COMPREHENSIVE Assessment of water management in agriculture

Research Report 7

Impacts of Irrigation on Inland Fisheries: Appraisals in Laos and Sri Lanka

Sophie Nguyen-Khoa, Laurence Smith and Kai Lorenzen

International Water Management Institute

Imperial College London

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Comprehensive Assessment of Water Management in Agriculture

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Cover Photographs by Thonglai Vannivong (photograph on the left) and M.M.C. Kumara (photograph on the right) show "Stakeholder workshops in Laos and Sri Lanka."

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Summary

There is an increasing recognition of the need for improved approaches for integrated water resources management (IWRM). In many river basins irrigation is the largest water use, and attention must be paid to its socioeconomic and environmental impacts, and to the potential for multiple-use of irrigation systems. This requires improved approaches for the planning, impact assessment and management of irrigation projects, and an important component, the assessment and management of impacts on inland fisheries. Such fisheries can be of social and economic importance, but have often been neglected in the planning and implementation of irrigation schemes. Irrigation development, however, can modify river hydrology and aquatic habitats, and impact on aquatic biodiversity, the productivity of fisheries, and the livelihoods of rural households.

Although assessing the impacts of irrigation on fisheries is important, the cost of assessments must remain reasonable in relation to the magnitude of expected impacts and the total project cost. Appraisal methods are needed, and must be practical and low-cost, while still able to generate information for scheme construction, rehabilitation or management of irrigation. Impact assessments for this purpose were conducted in Laos and Sri Lanka, using an integrated and participatory approach to environmental impact assessment.

In Laos an ex-ante appraisal of the possible impacts was made using a new 1,000 hectare irrigation development project in an area with rich fishery resources, and where fishing plays an important role in the diversified subsistence livelihoods of the majority of households. Ninety percent of rural households in the region regularly engaged in fishing, obtaining an average catch of 60 kg per household per year. This was second only to rice production in terms of food security and income generation, providing approximately 15 percent of household income.

The appraisal showed that 90 percent of fish production came from rain-fed rice fields and that this could be sustained within the irrigation system which provided the wet season rice crop with adequate water levels in the fields and ecological connectivity of rice fields and maintained perennial water bodies. Reduction in rice field water storage with irrigation, increased use of agrochemicals and barriers to fish migration created by irrigation infrastructure could threaten fisheries production. Agricultural productivity gains from such practices would need to offset the concomitant loss of fisheries to be beneficial in aggregate terms. Assuming that production from rice fields would be sustained the appraisal also predicted a modest increase in aggregate fisheries production in the catchment amounting to about 14 tonnes per year, because creation of a reservoir fishery would outweigh the degradation of the existing river and floodplain fishery downstream. Fishing effort could be expected to decline slightly (by about 10–20 percent) because of the impact of irrigation development on farm labor requirements and attractive employment opportunities, and to be partially redistributed from river-floodplain and rice field locations to the reservoir.

The overall impact on livelihoods was expected to be positive because the majority would gain benefits from irrigated farming, while being able to sustain fishing as their second most important activity. However, there would be a need to monitor impacts differentiated by location in the catchment, socioeconomic status and gender of vulnerable groups whose interest must thereby be safeguarded. Those who would be most at risk are the landless or land-deficient households and those who are heavily dependent on fishing but more remote from the reservoir, particularly if they are less able to exploit new labor market opportunities on which they could rely.

For project implementation the key impact mitigation or enhancement measures to protect fisheries will thus be those needed to sustain the fisheries production of the rain-fed wet season rice crop. Maintenance of lateral connectivity across the floodplain is important for this and may require “fish-friendly” cross-drainage culverts, where canals or access roads create barriers. Augmentation of river flow with “environmental” releases from the dam during key migratory periods may also be required in order to allow fish migration into rice field habitats. Drainage channels can also become key migratory pathways as long as fall structures are minimized, while fishponds within the command area could provide additional dry season habitat as long as they are perennial. From a policy perspective, given that the traditional and subsistence nature of the rural economy will persist for some time, the objective should be to maintain the contribution made by fishing to the diversified livelihoods of most rural households, as well as its role as a “safety-net” or activity of last resort for the most vulnerable.

