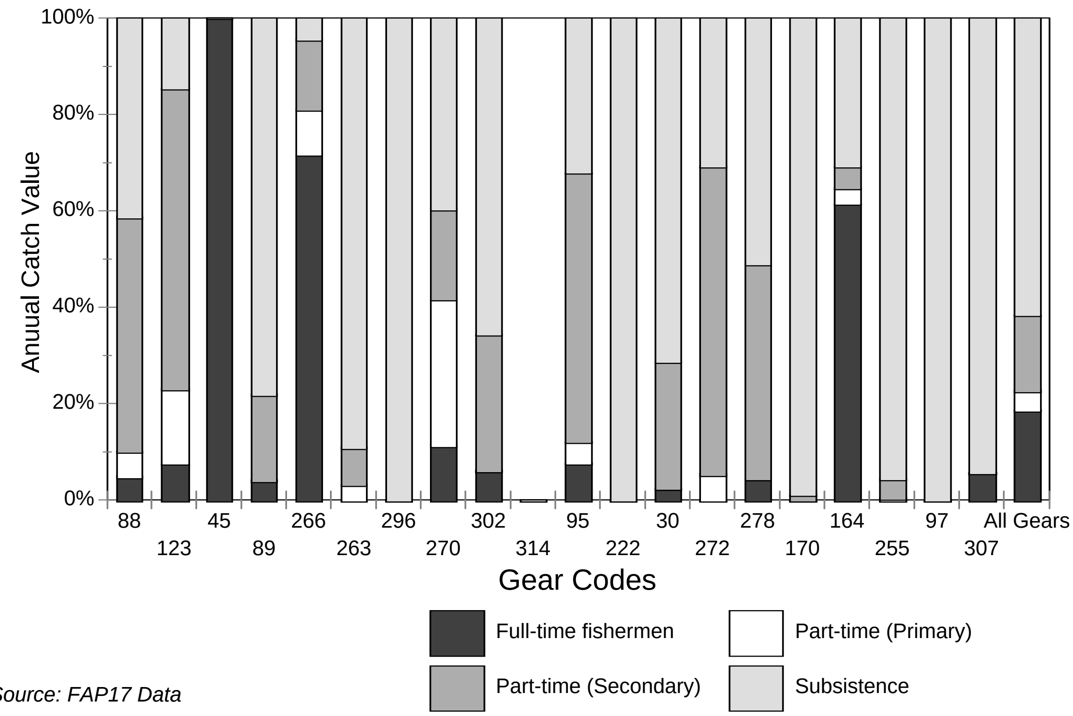
During the rising and receding floods, fishing methods are designed to take advantage of fish movement, directing them to places where they are more easily captured or retaining them in floodplain depressions where they can be captured more easily later. Barrage traps are common on the slower moving channels. In larger channels, static trawl nets and wing-traps are used, often with very high catch rates (Welcomme, 1979).

During high water season, when fish are foraging and widely dispersed, the main gears are gill nets, traps and hooks and lines.

During low water, as fish are more static, fishing methods tend to be more active. Seine nets and cast nets are widely used, often in conjunction with barriers or fish drives. In Bangladesh, the largest of these operations can involve the co-ordination of 10 or more teams of fishers and considerable prior investment in barriers and fish aggregating devices. These are complemented by the use of a variety of more specialist gears targeting fish evading these methods. Hook lines are used to capture larger predatory species. Fish can be extracted from fringing vegetation using traps, hooks or hand-nets made from robust netting or basket work.

Many of these gears are operated on a purely individual basis. Other gears, while deployed by an individual, may at times yield higher returns when their use is coordinated with others. But many of the largest, most efficient and costly gears have to be operated by a team. This produces patterns of gear ownership that, in some areas, corresponds to the status of the fisher, as professional fishers are more willing to invest in the larger, more costly gears and have greater levels of skill in using some of the smaller ones, such as cast nets.

Figure 3.5 illustrates the proportion of catch value taken by the same fisher categories in Table 3.1 above for each of the main gears in floodplain sites in the NC region of Bangladesh.



Source: FAP17 Data

Figure 3.5 : Catch value distribution by gear and fisher category, NC floodplains

In this habitat professional, full-time fishers take the majority of their catch with three gears - large seines (45), large lift nets (266) and cast nets (164) - and they dominate the ownership of all three. Knowledge of this skewing of the distribution of particular gears towards different groups, is an essential first step in identifying those who might gain or loose from stocking and its associated management measures. It is essential, though, to recognise that these divisions are not immutable and could respond to the changing set of opportunities.

But such a picture does not always hold. In the SW of Bangladesh gear ownership showed little association with fisher type, see Figure 3.6. Clearly, targeting any one of these groups by specific gear controls is unlikely to be successful.

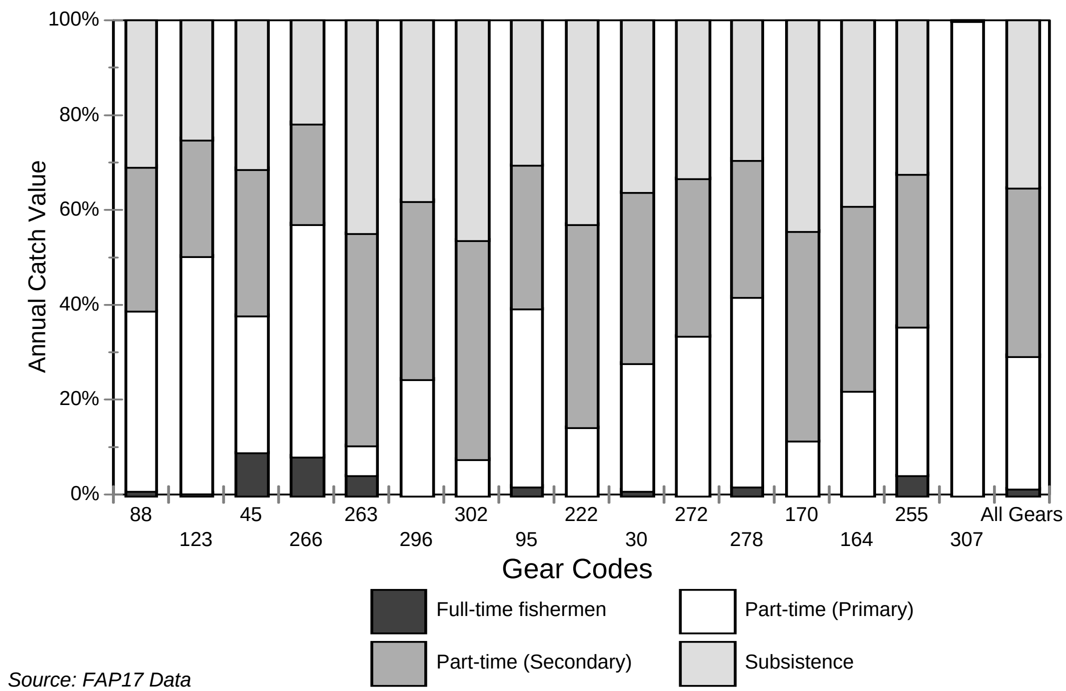


Figure 3.6 : Catch value distribution by gear and fishes category, SW floodplains

3.2.5 Fish Marketing

The marketing arrangements for these fisheries reflect the biophysical characteristics of the floodplain. Much of the fish is not marketed at all, as it is caught by subsistence fishers and there are few permanent primary markets, due to the fluctuating boundary of the flooded area.

Fish traders are as varied in terms of their degree of involvement as are fishers. A large number of occasional or part-time fishers are likely to become traders when they have catch to dispose of; and the sale or barter of fish is frequently carried out by the household members of the fishers themselves. Other rural households may regard fish trading as a seasonally important source of income in which they engage on a regular basis (FAP17, 1994b).

In addition to these "opportunistic" fish traders there are also groups of professional fish traders who are more or less completely dependent on fish trading as a source of income. These groups exist in various levels of the fish trading hierarchy.

On the one hand, there are specific communities in rural areas who are associated with fish trading. Sometimes these may be groups of traditional fishers who, because of changes in local water bodies or competition with other fishers, have been forced out of fishing and have moved into fish trading as an alternative. Groups of Hindu fishers who have turned to fish trading as a profession were encountered by FAP 17 researchers in several areas in the North Central and South West regions.

Significantly, the process can also function in the opposite direction, with groups of fish traders becoming increasingly involved in capture fisheries. In the North Central Region, a community of professional Muslim fish traders has, over the past 20 years, turned increasingly to capture fishing on local *beel* and *khal* as the Hindu traditional fishers who had exploited these water bodies in the past migrated out to India. They are now the most important group of fishers in the immediate vicinity and have also become very active in fish culture in the area (FAP 17, 1994b, 1995).

As a result of this fluidity in marketing channels, placing any form of levy on catch as it leaves the floodplain is extremely difficult, except where there is a tightly controlled fish-out. These occur on some of the richer floodplain depressions or in connecting channels during the dry season. This limits the options for revenue collection, as a fixed share of catch - which might be attractive in terms of equity - is hard to enforce.

3.2.6 Implications Floodplain Enhancement

Floodplain fisheries are highly variable, spatially and temporally, as is the nature and degree of participation of different categories of fishermen. The timing and extent of flooding is often unpredictable, making catch magnitude highly uncertain.

Some of these features fishery act to improve the potential for enhancement. The wide dispersal of fingerlings during the peak flood reduces their vulnerability in their initial growing period. The concentration of catch in certain areas creates an opportunity to control harvest and so improve cost recovery.

But many of these features do not assist enhancement. In particular the size and variability of the resource and the groups exploiting it make it difficult to gain consensus among fishers, to agree strategy or undertake mutual monitoring, and to control harvest so as to recover costs.

3.3 Decision Making Arrangements

The aspect of needs for floodplain enhancement involves the path by which patterns of interaction influence outcomes. The forms of interaction which dominate within a floodplain fishery are determined by the reaction of different stakeholders to the opportunities that it offers them. Incentives to act are provided by the characteristics of the resource together with the decision making arrangements that apply to it. Most floodplain fisheries will, in different seasons and/or habitats, demonstrate a variety of types of interaction. These occupy a spectrum between the purely competitive and the purely co-operative.

The potential advantages of co-operation are derived from two distinct sources. The first relates to the advantages of delayed capture - a common characteristic of many fisheries that is accentuated by floodplain hydrology. Delayed capture carries with it the advantages of maximising production by avoiding growth over fishing. But on floodplains delayed capture also results in reduced average costs as catchability increases significantly through the drawdown and/or into the low water period. The second advantage of delayed capture, which applies only in certain circumstances, relates to the advantage of co-ordinating operations to increase the vulnerability of fish to capture.

However, most interactions on floodplain fisheries tend to be competitive, as the catch of one gear reduces the stock available to another. Particularly in the earlier part of the season, this competition is mild. But as the drawdown progresses, the impact of gear interactions on potential incomes is recognised by fishers, who can be found in conflict on the more intensely exploited fisheries, if unregulated. But even where there are use rules designed to avoid such conflict, competition often persists in the form of poaching. This is a particular problem when use rules lack either an unambiguous definition or universal acceptance or when enforcement capacity is limited.

At a theoretical level, decision making arrangements include sets of rules on three distinct levels (Ostrom, 1990). *Operational rules* relate to issues such as: who can fish; when; where; with what gear; and even how the catch must be disposed. *Collective choice rules* determine how operational rules are decided upon. While *constitutional rules*, in turn, determine how collective choice rules are set. The degree of formality with which rules at these different levels are defined may vary. In many cases, the extent to which constitutional rules - or even collective choice rules - are open to debate and modification may be limited, as considerable weight can be attached to custom and precedent.

Rules based on local precedent can be closely tuned to the characteristics of the resource - connection 5 in Figure 2.2 - and produce outcomes consistent with the underlying political economy of the communities in which they have evolved. But this is not to suggest that changes in the character of the resource due to enhancement will result automatically in appropriate changes in operational rules. Nor does it mean that outcomes mediated by such rules, even if changed by accepted procedures, will be in line with project objectives.

While decision making arrangements have no direct impact on outcomes, they can be critical in determining the ways in which different groups gain access to the resource and the extent to which the activities of one group impinge on another.

3.3.1 Types of Rules and Their Influence on Outcomes

Generally, in floodplain fisheries there are different sets of rules for different periods/locations. During the high water period, access to the fishery is often unrestricted, at least within the adjacent community. But later, fishing opportunities in the connecting channels and the floodplain depressions are often subject to some degree of control. Methods of access control adopted vary significantly, from fish drives where all members of the local community are entitled to participate (Hoggarth, Aeron-Thomas, Sarnita and Ondara, submitted), to leaseholder controlled fishing operations, where fishers are simply employed as day labourers (FAP17, 1994c, 1994d).

■ **Indonesia**

In Sumatra, Indonesia, on smaller localised fisheries decision making is, by tradition, taken at the village level. Community fish drives on floodplain depressions were a well established annual ritual; these lasted two or three days, involved large numbers of people using relatively inexpensive gears and resulted in a wide distribution of benefits. But other components of the system, such as the connecting channels, can be leased out to groups or individuals and then operated at their discretion. This allowed investment in large, capital intensive gears, such as barrier traps, producing a high economic surplus, which brought benefits to the community through the lease fee (Hoggarth *et al.*, submitted).

In contrast, on the Ogan-Komering river system, where the floodplains were larger, the fisheries richer and there was no association with any particular community, decision making is taken at the District level. Here a traditional system of leasing through auctions is used. Operational rules on each water body are then entirely at the discretion of the leaseholder. Many of these leased water bodies are fished out by groups, using large barrier gears or fish drives during the low water period. Lessees allow individual fishers to use certain gears earlier in the season subject to payment of a licence fee (Hoggarth and Utomo, 1994).

In Sentarum, in West Kalimantan, a traditional village-based management system is used that allocates opportunities for gill netting, sometimes through a lottery. Co-ordination of fisheries exploitation over the whole floodplain system is being established through the creation of an umbrella organisation.

- **Bangladesh**

In Bangladesh, the floodplains are open access during the high water period. On the many floodplain depressions and perennial water bodies, there are a variety of systems of access control, where decision making may be exercised by different actors. In this, there is considerable regional as well as local variation (FAP17, 1995).

For perennial water bodies of more than 20 acres (8.1 ha) fisheries leases (*jalmahals*) are granted by the Ministry of Land and Revenue to private individuals or fishermen's co-operatives, through a process of nominally open bidding. These include most of the major floodplain depression fisheries, which may be leased as a unit or as subunits, as well as stretches of river. On minor water bodies fishing rights can be granted, either by the District Fisheries Officer or by local committees/individuals (Youssouf Ali, 1992). Subsequent to leasing, the operational rules of the fishery are determined by the leaseholder.

Leaseholders allow fishers access on different terms: fee payment, catch share, with rates that vary with gear used and season. They can also manage the fishery themselves, employing fishers directly. Their returns depend on the scale of water body managed, its specific characteristics and with the luck of the season. They can be sharply negative, when they have overbid for a lease or fishing has been prevented by flash flooding. They may only be marginally rewarding, particularly on the smaller water bodies, where obtaining a lease is often no more than a means of guaranteeing fishing employment for the leaseholder and their family. They can also be extremely profitable (Kremer, 1994a, 1994b; FAP17, 1994c).

The outcome for local fishers of this interaction between resource characteristics and operational rules is complex. Where fisheries are heavily controlled and a large share of the economic surplus is taken by the leaseholder, fishers may fare poorly. Figure 3.7 illustrates the share of monthly income attributable to fishing for landless households in two villages in Bangladesh. One was in the NE close to a valuable *beel* heavily controlled by a leaseholder - the fishers employed by him were brought in from a distant village, so their income does not appear here. The other was in an open-access *beel* in the SW, where local villagers were free to fish.

In the shallower floodplains access may be controlled by land owners once the bunds defining their plots emerge from the receding floodwaters. Farmers may also dig drain-in ponds in which fish collect; these are particular feature in the south-west (Third Fisheries, 1992). The spread of these practices in the last two decades - sometimes accelerated by stocking programmes (Kremer, 1994b) - has resulted in a greater control over fisheries by landowners and represents a modification of previous custom, fishers now have to negotiate a fishing contract in circumstances where they would previously have had open access (Kremer, 1994a).

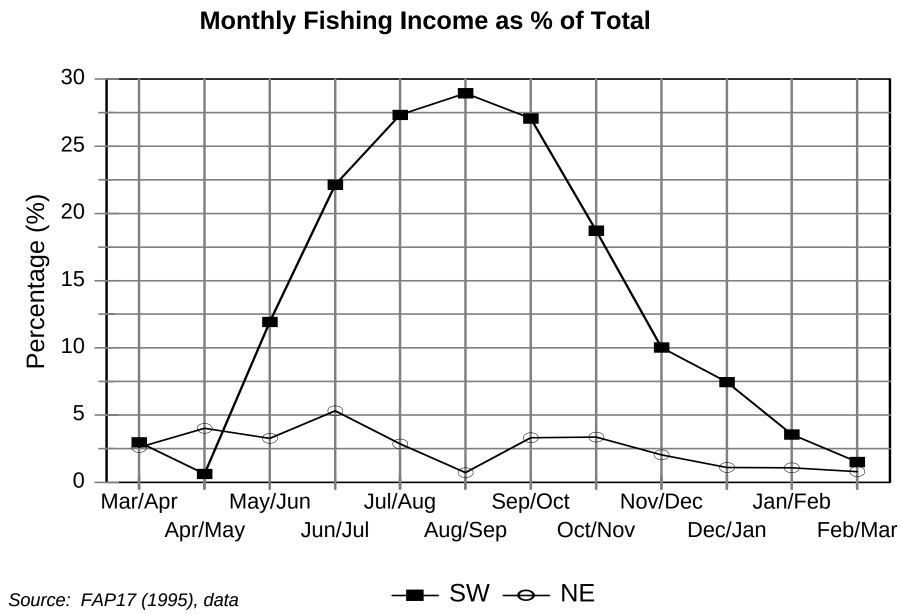


Figure 3.7 Monthly fishing income, landless households in NE and SW Bangladesh

3.3.2 Implications for Floodplain Enhancement

Existing operational rules (whether they be explicitly set or simply codified as social norms) influence what responses to the opportunities created by enhancement are open to different stakeholders in the fishery. Their resulting actions and interactions then feed through to outcomes. Any programme of enhancement which has objectives that extend beyond simply releasing fingerlings (or improving drainage etc.) must therefore come to terms with what these rules are and what their influence on outcomes is likely to be.

Enhancement projects which need to be financially sustainable, however, must go beyond a simple understanding of existing rules, as modification of the terms on which access is gained to the fishery (or parts of it) will be critical to cost recovery. The variability in the physical and biological characteristics of floodplain fisheries, discussed in Section 3.2, underscores the need for flexibility of operational rules and their adaptation to local conditions.

Defining the appropriate changes in operational rules and gaining acceptance for them is a task not easily accomplished by government alone, as it is often too remote and lacks enforcement capacity. NGOs can play a vital role in this context as they are better equipped to encourage community participation, tap into local knowledge of resource characteristics and foster a consensus that will allow mutual monitoring and enforcement to succeed.

Fishing in the most productive areas of the floodplain offers communities the greatest opportunity for generating an economic surplus. Enhancement should reinforce this by increasing the productivity of the fishery. Therefore, rules which encourage cooperative behaviour during the period of maximum concentration may offer a solution to issues of cost recovery. Concentrating management of harvesting to these more clearly defined areas, fishers and times would reduce the costs of control.

3.4 Enhancement and the Floodplain Environment: Overview

Floodplain fisheries are characterised by:-

- the large number of species that make up the wild stock and the differences in fish behaviour;
- the temporal and spatial variability of catch;
- the large number of gears used in different conditions;
- the lack of clear physical boundaries during the height of the flood;
- the undefined boundaries of resource user group;
- the large number of resource users (particularly on the larger floodplains);
- the diverse forms of involvement of different social groups; and,
- the blurred and flexible nature of existing ownership claims on the resource.

It has been forcefully argued that the inherent complexity and local variability of inland fisheries systems in the tropics renders them particularly unsuited to prescriptive planning and that an adaptive approach under local control is needed (Lorenzen and Garaway, 1997). Floodplain fisheries are unusually complex and locally variable even by these standards, making local control over resources and the rules governing their use all the more important.

These characteristics present significant constraints to stock enhancement projects. Using the framework provided by the Oakerson model, "successful stock enhancement" (i.e. the desired outcome) is determined by two pathways. Firstly, the physical and biological attributes of the resource and the technical constraints to enhancement and exploitation directly affect the success of stocking. The particular attributes of floodplains were discussed in Section 3.2. Secondly, the success of stock enhancement is determined by the particular patterns of interaction that arise from the combination of the nature of the resource and the decision making arrangements concerning enhancement and exploitation. These aspects of the model were discussed in Section 3.3. Referring to the diagrammatic representation of the framework, Figure 2.2 the first pathway refers to the arrow labelled 3 while the second path refers to the arrow labelled 4.

It is important to note that "success", in the context of enhancement projects, can only be judged with reference to the particular objectives of the project. Generally objectives for enhancement projects encompass three themes: one to increase returns from the fishery, another to benefit a particular community and finally that enhancement is sustainable. Taking each of the pathways in turn, the particular problems facing stock enhancement of floodplains can be highlighted.

The first pathway determines success of stock enhancement independently of human choice (Oakerson, 1992). The temporal and spatial variability of the floodplain environment exerts a strong influence on enhancement outcomes. This variability increases the complexity of the stocking strategy: when to stock, how much to stock, where to release from and what to stock are all affected by the variability described earlier. The complexities of gear use and gear interactions on the floodplain will have a direct effect on who will be able to harvest the stocked carp and therefore benefit from any increase in productivity. The lack of natural boundaries to the system makes it difficult to ensure that the stocked species do not escape. Though this may not affect the overall benefit of stocking, it reduces the proportion that accrues to the group that has financed it - undermining their incentive to sustain the programme.

The second pathway determining the success of stock enhancement involves human behaviour. So 'success' depends on how people, exploiting and enhancing the resource, respond to the constraints of floodplains and the arrangements regulating its management. The rules governing access to floodplain fisheries are complex, involving a mixture of private, government and common property rights. There are a mix of informal and formal rules and varying degrees of enforcement. As has been noted, behaviour may be either cooperative or competitive: however, the particular characteristics of the floodplain result in largely competitive interactions.

With the introduction of enhancement, it is inevitable that rules will have to be added to existing management arrangements. The variability of gears, habitats, fishing groups makes it difficult to introduce restrictions on resource use (timing, gears used etc.) that are likely to be adhered to voluntarily: those who bear the costs may not benefit sufficiently. This problem is accentuated by the presence of wild stocks and, for example, gear restrictions designed to protect the stocked fingerlings may severely affect those fishing, often for subsistence.

Moreover, even where a set of rules could be devised that resulted in proportionality of benefits and costs, there could still be problems of adherence. These stem from lack of enforcement due to the difficulties of achieving mutual monitoring. These difficulties arise from the number of resource users and lack of clear boundaries of the user group. Due to the inherent management difficulties, it is particularly important that fishers trust the organisation that manages on their behalf.

Where 'success' of stock enhancement is judged on sustainability, the issue of cost recovery is central. Two options exist to recover costs of floodplain enhancement: collecting licence fees or catch levies. The amount collected must guarantee sufficient revenue to pay for stocking. In the interests of both equity and economic efficiency, the amount collected must be less than the increase in catch value attributable to enhancement.

Catch levies
Monitoring how much is taken (and therefore what levy is due) is difficult. The catch on floodplains is seasonally and physically disbursed. Much of it is taken by individuals or small teams, often on a relatively casual basis. Fishing takes place both night and day and may be sold to itinerant fish traders at any time. So enforcing a levy is simply not practicable across most gears, seasons or habitats.

The exceptions to this are some of the floodplain depressions and the connecting channels which are fished out most effectively during the dry season. Due to the concentration of catch on these habitats and the highly organised way in which they are fished, the collection of levies is more practicable on these habitats. But is the incremental catch value on such water bodies large enough to support a levy that will finance stocking (and the costs of monitoring)?

Licence fees
Due to the diversity of gears, levels of involvement and catch rates on different parts of the floodplain, setting licence fees at levels which maintains some degree of proportionality between costs and benefits of stocking is difficult. The same gear used at different times/locations can generate very different levels of economic surplus. There is therefore, a choice between a simplified fee structure which glosses over these differences (and could discourage fishing for subsistence) and a more complex (and contentious) structure.

In either case, the lack of clear boundaries, the size of many floodplains and the migratory habits of professional fishers make fee payment difficult to enforce.

3.5 Summary

Strategies leading to successful enhancement are dependant on the particular nature of the floodplain as well as the response of individuals to their resource and its management. The *potential* benefit of floodplain stocking may be largely dependent on the technical enhancements to the fishery (number of fingerlings stocked, time of release etc.); but the *actual* benefit will be significantly influenced by the rules that affect stakeholder interactions. Which rules are introduced (and which institutions are used to support their introduction) can therefore be at least as important as the choice of technical modifications.

Floodplains are complex environments, characterised by a high degree of variability in their physical, biological, social and economic features. Enhancement is likely to be more successful if this variability is recognised and addressed. This is particularly important when cost recovery is a project objective.

The next two chapters examine the experience of past enhancement projects to see what lessons may be learned. Some of these were concerned with enhancement of floodplains; some involved cost recovery from enhancement.

4. Review of Enhancement Experience: Third Fisheries Project (TFP)

4.1 Introduction

The approach advocated in this review is that floodplain enhancement should be regarded as a special case of common-pool resource management. The objectives of enhancement projects and the activities required to achieve successful stock enhancement extend beyond the production and release of fish. The particular nature of the resource, the objectives, expectations and interactions of resource users all contribute to the outcomes of enhancement. The Oakerson framework, outlined in Chapter 2, provides a tool for the description and analysis of such a situation.

In 1988, the Government of Bangladesh with the World Bank and Asian Development Bank agreed to divide the Bangladesh in two with respect to the lending from each bank (World Bank, 1990). The World Bank focuses on the western part of the country with the ADB lending on the eastern districts. This chapter reviews the enhancement experience of the Third Fisheries Project. Chapter 5 reviews other enhancement projects.

This chapter is divided into three main sections: the first gives a brief description of the background to TFP and the enhancement approach taken; the second presents the analysis MRAG and BCAS completed as part of this review using data and reports from TFP; and the third section draws on this analysis and final reports produced by the Third Fisheries Project.

As part of this review, MRAG analysed two technical issues relating to floodplain enhancement using TFP data supplied by DoF (Dhaka). These issues were:-

- the relationship between hydrology and production in a variety of *beels*; and,
- the relative contribution of individual carp species from stocking and production data.

BCAS, on behalf of MRAG, reviewed the literature produced in the project regarding socio-economic aspects of TFP. The main findings of this report are summarised in this chapter: the full BCAS report to MRAG is presented in Annex I.

Discussion in the third section begins with a short overview indicating where the main contribution of the project experience lies with respect to the pathways in the Oakerson framework. Then the experience relating to the direct and indirect constraints to enhancement is reviewed in turn.

4.2 Third Fisheries Project (TFP) Project Background

Time Frame	1991-1996
Donor (US$)	World Bank (34.6m); UNDP (4.2m); ODA (4.3m)
Implementing Agency	Department of Fisheries, Bangladesh
Components	Floodplain fisheries; coastal shrimp culture; other fisheries; institutional support; research; technical assistance
Objectives	‣ Increasing incomes, particularly of the poor, and fish production for domestic consumption and export; ‣ Supporting the fisheries development programme in the west with emphasis on private sector participation; ‣ Accelerating the expansion of fish production in floodplains; ‣ Strengthening sectoral institutions.

The project area is Western Bangladesh, with floodplains from three divisions (Rajshahi, Dhaka, Khulna) being stocked. Carp fingerlings were released onto the floodplain at the beginning of the monsoon - June/July over six years. It was expected that the fingerlings would take advantage of the rise in productivity resulting from inundation and continue to grow throughout the flood before being harvested during the flood recession.

Analysis of historical data from the region show that, among the rivers of Bangladesh, there has been a marked decline in major carp catches (Payne and Temple, 1996). The rationale behind stocking in this project was that this decline had created a vacant niche in the floodplain fisheries that could be exploited by the stocked carps.

Seed fish can be produced in either the public or the private sector. This project chose the private sector on the key assumption that “expansion of private fingerling production for fish culture is constrained mainly by effective market demand” (World Bank, 1990). Therefore, the project assumed that there was sufficient capacity for the private sector to respond to the large demand for fingerlings generated by this project.

The original project document, the Staff Appraisal Report (World Bank, 1990) set out the details of the stocking strategy. The initial stocking density was to be 20 kg/ha, a figure that would progressively rise to a maximum of 30 kg/ha. Fingerlings were to be stocked at 9.5 cm (7.4 g) in the first year and increase in size to 14 cm (11 g) in year four. The document set out targets for the areas of floodplain that should be brought under the stocking programme, the initial area of 29,000 ha was to increase to 100,000 ha in the final year.

The project document (World Bank, 1990) specified the communities who were expected to benefit from the stock enhancement: 67,000 families within the project area, of which more than 90% would be part-time/subsistence fishers with the remainder being full-time fishers; fingerling producers; middlemen and consumers; and it was expected that roughly 12,000 full-time fishing jobs would be created (World Bank, 1990).

An important aspect of the floodplain component was its monitoring system. A stocking management information system (SMIS) was implemented to monitor the release of fingerlings (number, species, timing) while a production management information system (PMIS) provided monthly catch estimates. Three fisher categories were defined for the production monitoring (full-time, part-time and subsistence) and a range of gears were recognised, i.e. nets (seine, gill, cast and lift), hooks, bamboo traps, spears and bare hands. In the initial stages of the project the PMIS consisted of three separate surveys: household, gear and market based. Mid-way through the project, responsibility for the monitoring system was passed to the Department of Fisheries (DoF). The system was modified to a gear based survey which they could implement. As the importance of large gears (for example, lift nets and kuas or drain-pits) were recognised, individual surveys were implemented for these years and the catch estimates incorporated into total figures. The socio-economic benefits associated with the stocking programme were monitored through impact surveys.

The original project document outlined three potential mechanisms for the recovery of stocking costs (World Bank, 1990). Firstly, auctioning of fishing rights was seen to have the greatest potential, although it was acknowledged that modifications of the traditional system would be needed to secure equity and reflect the benefits of a particular resource. Secondly, licensing provided another cost recovery mechanism. Bangladesh introduced licensing of dry season water bodies under the New Fisheries Management Policy (NFMP) three years before the project document was drawn up. The transfer of water bodies to the new system of licensing was not complete at project inception. The third mechanism considered was devolution of financial responsibility of stocking to an administrative committee, Upazilas (previously and subsequently ‘Thana’ level), who could draw on their sub-district budgets which are supported by local taxes.

4.3 Technical Analysis and Socioeconomic Review of TFP Issues

The degree to which each of the analyses MRAG could carry out was determined by the availability and quality of the data. Both DoF and MTA assisted in defining reliable datasets that were appropriate to the analyses. The review of socio-economic impact of TFP was a desk based study relying on project documentation available to BCAS.

4.3.1 Hydrology and Fish Production

In order to investigate the extent to which hydrology is a factor determining production, the main source of the flood (rain and/or river) was noted for each *beel*. The key stations for river level and rainfall were determined and the water data requested from the Surface Water Modelling Centre (SWMC). Table 4.1 summarises the hydrological stations identified as relevant to each floodplain. The raw data is very detailed, often half hourly readings were provided. For this analysis the rainfall was summed by month and the maximum, minimum and average river levels were calculated.

Production data from the monitoring programme were provided on a monthly basis, and were disaggregated into catches of 'stocked' and 'non-stocked' species (MTA, 1996b). This analysis was used the data for non-stocked species only, i.e. wild fish production. The datasets which are most valuable for this analysis are those with the longest history of monitoring: Chanda, BSKB, Garalia and Hilna each have five years of data, albeit with some gaps.

Table 4.1 : Hydrological stations at each floodplain

Beel	Division	District	Thana	Key river	Water level station	Rainfall station
Chanda	Dhaka	Gopalgonj	Kashiani, Mukshedpur, Kotwalipara, Kalkini	Madaripur Beel-route	Haridaspur-198	Haridaspur, SW17, R409
Tungipara	Dhaka	Gopalgonj	Tungipara, Gopalganj sadar, Kotwalipara	Modhumati	Patgati-2310	Haridaspur, SW17, R409
BSKB	Khulna	Khulna		Nabangana Rupsa-Pasur	Gazirhat - 219 Kulna - 241	Mollarhat, SW25, R511
Garalia	Khulna	Jessore		Bhadra	Keshabpur - 27	Keshabpur, SW20, R459
Panjia Pathra	Khulna	Jessore	Keshabpur	Bhadra	Keshabpur - 27	Keshabpur, SW20, R459
Borobeel Rangpur	Rajshahi	Rangpur	Priganj			Mithapukur, NW10, R186
Hilna/Kasba	Rajshahi	Naogaon	Manda	Sib-Barnai	Nowhata-261, Pearpur-260	
Sadullahpur Kol	Rajshahi	Pabna	Pabna sadar			Sujanagar, NW40, R38
Uthrail	Rajshahi	Naogaon	Manda	Sib-Barnai	Nowhata - 261	

It should be noted that the system of production monitoring in each of the beels has undergone various changes. Both Chanda and BSKB were initially monitored by BCAS using a gear dependant survey, this system was in place for the first three years of monitoring (1990/1, 1991/2, 1992/3). During 1993 the DoF with technical assistance from MTA took over the monitoring, introducing a new system of surveying. Descriptions of the significance of the changeover will be provided in the final analysis of the TFP. In contrast, Hilna and Garalia beel were monitored continuously by DoF following the Fisheries Resource Survey System (FRSS) methodology.

The extent to which the floodplains have been modified by flood control measures will influence how effective rainfall and river levels are as indicators of floodplain hydrology. Chanda is a completely open floodplain, with eight (unmodified) khals connecting the catchment with the Madiripur Beel Route Canal (BCAS, 1991). The area is low lying and the hydrology is affected by both the canal and local rainfall. The khals and central parts of the beel retain water in the dry season. BSKB represents a large poldered area that encompasses four beels (Barnal, Salimpur, Kola and Basukhali), there are numerous khals connecting the individual beels (BCAS, 1991). The area within the polder is protected from the flooding of the river by 85.5 km of embankment. There are more than 20 gates that are used to control the exit of water at the end of the monsoon. Garalia beel is similarly a 'closed' beel, empoldered with more than 10 gates controlling inundation from the Bhadra river. The floodplain referred to as Hilna beel represents two beels, Hilna and Kasba, it is partially modified being connected to the Sib Barnai river in the monsoon via two sluice gates (MTA 1993). A series of khals connect Hilna to a network of beels in the east. The floodplain drains to a small swamp area in the dry season.

- **Unmodified Floodplains**

The monthly fish production, rainfall and river levels for Chanda beel are presented in Figure 4.1. As this floodplain is completely open, it offers the most insight into the relationship between floodplain hydrology, as represented by rainfall and river level, and fish production. The drought of 1992/3 is clear in the rainfall data from Haridaspur and the level of the Madiripur Beel Route does not exceed 3m in 21992/3 in contrast to other years plotted. The pattern of wild fish production, i.e. non-carp species, appears to follow a very similar trend to that evident in the water data.

To explore this relationship further, the data for rainfall and non-carp species were aggregated to an annual basis. However, as there are gaps in the data it was not possible to use the full 12 months. The longest period of continuous data was determined for both rainfall and non-carp production and the data summed for this period. Thus, figures are generated that can be viewed as indices of annual non-carp production and annual rainfall. A scatter plot of these indices (Figure 4.2) for Chanda beel shows a positive correlation between rainfall and production of non-carp fish species. A similar relationship between rainfall and fish catch has been shown using annual rainfall data from the upper catchment of the Ganges basin and fish catches at Padma (Payne and Temple, 1995). The positive correlation for that Bangladeshi data set was between fish catches and rainfall of the previous year. Five years of data were available for that analysis.

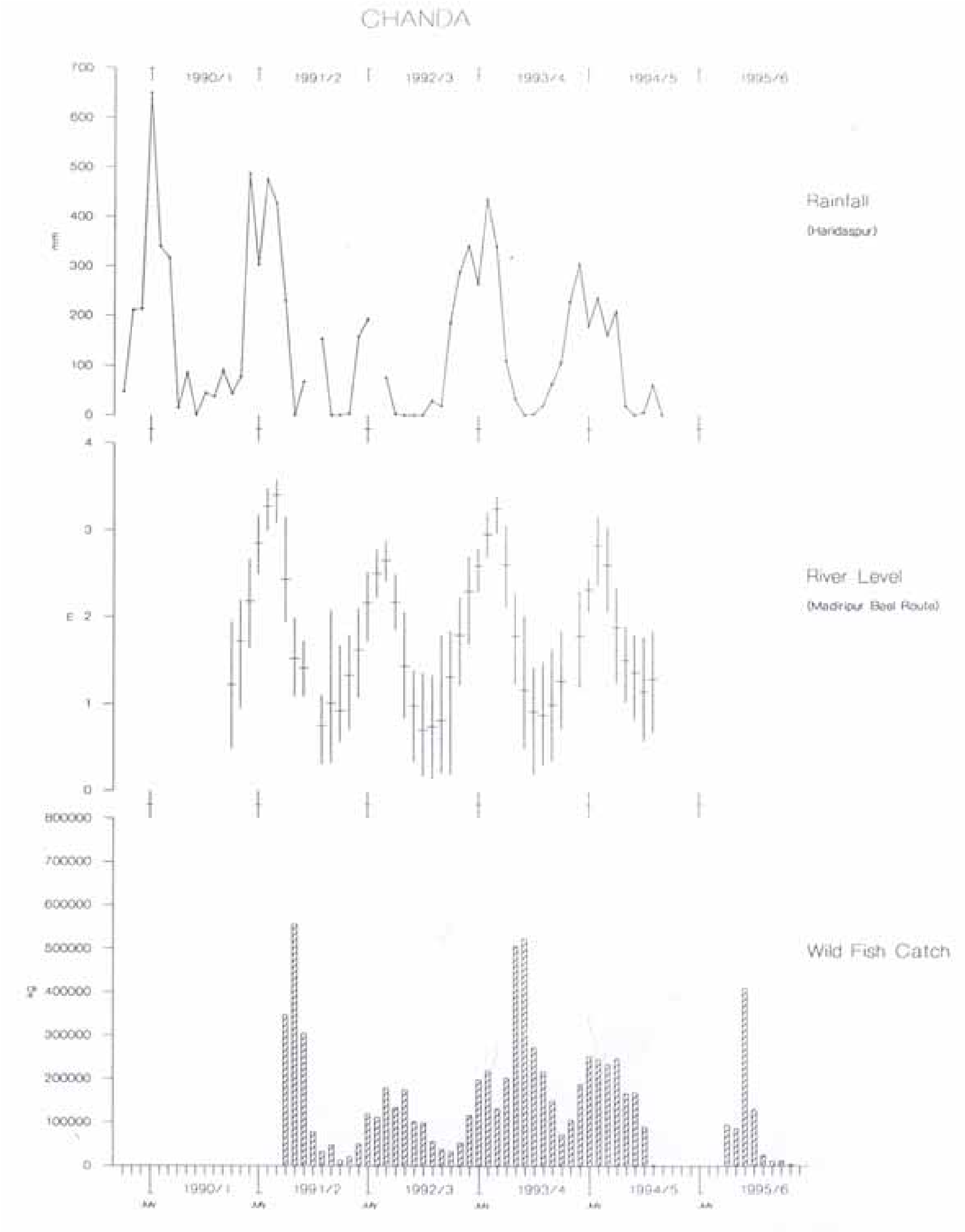


Figure 4.1 : Monthly rainfall, river level and wild fish catch, Chanda beel

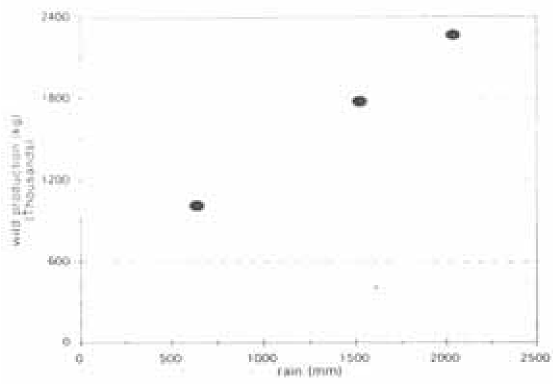


Figure 4.2 : Relationship between annual rainfall and non-stocked fish catches, Chanda

Several other beels stocked within TFP are, like Chanda, open floodplains. The monthly data for Borobeel-Rangpur and Tungipara are presented in Figures 2.3 and 2.4 respectively. Borobeel-Rangpur is completely rainfed while Tungipara is influenced by both rainfall and the levels in the Modhumati river. There is limited opportunity to look for trends in the data as they do not have as long a history of stocking, and therefore monitoring, as Chanda beel. Despite the limited data set, there is sufficient evidence that a relationship does exist between rainfall and wild fish production and so this type of analysis is worth pursuing.

- **Modified Floodplains**

The data for Garalia and Hilna are presented in Figures 4.5 and 4.6 respectively. Two figures were prepared for BSKB beel as there are two rivers which play a potential role in the hydrology of the area, Nabanganga (Figure 4.7) and Rupsa-Pasur (Figure 4.8). The drought of 1992/3 is clear in the monthly rainfall at Mollarhat (BSKB) and Keshabpur (Garalia) and also in the levels of the Sib Barnai which connects to Hilna beel. This drought year was of considerable significance to the Third Fisheries project as it coincided with the first stocking year in Chanda and BSKB beels. Both Hilna and Garalia beels had been stocked in the previous year, i.e. July 1991.

There are indications of a link between the level of the Sib-Barnai river and the production of wild fish in Hilna beel. Although this is a modified floodplain, the polder protecting Hilna often breaks (MTA, pers comm). Thus the simple separation of floodplains on the basis of presence or absence of flood control is inadequate. It is useful to regard modified floodplains on a continuum that is defined by the degree to which the flood control system is effective, i.e. from completely isolated to those that are essentially open. As a result, Hilna beel would appear at the 'open' end of modified floodplain classification. Details on the depth at which the Sib-Barnai spills over to the floodplain would be helpful in an attempt to quantify the relationship. The drought of 1992/3 is evident in both the maximum height of the river levels and also the number of months at which river level is peaking.