In Sri Lanka, an ex-post evaluation was made of an established 10,000-hectare irrigation and settlement project that revealed a complex picture of both positive and negative impacts at different locations within the catchment. The project constructed a new head reservoir and incorporated pre-existing reservoirs and command areas within a cascade system. In contrast to Laos the river-floodplain and rice field habitats had an innately low production potential (10–20 percent) and fisheries production was concentrated in the reservoirs and coastal lagoons. Approximately 7 percent of households in the project area engaged in fishing as a regular activity, producing 13 percent of the total income from the scheme (approximately US$1.4 million /year). Most fishing was either a full-time specialization or an opportunist activity for the poor and landless among other activities such as firewood collection and casual laboring. Part-time fishing by farming households in villages near reservoirs or lagoons did take place, but was much less common than in Laos. Fishing had provided above average incomes in the past but at the time of the evaluation incomes had declined because of the combined effects of over exploitation, recent droughts and negative impacts of scheme water management.

The evaluation showed that the project had significantly increased overall fish production potential through the creation of the large new head reservoir. This more than compensated in aggregate terms for any decline in output from the downstream floodplain. However, the level and sustainability of production from the pre-existing reservoirs has been adversely affected by low water levels during periods of water scarcity, when priority was given to irrigation releases. Drainage flows from the project have also affected the salinity, water levels and frequency of marine exchange in the coastal lagoons. The overall catchment production potential has increased by about 75 percent in output terms, but by only 10–25 percent in value terms given a decline in the premium shrimp fishery in the lagoons.

However, while the impact of construction has been to increase the aggregate potential productivity of fisheries in the catchment, scheme operation and water management has had a negative impact on the actual production of the pre-existing reservoirs and lagoons. In combination with failure to effectively enforce access restrictions, resulting overfishing and the effects of recent drought, this has degraded fish stocks and driven fishing towards being little more than an opportunistic and residual source of livelihood for households with few other alternatives. Given local population growth and unemployment rates this has provided an important social “safety-net,” albeit at low-income levels. Alternative livelihoods for the economically marginalized, such as firewood collection, shell mining and lime making tend to be more environmentally damaging.

Improvements in water management across the Kirinda Oya Irrigation and Settlement Project (KOISP) catchment thus have the potential to deliver a range of environmental, social and economic benefits. Productive fisheries can be restored in reservoirs if savings can be made in the water needs of farming, and management regimes can take account of minimum levels needed to conserve sustainable fish stocks. More research is required on the ecology of the coastal lagoons, but similarly a productive fishery can potentially be restored. An appropriate policy mix is needed, which can maintain the role of fisheries as a social "safety-net" along with promotion of small-scale commercial fisheries in the larger reservoirs, and regulation for environmental criteria of a rehabilitated fishery in the lagoons.

Transferable lessons can be drawn from these cases for multiple-use management of irrigation systems (particularly, irrigated rice systems) within the context of increasing water scarcity and need for integrated water resource management (IWRM). The studies show that aquatic systems modified by irrigation can still support fisheries provided attention is paid to the key characteristics of pre-existing habitats and to the design and operation of irrigation infrastructure. Integration of land, water and fishery management is crucial to achieving optimal use of water for farm and fish production, and for livelihood objectives. However, while impacts on biodiversity and ecological integrity (often the focus of environmental impact assessments) can be closely linked with production and livelihoods impacts, this is not necessarily the case. In the two cases investigated fisheries production and livelihood opportunities can be improved by irrigation development despite negative impacts on biodiversity and ecological integrity.