BOROBEEL - RANGPUR

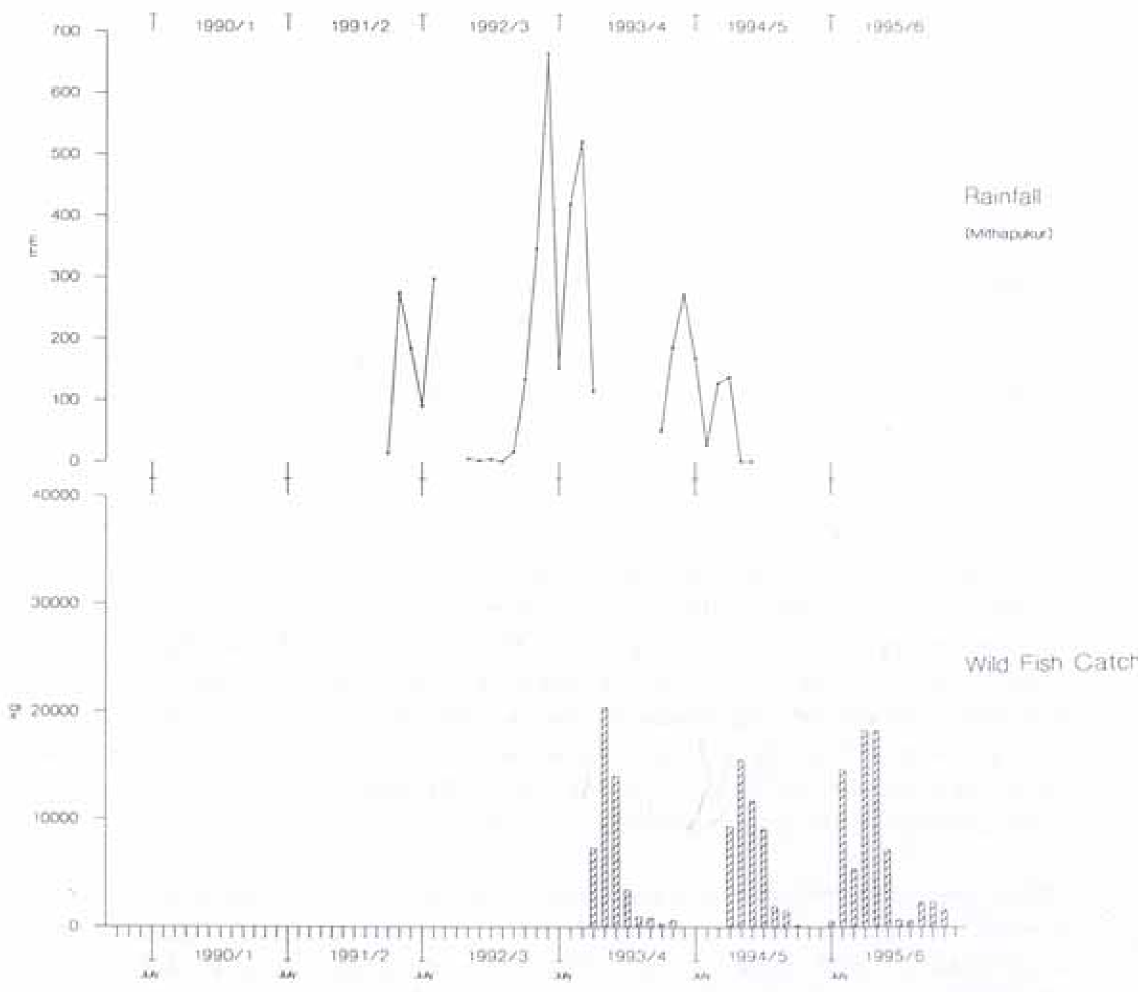


Figure 4.3 : Monthly rainfall, and wild fish catch, Borobeel - Rangpur

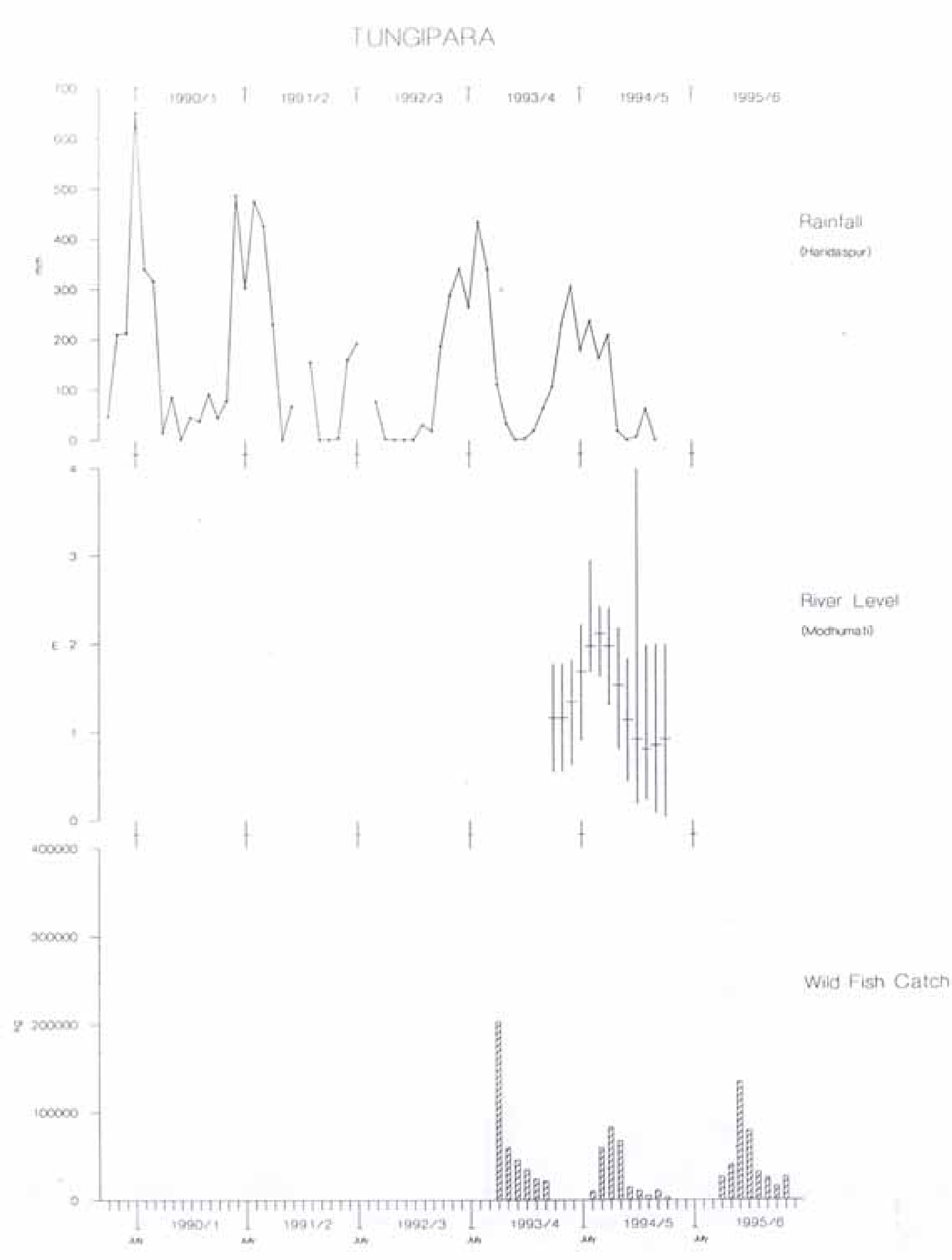


Figure 4.4 : Monthly rainfall, river level and wild fish catch, Tungipara

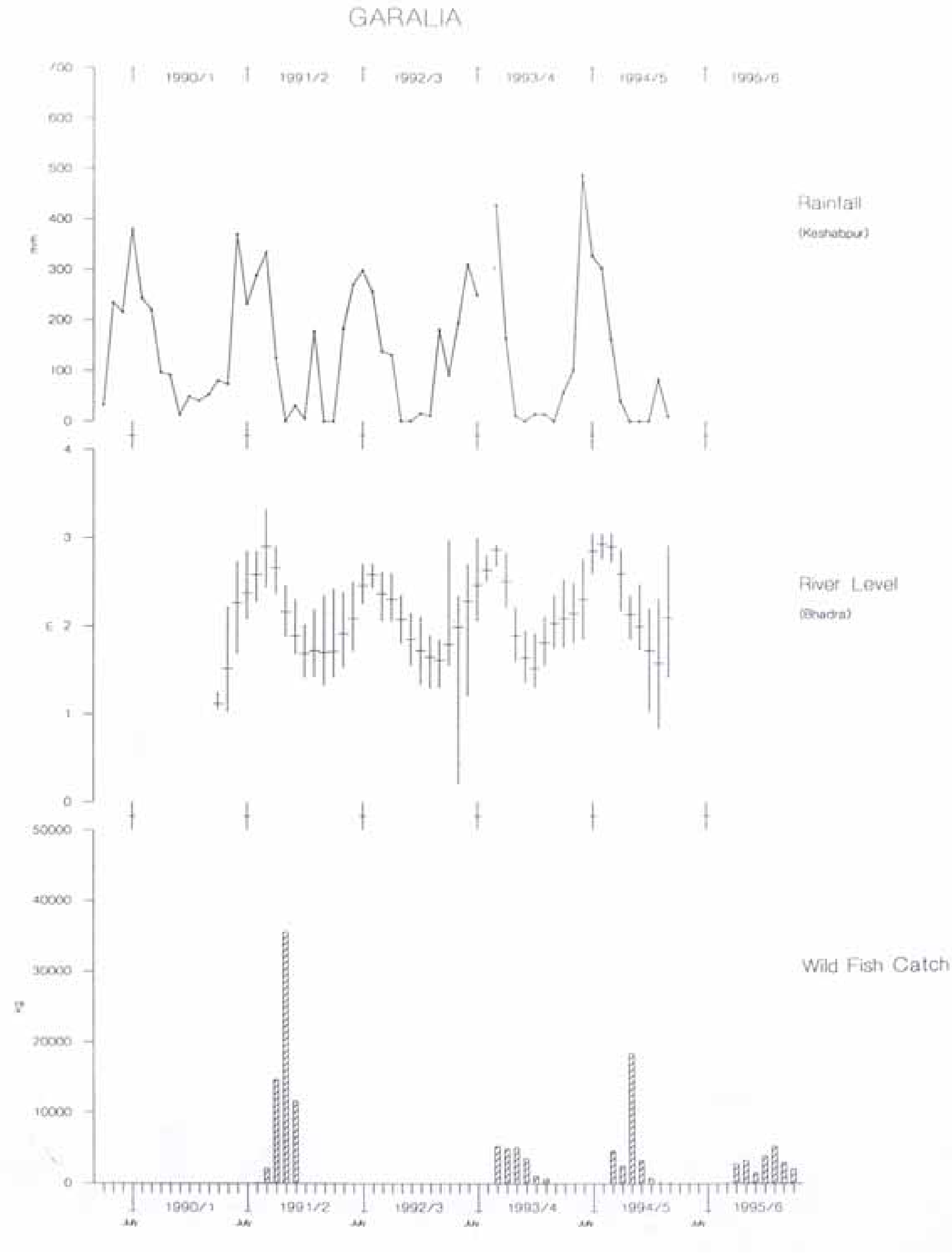


Figure 4.5 : Monthly rainfall, river level and wild fish catch, Garalia

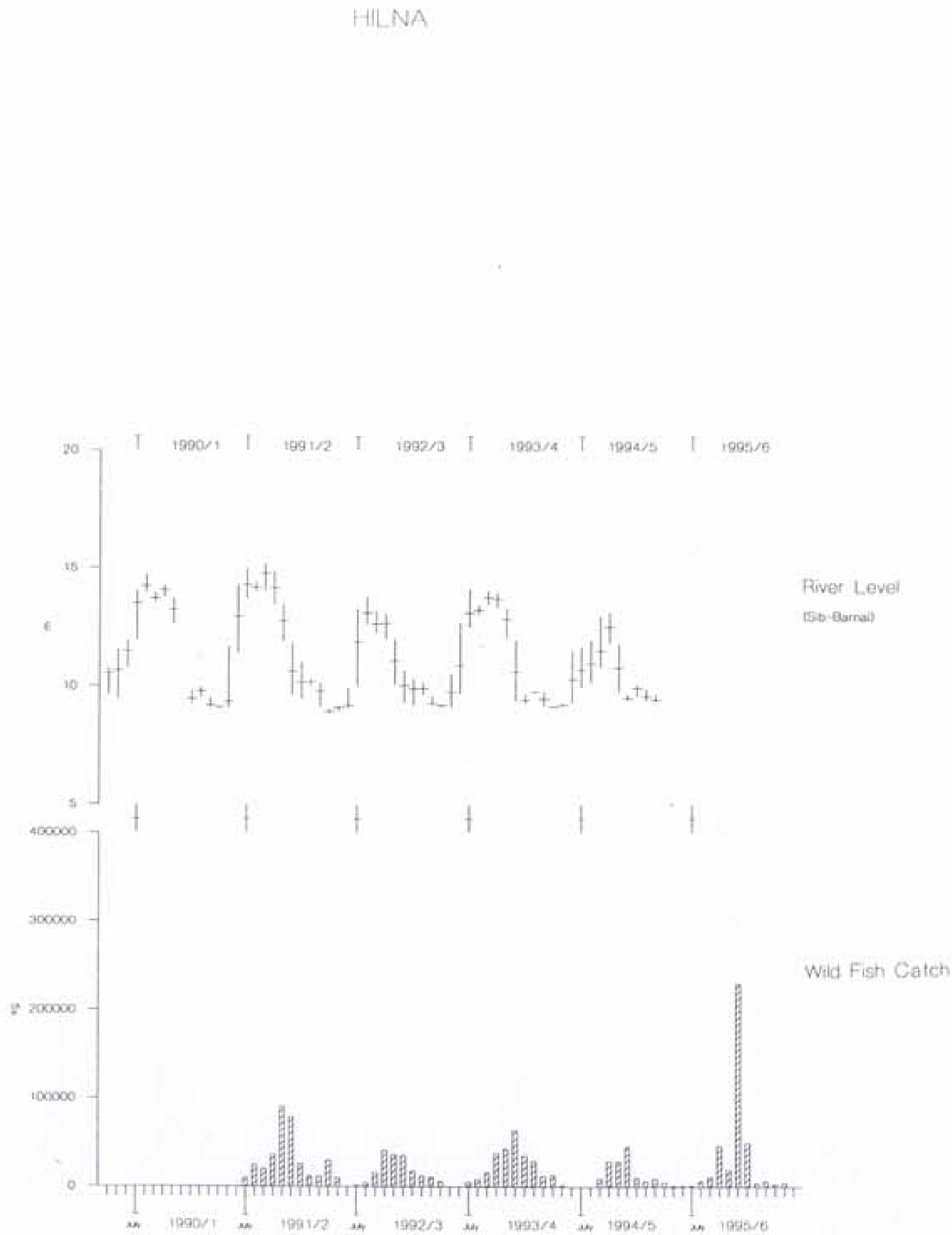


Figure 4.6 : Monthly river level and wild fish catch, Hilna

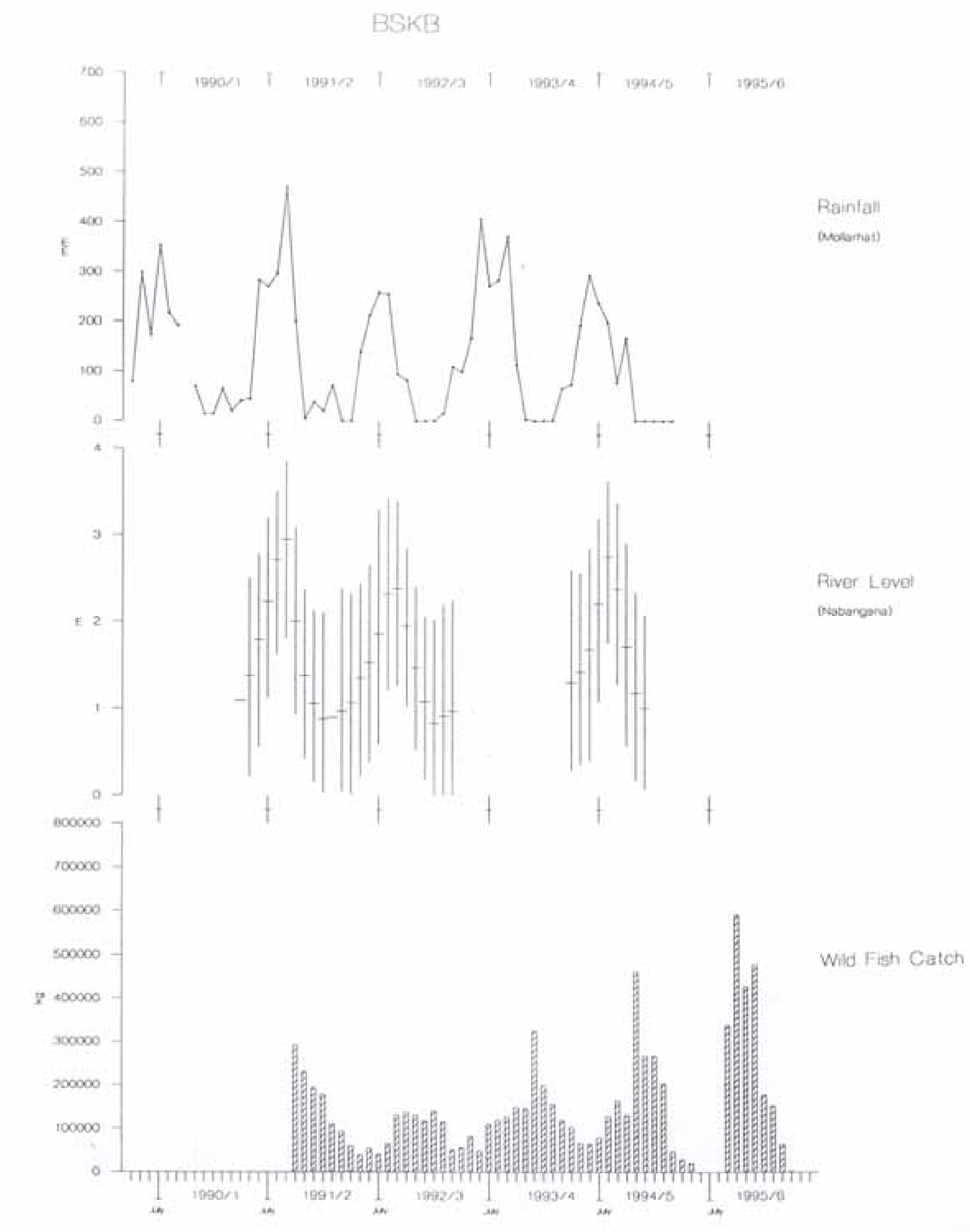


Figure 4.7 : Monthly rainfall, river level and wild fish catch, BSKB (Nadanganga)

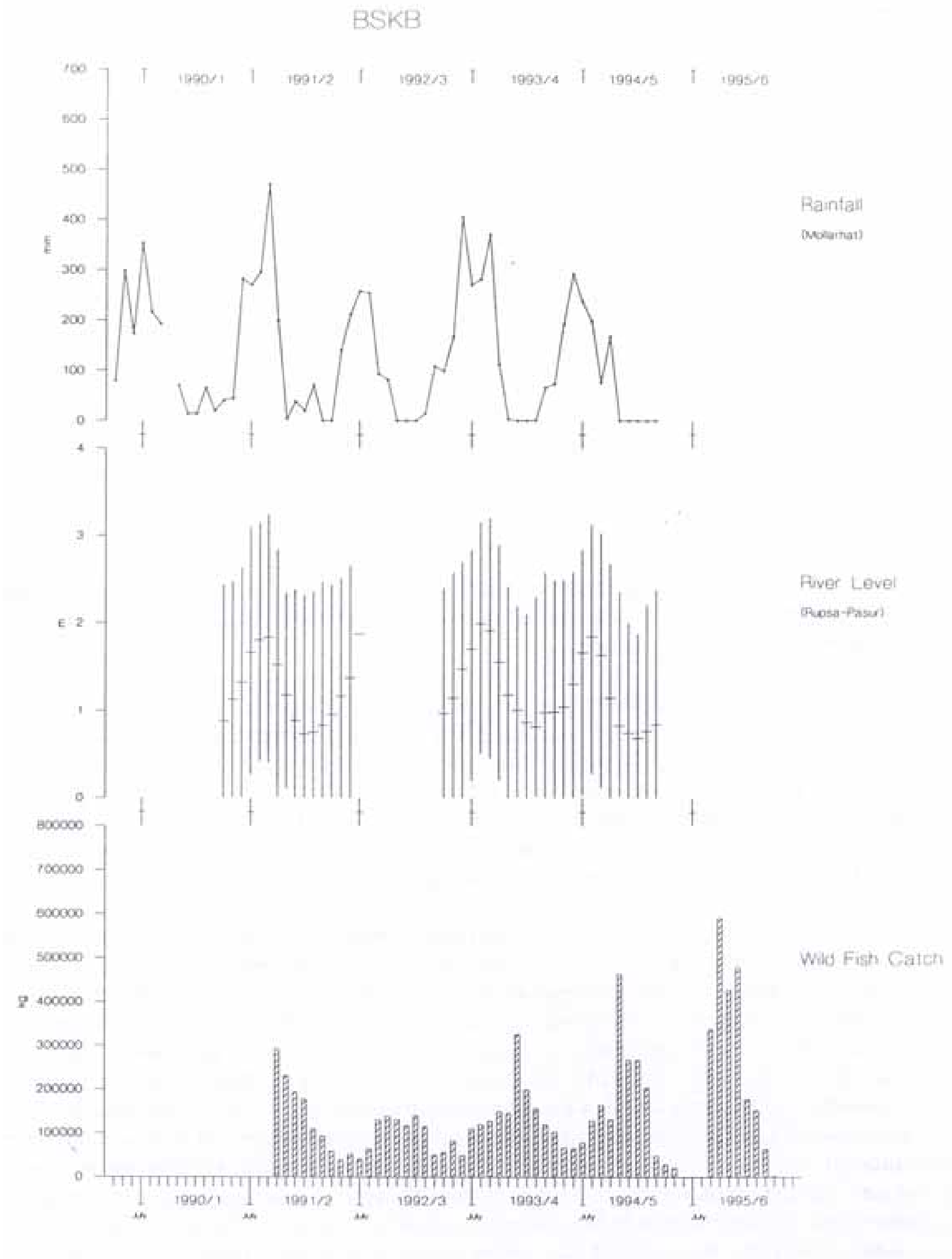


Figure 4.8 : Monthly rainfall, river level and wild fish catch, BSKB (Rupsa-Pasur)

The results for Garalia are more difficult to interpret, there was no monitoring of the floodplain production in the year 1992/3. The breaks in the data from both Rupsa-Pasur and Nabanganga complicate the picture of floodplain hydrology for BSKB.

In summary, the relationship between hydrology and wild fish production so clearly illustrated in Chanda beel is not as apparent in the data from the beels which are modified by flood control structures. This result is not surprising, and is probably due to the failure of rainfall to adequately indicate the changes in hydrology in the more effectively modified floodplain. This does not rule out a relationship between the flood regime in the beer and fish production.

If an area is completely empoldered, it is reasonable to assume that the local rainfall will be the prime source of flooding within the polder. However, the control of the gates connecting the floodplain with the rivers outside is critical. It has been found in a study of fisheries inside and outside flood control structures that sluice gates may be operated on an informal basis by local fishers and farmers. The research, carried out as part of an ODA project Fisheries Dynamics of Modified Floodplains, has collated data on water levels inside and outside a polder with information on the operation of sluice gates. Gates some distance from the officials with responsibility for their operation were opened and closed more frequently in response to demand for water in the vicinity of the gate (D Hoggarth, pers comm).

To explore the relationship between fish production and hydrology in modified floodplains, and thus take account of the annual variation in monitoring data, another indicator of the pattern of the flood is needed.

- **Implications for Monitoring of Enhancement Programmes**

The monitoring programme employed in TFP provided estimates of the annual production for each floodplain. These estimates were measured against the annual estimate of a baseline year which was monitored prior to stocking. Given the amount of variation illustrated in this analysis the static baseline does not reflect the true outcome of stocking as the inherent variation is incorporated in the comparison with the baseline year. Clearly this has implications for monitoring of enhancement programmes.

Monitoring to provide a long data series prior to stocking would overcome the problems of a static baseline but is not a viable option due to the costs associated with monitoring and delaying of stocking until an adequate baseline has been generated. Another option is to include monitoring of control sites so that production monitoring in stocked beels could be compared to unstocked beels in the same years. Finding floodplains that are similar enough to the stocked site in terms of hydrology, degree of modification and socio-economic characteristics etc precludes this option. A potential solution lies in the relationship between hydrology and the level of fish production. If this relationship defined through the development of a model, then it would be possible to disentangle the changes in fish catches that are due to stocking from those that are related to the annual cycle of the flood. Research into potential hydrological indicators that may be used as predictors of fish catch has been carried out (for example, Payne and Halls, 1994, and Payne *et al,* 1993).

- ■ **Conclusions**

- Results from an open floodplain illustrate that there is a strong relationship between hydrology and wild fish production. This supports results found elsewhere in river and floodplain environments where there is a large degree of environmental variability.

- Rainfall is a reasonable indicator of floodplain hydrology when floodplains are open or ineffectively controlled by flood control modifications. In comparison, the hydrology of modified floodplains requires alternative indicators such as direct measures of depth within the floodplain.

- Assessment of the performance of stocking in terms of fish production on the floodplain should take account of the considerable natural variation that occurs due to changes in hydrology between years.

- Exploration of the relationship between hydrology and production though the development of a model may provide a solution to the problems of gathering adequate baseline or control data to assess performance.

4.3.2 Species Performance

One of the key technical decisions to be made within an enhancement programme is the selection of appropriate species to be stocked. This aspect of enhancement has been studied most intensively in well defined water bodies such as ponds and reservoirs. There is a long history of polyculture in China where carp fingerlings have been released into ponds for centuries. Similarly, there is long experience of stocking in India where hatchlings of major carp are released into reservoirs. However, the differences between the floodplain environment and these other water bodies limits the extent to which the experience gained on species choice is transferable. The source of productivity is a critical difference: ponds and reservoirs are driven by primary production while floodplains rely on the detrital food chain which breaks down and recycles nutrients held in the vegetation.

The effect of this difference in source of productivity on the performance of individual species was illustrated clearly within TFP. Initially, the species selected for stocking were those that had performed well in Chinese systems, i.e. a mixture of Chinese carp (silver, bighead and common carp) with the addition of indigenous major carp (rui, mrigal and catla). However, silver carp did not perform - being a planktivore there was limited food reserves on the floodplain for this species. In addition, it was found that silver carp tended to migrate out of the floodplain area and so was not represented in the catches that were monitored within the project (Reports on fingerling escapement). As a result the reliance on silver carp as part of the species mix has declined during the stocking programme.

This sub-section investigates the performance of individual species in four floodplains stocked within TFP. There are several aspects to analysis of performance: initially, the returns by weight are analysed, then the catches by gear type are explored and finally the economic return is addressed. This sub-section concludes with a brief discussion of a potential framework for decision making that allows the full range of the issues that influence enhancement of individual floodplains to be taken into account.

■ Yield Per Kilogram of Stocked Carp

The weights of fingerlings stocked in each beel were analysed for any significant differences between years, between species and between floodplains (Figure 4.10). There was no significant variation between average weights of fingerlings between years. Common carp fingerlings were generally heavier that any other species, while the average weights of Thai Sarputi were lower. There was no significant difference among the average weighs of the Indian Major carps stocked. Similarly, there was no significant difference between the weights of fingerlings stocked in each floodplain. This reflects the arrangements made within TFP to control the size of fingerlings released through a system of contracts between DoF and hatcheries.

The stocking programme of TFP was closely monitored using a Stocking Management Information System (SMIS). The following data were used for each beel included in the analysis: the weight (kg) of individual species stocked, the average weight of fingerlings.

Data from the four beels with 3-5 years of stocking experience were used for this analysis. Yield per kilogram of stocked fingerlings was calculated for each of the carp species released onto the floodplain in each stocked year. The figures are presented as a percentage, i.e. 1000% represents a ten-fold increase - 500kg of fingerlings yields 5,000kg of fish.

Common carp (CC) out-performs all other species rather dramatically in Chanda beel (Figure 4.11) with a yield per kg consistently in excess of 1000% whilst the other species fall well below this level. There are several potential explanations as to why common carp performs so well in Chanda. Firstly, Chanda is an open floodplain with a dense canopy of vegetation which will generate a thick mat of detritus. As common carp is a bottom feeder it will be able to take advantage of the high productivity. Differences in the mobility of the species may also contribute to the illustrated success of common carp: it is more stationery than the India major carps which may have migrated out of the open beel and therefore not be represented in the monitored catches. BSKB is similar only in that both silver carp (SC) and thai sarputi (TS) perform badly, however no individual species stands out from the others. The returns by weight are generally higher in Garalia and Hilna (Figure 4.12) with annual performances of most species often in excess of 1000%. Thai sarputi performs well in Hilna beel in the first year it is stocked (1992) and then drops to similar performance levels of the Indian major carps. There is a decline in performance of common carp over time in both Hilna and Garalia, with the highest returns in the first or second year of stocking.

In order to provide a more direct comparison of species performance by individual floodplain, the annual performance figures were averaged (Figure 4.9). This plot clearly shows the poor performance of silver carp (SC), which as was previously noted, has already been largely dropped from the project. The overall conclusion from this picture is that individual species performance, measured as yield per kg of stocked carp, varies between floodplains. The final figures are presented in the matrix below the figure.

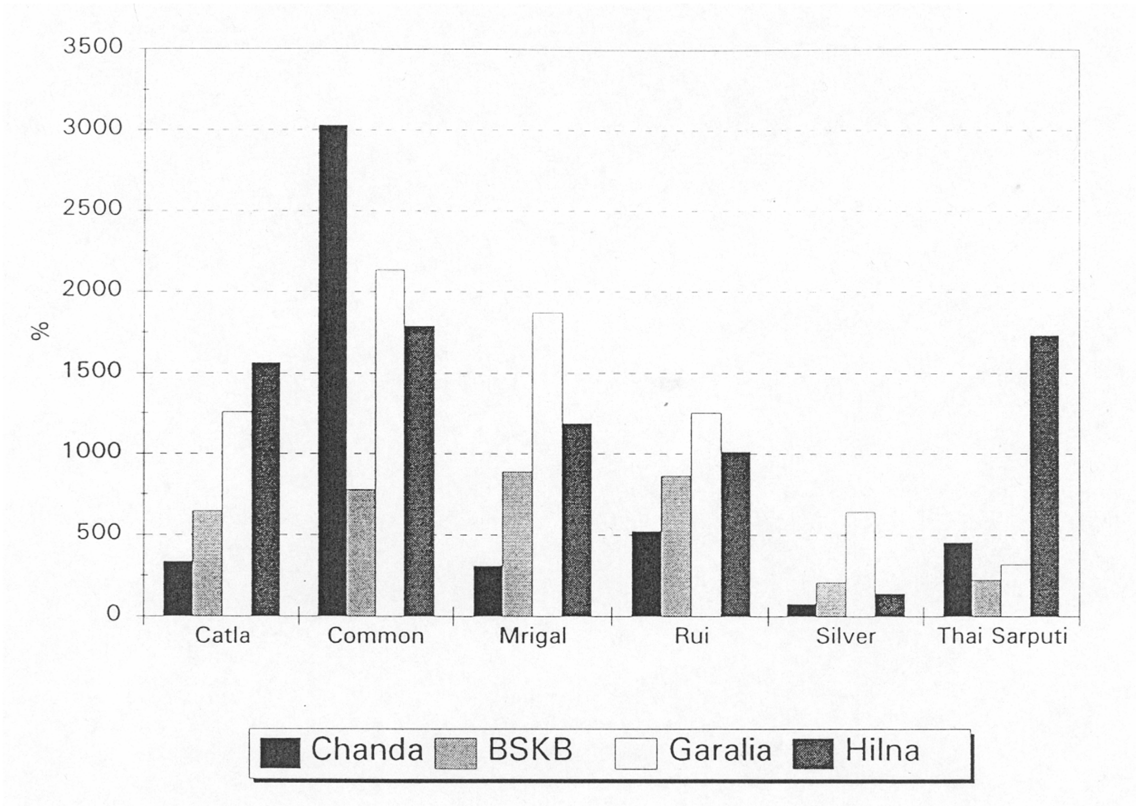


Figure 4.9 : Performance (return by weight) of stocked carp in individual floodplains

% return by weight	**Catla (CA)**	**Common (CC)**	**Mrigal (MR)**	**Rui (RU)**	**Silver (SC)**	**Thai Sarputi (TS)**
Chanda	336	3031	309	522	78	456
BSKB	647	777	888	861	210	222
Garalia	1255	2134	1871	1250	642	317
Hilna	1563	1790	1187	1013	141	1734

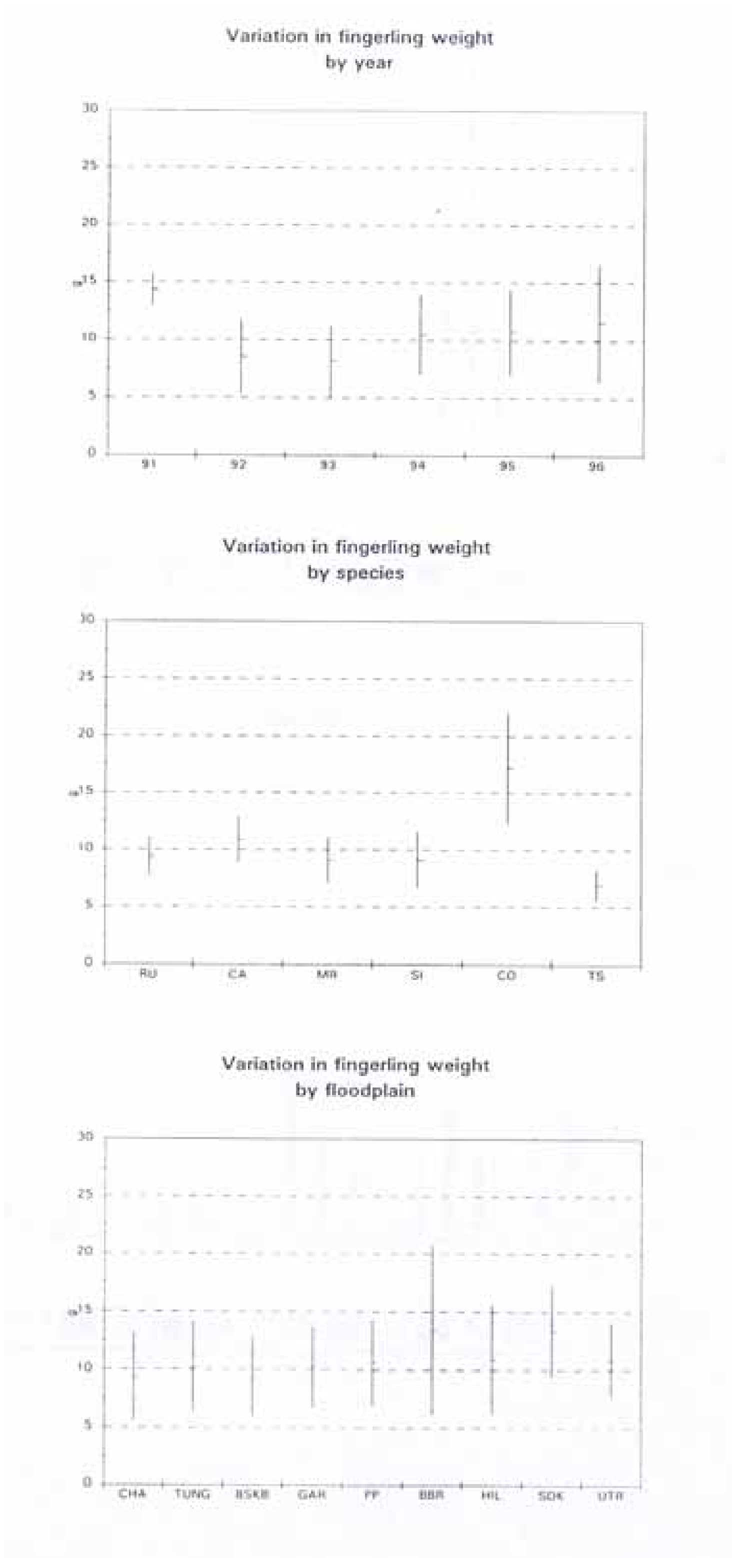


Figure 4.10 : Variation in fingerling weight by year, by species and by floodplain

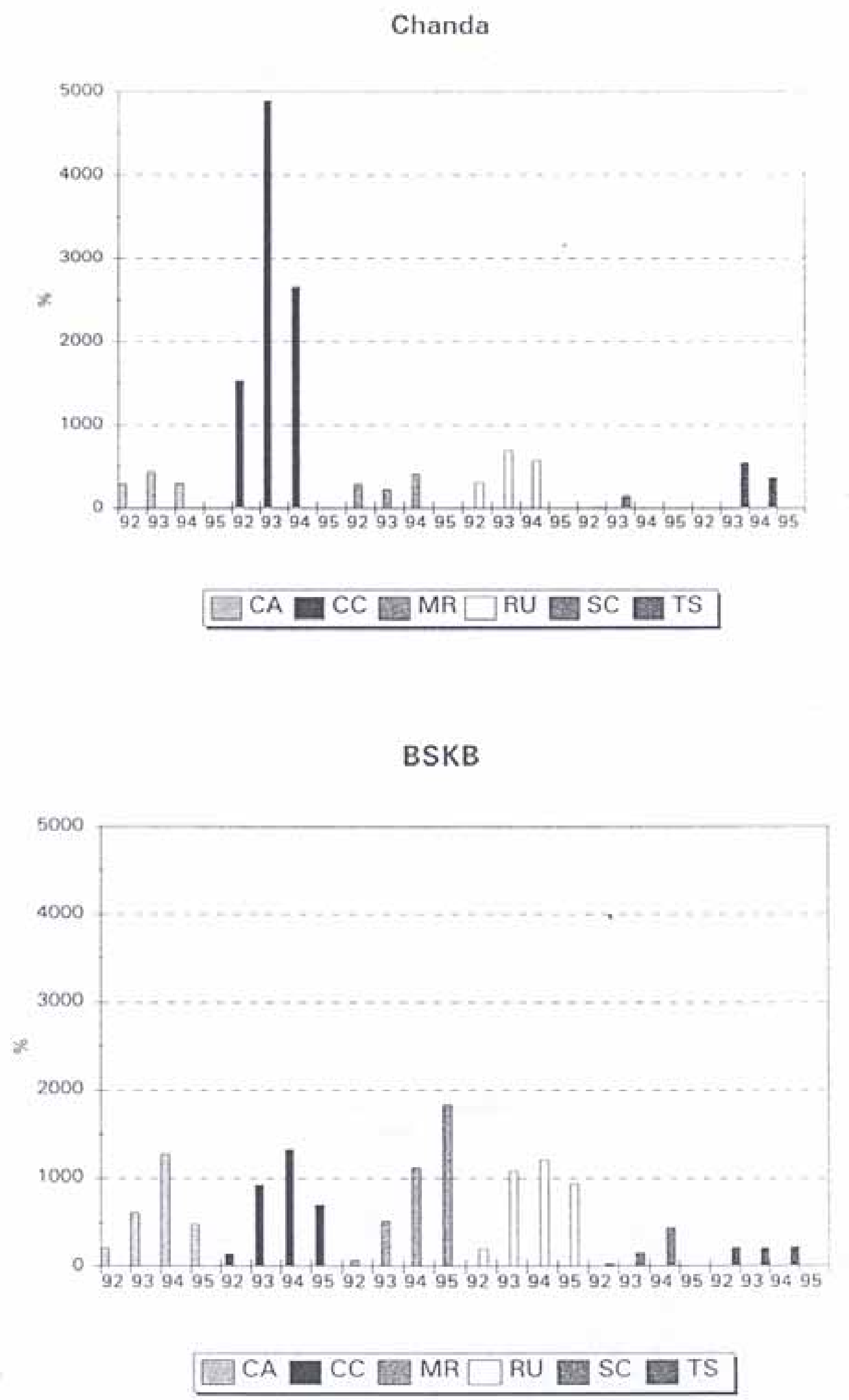
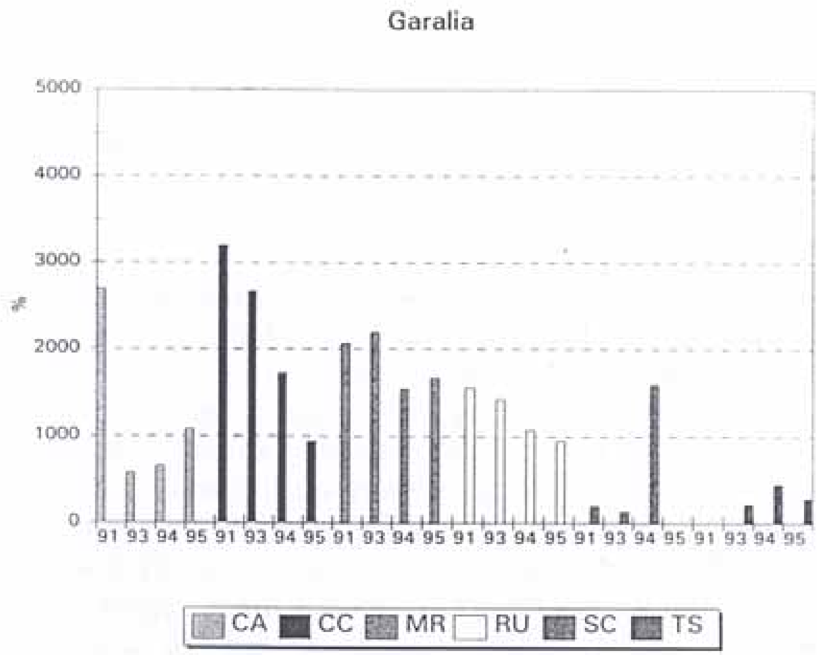


Figure 4.11 : Yield per kg of stocked carp, Chanda, BSKB



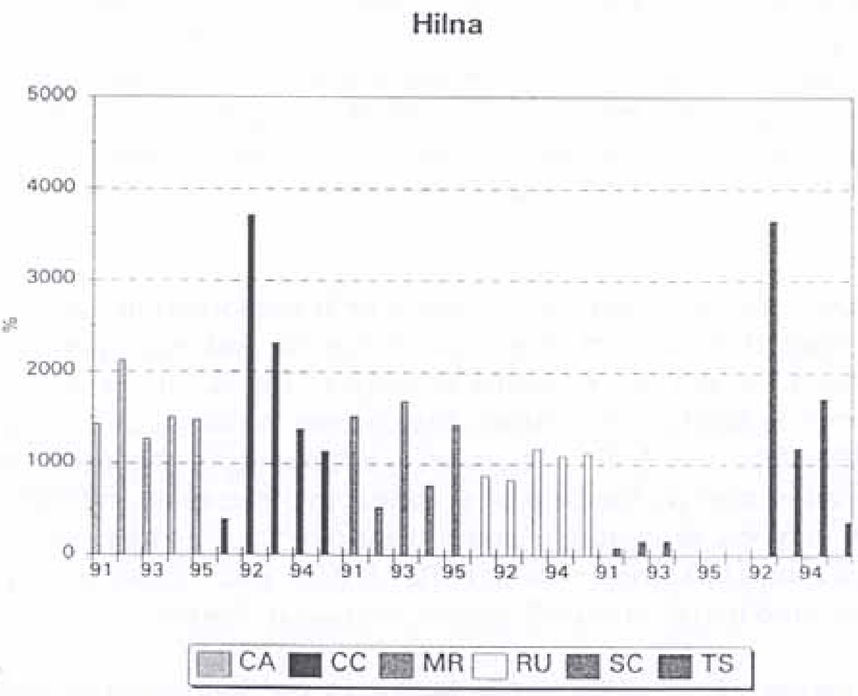


Figure 4.12 : Yield per kg of stocked carp, Garalia and Hilna

■ Species Catch by Gear Type

The catch by individual gear type provides information on which gears are harvesting the stocked carp and by implication may help to identify the main beneficiaries of enhancement. Data from Chanda and BSKB in the first three years of monitoring have been used to look at these issues, the data were summarised in annual reports to the project (BCAS, 1993). Results from the gear dependent monitoring programme were used for the small gears. The importance of the larger gears (veshal, kua pits, katta and bamboo fences which were introduced into Chanda beel) to the floodplain fishery was recognised within the project. A separate survey for each was incorporated into the monitoring programme to ensure that these yields were included in the estimates of total production.

The data is plotted by gear type for each of the three years monitored, 1991/2, 199213 and 1993.4. It should be noted that the results for 1991/2 (the 'baseline' year) cover the period October 1991-June 1992, i.e. not the full 12 months. Species are listed individually, beginning with the stocked carp species and followed by the wild, non-carp, species that were identified within the monitoring programme. The stocked species have been marked with a bar to increase their visibility on the plots. The results for Chanda are presented in Figures 4.13, 4.14, 4.15 and those for BSKB in Figures 4.16, 4.17,4.18. Each figure consists of three sets of plots which are grouped by gear type: the four main nets are together, similarly the smaller gears (hooks, traps, spears and bare hands) are grouped, while the larger gears (veshal, kua, katta & kheo and bamboo fences) are presented together.

Carp do not appear in the catches of all four small nets until the second stocking year. The first stocking year was a drought and few carp appeared in the monitoring data. Common carp is the main species caught in gill, seine and cast nets operating in Chanda, while rui is caught in greatest amount in the lift nets (Figure 4.13). Amongst the small nets of BSKB, cast net catches contain the greatest amount of stocked species, with gill nets showing the least (Figure 4.16). Rui is the species caught in the greatest amount in BSKB nets.

The harvest of hooks and line does not contain a high proportion of carp species in either beel, the main harvest is one of the carnivorous snakehead species, taki *(Channa punctatus)* (Figures 4.14, 4.17). A greater amount of fish is caught using hooks and line in Chanda compared to BSKB. In contrast, the catches of all species using bamboo traps is greater in BSKB (Figure 4.17). There is a difference in the catch composition of bamboo traps between the two beels as carp appear in the catches in BSKB but are absent from Chanda trap catches. In contrast, spear fishing in Chanda does catch carp species, primarily common carp, while spear fishing in BSKB does not. There is very little common carp caught when bare hands are used as the method of harvest.

Kua pits are an integral feature of floodplain fishing in the Southwest of Bangladesh. The most striking feature of the kua catch in this data set is the range of species harvested (Figure 4.15 and 4.18). This method of fishing is very effective at capturing wild and stocked species in both Chanda and BSKB. Amongst the stocked species caught in kuas, common carp and rui are caught in the greatest amounts in Chanda whilst rui is the most dominant species in BSKB. Kua pits are numerous in Chanda: a frame survey in 1994 found 4,607 kuas in Chanda whereas BSKB, a beel of similar size, had only 1,588 kuas (BCAS, 1994).

Figure 4.13 : Individual species catch by gear type, Chanda (gill, seine, cast and lift nets)

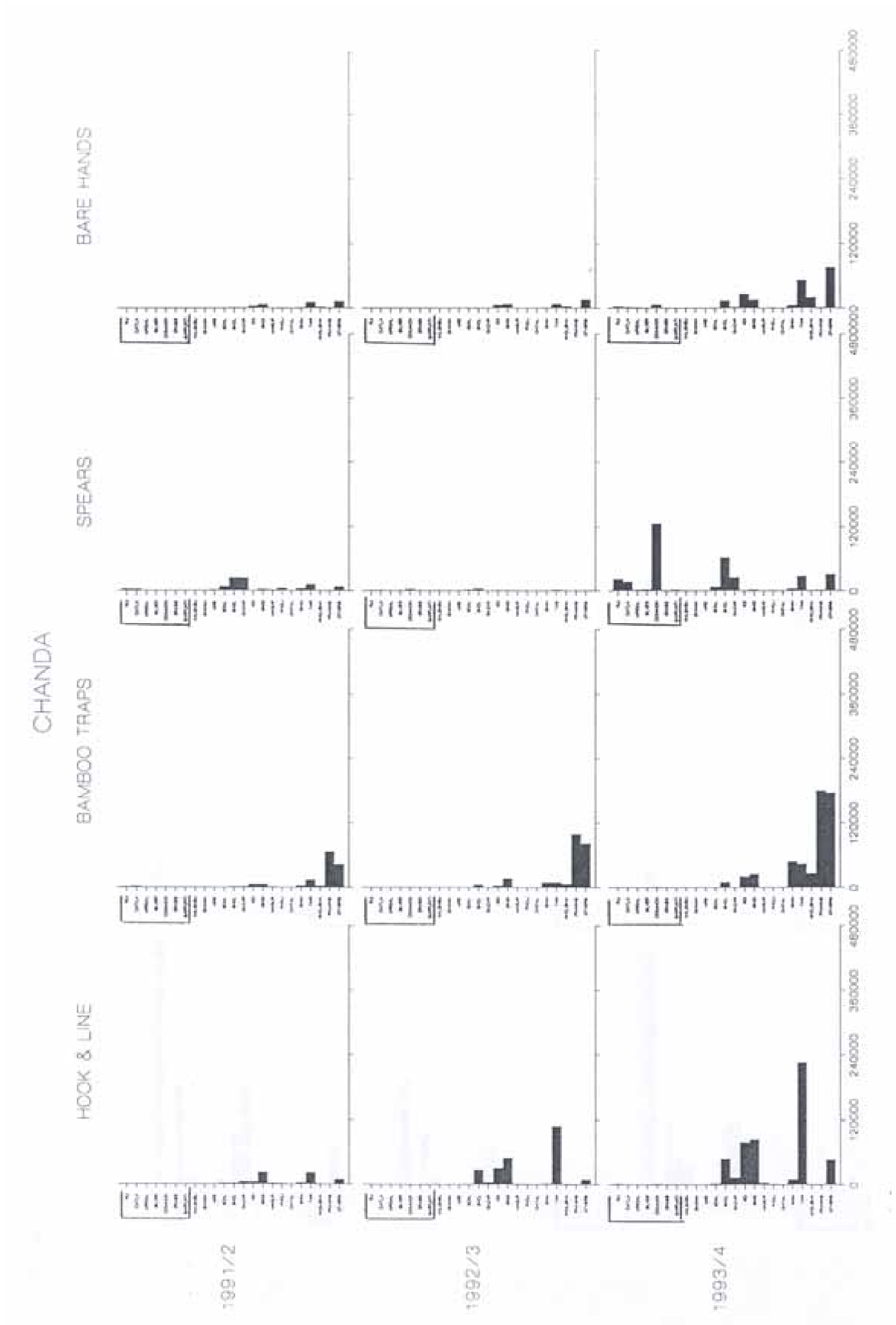


Figure 4.14 : Individual species catch by gear type, Chanda (hooks, traps, spears and hands)

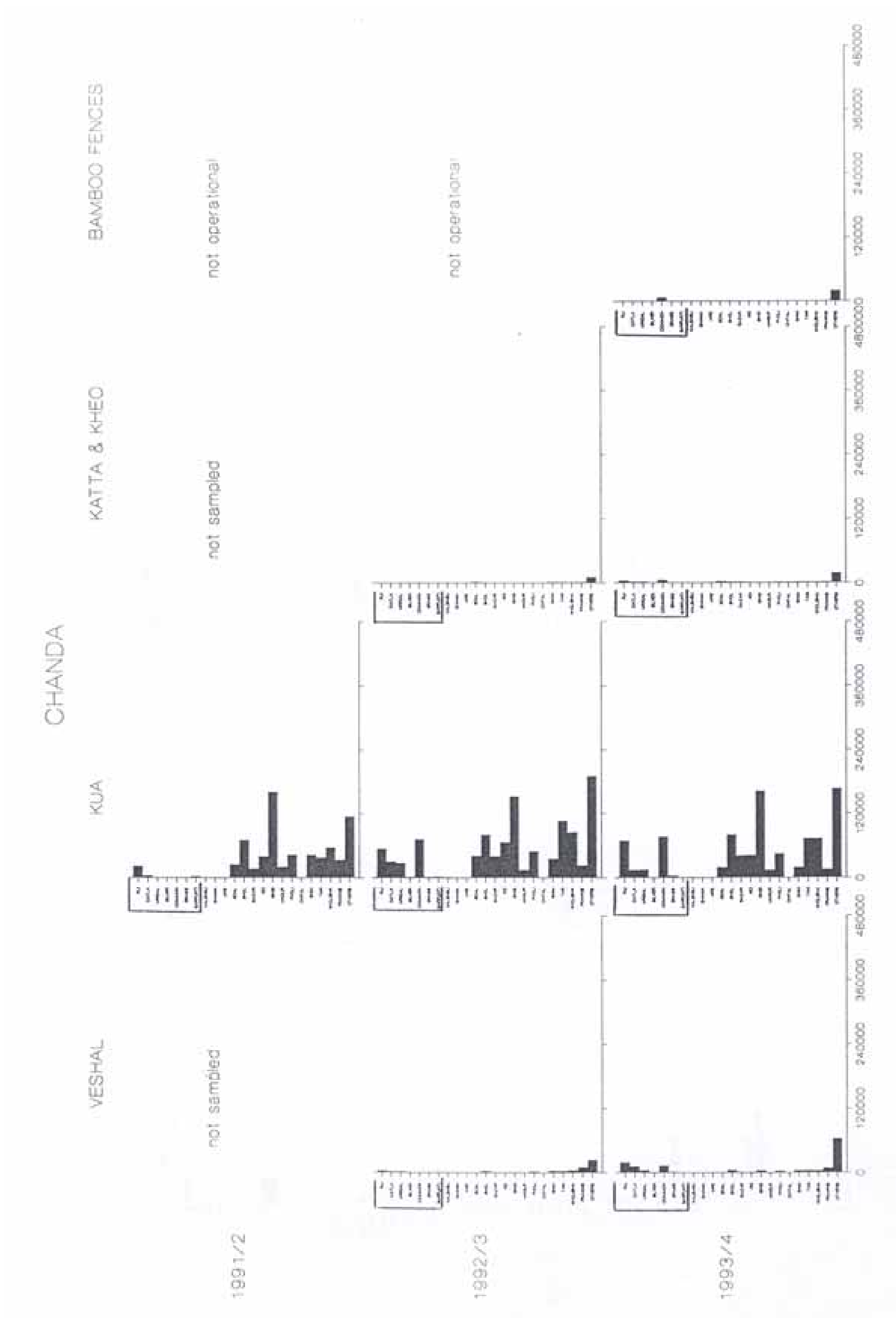


Figure 4.15 : Individual species catch by gear type, Chanda (veshal, katta, bamboo fences)

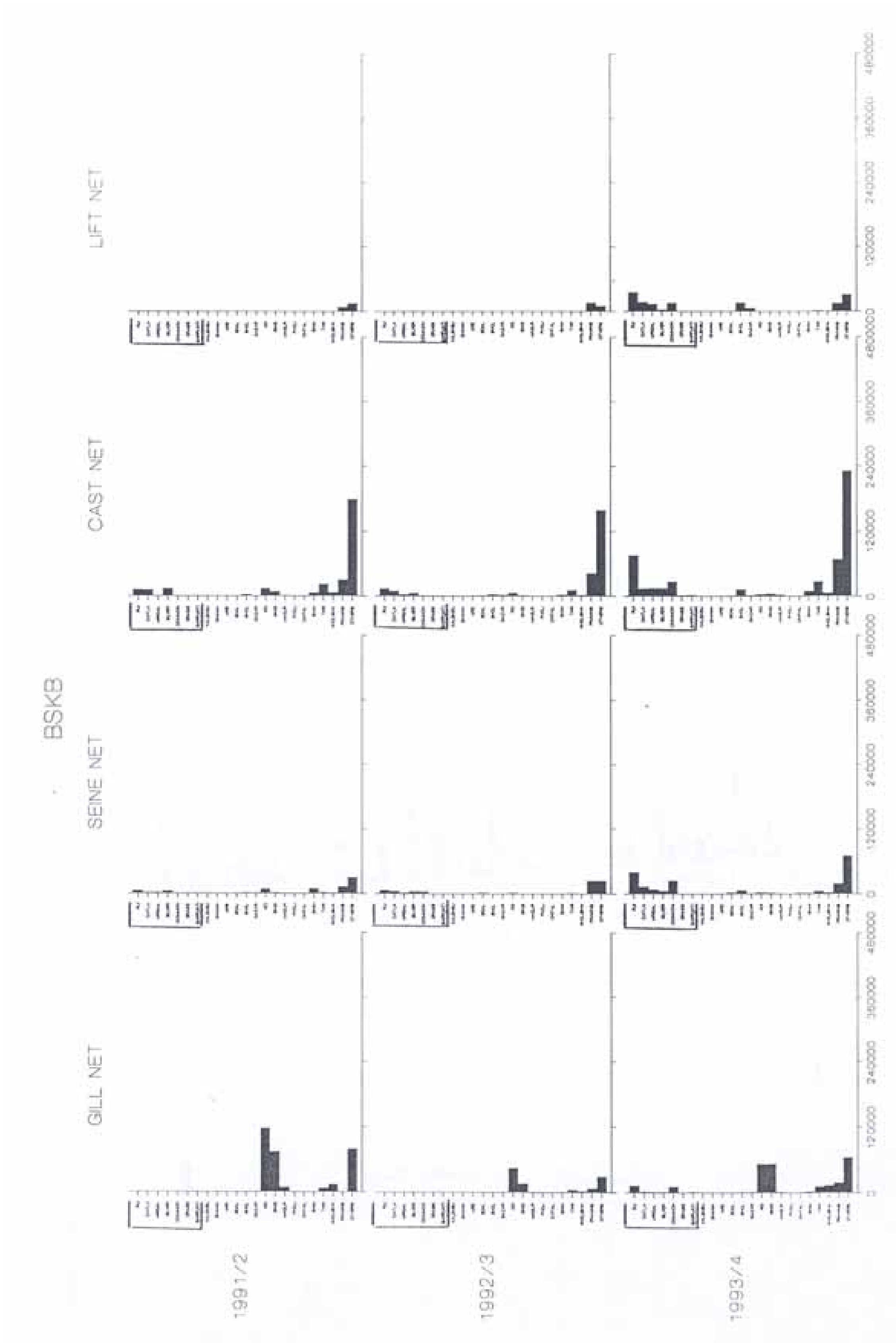


Figure 4.16 : Individual species catch by gear type, BSKB (gill, seine, cast and lift nets)

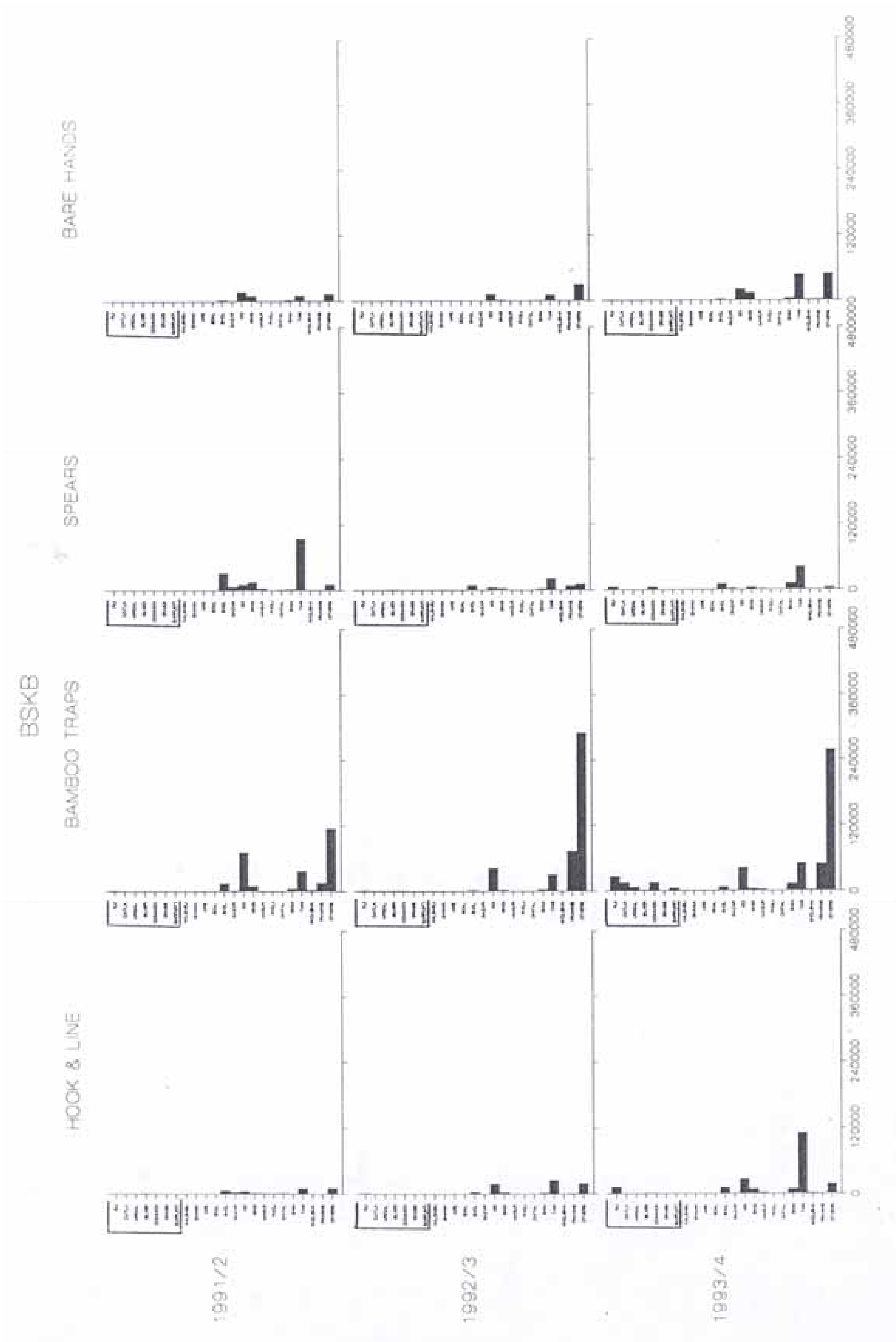


Figure 4.17 : Individual species catch by gear type, BSKB (hooks, traps, spears and hands)

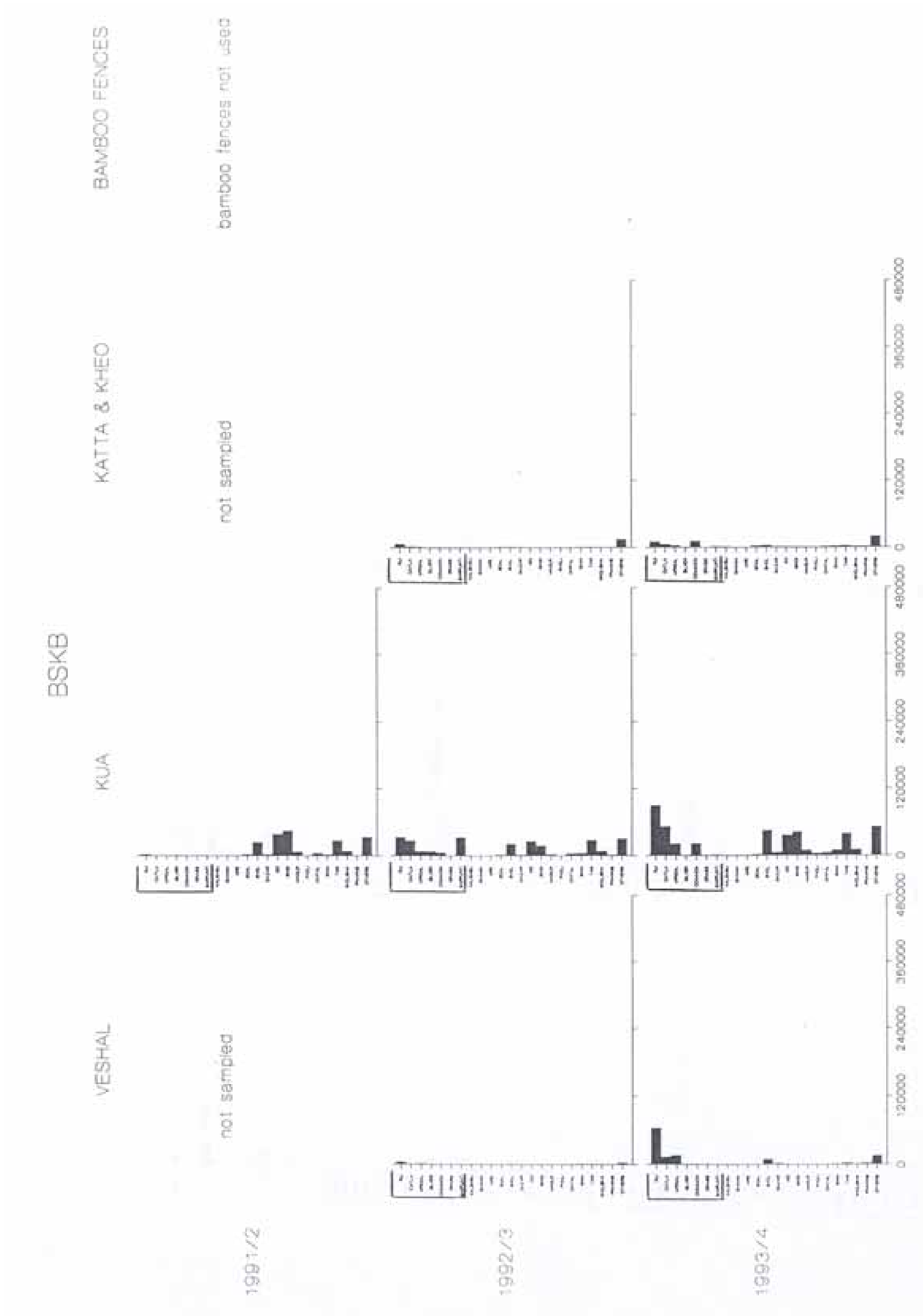


Figure 4.18 : Individual species catch by gear type, BSKB (veshal, kua, katta and kheo)

It is interesting to note that in the drought year of 1992/3 almost all stocked carp were harvested from kua pits in Chanda (Figure 4.19). However, the relative contribution of the kua harvest to the total catch drops to roughly a quarter in the following year (1993/4). Kua pits in BSKB harvested roughly half the stocked carp in 1992/3. In both BSKB and Chanda the increased catch of stocked carp in 1993/4, the second stocking year, was harvested through the operation of the smaller gears (Figure 4.19).

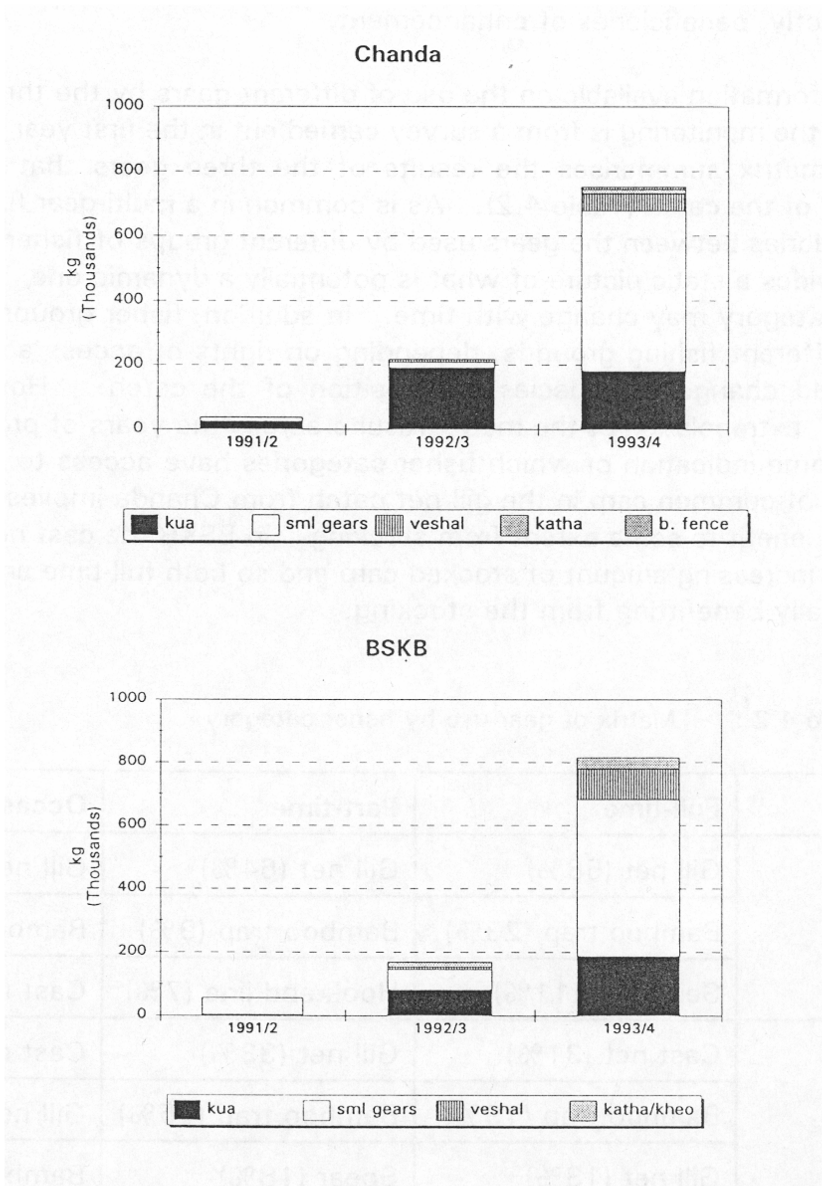


Figure 4.19 : Harvest stock carp by gear type

There were also increases in the catches of veshal and katta and kheo in the second stocking year. Veshal were not sampled in the first monitoring year. The importance of stocked species in the veshal catch in BSKB increases to the point at which these species dominate the catch in

1993/4 (Figure 4.18). Bamboo fences were introduced as a method of fishing at Chanda during the second stocking year. This is interesting as this introduction of a 'new' gear may have been in response to the stocking programme. As the graph shows (Figure 4.15) common carp is the only species harvested and the catches are low in comparison to the kuas.

The importance of kuas in the harvest of stocked carp indicates that at least one of the main groups of beneficiaries of the stocking programme were landowners. Kua pits are excavated on private land and the rights of access are tightly controlled by the landowner. Fishers are often employed in the harvest and marketing of fish from kua pits and so are also, indirectly, beneficiaries of enhancement.

The only information available on the use of different gears by the three fisher categories sampled in the monitoring is from a survey carried out in the first year of monitoring. The following matrix summarises the results of the three gears that catch the greatest percentage of the catch (Table 4.2). As is common in a multi-gear fishery, there are not clear boundaries between the gears used by different groups of fishers. In addition, this matrix provides a static picture of what is potentially a dynamic one, i.e. gear importance by fisher category may change with time. In addition, fisher groups may use the same gears in different fishing grounds, depending on rights of access and seasonal factors, which could change the species composition of the catch. However, given these constraints, extrapolation of the matrix results across the years of production monitoring provides some indication of which fisher categories have access to stocked carp. The dominance of common carp in the gill net catch from Chanda implies that all three fisher categories benefit to some extent from stocking. In BSKB the cast net is one gear which catches an increasing amount of stocked carp and so both full-time and occasional fishers are potentially benefiting from the stocking.

Table 4.2 : Matrix of gear use by fisher category

	Full-time	**Part-time**	**Occasional**
Chanda	Gill net (58%)	Gill net (64%)	Gill net (54%)
	Bamboo trap (23%)	Bamboo trap (9%)	Bamboo trap (16%)
	Seine net (11%)	Hook and line (7%)	Cast net (13%)
BSKB	Cast net (31%)	Gill net (33%)	Cast net (27%)
	Bamboo trap (19%)	Bamboo trap (25%)	Gill net (22%)
	Gill net (13%)	Spear (18%)	Bamboo trap (21%)

■ **Economic Return of Individual Species**

Another issue relating to species composition is the relative value of each species in the local markets and also, to some degree, consumer preference. So, the economics of the fingerling production and harvested fish also contributes to the discussion of individual species performance. Previous results from stocking in Hilna beel found that the value of harvested silver carp was less than the stocked value in the stocking period 1992/3 (MTA, 1993).

A similar analysis to that completed for the returns of individual species by weight was carried out using prices of fingerlings and harvested fish. Analysis of the prices paid for individual fingerling species showed wide variation and so a standard price of 80 taka/kg was used (SMIS data). Data from FAP 17 were used to provide prices for the harvested fish, the values represent the (1993) fisher prices rather than the market price. The prices used for each species are as follows:

Species	**Taka/kg**
Catla	49.06
Common carp	49.76
Kalbashu	42.46
Mrigal	45.36
Rui	68.49
Silver carp	35.32
Thai Sarputi	42.17

The resulting picture is not significantly different from that generated by using return by weight as the performance indicator. Due to the similarity, the annual returns in each floodplain are not included and the results presented are return by value for each floodplain. Both Silver carp and Thai Sarputi perform poorly, while the performance of Catla, Common carp, Mrigal and Rui varies with floodplain. The following matrix summarises the percentage return by value which are plotted in Figure 4.20.

% return by value	**Catla (CA)**	**Common (CC)**	**Mrigal (MR)**	**Rui (RU)**	**Silver (SC)**	**Thai Sarputi (TS)**
Chanda	183	1676	156	397	30	214
BSKB	353	429	447	655	62	78
Garalia	684	1180	943	951	252	149
Hilna	852	990	598	771	56	813

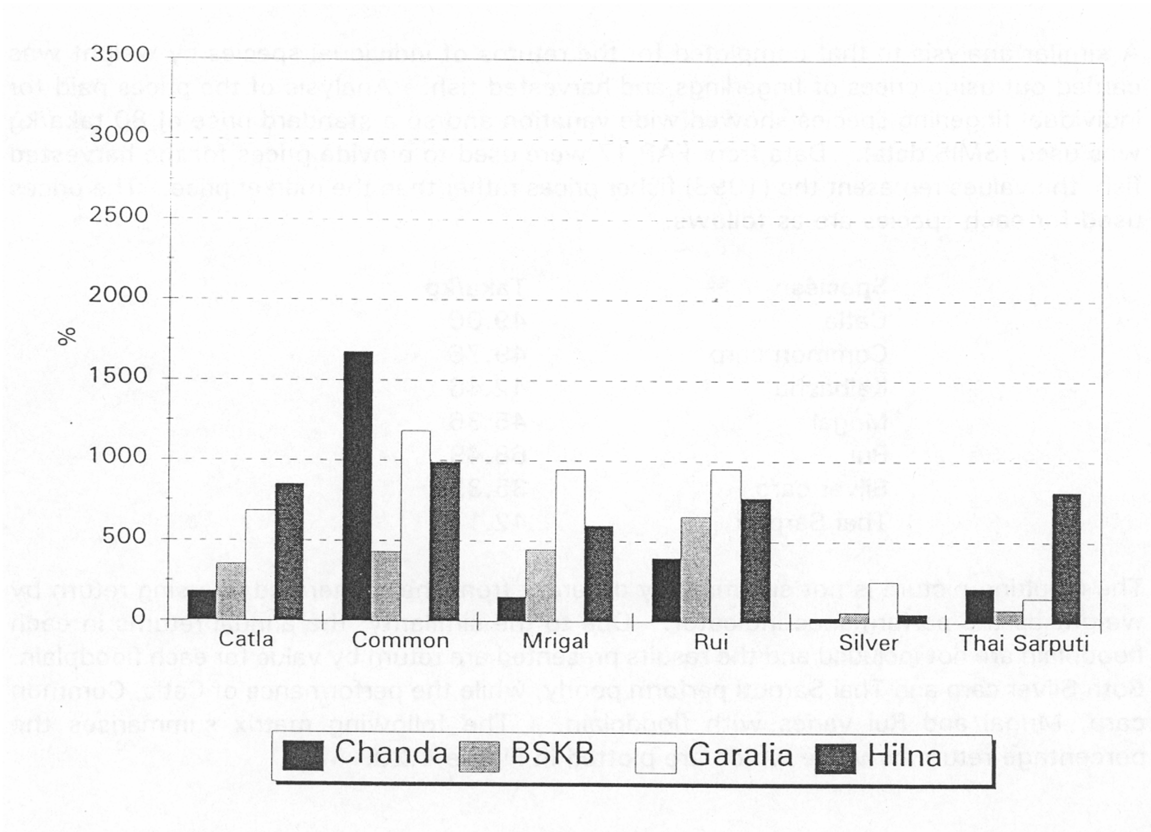


Figure 4.20 : Performance (return by value) of stocked carp in individual floodplains

■ Decision Making Options

Due to the different constraints presented by the floodplain environment, technical experience of stocking in other water bodies must be applied with caution. This issue of transferability of approaches has been addressed by Lorenzen in his work in culture based fisheries in reservoirs and lakes (MRAG, 1996). An adaptive approach is proposed where 'learning by experience' is placed within a formal strategy. Management experience is evaluated and may be supported by controlled experiments which should address identified gaps in knowledge or understanding. Through a process of developing management experience, the decisions made with respect to enhancement will take into account both technical and local issues and therefore be most appropriate to the floodplain under consideration. This strategy of adaptive management was first proposed by Walters (1986).

Given that this analysis showed that stocked species performance varies between floodplains, adaptive management offers an appropriate strategy to help determine optimal species mix in a floodplain. Many factors relating to the physical and biological characteristics of a floodplain will contribute to the success or failure of each species. Economic returns are a useful indicator of performance especially where cost recovery is to be addressed. In addition, a variety of factors such as local preferences and ease of marketability should contribute to the decisions on species performance which will lead to decisions on optimal species mix for floodplains. A participatory process carried out within the project would allow these issues to be explored with the communities harvesting the stocked carp and the opportunities for adaptive management could also be discussed.

■ **Conclusions**

- Returns by weight and returns by value of stocked carp clearly illustrate the poor performance of silver carp in each of the four floodplains analysed. In contrast, there is variation in the performance of the other stocked species, (common, catla, mrigal, rui and Thai. Sarputi) between floodplains. An outstanding example is the very high return from common carp in Chanda.

- Kuas, an important feature of floodplains in the southwest of Bangladesh, harvest a wide range of stocked carp and wild species. During the drought year, kua owners and the fishers employed to harvest and market the kua catch were the main beneficiaries of enhancement in Chanda. The increase in stocked carp catches during 1993/4 were mostly harvested by the smaller gears: kua catch remained constant despite the rise in total harvest. Common carp appears in good numbers in the gill net catch in Chanda, which implies that all three categories of fisher are benefiting to some extent from enhancement. Cast nets are the most important gears for both full-time and occasional fishers in BSKB, and of all the smaller gears these nets catch the most stocked species (in particular rui) and so these fisher categories are potential beneficiaries of enhancement.

- Adaptive management would provide a strategy in which floodplain enhancement could be developed in a way that is appropriate to the environment (physical, biological and social) in which it is carried out.

- Decisions on the correct species mix for a particular floodplain should be determined using a range of performance indicators: for example, return by weight, return by value, likelihood of capture by the targeted beneficiary group, ease of marketability and consumer preference. This breadth of perspective should ensure that the choice of species stocked in a floodplain will meet the objectives of enhancement.

4.3.3 Socioeconomic Evaluation of TFP, BCAS

This section summarises the findings of the full report prepared by BCAS which is presented in Annex I.

The original project document specified in detail the anticipated beneficiaries and the improvements expected to follow from stock enhancement. They were as follows:-

- 67,000 families, totalling about 4,000,000 people living in and around 10,000 hectare project stocked area;
- Of these 376,000 would be part-time/subsistence fish-folk, including destitute women and children; this would provide about Tk720 value per person per year, representing 14 % addition to their current income of about Tk5,000;
- About 24,000 existing full-time fishermen from 6,000 families would earn an extra Tk. 3,570 net per person per year, representing a 75% increase in income;
- About 12,6000 new full-time fishing jobs would be created.

■ Monitoring Approach

The methods and approach TFP used to monitor the socio-economic aspects were not uniform throughout the project and different agencies were involved at different times. As a result it was difficult to synthesise the information gleaned from the variety of surveys and investigations conducted.

Classification of beneficiaries proved to be a difficult task. At least two schemes were used: one following the general project description and the second was developed by Proshika who felt that the original scheme did not reflect the categories of resource users adequately. Participants at a Proshika workshop redefined the beneficiaries as follows with the third column showing how the new categories correspond to the original division of beneficiaries into full-time and part-time/subsistence fishers.

Main Proshika categories	Proshika subcategories	Equivalent 'original' category
Professional Fish for a living	**Traditional** Household heads been fishers for generations	Full-time
	Non-traditional Household relatively new to fishing - may retain some previous income earning activities	Part-time
Casual Fish for household consumption, surplus sold)	**Marginal**	Part-time/subsistence
	Non-marginal Land holdings are less then 50 decimals and no significant income from remittances, employment or business	

These problems associated with establishing a reliable monitoring programme illustrate some of the difficulties inherent to floodplain and their communities. This is also a clear example of the importance for projects to develop a commonly agreed and appropriate approach to monitoring the effects of management interventions. Establishing a clear relationship between indicators of benefits and a stocking programme in a floodplain presents a large challenge without the added complication of different approaches to the monitoring.

The indicators used assess benefits was another discrepancy between approaches. Finding quantifiable indicators appropriate to floodplain communities and which could be clearly linked to the activities of an enhancement programme was also difficult. There was no consistent approach taken across the project. Broad categories of indicators were assessed by Proshika and indicators appropriate to Bangladeshi floodplain communities selected. The following table summarises their general experience (Proshika, 1996).

Indicator	Proshika experience
Income indicators	
Income	Not straightforward in rural communities as many activities are 'income saving' rather than 'income generating'. For example subsistence fishing saves money which would have been spent at the market.
Nutrition	Enhancement projects would expect to have significant impact on fish consumption. Information on species, quantity and source of fish in the 2 days preceding survey established patterns of consumption.
Health and Sanitation	Difficult to establish direct relationship between stocking and health. ownership of sanitary apparatus were used as an indicator of standard of living.
Clothing	Good indicator of modest increases in income.
Education	Impossible to establish relationship between stocking programmes and education.
Housing	Good indicator of significant increases in disposable income as is a popular aspiration of all households.
Moveable assets	Good indicator of changes in 'fortune' across all categories sampled.
Credit	Sensitive topic to survey routinely.
Sources of funds	
Windfall	Proshika added a question on
Non-income indicators	
Fishing activity	A range of indicators were used to determine changed in fishing activity: fishing location; obtaining more fishing gears; marketing methods; samity (fisher cooperatives) membership; access to fishing.

■ **Key Findings**

BCAS - source BCAS report in Annex I.

- land value in all stocked beels improved with stocking, however non fishers had more land assets than fishers thus gaining more benefit;
- professional fishers owned less fishing grounds than non-professional fishers and non fishers;
- increase in income for professional fisher was only 8% and 5% for non-professional fishers, anticipated percentage increase was 75% and 14%;
- using 'movable property' as an indicator of income, non professional fishers and non fishers accumulated more than professional fishers over the period the water bodies were stocked;
- professional fishers acquired more fishing gear in the post-intervention period than the other two sampled groups;
- overall economic condition of the stocked beels improved in the post-intervention period. However, total fish income is a small proportion of total household income so any improvement was difficult to ascribe to the stocking programme;
- value of houses in the post intervention period increased, however professional fishers had least valuable dwellings than other sectors of communities;

- perceptions among surveyed communities that Kua owners benefited greatly from stocking was supported by the increase in the numbers of middlemen in the stocked beels. Kua owners are traditionally farmers or absentee landlords and so need the skills of middlemen to market the increased catch;
- landowners construction of kuas increased post-intervention, both on private land and the land adjacent to their land;
- professional fishers were disadvantaged by stocking particularly when the three month conservation period was enforced. Opportunities for alternative income earning activities very small in this period. Conflict due to enforcement when fishing gears were confiscated and fishers arrested. Professional fishers sold household property and borrowed money in this period of banned fishing; and,
- consumption surveys showed that, post-intervention the amount of fish eaten in fishing households increased.

Proshika - sources BCAS report (annex I) and Proshika (1996)

- No evidence of income difference between traditional fishers in stocked and non-stocked beels were found;
- professional fisher incomes show regular seasonal variation and no differences were observed in stocked and non-stocked beels, similarly annual consumption patterns were not different in stocked and control beels;
- results from beels which were stocked consistently indicate more potential for benefits than those stocked intermittently. This conclusion was drawn from analysis of BSKB which was stocked in three consecutive years where communities did not experience the same decline in income as communities in other beels;
- very little change was observed in the fishing communities before or after stocking, i.e. few people entered or left the fishery. Agricultural activities were preferred over fishing in the non-traditional category (the most likely source of new fishers);
- fishers did not change their fishing grounds in response to stocking;
- professional fishers bought more gear than the other categories of fisher, indicating a high fishing effort requiring gear replacement; and,
- the change from leases to licensing wasn't widely welcomed by fishers and the report concluded that each floodplain should be assessed and management proposed individually.

■ **Summary of Socioeconomic impact review**

Economic condition of communities in stocked beels did improve due to stocking, however the distribution of benefits did not match that anticipated by the original project document. Full time (professional) fisher's income did not increase to the degree expected and this group, given such a high profile in the original document, bore a considerable cost as a result of stocking activities. The costs to full time fishers included increased conflict with authorities over fishing in conservation period, loss of gear through confiscation, arrest and declining income resulting in the selling of property to support their households.

4.4 Discussion

The discussion draws from the analysis completed by MRAG and BCAS described above and also from TFP analysis reported in the final documents of TFP. The section begins with a summary of the project's achievements and discusses in more detail the experience of TFP in addressing the direct and indirect constraints to outcomes. These are the two pathways made explicit in the Oakerson framework.

4.4.1 Overview of Achievements

The project's final reports assess TFP outcomes in terms of the original project objectives and against targets in the original project document. Briefly, the main objectives were increasing fish production, private sector participation, institution strengthening and increasing incomes of poor. This section gives a brief overview of each of these in turn, describing the criteria used to assess the outcome related to each objective and the comparison of actual results with the targets. The source of the data was the final project report for the floodplain component: DoF/MTA, 1996b.

Table 4.3 summarises some of the key technical outcomes of TFP. The figures are averages of all floodplains that were stocked in the project. The names and areas of these floodplains are listed in Annex II.

Fingerling Stocking - Comparision of SAR targets and actual results

	Area to be Stocked		Stocking Density		Total Stocking Quantity		Production		Weight Increase	
	Planned (ha)	Actual (ha)	Planned (Kg/ha)	Actual (Kg/ha)	Planned (Kg)	Actual (Kg)	Planned (mt)	Actual (mt)	Planned	Actual
PY 1 (1991)	3,700	3,700	20	19.7	74,000	73,000	740	696	10	9.5
PY 2 (1992)	29,000	23,200	20	17.5	580,000	405,590	5,800	733	10	1.8
PY 3 (1993)	60,000	24,700	25	17.5	1,500,000	432,476	15,000	2,911	10	6.7
PY 4 (1994)	100,000	23,900	30	18.0	3,000,000	430,741	30,000	4,640	10	10.8
PY 5 (1995)	100,000	33,900	30	17.7	3,000,000	601,597	30,000	5,222	10	8.7
PY 6 (1996)	100,000	44,900	30	14.7	3,000,000	661,031	30,000	**6,610	10	**10
Totals:	100,000	*59900	26	17.3	11,154,000	2,604,435	111,540	20,811	10	8.0

* See Table 6.
** Estimated

Table 4.3 : Summary of Third Fisheries Project performance against original targets (Source: DoF/MTA, 1996b)

To assess the degree to which the stocking programme raised floodplain fish production the project used: (I) seed fish production over the life of the project and (ii) increases in biomass (total fish production/fingerlings stocked). A total of 20,000 mt of fish was produced, equivalent to the average annual consumption of 2.8 million people. This, however, is only 19% of the planned total. Technical and logistical constraints experienced during project implementation meant that the original targets were not met. Briefly, fewer water bodies than anticipated were brought into the stocking programme because of difficulties meeting the floodplain selection criteria (especially area requirements), problems with fingerling supply, uncertainty about the area of individual floodplains, concern over the economic advantages of the planned increase in stocking densities. Delays in the transfer of leased water bodies to the required licensing system also reduced the area brought in to the programme. These issues are dealt with in more detail in Section 4.4.2.

A tenfold increase in the biomass was the target for the programme set in the original project document. The average for all floodplains in every year of the project was eightfold, with some floodplains showing an increase in biomass as high as 15-fold (DoF/MTA 1996b). The features that result in high returns of biomass are obviously key to understanding the technical success of floodplain stocking. The variability among floodplains requires analysis of annual results from individual floodplains to understand why stocking succeeded or failed in light of the physical and biological attributes of the particular floodplain and the behaviour of the fishery's stakeholders.

Involvement of the private sector, one of the objectives, was achieved at the fingerling supply stage. All fingerlings stocked in the enhancement programme were supplied by private contractors. Monitoring of procurement and delivery showed that an increased quantity of fingerlings was delivered each year. Contractor performance varied in different regions; poor performance was observed in regions with greater distance between hatcheries and release points.

The objective of strengthening institutions was assessed in terms of establishing managerial routines for various aspects of floodplain stocking. Namely, assessment of floodplains for inclusion, inspection of fingerlings, fingerling procurement procedures, quality inspection of fingerlings, stocking management information, verification of stocking and production monitoring. These activities are largely targeted at the Department of Fisheries although NGO and other institutions involved in floodplain stocking were included in the final stages of the project. The issue of institutional strengthening is included where possible in later sections.

The objective to increase the incomes of the poor is stated as having been met as the total incremental fish production over the entire project was estimated at 660m Tk (DoF/MTA, 1996b). This figure was estimated using fishermen selling prices. It was estimated that this figure was shared among 102,000 fishers of various categories. However, the distribution of benefits among beneficiaries, assessed through a variety of monitoring programmes, did not meet original objectives. General conclusions drawn in the project's final report were that all sectors of the community benefited but that benefits were skewed to landowners, leaseholders and owners of expensive gears. Difficulties defining target groups and methods to quantifying benefits for the project resulted in problems with the monitoring programmes. However as reported in Section 4.3.3, 5.4.1.3, full time fishers - one of the main intended beneficiary communities, did not benefit from stocking and in some instances were disadvantaged by the programme. The primary source of this unexpected outcome was incorrect enforcement of a conservation rule excluded people from their fishing activities. More detailed discussion on these issues is presented in Section 4.4.3.

Due to the lack of previous experience of stocking in this environment, the initial focus of the project was on identifying the best technical strategy to increase the harvest of floodplain fish. In Oakerson's framework this is the direct relationship between the technical constraints of stock enhancement in the floodplain environment and the outcome of stocking. This strategy had to address two principal areas of concern: those relating to hydrological characteristics of the resource (the choice of floodplains); and those relating to modifications of its ecological characteristics (the choice of stocking parameters - species, density, timing, fingerling size etc.). The lessons from this experience cover issues of project implementation as well as those of a more purely technical nature. These are reviewed below (Section 4.4.2).

Despite the initial emphasis given to technical issues, during the course of the project it became clear the that behaviour of stakeholders in the fishery and the nature of the rules governing floodplain fisheries also influenced the outcome of stocking. That is, project experience showed that indirect constraints, made explicit in Oakerson's framework as the second pathway, are important determinants of successful floodplain stocking programmes. In recognition, the project initiated activities to address the way fishers interacted with their (enhanced) resource and how that resource was managed. A critical change in emphasis was the active involvement of NGO's in the stocking programme. The experience illustrating the importance of this pathway in determining outcomes of stocking is discussed and the result of community consultation is outlined (Section 4.4.3).

4.4.2 Direct Constraints to Enhancement: TFP Experience

As noted earlier, TFP gave the technical aspects of floodplain stocking highest priority in the early stages of the project. The experience of TFP offers much insight into the technical constraints of releasing seed fish into a characteristically variable resource, the floodplain.

- **Hydrology and Fish Production**

As discussed, hydrology is a major determinant of floodplain activities and this distinguishes stocking programmes on floodplains from those in perennial water bodies. The relationship between hydrology and fish production is well established). Therefore, any estimate of fish catch made to determine the success of floodplain stocking must take into account year to year variability in the flood regime. This adds yet another layer of complexity to interpreting results from monitoring programmes in floodplain fisheries.

Analysis showed that the catches of non-stocked species of fish on an unmodified floodplain were positively correlated with rainfall (Section 4.3.1). Using annual rainfall data from the upper catchment of the Ganges Basin and fish catches at Padma, a similar relationship was found between fish catch and rainfall from the previous year (Payne and Temple, 1996). Suitable indicators of floodplain hydrology need to be identified and these will differ for open floodplains and highly modified floodplains (Section 4.3.1).

The influence of hydrology must be considered when assessing the outcomes of stocking. For example, the outcome given highest priority in the early stages of the project was the productivity of the enhanced resource. To assess the extent to which stocking improved the fish catch from the floodplain, annual estimates were judged against a single baseline year monitored before the first release. The objective was to achieve a ten-fold increase in annual fish production with stocking. However the reliance on a single baseline provides a very static picture of what is a dynamic system. The variability in the system due to changes in hydrology can be significant, indeed the first stocking year (1992) coincided with a drought year and catches were noticeably reduced - despite stocking. Some consideration of the natural variability in the system would provide a clearer indication of the effect of stocking on floodplain catches.

Annual catches for the floodplains stocked and monitored over the course of the project ranged from less than 100 kg/ha to a maximum of 800 kg/ha (DoF/MTA, 1996a). Analysis related the high returns from the stocked carp to inherent productivity of individual floodplains, release of the appropriate number of fingerlings, the timely release of fingerlings in relation to the flood, and the protection of fingerlings from fishing pressure for a period after release. A final project report for TFP also noted that the environmental conditions in beels could be improved with respect to siltation of khals (canals) and sluice gate control in empoldered areas (DoF, 1996a).

To plan stocking and harvesting activities it is desirable to have some degree of predictability of flooding in individual floodplains. Thus, the hydrological regime of individual floodplains should be one of the criteria used to select new floodplains.

- **Floodplain Selection Criteria**

The technical criteria used to select floodplains were the extent and duration of the flood, the degree of connection with other floodplains, soil type, land use and degree of aquatic vegetation cover. The original project document indicated a minimum size for stocked beels of 5,000 ha. However, it proved difficult to find floodplains of this size and so the project reviewed this criterion to a minimum of 1000 ha. Problems occurred even with this revised criteria and floodplains as small as 100-200 ha were accepted for stock enhancement. Determining the actual size of floodplains contributed to the problems identifying suitably sized areas. Note that a definition of area, important given the dynamic nature of floodplain hydrology, was not provided in the original project document. The project used the following definition of area: the extent (ha) of floodplain flooded to at least 1m for 4 months of the year.

These problems had important implications for the project meeting targets set out for increasing the area brought under the stocking programme. The original target of stocking 100,000 ha by the end of the project was revised to 60,000 ha (DoF/MTA 1996b).

Floodplains with minimal connections to neighbouring water bodies were preferred in order to reduce opportunities for fingerling escape. Unfortunately very little documentation was available on the details of the other technical criteria such as how decisions were made on soil type and land use.

Selection criteria also included that new floodplains included in the programme should be managed under a licensing system. This required that the existing leasing system be cancelled: the delays in cancelling leases slowed down the inclusion of new floodplains in the programme (DoF/MTA 1996b). This aspect of the selection criteria relate to the indirect constraints in Oakerson's framework as the decision making arrangements cause particular forms of behaviour of stakeholders on the floodplain. As a result this is dealt with in more detail in Section 4.4.3.

- **Fish Seed Production**

The procurement contracts between the project and private hatcheries specified species mix, fingerling size and timing of delivery. With experience it was found that the private contractor's ability to meet the contractual arrangements improved. Progressively more fingerlings were delivered each year, 661 mt were supplied in 1996 as compared with 73 mt in 1991 (DoF/MTA 1996b).

With respect to supply of particular species, common carp proved the most difficult. The reason given is that common carp breed earlier in the season than the other species stocked. Although favoured because of their high returns by weight, reliance on common carp was limited due to supply problems. Thai Sarputi (*Puntius* spp) were introduced to the species mix later in the programme, however supply problems were experienced with this species too.

The release points in floodplains were often remote from the hatcheries and access was frequently difficult, increasing the problems of fingerling mortality during transport. Results from the SMIS monitoring showed that the regions where hatcheries were close to the floodplains, the greatest percentage of contracted quantities was delivered (DoF/MTA 1996b). A consultation workshop held near the end of the project recommended that further improvements could be made by establishing hatcheries within the boundaries of the floodplains that are to be stocked (MTA, 1996a). An additional motivation for this is that as the seed fish producers were major beneficiaries of the project; so, promoting beel side nurseries would tie more of the benefits of enhancement to the communities relying on the resource. If the potential beneficiaries are involved or at hand, such a move would also reduce the risk of collusive fraud between suppliers and those assigned to supervise them.

- **Stocking Density**

Determining the area of a floodplain to be stocked proved to be a key limitation to understanding appropriate stocking densities. As the extent of the flood is seasonal it is considered appropriate to use the area at maximum inundation (floodable area) as the best estimate. Initially the project focussed on three floodplains, Chanda, Halti and BSKB, and the floodable area of each these was determined before project implementation. As new floodplains were incorporated into the stocking programme, their floodable area was estimated. These estimates proved unreliable and therefore, it proved impossible throughout TFP to accurately determine stocking density and so understand whether floodplains were being overstocked or understocked.

Originally the project documents set out an increase in stocking density, from 20 kg/ha to 30 kg/ha, over the course of the project; this was not implemented. This was partly due to supply problems with fingerling producers failing to fulfil contracted quantities. There were also questions raised about the cost effectiveness of such an increase and problems with determining floodplain areas increased the uncertainty surrounding stocking density decisions. Indeed the original target of 20kg/ha was often not met in the project due to a variety of constraints.

In the final year of the project the floodable area of each floodplain was determined using GPS. Retrospective analysis of stocking densities, using GPS measures of floodable area, and returns by weight showed that densities between 13 and 26 kg/ha resulted in production at or above the desired ten fold increase (DoF/MTA, 1996a). It should be noted that these densities were appropriate to the size of fingerlings actually released in the project, i.e. carp were stocked in the range of 8-15cm and Thai Sarputi between 6 and 11 cm.

The appropriate stocking density will be a function of the physical and biological characteristics of the floodplain. As a result of the final analysis, it was proposed that initial densities of 13 kg/ha for less productive floodplains and 26 kg/ha for more productive floodplains is a reasonable strategy. As experience is gained in individual floodplains, adjustment of these initial densities would be made and appropriate stocking densities would be developed.

It should be noted that a key technical constraint to floodplain stocking is that fingerling production occurs ahead of the rain. This limits the extent to which plans for fingerling procurement could change in response to high or low water in a particular year. Where there is significant year to year variation in hydrology of individual floodplains, some flexibility in the number of fingerlings to be released would be beneficial. Stocking the ‘usual’ amount in a poor flood results in overstocking and therefore a decrease in potential returns. This is a key issue to be resolved.

■ Timing of Release

The main premise behind stock enhancement of floodplains is that by stocking at the beginning of the flood, fingerlings are released into a productive environment promoting rapid growth and the expanding water provides some measure of protection from fishing pressure. Years in which fingerling supply was delayed resulted in lower returns as the growth period was contracted. From the point of view of project planning of the entire stocking programme, differences between regions of Bangladesh with respect to onset of the flood had to be taken into account (MTA, pers comm).

One of the conclusions of TFP was that the timing of the fingerling release should be more closely aligned to the hydrology of a particular floodplain (DoF/MTA, 1996b). For example, floodplains which drain rapidly should be stocked at the beginning of the rains. This indicates that some degree of flexibility is needed within the overall stocking strategy, as there will be variation between floodplains and also year to year variation within a floodplain.

■ Fingerling Size

The size of fingerlings was pre-set in the original project document at 9.5 cm (7.4 g), the size was to increase as the technical skills of fingerling producers improved. The rationale behind the planned increase in fingerling size was that larger seed fish are less susceptible to predation (World Bank, 1990).

Due to the cost implications of increased fingerling size and doubts over the advantages of larger fingerlings, a decision was taken to maintain the initial sizes indicated in the project document. The contractual arrangements for fingerling supply defined size requirements and the procurement system was tightly monitored. Analysis of fingerling size showed that there was no significant difference between years, between floodplains and amongst species (Section 4.3.2). As fingerling size did not vary significantly, its effect on production cannot be assessed.

The economic implications of changing seed fish size will be an important determinant of the optimal size for floodplain release. Should it prove economically viable to release smaller fingerlings, the appropriate stocking densities will have to be re-evaluated in light of the change in seed fish size.

■ Species Choice

As noted above, a range of carp species were identified for release in a specified ratio. An analysis of individual species performance confirmed the poor performance (by weight) of silver carp - this had been obvious from field experience as stocking progressed. Silver carp (*Hypophthalmichthys molitrix*) are highly mobile and so migrated out of the project areas and were not represented in the catch estimates. Over the course of the project silver carp were phased out.

The performance of the other species stocked, i.e. common carp (*Cyprinus carpio*), catla (*Catla catla*), mrigal (*Cirrhina mrigala*), rui (*Labeo rohita*) and Thai. sarputi (*Puntius* spp) was variable between floodplains (Section 4.3.2). An example is common carp in Chanda beel where this species dramatically out-performed all others: the yield per kg of common carp was consistently in excess of a ten-fold increase, while the other species fall well below this. This can be interpreted in terms of the characteristics of the resource which is an open, fertile floodplain with a dense canopy of vegetation which will generate a thick mat of detritus - ideal for the bottom feeding common carp. Fishers, when informally consulted on species choice, indicated a strong preference for common carp.

With the exception of silver carp, each of the remaining species gives a ten-fold increase in at least one of the floodplains analysed (Figure 4.21). Therefore, this selection of species is a reasonable first choice for floodplain stocking. But factors other than returns by weight must also influence decisions on species choice. For example do the intended beneficiaries have the capability (skills, resources or gear) to harvest a stocked species, what is the relative value of species in the markets, what are consumer preferences. As was noted in Chapter 3, a huge variety of gears are operated by a heterogeneous community of fishers on the floodplain. This is in response to the variety of habitat types and marked seasonality of the fishing grounds. Differences in the physical nature and seasonality of individual floodplains will alter the pattern of gear use and so affect who will benefit from the enhancement.

In order to develop the most appropriate species mix for individual floodplains, a strategy of adaptive management has been proposed (Section 4.3.2.4). This formalises ‘learning from experience’ and should result in the stocking strategies that are appropriate to the physical, biological and socio-economic characteristics of individual floodplains.

- **Exotic Stocked Carp and Wild Fish**

One of the questions often raised in relation to release of exotic fingerlings is the potential for negative impact on wild fish stocks. A dramatic example of this potential is the change to the ecosystem of Lake Victoria with the release of Nile Perch (*Lates niloticus*) (Ochumba, Gophen and Pollingher, 1994).

To analyse the potential for stocking to affect wild fish negatively, TFP looked at the relationship between stocking density and wild fish production. Data sets with a time series of at least three years were used. Analysis of individual floodplains and annual averages did not yield a significant relationship. Therefore, it could not be said ‘with confidence that there has been an impact on wild fish’ (DoF/MTA, 1996a). It was noted that longer data sets would be valuable so that trends could be assessed. This issue requires focused research.

- **Monitoring**

Monitoring is an activity that provides information for a project to assess both cost effectiveness and impact and information that guides management decisions. Initially the production monitoring system consisted of three separate surveys: household, gear and market based. There were major problems with the gear based surveys: the enumerators were required to observe the number of gears operating and sample the catch in the fishing grounds but most fishing is done at night and so the system failed. By default, enumerators collected data from fishers as they landed at officially recognised sites, however fishers who did not sell their catch or who had sold directly to traders were not sampled. When the importance of kuas and other large gears became apparent, individual surveys were conducted and the estimates of fish catch were added to the total for the floodplain. There was a change in the institution implementing the monitoring three years into the project, when the contracted NGO, BCAS handed over to DoF. With the takeover DoF rationalised the monitoring programme and a refined gear based survey was implemented for the remainder of the project.

Several important issues were raised in relation to the TFP monitoring systems. The accurate recording and interpretation of data were not straightforward in such a variable and complex environment. This is, however, essential. In addition, the scale at which the enhancement was carried out was large. During the course of TFP some 1,900 tons of fingerlings have been stocked in 20 floodplains representing an area of 107,500 ha in Western Bangladesh

(DoF/MTA, 1996b). Four of the floodplains stocked in TFP were greater than 4,000 ha, which increases the logistics of data collection considerably. Apart from monitoring production issues, socio-economic impacts were also surveyed (see Section 4.3.3, 5.4.1.3).

The assessment of the project monitoring system provides insight into the required capacity of institutions to implement monitoring. The procedure within DoF developed to the point where the flow of production data from floodplain to Dhaka functioned well. However, concern was expressed about several important issues such as the quality of data entered, its verification at source and the inclusion of local understanding for meaningful interpretation of results. Improved coordination within DoF was regarded as the solution to these problems in conjunction with the development of guidance and supervision skills of staff with responsibility of overseeing field work. There are several instances of individual beels where the quality and quantity of data was "almost flawless" proving that there is potential within the institution for high quality performance (MTA, 1996b).

Monitoring is an integral part of enhancement activities for at least two reasons, to assess the impact of the project and to inform management. The floodplain environment presents many constraints to the implementation of a rigorous survey. These difficulties are compounded when the survey area is large. Involvement and agreement of local communities to participate and support monitoring should be encouraged as a means by which the resource can be better managed.

4.4.3 Indirect Constraints to Enhancement: TFP Experience

This section discusses those aspects of the project where the decision-making arrangements and the subsequent actions of different stakeholders on the floodplains were addressed in an attempt to improve the outcome of stock enhancement.

- **Enforced Ban on Fishing to Protect Fingerlings Post-release**

As the stocking programme developed, it became clear that the behaviour of the fisher communities had an important affect on the outcome of enhancement. Experience showed that it was technically possible to improve the returns by weight if a protected growth period could be implemented (DoF/MTA, 1996a). A three month 'conservation period' separating fingerling release from the onset of harvest was considered optimal. So, in addition to the technical intervention of fingerling release, the project introduced rules governing fishing on the enhanced floodplain.

As noted in previous chapters, the point at which fingerlings are released onto the floodplain is very significant as the common pool nature of the resource determines the outcomes of stocking. As discussed in the previous chapter, floodplain fisheries are often exploited by significant proportion of the population using a wide variety of gears targeting a range of species. Together with the size of many floodplains and the limited enforcement capacity of the DoF, this makes the protection of carp fingerlings in the period after release difficult to achieve and equivocal in its effect on outcomes.

Assessment of the impact of the conservation period revealed unexpected and undesirable outcomes. Professional fishers, banned from their sole source of income, carried a high cost of the implementation of this rule. In addition, subsistence fishers, accustomed to using smaller gears to catch wild stocks in the flood margins, found themselves unable to fish. As they usually also lacked the gears to exploit the stocked carp at the end of the season, this left them disadvantaged. The rule had in fact been developed to restrict capture of stocked species, so fishing for indigenous species was allowed. However, this exemption was not widely understood by communities or the implementing agency (DoF) and often a total ban was enforced. It is questionable if such a rule is in fact enforceable, as it requires that one group of species (stocked carp) are distinguished in a multi-gear, multi-species fishery.

Without the understanding and cooperation of fishing communities, protection of stocked fingerlings through control of fishing is an improbable task. So given the reported technical advantages of a ban on fishing, a more flexible and appropriate solution needed to be found through increased involvement of floodplain communities. TFP contracted NGO's to play a facilitating role between the project and the communities who were its intended beneficiaries. The specific activities of the NGO's in 'successfully enhanced' floodplains were not documented in final reports, although NGO involvement was generally reported to lead to improved outcomes of stocking.

- **Access to Productive Fishing Grounds**

There are many access regimes in operation on the floodplain: seasonally inundated land is usually open access during high water but during the flood recession and the dry season exploitation of the permanent water bodies (which are owned by the government) may be controlled through leases or licences, while exploitation of residual waters on private land is often controlled by the owner.

The impact of these access regimes on the patterns of interaction and on outcomes is not fully understood, as the monitoring programme initially only collected data by fisher category and gear type, not by water body type[5]. However, in one area the impacts of the stocking programme on fishing strategies and, hence, project outcomes was most clear.

Because of the nature of floodplains in the Southwest of Bangladesh, land owners benefited significantly more from the stocking programme than was originally anticipated. In this region, the floodplains are shallow and the dry season long enough to permit cropping even on the lowest land (Wood, 1994). Nearly all the floodplain is, therefore, agricultural land and owned or claimed by private individuals. Kua pits have always been an integral feature of floodplain fishing in this part of Bangladesh. Dug on private land, kua's aggregate fish as the floods fall. The response of landowners to floodplain enhancement was to construct kuas and thus claim a greater proportion of the benefits of stocking. In addition, the harvesting arrangements for kuas were changed after enhancement: before stocking, professional fishers exploited the kuas and shared the catch on a 50-50 basis with the landowner, after stocking landowners changed the arrangement to a 40-60 basis. It was noted in a project briefing paper (1993) that this arrangement was expected to deteriorate in subsequent years. As a result the intended beneficiaries, the poorest fishers, lost out.

This is a clear example of how the behaviour of stakeholders in the fishery (landowners) influences the outcome. To achieve the desired result, anticipating how communities will respond to enhancement of the resource is important. Understanding the arrangements - both informal and formal - that govern floodplain fisheries' exploitation, would allow some prediction

[5] Later in the project, data was collected according to fishing ground type. The categories identified were *jalmahals*, deep water, shallow water, paddy area, major khal and minor khal. Unfortunately, this aspect of the database is not sufficiently developed to allow analysis of data at the time of final reports (MTA, 1996b).

of stakeholder response to the project. These arrangements (i.e. the rules and the communities who set, enforce and are regulated by them) also provide the opportunity to encourage behaviour that meets the objectives of stocking.

- **Responsibility for Decision-making**

There is widespread recognition that resource management is more likely to be sustainable when the community is involved in the decision making process (Pinkerton, 1989). Initially, DoF had very little contact with fisher communities - the intended beneficiaries. At the midterm review, emphasis was given to changing this aspect of the project to improve benefit distribution. Project involvement of NGO's was a key step in drawing the communities into the enhancement programme and thus ensuring that advantages of stocking were maximised for floodplain communities. The NGO's raised awareness of the stocking programme within fisher communities and represented the needs of these communities to DoF. The presence of a strong NGO has been linked to 'successful' stocking in some floodplains (MTA and Imtiazuddin Ahmed, World Bank, pers comm).

In the final stages of TFP, the project held a series of workshops with the stakeholders of floodplain enhancement, namely DoF, NGO's and fishers (DoF/MTA 1996a). To explore ways in which communities could play a more active part in the stocking programme the workshops considered various committees as potential mechanisms. Two of the committees considered reflect the existing administrative structure within Bangladesh: villages are grouped to form a Thana, while several Thana's are grouped within a District. In some areas, District and Thana committees were already established and the Government recognises the right of these committees to manage floodplains within their jurisdiction. However, several problems were noted in relation to these committees: they are dominated by government officials and so there is little representation of communities harvesting the floodplains; revenue collection dominates management and technical issues; and often individual floodplains do not fall neatly within one committee's remit.

The formation of a third committee, a Beel Management Coordination Committees (BMCC), was proposed as the solution to the blurring of individual beel boundaries between existing committees, the lack of focus on management and the exclusion of fisher groups. The membership of the BMCC would include DoF, NGO and fisher representatives and responsibilities would relate to an individual beel, crossing existing administrative areas where necessary. It was agreed that fisher representatives should be democratically elected by their community. The decisions made by this committee, covering technical, managerial and social aspects of management would be submitted to Thana and District committees for Government approval. At present it is considered that, as most of the experience resides within DoF, that this institution will play a lead role in decision making and coordinating future stocking programmes. It is, however, possible that with time there will be a transfer of skills and the communities will assume all responsibility for enhancement of their floodplains.

The formation of fisher groups was also mooted, although it is not clear whether representatives from these groups would be members of the BMCC. Several questions were posed as to the exact nature of the groups: should groups be formed according to fisher categories or mixed fisher types, should groups cross village boundaries, how should *kua* owners be incorporated, what status should the groups have. The NGO's were seen as the main facilitators of the formation of these groups.

The project collated the conclusions of the workshops into a Master Work Plan that could be implemented by the BMCC's (MTA, 1996a). The expected time horizon for implementation of this work plan was at least five years, note this is beyond the life of the project and it is unlikely to occur without external support.

These workshops were the first step taken by the project to address the issue of what institutional arrangements should accompany the technical activities of fingerling supply. The discussions raised several issues that remain to be resolved with respect to the institutional arrangements for floodplain stocking programmes. Namely, what are the respective roles for governments and local communities, i.e. which activities are best undertaken by a central institution compared to responsibilities best taken by resource users. It is clear from the experience of TFP to date that responsibility for some tasks should be taken by local communities. However, throughout the discussions a role for government, at least in the early stages of any stocking programme, was presumed. Therefore, a clearly defined relationship between government and local communities with respect to enhancing a resource is important.

4.5 Summary

In overview, the lessons from TFP experience can be divided into two, the technical strategy and the institutional strategy. First, the technical success of TFP provides useful guidelines for future enhancement strategies: with the corollary that, within the overall strategy, flexibility to allow a suitable technical response to the characteristics of individual floodplains would be optimal.

Second, TFP experience highlighted the importance providing an institutional framework to support the technical strategy, particularly with respect to activities occurring post-release. Instances where the anticipated outcomes of stocking did not occur, i.e. particularly the flow of benefits to targeted communities, were largely the result of the response of floodplain communities to enhancement. That is the activities of fishers and other stakeholders at the point at which the resource became common-pool, i.e. post release. The organisations and rules to support pre-release activities existed, however the involvement of NGO's was the first step to providing institutional support on the floodplain. Near the end of the project, TFP proposed greater participation of communities in all phases of enhancement. They were beginning to develop appropriate rules and relationships between stakeholders at this time.

5. Review of Enhancement Experience: Other Projects

5.1 Introduction

This chapter reviews projects whose experiences contribute to the overall understanding of floodplain enhancement issues. The projects are drawn from the Asian region and include experience of stock enhancement in floodplains and perennial water bodies. Two main floodplain projects were carried out in Bangladesh: Third Fisheries Project (TFP) was the subject of the previous chapter and the Second Aquaculture Development Project (SADP) is reviewed in this chapter.

Projects on perennial water bodies are included despite their differences to floodplains, as they provide important lessons on both the technical aspects of stocking and issues raised by management of an enhanced common-pool resource. A series of research project addressing reservoir stocking are also reviewed as the integrated approach to evaluating enhanced systems yielded many insights to technical and institutional issues.

Though the main focus of this report is on stocking, there are other methods for enhancing floodplain productivity. One project in Bangladesh reviewed here addressed the issue of declining fish yields on the floodplain through habitat restoration.

The experience gained from individual projects reflects the particular objectives and approach taken. The Oakerson framework is used to structure the experience. The lessons are divided into two categories corresponding to the two pathways which affect the outcome of fishery enhancement. First experience related to meeting the 'direct' constraints to enhancement, i.e. the physical, biological and technical characteristics of the fishery that provide the basic limit to what can be achieved through enhancement. Second, experience of addressing the indirect constraints, i.e. the combination of fishery characteristics and arrangements governing it's management that will affect collective behaviour of stakeholders and thus the outcomes of enhancement.

The lack of previous stocking experience on the floodplain renders the experience of TFP (Chapter 4) and SADP invaluable. A number of positive lessons have been learned, particularly with regard to the direct constraints - the first pathway. Their experience has also served to underline the need for early attention to the indirect constraints, the second pathway.

The experience of those projects on perennial water bodies provides much insight into handling indirect constraints, the second pathway. The longer history of stock enhancement in these habitats, and their greater inherent stability, has meant that the direct constraints have largely been overcome. As a result, recent efforts have been applied to the indirect constraints, i.e. the interaction between communities and their resource, as a key limitation to successful enhancement.

Each review begins with a brief description of the background to the project and the approach taken. A short overview indicates where the main contribution of the project experience lies with respect to the pathways in the Oakerson framework. The experience relating to the direct and indirect constraints to enhancement is reviewed in turn: subheadings separate the experience of larger projects.

5.2 Second Aquaculture Development Project (SADP), Northeast Bangladesh

5.2.1 Project Background

Time Frame	1988-1996
Donor (US$)	Asian Development Bank (47.9m)
Implementing Agency	Department of Fisheries, Bangladesh
Components	Floodplain fisheries enhancement; Shrimp culture development; Carp culture development; Institutional support
Objectives	‣ to provide extension and credit services for the improvement of: i. shrimp culture in four coastal districts ii. carp pond culture throughout 21 districts; ‣ to enhance the floodplain capture fishery in six northeast districts.

The floodplain component of SADP was carried out in Northwest Bangladesh in six districts: Syhlet, Sunamganj, Moularibazar, Habiganj, Netrakona and Kishoreganj. Carp hatchlings were stocked in 'nursery areas' which connect with the floodplain as water levels rise at the beginning of the monsoon. The nurseries were physically isolated and then prepared for the hatchlings using rotenone (piscicide), sumithion (pesticide) and sonar (herbicide). The hatchlings were stocked around March - May which allowed a rearing period of 30-100 days before inundation. The stocking procedure is similar to a system used in India and the need for complex infrastructure is reduced. The species were a mix of exotic carp (silver, bighead, grass, common and mirror) and local carps (mrigal, catla, rohu, kalbashu). Both private and public hatcheries supplied the hatchlings.

The floodplain fisheries programme was designed to include a fisheries resource and socio-economic impact survey to determine the viability of stocking and the impact on the fishery and both fishers and non-fishers in the area. However these surveys were not implemented until 1994. Although there was a mechanism proposed in the project design for cost recovery none was implemented within the project.

5.2.2 Floodplain Enhancement: Overview of Experience

As the final reports for SADP were not available at the time of this review, the experience discussed here is drawn from interim reports and interviews.

The experience of SADP is, in essence, very similar to that of Third Fisheries. The main focus at the beginning of the project was the development of a stocking strategy, i.e. the production and release of seed fish into floodplains in order to increase fish yields. As the technology of stocking differed from TFP, hatchlings rather than fingerlings were released, SADP provides an alternative stocking strategy. This is described below. The late start to the monitoring programme (1994) limits the degree to which experience can be gleaned from this project.

The impact that communities interacting with their resource can have on the outcome of stocking was recognised within the project. Similar activities to those implemented by TFP were proposed within SADP, i.e. the involvement of NGO's and the communities from the enhanced floodplains. Unfortunately, as the final project documents were not available in time for this review it is not known to what extent these proposals were carried through. As a result, the experience reviewed here is largely the technical aspects of enhancement using hatchlings. Hydrology proved to be a dominant force in this project, as it had in TFP. SADP used a different set of criteria to select floodplains to enhance, than that used by TFP. In addition, the preferred species for stocking also differed. The use of chemicals in the preparation of nursery areas for hatchlings raised considerable concern within NGO circles.

5.2.3 Direct Constraints to Enhancement

- **Hydrology and Hatchlings**

The stocking method used, i.e. rearing hatchlings in nursery ponds on the floodplain, is dependant on a reasonable period of growth before inundation. The northwest region of Bangladesh is characterised by early flash flooding which often resulted in the inundation of nursery ponds before the intended growth period (1-2 months) was complete. In some instances the hatchlings were less than 10 days old when flushed onto the open floodplain, reducing survival of hatchlings and the effectiveness of the stocking programme. The hydrological regime of the northwest is regarded as one of the major constraints to the effectiveness of SADP (Nasir Uddin Ahmed, DoF pers comm). This indicates that this method of enhancement is perhaps more suited to floodplains with a more predictable flood regime.

Despite the problems of flash flooding, an analysis of the 1994-5 stocking year concluded that the technology did increase the catch (DoF, 1995). This analysis resulted from the monitoring system started in 1994 and used comparable non-stocked floodplains to assess the effect of stocking. The total catch per hectare from control floodplains was 894 kg/ha while total catch from enhanced floodplains was 1409 kg/ha (DoF, 1995). Carp catches from enhanced floodplains were three times the carp catch from the controls. These figures were calculated using all districts, although it was noted that productivity varied widely across districts and water bodies.

The project area also included haors, large perennial depressions. These components of the floodplain do not have areas which are physically suitable to isolate as nurseries: SADP stocked fingerlings in these areas. The analysis of the 1994-5 stocking year showed that the problems of seed fish survivability were less than with hatchlings, however harvesting of undersized fish still occurred in these water bodies.

Beel selection and species choice

The importance of assessing logistical constraints when selecting floodplains was critical for SADP, as it was for TFP. There had to be suitable areas of the floodplain that could be converted to nursery areas and infrastructure had to allow easy access for preparation, stocking and control of nurseries. A key difference between the two projects is reflected in criteria specifying the nature of the floodplains to be stocked. SADP favoured very open floodplains with many khals (canals) to facilitate the wide dispersal of stocked fish, while TFP preferred floodplains where opportunities for fingerling escape were minimised. This reflects a difference in objectives between the two projects and therefore the criteria by which outcomes would be judged. A desired output of the stocking in SADP was a general increase in the inland catches recorded for carp species (MD Nasir Uddin Ahmed, pers comm). However, TFP stocked floodplains with the specific aim of benefiting communities associated with on the enhanced resource.

The two projects also differed with respect to preferred species: silver carp, dropped from TFP due to poor returns to intended beneficiaries, was favoured by SADP as the exotic carp was used as an indicator to show that stocked species were adding to the production of inland fisheries. The two main changes to the original species list (Section 5.2.1) were that bighead and grass carp were dropped from the programme.

- **Environment**

The environmental impact of the use of chemicals in the preparation of nursery areas has been raised as an issue for SADP. In the early stages of the project, chemicals were used to prepare the entire dry season water body. In response to international NGO concern, the project revised procedures so that nurseries were confined to areas that could be separated from the main beel. This reduced the total area affected by preparation chemicals. The delay between project identification and implementation may explain the use of a technology (reliance on chemicals) that had become unacceptable (Rosengren, Asian Development Bank, pers comm).

An assessment of the environmental impact of the chemicals used in SADP was completed in 1992 (Hill, 1992). The conclusions of the study were that the chemicals were safe because they quickly biodegrade, do not bioaccumulate and are target specific. Therefore, it was expected that “there is no significant impact or irretrievable loss to the existing fishery, rare or endangered species, wetlands or ecologically sensitive areas” (Hill, 1992).

5.2.4 Indirect Constraints to Enhancement

The delay in setting up a monitoring programme and the emphasis given to increased fish catch as the indication of enhancement ‘success’ has meant that SADP did not give early recognition to the importance of communities. The involvement of NGO’s in the stocking programme is noted as a desirable change in some interim reports, documentation on the extent to which this has been implemented was not available.

An assessment of the 1994-5 stocking year found that the beneficiaries of the SADP enhancement differed between floodplains according to the management regime in place (DoF, 1995). Where the floodplain fishing access was leased (to private individuals or groups) then these lease owners were the main beneficiaries. In floodplains managed under the New Fisheries Management Policy (NFMP), i.e. a system of licensing fishers, these fishers benefited from the addition of carp. When the water body was open access, the fishers also benefited but it is believed that there was little control of harvesting under sized carp. The involvement of DoF as the controlling institution of floodplain management was advised, with the change to the NFMP. This was seen as an essential prerequisite for cost recovery.

However, as cost recovery was not implemented at the time of the 1994/95 assessment, a pilot scheme for community management of two beels was proposed. It was expected that if the benefits from stocking were directly available to the communities some form of cost recovery could result. Clearly as with TFP, the early emphasis given to the technical aspects of stocking delayed consideration of the institutional aspects leaving little time to address them as thoroughly. Therefore, the relative roles of the community and DoF in the management of enhanced floodplains are still outstanding issues to be resolved.

The awareness of the stocking programme within fisher communities was very low; this mirrors the experience of TFP. Both projects raise this as a concern and its solution is linked to the improvement in community involvement in stocking programmes.

5.3 Oxbow Lakes Small Scale Fishermen Project, Southwest Bangladesh

5.3.1 Project Background

Time Frame	1988-1996(7)
Donor (US$)	International Fund for Agricultural Development, IFAD (7.19m), Danish International Development Agency, DANIDA (3.13m)
Implementing Agency	Department of Fisheries, Bangladesh. BRAC (Bangladesh Rural Advancement Committee, an NGO)
Components	Formation and training of fisher groups; Infrastructure building (roads, fish landing platforms, embankments, nursery ponds); Provision of institutional credit; Carp fingerling supply.
Objectives	➢ increasing the productivity of chosen water bodies and provide nutritional benefit for the population at large; ➢ assisting the poorest fishers increase their income and social status.

Oxbow lakes, baors, are former meander bends cut off from the main channel when a river changes course. They are still part of the surrounding floodplain, being connected in months of high water via old river channels or, in years of high flood, by bank overspill.

This project involved the stocking of carp fingerlings in oxbow lakes and built on the experience of the first Oxbow Lake Project (1980-1985). The project operates in five districts in West Bangladesh - Jessore, Jhenaidah, Kushtia, Faridpur and Chuadang. The project's 23 oxbow lakes range in size from 10 ha to 153 ha - over half are less than 50 ha. A culture-based fishery operates in the main body of each baor, while shallow areas are excavated to fishponds. The fingerlings were supplied by private producers, government hatcheries and traders.

The guidelines for stocking oxbow lakes were developed in the earlier project. With respect to stocking density, a range of 2500 - 4000 fingerlings/ha was proposed, with an average fingerling size of 38 g these figures equates to 95 - 152 kg/ha. The following species were stocked: silver carp, grass carp, rohu, common carp, mrigal and 'others'. To prevent stocked fingerlings escaping, the water inlets and outlets are screened with bamboo or metal fences.

5.3.2 Oxbow Enhancement: Overview of Experience Project Background

From the picture of floodplain fisheries developed in the previous chapter it is clear that the characteristics of the resource exert a strong influence on the prevailing management issues. Oxbow lakes remain discrete in most years, their boundaries are relatively clear and, being much smaller than the floodplains themselves, there are fewer stakeholders. These differences must be kept in mind when considering the enhancement experience of this project. The value of reviewing it is that it represents a more mature phase of development assistance than TFP or

SADP and able to give greater attention to the critical institutional issues. It also illustrates the potential for successful community involvement in Bangladesh.

The primary objective of OLPII was to help the poorest fishers increase their income and social status. The project which it followed, OLPI, had already resolved many of the technical issues of how best to enhance oxbow lakes. Therefore, using Oakerson's terminology, OLPII's principal challenge was development of decision-making arrangements that would promote behaviour in the fisher communities that resulted in the desired outcomes.

On each lake, fishers were organised into fishing teams that together formed a Lake Management Group (LMG). The LMG was allocated the tenurial rights of the water body for a period of ten years: previously, leases had been granted annually, usually to individuals. The project provided support (training and facilities) for the formation of management committees and their technical decisions. The activities of the project in order to bring about community management and some of the advantages gained are discussed below.

5.3.3 Direct Constraints to Enhancement

Analysis of the technical aspects of OLPII show that lakes with high average Secchi disk depths (SDD) yielded lower amounts of carp: high SDD indicates clear water with little food for filter feeders (silver carp and catla) (Middendorp, Hasan and Apu, 1996). Stocking density was also a significant determinant of carp yield. There were positive correlations between yields of silver carp and *mrigal* and also between *catla* and common carp. Silver carp and *catla* did not perform well together. Grass carp and *rohu* perform well in lakes with dense macrophytes, grass carp eating the vegetation and *rohu* the periphyton growing on it. Silver carp does not perform well in lakes with dense macrophyte growth.

Fish yields from the oxbow lakes have increased from 137 kg/ha in 1991/2 to 565 kg/ha in 1994/5. The average carp yield from 19 lakes was 520 kg/ha in 1994/5 (Middendorp *et al*, 1996).

As experience of managing the resource has increased, some LMG's have adapted their stocking and harvesting strategies to improve productivity. A strategy of over stocking and harvesting smaller fish (0.5 kg compared with the initial recommendation of 1kg) has proved very successful in one baor in particular. The advantages from harvesting smaller fish were that smaller fish were easier to market in rural areas and were found to hold less appeal for poachers. This is a good example of adaptive management: although overstocking was an error initially, the LMG learned from the experience and so adapted future management to recreate the desired outcome. This is a marked departure from the traditional system of research and extension where management advice is preset by outsiders, usually through projects. The flexibility to experiment with management and evolve a system that works for particular situations is a more sustainable approach when projects are establishing new management systems. The levels of uncertainty about technical, social and institutional aspects of management are generally highest at this time, therefore adaptive management is the most appropriate strategy.

5.3.4 Indirect Constraints to Enhancement

The project made considerable progress in establishing an environment in which fishers were prepared to co-operate in enhancing the resource to produce outcomes that were in line with project objectives.

- **Security of Tenure**

A critical contribution to the decision-making arrangements was securing the tenure of the oxbow lakes for the fisher groups who were to manage the resource (DANIDA, 1995). There were two levels at which security of tenure was assured: the lake management groups were granted a ten-year lease in respect of their oxbow lake and individual fishers were granted licences which were renewable each year, providing they complied with certain conditions. The lease was guaranteed by the Ministry of Fisheries and Livestock in agreement with the Ministry of Land and fisher licences were issued by Thana Fisheries Officers (DoF).

- **Lake Management Groups**

The lake management group (LMG) in each oxbow lake consisted of fishing teams organised by fishing practice (DANIDA, 1995). Three key practices were recognised: nets used with brush piles which act as fish aggregation devices (deep water), seine nets fishing the middle water and plunge nets deployed in shallow water. The activities undertaken by the LMG's included: guarding against poaching, fishnet maintenance, procurement and release of fingerlings, selling and marketing the harvest and various financial tasks. LMG's across the project developed a variety of solutions to provide this labour: they hired people, members took turns or committee members took the responsibility while in office.

Many rules were developed for the establishment and operation of the LMG's. These rules empowered the fisher community and promoted the sustainability of the management groups themselves - a critical step in achieving the desired project outcomes. Ensuring that outcomes (the distribution of costs and benefits from the operation) are perceived to be fair, is one of the key criteria for maintaining co-operation among group members. This was achieved by adopting rules that ensured that power was not monopolised and which distributed income in line with the amount of work undertaken.

Membership of LMG's was limited to individuals from households that earn less than $US250 / year and own less than 0.2 ha of land. This ensured the project benefited the poorest members of the oxbow lake communities as set out in the objectives. Members also had to participate for at least 80% of the fishing days in a season. This excluded the former leaseholders from decision-making, preventing them from reasserting control over the resource. In lakes where this rule was successfully implemented, it enabled the project's target group of fishers to take control of the resource (DANIDA, 1995).

The LMG's decisions were made by an elected committee made up of the elected leaders of each fishing team. The entire LMG membership then elects which of the committee members will act as chairperson, secretary and cashier. No consecutive terms were allowed by any committee members, thus preventing individuals from retaining positions of power.

The transfer of baor control from formal leaseholders to fisher communities was not a straightforward process: in some cases resistance from former leaseholders resulted in court action. However, by the project year 1993/4 22 of the 23 project sites had established LMG's (PIU/BRAC/DTA, 1996). The rules established for the LMG's have provided the main mechanism by which former leaseholders have had to relinquish control. Rules established by the LMG's were broken, for example poaching occurred and the groups dealt with these free-riders through improved monitoring and a system of penalties.

The size of the baors had an impact on the functioning of the LMG's: smaller baors had less problems organising LMG meetings and monitoring both enhancement and harvesting activities. The higher incidence of "face-to-face" interactions among fishers within a baor improved the collective management of the enhanced resource (DANIDA, 1995).

- **Monitoring of Activities**

The LMG's managed all activities in the stocking process, i.e. making decisions on the stocking strategy, organising fingerling supply and managing the baors post-release. Monitoring of these activities to ensure rules were obeyed was an essential part of maintaining fisher's confidence in the management system and therefore their own continued compliance with the rules. The monitoring was carried out by the members of the management group, i.e. fishers in the communities involved in enhancing and harvesting from the resource. A key aspect to the success of this self monitoring was the broadening of the fisher's skills: this led to greater detection and, therefore prevention, of rule breakers. The broadening of fishers' skills was largely achieved through them taking responsibility for a range of activities during their term as committee members. Skills, previously limited to harvesting, developed to include: technical aspects of enhancement (quality of fingerlings etc.), procurement process, marketing of the catch etc.

- **Equity of Benefits**

Promotion of equity from the use of resources may be achieved through two methods: either by ensuring equal access to the resource or by ensuring that there is equality of income. Where significant differences in fishing skill exist, the outcome of equal access is not the same as that of equal income. As significant differences in skill did occur between fishers, sharing of income was adopted as the more equitable option. The gross income of a days harvest was split in two, half going to the central fund of the management group and the remainder shared amongst participants. As a result, the distribution of income was proportional to the number of days an individual participated in the fishing.

This system generated some difficulties because skilled fishers, traditional Muslim fishing communities, receive the same benefit as less skilled fishers, largely the poorer Muslim communities. Thus creating the incentive for skilled teams to under-report catches, and so undermine the rules of the LMG's (DANIDA, 1995). LMG's adopted a variety of schemes in different baors to address these problems, to varying effect. For example, forming fishing teams of mixed skills so one team couldn't dramatically outperform other teams. By fixing the quantity each team could catch, members had the opportunity (time) to pursue other income-earning activities. Recognition that variation in individual fishing skill creates an incentive for fishers to break the rules is an important area to be addressed (DANIDA, 1995).

This rule had an additional advantage where a reduction in fishing effort is desirable, such as inland fisheries of Bangladesh. By limiting the profit an individual could extract from the enhanced fishery, the incentive for those with more profitable opportunities was reduced. The fishery was therefore operated and maintained by the poorest members of the society, i.e. those with the most limited opportunities for alternative employment.

■ **Relationship Among Stakeholders**

The project clarified the stakeholders' roles for boar enhancement: fisher communities managed the resource; government (i.e. DoF) assisted by providing technical advice and, in return for an annual licence fee, secured the resource tenure to the LMG's; BRAC, an NGO, supported the development of the community through training and provided credit to assist fishers in the establishment of their management system.

The provision of credit was an important component of the transfer of control of the resource from the traditional leaseholders to the fishing community (DANIDA, 1995). Fishers could maintain independence from money-lenders in their community and thus retain financial control of the baor management. Financial management was another skill to be developed in establishing management groups: it was noted that poor financial management threatened to undermine the activities of several LMG's (PIU/BRAC/DTA 1996).

The clarification of these institutional arrangements set a framework for recovery of costs. The government receives a fee in return for assuring tenure: the annual fees paid by individual LMG's to the Government in 1995-96 ranged from Tk.81/ha to Tk.5,543/ha. It was noted that the fisheries production did not support the higher fee (PIU/BRAC/DTA, 1996). The costs of stocking were born by the LMG's who received a proportion of the income generated by the harvest and may undertake other income earning activities. As noted above, fishers took a share in the total income earned from harvesting in relation to the number of days they fished.

5.4 Series of Research Projects in Asian Small Reservoir Fisheries, Southern Asia

The projects reviewed in this section are grouped together as they form a series of research projects, each building on the knowledge and understanding of the previous work. The projects were undertaken by researchers at MRAG and focus on fisheries in small reservoirs in Southern Asia.

The first project in the series, 'Potential Yield of South Asian Small Reservoir Fisheries', was based in Thailand, India and China. The project's main activities were the development of quantitative methods for assessment of culture-based fisheries; evaluation of methods through case studies; analysis of socio-economic and environmental constraints and opportunities (MRAG, 1994).

The second project, 'Culture Fisheries Assessment Methodology', based in the same three Asian countries (MRAG, 1996). This project built on the quantitative approach taken to stocking and broadened the perspective to include bioeconomics and socio-economic issues related to reservoir stock enhancement. The final outcome was an integrated framework for the appraisal of culture fisheries development.

'Reservoir Fisheries Management in Savannakhet Province, Lao PDR' is the third project reviewed here. This project studied a set of reservoirs and small water bodies that were managed under three different systems - open access, community management and individual renting. The outcomes of different management systems were assessed in terms of their effects on fish stocks and the benefits derived from the fishery.

Time Frame	1992 - 1997 (for the series of projects)
Donor	UK Department of International Development (DFID, formally ODA)
Implementing Agency	MRAG Ltd, UK; Zhejiang Institute of Freshwater Fisheries, China; Asian Institute of Technology Aquaculture Outreach and Royal Thai Department of Fisheries, Thailand; Mangalore Fisheries College, India, Laos; Savannakhet Livestock and Fisheries Section, Agriculture Division.

5.4.1 Potential Yield of South Asian Small Reservoir Fisheries

- **Background**

Objectives	‣ estimate the yield of capture fisheries based on stock enhancement programmes in small reservoirs; ‣ assess opportunities for enhancement of fish production through optimum stocking and harvesting strategies.

Reservoirs from the region were used as case studies, these included Thai communal village ponds, Chinese reservoirs and Indian irrigation reservoirs. Table 5.1 summarises the features of the case study reservoirs and some of the technical aspects of enhancement.

- **Overview of Experience**

This project largely contributed to the understanding of technical aspects of reservoir stocking. The strength of the work is that it provides a quantitative method to assess stocking and harvesting strategies. The insight gained into stocking is of particular relevance here as it explores the relationship between stocking density and seed fish size. Experience with stocking and harvesting regimes in one lake from OLP II supports the findings of the model.

	Thailand	**China**	**India**
Surface area (ha)	**< 20**	**100-600**	**1,000 and 10,000**
Production (kg/ha/yr)	200-600	100-900	10
Contribution of enhancement to total yield	>90%	>90%	20-40%
Stocked species	silver, bighead, common, (grass) rohu, mrigal, thai silver barb, tilapia	silver, bighead, (common, grass)	common catla rohu, mrigal
Stocking density (#/ha)	3,000-25,000	200-1,400	100-400
Size of seed fish (cm)	2-3	13	5-7
Users	Part-time subsistence	Full-time commercial	Fulltime and part-time Commercial and subsistence
Use rights	communal	state/cooperative	common
Characteristics	culture system managed for community income	Highly developed extensive culture system	Artisanal fishery with limited enhancement

Source: MRAG reports.

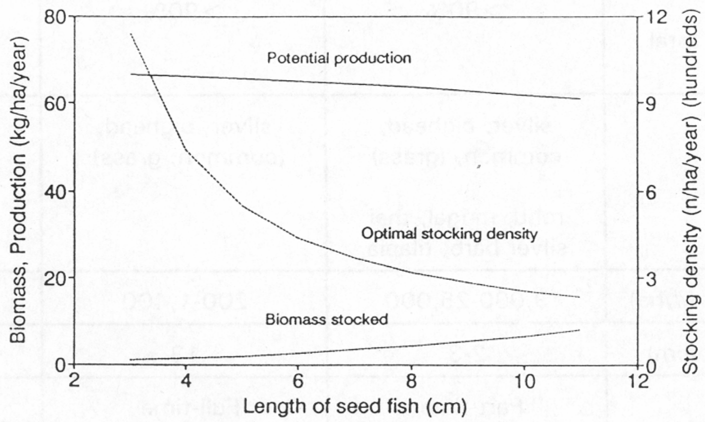
Table 5.1 : Summary of case study sites for series of projects in Asian reservoir fisheries

■ **Model**

A population dynamics model was developed, based on two sub-models, density-dependent growth and size-dependent mortality. The model allowed quantitative evaluation of stocking and harvesting regimes in culture-based reservoir fisheries (MRAG, 1994).

The model showed that the optimum stocking and harvesting strategies were closely related and must be determined simultaneously. The highest production resulted from stocking fingerlings at high densities and harvesting fish at their smallest marketable size. An increase in the stocking density will balance the effects of overfishing, and conversely if seed-fish supply is a constraint then fishing effort must be limited.

Lorenzen's model (1995) yielded results on the relationship between stocking density and optimal size of fingerlings for culture-based fisheries. With appropriate stocking density, a wide range of seed fish sizes resulted in similar levels of production (Figure 5.1). However, the same level of production required a greater biomass of larger seed fish stocked at low densities than of smaller fish stocked at the higher densities. Also, the selection of appropriate density becomes more critical as the size of the stocked fingerlings increases. This work has two implications for enhancement: release of large seed fish is not necessarily the best option, especially where there are constraints to production of bigger fingerlings; in circumstances of uncertainty, the release of smaller seed fish carries less risk in terms of production results.



Influence of the length of seed fish on potential production, optimal stocking density and the corresponding biomass stocked. Optimal stocking density is the density required to realize potential production. Standard parameter values (Table 1), gear selection length $l_c = 30$ cm, and very high fishing mortality.

Figure 5.1 ; Relationship between stocking density and seed fish size and potential production. Source: Lorenzen, 1995.

It is useful to consider the experience of the Third Fisheries Project against the understanding gained in this research project. In TFP, acceptable increases in production (ten times the weight stocked) were achieved for a constant fingerling size (~ 10g) by varying stocking densities (13-26 kg/ha). Developing the ‘optimal’ technical strategy for stocking individual floodplains requires a balance between stocking density and fingerling size. This strategy is best achieved through a process of adaptive management as noted in Section 4.3.2 of this report.

The patterns of harvesting considered alongside stocking strategies were: single complete harvests, staggered harvests and multiple complete harvests. These options are not appropriate to the open floodplain, although it may be possible to manage the perennial water bodies within the floodplain in this way.

- **Relevant Oxbow Lake Experience**

Within the Oxbow Lake Project II, reviewed above, the management group of one site (Marufdia) discovered through experience that highest production resulted from high stocking densities and harvesting at the smallest marketable size. This empirical result is in line with the quantitative predictions of the model developed at MRAG.

5.4.2 Culture Fisheries Assessment Methodology

■ **Background**

Objectives	Development of methodology for the assessment of culture fisheries, in particular:- ➢ quantitative assessment of technical management options • quantitative bio-economic analysis ➢ socio-economic assessment of management options ➢ integrated framework for the appraisal of culture fisheries development options

This project extended the quantitative approach taken to assessment of technical stocking options. In particular a spreadsheet version of the mathematical model was developed to analyse stocking and catch data from reservoirs (Lorenzen, Xu, Cao, Ye and Hu, in press). The model was linked with tools of economic analysis to allow bio-economic assessment of culture fisheries (MRAG, 1996). Socioeconomic aspects of culture fisheries were assessed using rapid and participatory appraisal methods. This project drew together these methodologies into an integrated framework for the assessment of reservoir enhancement (MRAG, 1996). The framework includes a checklist of key issues and pertinent questions are raised under each of the following headings: technical, economic, socio-economic, institutional and environmental.

■ **Overview of Experience**

The methodologies were applied to case studies in each Thailand, India and China. Chinese extensive aquaculture systems were analysed with respect to economic and technical efficiency, Indian artisanal reservoir fisheries with moderate enhancement were assessed with respect to stocking and effort control, while Thai village fisheries were assessed for technical stocking options and use conflicts and distribution of benefits.

China has a long history of reservoir culture fisheries, and the case studies were efficiently managed for production. However, this traditional emphasis on production was shifting towards profitability. The bioeconomic analysis, based on long-term data sets, identified the key points in the enhancement strategy where improvements would support this change to an economic emphasis. The activities of fish seed production offered opportunities for improved economic performance, particularly changing species composition and shortening nursing periods. Changing the management of post-release activities would also address economic constraints of the traditional system. In particular, the costs of labour indicated that fishing effort should be decreased. This quantitative economic analysis is particularly appropriate for well documented fisheries. Such analysis is valuable where production cycle is long, in these reservoirs the cycle is two-three years.

The nature of the fishery in Indian reservoirs results in two distinct resources: ‘government fish’ (i.e. stocked carp) are caught off shore with large mesh nets while ‘local fish’(mainly predators) are caught inshore with small mesh nets. Quantitative analysis of the carp fishery indicated good technical prospects for enhancement. However, for individual fishers to benefit from stocking some form of ‘effort control’ would have to be introduced. An increase in effort as a result of stocking would increase the total numbers of fishers supported by the fishery, but catches for individual would not necessarily rise. This has implications for cost recovery: the profitability of individual fishers, and therefore their ability to contribute to stocking costs, would remain low. The conclusions drawn from the analysis were that technically stocking has potential but effort control will determine the economic sustainability and the benefits gained by individual fishers.

Village-based fish ponds are promoted by the government of Thailand, the ponds are usually physically developed (deepened) and are then stocked. These communal fisheries are the focus of range of Government programmes and so many objectives exist for stock enhancement. The ponds assessed here were primarily managed for village income, the contribution to village diet was marginal. The property regime of the fishery's were changed with development: previously open access water bodies became restricted resources with entry to the annual fishing day by ticket. Technically, the production of the village ponds could be improved through a change in species composition and decreasing overall density. However, as desired outcome from the fishery is communal income, development of the resource may result from non-technical aspects of management.

5.4.3 Reservoir Fisheries Management in Savannakhet Province, Lao PDR

- **Background**

Objectives	▸ Identify management strategies to increase the individual and community income from reservoir capture and culture fisheries, while maintaining the role of reservoirs in providing subsistence and dry season habitat for natural fish populations.

A range of research methods were used: rural appraisal methodologies in the early exploratory phase; test fishing and household surveys for quantitative information and detailed interviews for further qualitative information. Three types of management regime were investigated with respect to the impacts on: total yield; standing stocks of fish and their species composition; degree and nature of benefits from the fishery; and, distribution of benefits among socio-economic groups.

The detailed analysis of costs and benefits associated with community management was carried out in seven villages, with particular attention being paid to four villages, with enhanced fisheries, that were being managed by the community. Other villages served as control sites. A key focus was the impact of fisheries management on users of small water bodies and so the villages were stratified and selected according to the number of perennial water bodies they had access to. This was considered to be one of the main factors affecting use and importance of water bodies in general. The three types of management commonly encountered are briefly described.

Open access water bodies had no formal management. However, informal village rules on fishing suggested resources were managed as common property and were not strictly open access at all. The renting of water bodies to individuals was relatively common practice in the district, with its history based in pre-communist times. After banning the practice during communist rule, recent political changes had seen the practice restarted. The fee is set by the village administration and individuals able to pay are given temporary ownership of the water body. Community fisheries were jointly owned and managed by the members of a single village community. Management was organised by the village and involved annual stocking with small amounts of cultured fish. Harvesting was usually carried out by fishing teams and individual access was heavily restricted or banned. Community involvement in the various management activities varied between villages, ranging from a rotational system requiring all the community to participate through to smaller set teams who carried out duties such as fishing. The majority of catches were usually sold and the income was spent on community development projects. This is a relatively new form of community management in Laos, having been first introduced in 1991.

■ Overview of Experience

Stocking activities, in the absence of harvesting management, did not result in increasing standing stocks (MRAG 1997). Water bodies which were stocked and had restricted access to the enhanced fishery had the highest stocks of wild fish, plus variable but often substantial stocks of released species. Fishing effort was lower by an order of magnitude in community fisheries when compared to open access, and the resultant catch per unit effort was considerably higher. In terms of outcomes, the main benefit derived from community fisheries was income used for village projects. The contribution of catches from these water bodies to household diet was minimal, and probably less than that obtained before the introduction of the new management system. However, in general, this was not perceived to be a problem as other water bodies were available for subsistence. Where other options for subsistence fishers were limited, villages modified access rules to allow small gear use in the communal pond, showing the possibility for, and importance of, locally adapted and controlled management.

Community fisheries were a prime source of village income -often more than 50% of the total (MRAG 1997). The importance of this benefit was widely accepted and had indirect effects on households as income from the fishery lowered the contributions claimed from individuals in the community.

The systems were designed to keep management costs low rather than maximising benefits (MRAG 1997). The technical potential for improved productivity of the fishery exists, although this would require stronger incentives for participation and improvements in marketing. It was not clear that this was a priority in the villages studied.

The villages sought management strategies for communal water bodies that satisfied their objectives, and experimented with different strategies as and when they were required. In particular, technical management measures, access arrangements and incentives for participation were varied between villages and were subject to experimentation. The MRAG researchers concluded that this process of experimentation and adaptive management should be supported and encouraged by external agencies such as governments and NGO's.

Key findings of this project were a result of the integration of technical, socio-economic and institutional analyses. Previous technical and economic studies have concluded that stocking may lead to increased fishing effort and thereby endanger natural stocks. However, the results of this study indicate that for these systems the reverse is true. Specifically, stocking, in connection with other factors, initiates institutional changes that effectively result in more sustainable exploitation (if not under exploitation) of natural stocks. This finding increases understanding of enhancement issues and also shows that even the technical effects of stocking on fish stocks can not be understood using technical analyses alone. What is required is an integrated approach to the study of resource management issues, this research has been strongly influenced on the ideas presented by Oakerson and other researchers into common-pool resource management.

5.5 Indo-German Reservoir Fisheries Development Project Kerala, India

5.5.1 Project Background

Time Frame	1992 - ongoing
Implementing Agency	DoF, Government of Kerala and consultants for the German Agency for Technical Cooperation (GTZ)
Components	Technical support for culture based fishery (fingerling production, fishing technology and marketing). Support for the increased efficiency of existing fisher organisations.
Objectives	➢ sustainably increase fish production in culture-based fisheries in reservoirs and therefore, income for a maximum number of families from groups of people from Scheduled Caste and Scheduled Tribe communities.

The project was set up to support the Kerala Government in its development of reservoir fisheries. The Department of Fisheries (DoF) aim was to establish culture-based fisheries in reservoirs that would be harvested by cooperatives of fishers from socially and economically marginalised populations.

The fisher cooperatives are an important characteristic of these Indian reservoir fisheries. DoF established these cooperatives in response to a wider policy objective of the Kerala government to develop programmes benefiting scheduled castes and tribes. The cooperatives are controlled by the Government and fisher communities play a very passive role in their maintenance and operation.

Initially, the project was to follow DoF's model but improve the technical components such as fingerling production, fishing technology and marketing. However, as the project progressed it became clear that institutional reform was essential to achieve its technical objectives (Kumar and Hartmann, 1995).

5.5.2 Kerala Reservoir Enhancement: Overview of Experience

The five project reservoirs ranged in size from less then 200 ha to 2500 ha. Yields in 1993/94 ranged from only 6.9 kg/ha to 244 kg/ha, with an average of 19 kg/ha (Taege and Peters, 1995). The low yields provide no resource base for the cooperatives to invest in fingerlings for enhancement: thus, the government funding was essential. Indian major carps (catla, mrigal, labeo and rohu) and common carp were stocked (Taege *et al*, 1995). The project's strategy for the technical aspects of reservoir management was adaptive. That is, the stocking strategy and options for harvesting the enhanced reservoir developed as the managers in each project site gained experience and understanding.

The key constraint to enhancement of the reservoirs was institutional capacity (Hartmann, 1995). Therefore, the critical experience gained in this project relates to the development of appropriate institutional arrangements for effective stock enhancement. This corresponds to the 'decision making arrangements' of Oakerson's framework. In this respect, the Kerala project provides insights to similar issues and problems that the Oxbow Lake Project addressed (Section 5.3).

5.5.3 Indirect Constraints to Enhancement

The process by which management plans were developed is reviewed, the focus was to engage resource users in planning and carrying out the management of the reservoir fisheries, including their enhancement. Hartmann (1995) analysed these reservoir fisheries using the Oakerson framework: experience pertinent to this review is summarised from his analysis.

- **Cooperative Action Plans (CAP)**

The community of resource users, with the support of specialists, developed and implemented reservoir management plans (called CAPs). The project initiated this process to promote ownership of resource management activities among users (Kumar *et al*, 1995). This had been missing from the Indian reservoir fisheries but is widely accepted as a fundamental aspect of sustainable resource management (see Pretty and Scoones, 1995).

The scope of resources covered by the CAPs was broad: fish, government services, welfare funds, external resources and those resources to be mobilised within the cooperatives. This was a critical change from the previous planning process which was entirely driven by central government agencies without input from resource users. The CAPs provided an essential link between cooperatives and established planning processes at the district level. Resolution of conflicts between competing resource users was the responsibility of another committee. Individual cooperatives were brought together for workshops, where the exchange of experience contributes to the development of the institutions (Kumar *et al*, 1995).

The organisation and support of local planning processes, like those introduced in this project are management intensive. Such projects demand trained personnel and sufficient time to allow for the process of institutional change, which is naturally slow. In this context, the term "institution" includes the set of rules that members understand, agree on and will comply with.

- **Appropriate Institutions**

The cooperatives proved to be a key constraint to the development of the resource. In summary, the characteristics of the institutions are as follows: dominated by government officials; had no resource base, i.e. the reservoir fisheries were not viable; inconsistent in their membership with respect to the fishery - fishers and non-fishers alike were given incentives to join and due to the cultural aspects of the cooperatives, many fishers not belonging to the scheduled castes and tribes are excluded; ineffective at the point of harvest as non-members ("poachers") often outnumbered members (legitimate fishers); the focus of a catch share arrangement between the fishers, the cooperative and DoF which reinforced perceptions of the cooperatives as a government institution; rules governing harvest (access, gear and season restriction) are unclear and so are not commonly understood or applied. These characteristics all contribute to the inappropriate nature of the institution for resource management (Hartmann, 1995).

To analyse the most appropriate responsibilities for different institutions, Hartmann (1995) identified the key activities for the establishment of a sustainable culture-based fishery. These included: fingerling production, fingerling release, harvesting, fish marketing, resource use planning, enforcement, accessing welfare funds and political identity and recognition. As part of the analysis, the institution implementing the activity was considered against the institution deemed to be ‘ideal’. For the activities where there were differences between actual and ‘best match’, a programme of reform was proposed.

The main trend of the proposal was transfer of responsibility from centralised institutions to more locally based institutions either singly or in combination. Naturally, these proposals are strongly influenced by the characteristics of these resource systems as outlined above. However, the issues raised in the analysis are relevant to floodplain stocking programmes.

Hartmann concluded that enhancement of the reservoirs was beyond the capability of the cooperative fishers due to the financial burden, which at current levels of harvest would be too great, and the lack of clarity of resource ownership. Therefore, central government would fund the stocking, recouping at least some of its costs through licence fees. Cooperative hatcheries should produce fingerlings rather than government hatcheries so that cooperatives gain another source of income. Similarly, one recommendation from the TFP consultation with resource users was the establishment of hatcheries within the floodplain boundaries (see Section 4.4.2).

The harvesting of these fisheries was controlled by government through supply of gear and boats, privatisation of harvesting and diversification of the fishing practices and species stocked was recommended. Greater options for fish marketing should replace the current government control and DoF price-fixing. Stakeholders should define the legitimate fishers and form a community of users to manage the reservoirs. Licence fees would then fund enhancement. Planning of resource use should follow the model described above for CAP’s: this requires that stakeholders (fishers and DoF) redefine their role. Community elected individuals will manage the cooperatives, replacing government officials. DoF staff will be trained to provide technical assistance to the cooperatives and facilitate the relationship between the government and the community-based cooperatives. NGO involvement was seen as a critical step for the transfer of responsibility and control from government to communities.

5.6 Community-based Fisheries Management and Habitat Restoration, Central Bangladesh

5.6.1 Project Background

Time Frame	1994 - 1997
Donor (US$)	Ford Foundation (200 000)
Implementing Agency	Centre for Natural Resource Studies (CNRS); Proshika
Components	Rehabilitation of Khals and Beels; Socioeconomic and biological monitoring; Motivation and awareness in resource management.
Objectives	➢ to test an alternative method of increasing fish production and species diversity in floodplain wetlands through ecological processes which communities can manage themselves, and more specifically: ➢ to create awareness among the local communities about conservation of habitats and biodiversity; ➢ to strengthen organisational and functional capacity of community groups and NGOs in ecological management of aquatic resources; ➢ to promote community-based management and protection of fisheries resources.

The work was carried out in a single beel, Singharagi, which is connected to the Dhaleshwari River in central Bangladesh (CNRS, 1995). The project area included 990 households. A project implementation committee comprising floodplain users and stakeholders with NGO staff was established . A system of biological and social monitoring of the project was set up. The main community intervention involved the de-silting of a canal which was the main migration route for fish between the floodplain and river (CNRS, 1995).

The area covered by this project was significantly smaller than any of the floodplains stocked in the large enhancement programmes such as Third Fisheries and Second Aquaculture projects. However, the experience of the participation of the community is of particular relevance given the issues raised in these larger projects. An advantage of smaller projects is the opportunity to work directly with the community. This project involved stakeholders directly in the development and management of the resource.

5.6.2 Floodplain Enhancement: Overview of Experience

In order to achieve the outcome of improved yield of fish from the floodplain the physical environment was modified and communities agreed on various patterns of exploitation. Relating this to the Oakerson framework, the project used both pathways to effect the desired outcome. De-silting canals is an activity which was expected to directly improve productivity of the floodplain. In comparison, the stakeholders recognised the importance of fisher behaviour in determining outcomes by addressing the rules governing management of the resource.

The project reported several achievements in terms of improvements in the productivity of the resource as a result of habitat enhancement (Rahman, Halder and Capistrano, 1996). The reported catches from deepest components of the floodplain showed an increase from 1863 kg to 11,384 kg (area of these fishing grounds not reported). The increase in relative abundance of major carps, large catfish and minor carps in catches from all habitats was directly attributed to the improved connection with the main river channel. Fish consumption in the individuals living around the floodplain improved after the intervention, average daily fish consumption rose from 27 g to 33 g. Official figures estimated the national average in 1991 at 22 grams of fish consumed per capita. The source of fish consumed also changed after the khal had been desilted and management measures implemented: less fish was bought and more caught by members of the household. Landless fishers, in particular, appeared to benefit as the percentage of fish caught increased from 26% pre intervention to 52% post intervention.

5.6.3 Direct Constraints to Enhancement

- **Excavation**

Communities in the floodplain associated the decline of fish in the floodplain with the blockage of the khal that was the main connection between the floodplain and Dhaleswari river. To rectify this, a project implementation committee was formed; membership included representatives of the floodplain users (fishers and farmers), local leaders and professionals as well as individuals from the NGOs (CNRS, 1995).

The committee planned the de-silting of the canal and paid labour completed the excavation work. Compensation was sought by farmers who had been using the silted banks of the canal which was granted in one case where the crop loss was significant. Other claims were refused on the basis of minimal crop loss, the decision was perceived as fair and practical by local villagers (Rahman *et al*, 1996).

5.6.4 Indirect Constraints to Enhancement

- **Management of Exploitation**

Several limits to the harvesting pattern were agreed within the communities. Fishers cooperated to enforce a ban on the use of certain gears (current net and long line) in some seasons *(ashar-shraban* which corresponds to mid-July through mid-August) and prohibited fishing in ditches prior to inundation. Dry season fishing grounds were protected from fishing to provide refuges for wild fish (CNRS, 1995). Thus the fishing community collectively agreed to forego immediate benefits in order to improve future catches.

- **Monitoring**

Two systems of monitoring were used to assess the impacts of the intervention (CNRS, 1995). Biological surveys collected data on fish catches, fishing intensity, species diversity and migration in three habitat types (perennially inundated, seasonally inundated and ponds). These were carried out by one member of the project staff and an assistant hired from the community. Social surveys were conducted by women from the village trained for the task by the project. This survey was household based (sample of 56) and collected data on fish consumption, range of species eaten, fishing rights and access to fishing grounds and participation in fishing. The households were separated on the basis of landholding: landless, small farmers and medium/large farmers.

5.7 Summary

This chapter has reviewed a range of enhanced inland fisheries systems, from floodplains to small village ponds. The fishery was always strongly influenced by the inherent characteristics of the resource and also the nature of the fishing activities and objectives of management. The main method of enhancement involved stocking, using either hatchlings or fingerlings, however one project addressed declining fish yields on the floodplain through habitat restoration. The projects varied in the degree to which communities were involved. In general, greater participation of fisher communities was facilitated through the development of an institutional framework for stocking activities. In turn this then provided a mechanism by which projects would address the problem of recovering costs of stocking. Many of the insights into enhanced fisheries have resulted from projects using an integrated approach to evaluate the outcomes. The series of research projects MRAG carried out in Asian small reservoirs was particularly rigorous in this respect, reflecting the research focus of the project.

6. Evaluation of Stock Enhancement

6.1 Introduction

The aim of this review is to glean from past experience those factors which result in successful stock enhancement of floodplains. The outcomes of enhancement are determined by both the nature of the fishery and the behaviour of fishers and other stakeholders. Enhancing a fishery provides strong economic incentives for powerful interests to establish or increase their hold over it. A technical strategy for enhancement must therefore be supported by a complementary institutional strategy, if induced changes in behaviour are not to undermine distributional objectives. A change in rules governing access to the fishery is particularly important when cost recovery is a project objective. This chapter synthesises project experience and distils key themes for the design of enhancement projects under two key areas, technical and institutional strategies. Note that these strategies interdependent, demanding an integrated approach for successful stock enhancement.

6.2 Technical Strategy

Both TFP and SADP were large stocking projects, aiming to enhance a huge area of Bangladesh's floodplains. Due to the lack of previous experience many technical constraints to stocking floodplains had to be overcome in each of these projects. The development and implementation of the stocking strategy was further complicated by the scale at which both projects were operating. For example, each year TFP had to stock many floodplains in three districts of west Bangladesh.

The enhancement strategy developed by TFP was found to be technically successful. Fingerlings (~10g) produced by private hatcheries were released to the floodplain at the onset of the flood. A species mix of common carp, catla, mrigal and rui performed well at combined stocking densities between 13kg/ha and 26kg/ha. The performance of common carp was often exceptional in floodplains. Migratory species (e.g. silver carp) did not benefit communities harvesting the floodplains enhanced by TFP. Hydrology was a dominant constraint. It was found that the timing of fingerling release onto the floodplain must coincide with the onset of the flood, so the year to year variation in hydrology demanded a flexible approach. Definition of area, essential for accurate estimation of stocking density, proved difficult. Within this overall strategy, some flexibility was required in the stocking approach between different floodplains to optimise productivity. Adaptive management would provide a rigorous approach to the modification of stocking strategies to local conditions.

A particular characteristic of floodplains in the North east, early flash flooding, proved to be a key technical constraint to SADP's technical strategy. In addition, the strategy required revision in response to concern expressed over the environmental impact of nursery preparation.

A quantitative approach to assessment of reservoir stocking yielded information on optimal fingerling size and stocking density (Section 5.4.1). It was found that larger fingerlings are not necessarily the most productive or economic option for stocking and that more precise information is required to determine optimal stocking density when larger fingerlings are released. The importance of joint consideration of stocking and harvesting strategies was illustrated in this quantitative work. Indeed, management experience in one baor in the oxbow lake project came to the same conclusion: production was optimised when a strategy of 'overstocking' combined with earlier harvests was followed. The capture of more small fish had both social and management advantages (Section 5.3.3).

As the causes of declining yields have been linked to the physical changes due to flood control structures, habitat rehabilitation offered a viable alternative to stocking as a method of enhancing a floodplain fishery (Section 5.6).

A cost effective means of seed fish production is fundamental to the success of stocking projects, private hatcheries proved to have the capacity to support the large requirements of TFP. The technical aspects of fingerling production were largely overcome with private contractor performance improving over the course of the project. Some difficulties were experienced with production of common carp, a species which performed well and was a desirable catch for fishers. The main constraint to fingerling supply was transport: hatcheries closer to release points proved more effective. Towards the end of the project, as part of floodplain community consultation, the establishment of beel-side hatcheries were recommended (Section 4.4.2). This was a component of a wider approach to increasing community involvement in stocking and managing the floodplain. As well as the technical advantages of beel-side nurseries, their establishment would ensure that more benefits were available to the target communities. The opportunity to consider stocking and harvesting strategies together would be increased with the establishment of beel side nurseries as the same community would be involved in both activities.

The extensive monitoring programme which accompanied TFP yielded information on the extent to which objectives of the project were met. It also provided useful information on the constraints to enhancement. The project enforced a strict system of monitoring on fingerling supply phase of enhancement: contracts to supply fingerlings were annually tendered and suppliers were paid on delivery against a set of firm conditions. This rigorous approach was possible as fingerlings are privately owned in this phase, so stakeholders can be clearly defined (hatchery owners, DoF) and their behaviour controlled through formal agreements (contracts). The mass supply of fingerlings, an essential component of large stocking programmes, was deemed successful. The capacity of DoF to manage activities of fingerling supply and the technical skills of the hatcheries improved over the course of the project.

In contrast, monitoring of the activities after release was considerably more complex, as the fish have become a common-property resource. Thus production monitoring required large amounts of project support. The project rationalised the three surveys carried out to estimate fishery production at the beginning of the project to one, a gear-based survey, when DoF took responsibility for monitoring. Additional surveys of larger gears such as kua pits, khatta and kheo (fish aggregation devices) and lift nets were carried out so to improve the estimates of total production from individual floodplains.

The monitoring programme to assess the distribution of benefits underwent several iterations during the course of the project (Section 4.4.3) and involved a succession of different agencies. There were numerous inconsistencies between surveys, including: definition of categories of beneficiaries; benefit indicators; and survey methodology - longitudinal vs. cross-sectional. These difficulties reflect the characteristics inherent in floodplains and the constraints they present to the implementation of stocking activities.

Despite the lack of continuity in approach, the conclusions from each study broadly confirmed that many equity problems were experienced and the impact on beneficiaries was not as anticipated in the original objectives. Most importantly, full-time (professional) fishers were often disadvantaged by enhancement. Contrary to the expectations, many full-time fishers experienced a drop in income and increased conflict (gear confiscation and arrest, due to the fishing ban enforced to protect fingerlings post-release. These outcomes illustrate importance stakeholder behaviour in determining enhancement success and demonstrate clearly the need for an institutional strategy to support the technical interventions of stocking.

Fisher communities had responsibility for monitoring of stocking and harvesting activities on the enhanced oxbow lakes. This monitoring ensured that the agreed management rules were observed. CNRS actively involved the local communities in monitoring the outcomes to floodplain enhancement. Illiterate women in the community who were trained to assess the outcome of desilting the khal and local fishers were involved in regular catch sampling. The greater participation of fisher communities in these enhancement projects broadened skills and enabled people to take greater responsibility for many 'project' activities. In both of these cases, community participation has additional advantages which offer at least partial solutions to two of the key problems faced by the large floodplain enhancement projects, namely monitoring and fisheries management. Assessment of enhancement success requires information gleaned from monitoring programmes, the quality of the information is reduced where communities neither understand or are involved in its collection. Monitoring of fishing activity at the level of detail required for management in a floodplain is beyond the capacity of a remote government institution. Therefore, any management of fishing must have the agreement of the fishers who, ideally, should play an active role in developing and monitoring the system set in place.

The delay in implementation of monitoring enhancement activities in the SADP project is a severe constraint to learning from the experiences of this project. Some of the outcomes experienced by SADP enhancement mirrored that of TFP, particularly with respect to the flow of benefits to targeted stakeholders. The influence of the property regime controlling access to the enhanced resource was recognised and similar solutions proposed, i.e. greater NGO involvement to improve the participation of floodplain communities. The failure of both projects to implement a programme of cost recovery is of key concern; as this leaves stocking heavily reliant on external support.

Floodplains have different physical components which correspond to different fishing grounds - rivers, shallow water at high flood, deep areas (dry season water bodies) and to some extent these have been recognised as access regimes differ between them (lease/licence, open). Problems occur when considering the harvest of fish after enhancement as these 'internal' boundaries overlap due to flooding. As it is impossible to isolate one component for an entire production cycle, the management of the fishery must recognise the interaction of components and the communities who access each of them.

This has important implications for cost recovery. Some water bodies, particularly the deeper beels, have times when there are considerable economic advantages to using capital intensive fishing practices. Examples of these include barriers, fish attraction devices, seine nets etc. which require that fishers cooperate to improve fishing efficiency. Therefore, there are times and places on the floodplain with great potential to produce an economic surplus and so could be the largest potential source of revenue. The limit on the opportunities to participate in these operations may undermine objectives of equity, i.e. less skilled or poor fishers do not usually have access to this method of fishing. To address the equity issue, a suitable mechanism to share access and/or income must be identified. Examples include the use of lotteries and team rotations. Setting up a mechanism by which costs can be recovered is discussed in more detail in the institutional strategy section.

6.2.1 Key Lessons for the Technical Enhancement Strategy

I. Flexibility is essential as floodplains are complex environments, in both space and time, with hydrology the dominant force. In summary, a heterogeneous community of fishers harvest a variety of species, using many gears from a range of seasonal habitats. These characteristics are the key technical constraint to introduction of successful stocking activities. Variability within and between floodplains demands that projects tailor the overall enhancement strategy to the particular characteristics of individual floodplains. Adaptive management, the process of formal learning through management experience, is the best approach to refining the strategy to local conditions.

II. Support for beel-side nurseries has many advantages: reducing the technical problems of transporting fingerlings to release points; building the capacity of communities to manage the floodplain fishery; linking stocking strategies to management of harvesting and so setting a framework from which adaptive management could take place.

III. Development of an appropriate monitoring system is a key component to all enhancement projects. Management information is required at three levels: direct management of the resource; management of the national enhancement programme; and a comparison between enhancement programmes and other forms of assistance (donor requirements). There are overlaps between the information needed at each level, but there are also major differences. The appropriate level will be determined by the objectives of an enhancement programme and the capacity of the relevant institution to carry out monitoring.

IV. Understanding the flows of benefits in floodplain fisheries is essential for the identification of opportunities for cost recovery and the development of an institutional strategy.

6.3 Institutional Strategy

The enhancement projects reviewed in the previous chapters introduced decision-making arrangements (rules and institutions) to varying degrees. The two large floodplain stocking programmes, TFP and SADP, worked with the Department of Fisheries in managing the development of stocking strategy and fingerling supply phases of the enhancement activities. The resource (i.e. the seed fish) during these phases are essentially private property. A very formal system governed the production and delivery of fingerlings in TFP: private hatcheries tendered annually to supply DoF with fingerlings and signed a contract, payment was made at the point of release. The performance of hatcheries in terms of meeting their contractual obligations (quantity, quality, species mix, size) improved over the course of the project. So the decision-making arrangements for fingerling supply ensured that this aspect of fisheries enhancement was ‘successful’.

The introduction of a conservation period, restricting particular gear use in the months after stocking, was the only formal rule TFP introduced to manage enhancement post-release (i.e. the third phase illustrated in Figure 2.1). Early in the project, management of the post-release phase was primarily the responsibility of DoF with technical assistance from the project. Initial implementation of the conservation rule by DoF was incorrect as important exemptions to protect particular stakeholders (poor fishers) were not understood and difficulties enforcing a complex rule were simply overcome by instituting a complete ban. The impact of this action on some communities, particularly full-time fishers, demanded resolution. NGO's, and through them floodplain communities, became involved in developing understanding and then applying the conservation rule in some enhanced floodplains.

The institutional focus in both TFP and SADP was strongly targeted at increasing the capacity of DoF to manage the enhancement: in line with the objectives of both projects. However, this resulted both projects having a low profile with their intended beneficiaries, i.e. poor fishers. TFP changed their approach by promoting NGO activities in enhanced floodplains, and the resulting interaction between DoF, fishers and the project reduced conflict in some floodplains resulted in an improvement in the stocking outcomes. Private landholders in some floodplains in the south-west of Bangladesh reacted to stocking by excavating more kua pits, allowing them to exclude others from the benefits of stocking. TFP had no institutional mechanism to address this outcome - despite it being counter to the flow of benefits originally anticipated.

The consultation workshops held at the end of TFP were the first mechanism introduced by the project to involve floodplain communities in enhancement activities. The potential to involve local communities in all activities from development of a stocking strategy, through fingerling supply and management of the enhanced floodplain were explored. The types of arrangements recommended in the workshop were: definition of legitimate fishers, use of licenses for cost recovery, involvement of communities in enhancement through promotion of beel-side nurseries, introduction of mechanisms to ensure financial transparency, clarification of the relative role of DoF, NGO's and communities

In contrast, the institutional focus in both OLPII and CNRS projects was the fishing communities, specifically to improve the capacity of communities to manage their resource. BRAC, a Bangladeshi NGO, was a key player in OLPII, supporting community development through the provision of credit. OLPII is of particular interest to this review, as it represents experience one stage in advance of TFP and SADP in terms of developing institutional arrangements to accompany an enhancement programme. The particular outcomes desired from objectives set for enhancement of oxbow lakes (OLP II) were increases in the status and income of poorest fishers through improved productivity and management. As the technical strategy had largely been developed in a previous project, OLPII sought to improve the capacity of fishing communities to undertake enhancement and management of the baor fishery.

Within OLPII the success of enhancement varied between lakes. In general success occurred when an independent community institution was established, complete with stocking and harvesting rules which were observed. Failure to establish the rights of community management was the fundamental limit to project 'success' and occurred in sites where powerful individuals, often previous leaseholders, contested the change to a community-based system and so undermined the project's strategy. The rules of the newly established lake management groups were the key mechanism to overcome this resistance and in some instances were sufficient. Outcomes within the group of 'successful' project sites also varied with respect to the extent equity was established.

OLP II introduced many mechanisms to address these problems of equity: the primary one being the operation of the lake management committees which was supported by DoF, BRAC and the project. The recovery of enhancement costs in these oxbow lakes has become the responsibility of the lake managers, i.e. local communities. The provision of credit to these communities was a key step in enabling their takeover of management responsibility.

Repayment of loans was variable between project sites. Ideally lake management committees would become independent from this form of external support.

Securing the resource tenure for lake management groups underpinned all the rules developed to guide stocking strategy, fingerling supply and management of the baors. This provided a strong incentive for fishers to participate in enhancing the lakes and observing the harvest rules as they were assured access to the future benefits resulting from the improved management system.

The relationships between the various stakeholders: baor communities, NGO, DoF and the project were defined and transparent. This provided a framework from which problems arising in individual baors, and many of these were serious, could be addressed. The complexities of floodplain fishery's boundaries (both physical and social) present a great challenge to the development of an institutional framework for floodplain enhancement.

The CNRS project involved the floodplain community in all stages of project development and implementation. This resulted in the communities agreeing on specific use rules, such as the setting aside of reserves, closed seasons and gear restrictions. So as a result of participating in one management intervention, desilting a khal, the community developed a wider approach to managing the fishery cooperatively. The inclusion of community members in the project monitoring of outcomes also generated 'ownership' of floodplain management within the local communities.

Analysis of Laotian community-based fisheries showed unexpected benefits arising from enhancement activities. The rise in productivity reported in the village ponds was found to be a direct result of effort control, rather than the release of fingerlings. Thus the institutional strategy developed to accompany enhancement proved to be of greater benefit to the fishery output than the technical intervention per se. This unexpected outcome was revealed because of the integrated analysis of the fisheries and illustrates the importance of joint consideration of the technical and institutional issues of enhancement.

6.3.1 Key Lessons for the Institutional Enhancement Strategy

1. Greater participation of floodplain communities improves the outcomes of enhancement, profile of the project must be high - ideally generated through early community involvement in all stocking activities.

2. NGO involvement was one mechanism employed to improve community participation. NGO's can be valuable as: intermediaries between fishers and government agencies; support for fishers in confrontations with displaced former stakeholders, umbrella organisations co-ordinating more local groups; honest brokers able to balance the interests of different communities or groups; experienced facilitators of group formation among the poor; and, providers of credit. Additional mechanisms include consultation workshops, formal and informal meetings, shared responsibility in project development and execution (for example, fingerling production and monitoring) and proper decision making structures.

3. Transfer of more responsibility to floodplain communities requires intensive external support. During establishment, this support must include training and guidance in

technical, financial, social and institutional aspects of resource management. The credit scheme provided baor communities with the financial independence necessary to establish and maintain their responsibilities as baor managers.

4. Transferring responsibility to communities often involves a change in the existing control of the fishery. Resistance to this change should be appropriately planned for with a range of mechanisms to address potential problems. Mechanisms used in past projects include provision of credit to helped establish the community's right to manage, commonly agreed and observed local rules, legal backup and 'external' support from government, NGO's and enhancement projects.

5. A complete system of rules is required if communities are to manage the enhanced resource, i.e. use-rules, collective choice rules and external rules. Use-rules govern fishing (who can fish, where, when and how) and enhancement (who, what, when and how will the resource be enhanced). Collective choice rules define the operation and remit of institutions (management groups, cooperatives etc.). For example, membership rules, sanctions for rule-breakers, rules defining the relationship between different stakeholder institutions, rules for conflict resolution etc. Rules determining membership of legitimate fishers offer powerful tools to control the distribution of benefits flowing from enhancement. External rules are those defined outside the community, e.g. by the state, but which have an impact on the community. For example, the government securing tenure to Lake Management Groups and instances where conflicts in some OLPII baors had to be dealt with in court.

6. Definition of floodplain communities who have a legitimate stake in the fishery is essential, similarly the boundary of the floodplain over which they have a stake must also be widely understood and agreed. This allows self monitoring and provide incentives for 'successful' patterns of interaction leading to commonly agreed and desired outcomes. The 'internal' boundaries of a floodplain will also require clarification and agreement, particularly if a cost recovery system is based around the differential productivity of fishing grounds within a floodplain system.

7. Rules must be appropriate to the system in which they are to be implemented: involvement of resource users, i.e. fishers, in their development and enforcement increases the likelihood of this.

8. A role for government is still essential for the development of floodplain enhancement due to the uncertainties surrounding floodplain enhancement activities. This means that some degree of trial and error is unavoidable and the year to year variability of floodplain fisheries make the lessons harder to learn. Government can therefore play a critical role in providing initial support while this process continues. The relationship should not encourage community dependence on government.

9. Government provides critical support as they provide the legal and institutional framework for resource use and have the official power to grant tenure. Therefore, where resource ownership issues are complicated the government's role is significant. In addition, government staff often have the skills and experience to provide technical support for enhancement.

10. An institutional framework (i.e. recognised organisations with a clear remit in the fishery, supported by a system of rules) to support stock enhancement is the only basis from which cost recovery can be addressed. Fishers with no guarantee that they will have access to future benefits have little incentive to contribute to the costs of enhancing the resource. Securing the tenure of a fishery is fundamental to an institutional strategy for enhancement which requires cost recovery.

11. Rules determining the recovery of costs must reflect the particular characteristics of the resource. For example, the fees demanded of different fishing grounds in the floodplain could reflect the level of economic surplus available from that habitat. Differences between the level of involvement of fishers and in the types of gears used, make it difficult to define a payment for resource access that is both uniform and fair. Rules governing cost recovery must be simple enough to administer and enforce.

6.4 Summary

This chapter has drawn together the experience of enhancement projects from floodplains and perennial water bodies. Consideration of the broad range of issues raised by projects, within the framework provided by Oakerson, has distilled key themes to guide the design of stock enhancement projects. The themes presented in this chapter are issues to be taken into consideration and are purposefully not prescriptive recommendations.

In order to design a stocking programme, three central questions have to be addressed:-

- What are the desired *outcomes* of stock enhancement. The criteria by which these can be judged are the project/programme objectives which must be clearly defined in order to develop the stocking strategy;

- What are the key characteristics of the resource that will place a fundamental limit on what can be achieved through stocking. Given this, what is the best *technical strategy* for releasing seed fish that will ultimately increase yields from the fishery; and,

- What is the best *institutional strategy* that should be established to support stocking and so ensure that stakeholder behaviour on the floodplain will result in the desired outcomes.

Enhancement of floodplain fisheries must balance the claims of competing societal objectives (fish production, income, nutrition, equity, biodiversity, government revenue) within the physical, biological and socio-economic constraints imposed by the system. Project design must cover a hierarchy of issues from the technical (species stocked, densities, timing of release, fingerling size, management of exploitation etc) to the institutional (organisations/institutions involved, responsibilities, participation of beneficiaries etc).

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