The studies also show that impact assessments can draw on existing knowledge to identify measures to mitigate or enhance impacts on fisheries, although location and system-specific knowledge gaps and research requirements may remain. The importance of recognizing the diversity of functions that fishing may perform within the livelihood strategies of rural households is demonstrated, as well as the need for an analysis that is disaggregated by location and by socioeconomic group. It is shown in Sri Lanka that it is worth conducting assessments for operational as well as planned schemes. Finally, a range of benefits derived from genuine stakeholder involvement in planning and impact assessment is demonstrated.

Impacts of Irrigation on Inland Fisheries: Appraisals in Laos and Sri Lanka

Sophie Nguyen-Khoa, Laurence Smith and Kai Lorenzen

Introduction

Increasing attention is being paid to the socioeconomic and environmental impacts of the development, expansion or continuation of irrigated agriculture (including associated dams, reservoirs and other infrastructure) within the context of holistic and integrated management of water resources and river basins. This has emphasized the need for multiple-use management of irrigation systems, and improved approaches for the planning, impact assessment and management of irrigation projects. An important part of this is the assessment and management of irrigation impacts on inland fisheries, which can be particularly challenging given both the range and complexity of issues that may need to be addressed, and the common deficiencies in knowledge of the hydrology and ecology of many freshwater systems and the livelihoods that are dependent on them.

The level of complexity and, therefore, the cost of impact assessment must be reasonable in relation to the magnitude of the expected impact and the total project cost. As a consequence, the time and resources available for fisheries impact assessments are likely to be limited, certainly for initial assessments, and more generally for all but the largest projects and most significant cases. This means that appraisal methods are needed, and they should be practical and low-cost, while still capable of generating results that facilitate informed decision-making on scheme construction, rehabilitation or management. This report presents the results of impact assessments conducted for this purpose in Laos and Sri Lanka.

An ex-ante appraisal of a 1,000 hectare irrigation project in Laos, and an ex-post evaluation of a 10,000 hectare irrigation and settlement scheme in Sri Lanka were completed. Both concerned irrigation development in rice-based farming systems where man-made habitats like rain-fed rice fields in Laos and ancient reservoirs in Sri Lanka contributed substantially to the total aquatic habitat and fisheries production in each country. The impacts therefore occurred within cultural landscapes that were already substantially modified from their pristine state. The focus was on impacts of irrigation on the biophysical environment, fisheries productivity and rural livelihoods rather than biodiversity. Transferable lessons are identified for the multiple-use management of irrigation systems (particularly, irrigated rice systems) within the context of increasing water scarcity and the need for IWRM, and for the practice of environmental impact assessment for inland fisheries.

The Importance of Appraising the Impacts of Irrigation on Inland Fisheries

Fisheries are the exploitation of natural living aquatic resources held in some form of common property regime, in contrast to aquaculture, which implies active husbandry and private ownership of stocks. In this study, inland fisheries refer to freshwater systems (including a wide range of habitats such as rivers, lakes and wetlands) as well as lacustrine and estuarine systems. To the extent that access is open to all and fishing requires few resources, fisheries can be a significant source of livelihood, especially for the poor people. Livelihood functions can range from an activity of last resort through part of a traditional and diversified subsistence strategy (usually integrated with farming and collection of other wild foods), to a full-time and market-oriented occupation (Lorenzen et al. 2004; Smith et al. 2005).

The importance of inland fisheries to livelihoods in developing countries, and in particular the accessibility and importance of these fisheries to the rural poor, has only recently been fully recognized. Rural households in locations as diverse as the lower Mekong (Guttmann 1999; Lorenzen et al. 2000; Jensen 2001), the Amazon (Almeida et al. 2002) and the Lake Chad basin in Africa (Béné and Neiland 2003) typically obtain between 10 percent and 30 percent of their total income from inland fishing. Despite this artisanal fisheries are often neglected by policymakers and planners, who regard this important livelihood to be merely an activity of last resort and a refuge for the economically and socially marginalized. Fishing households are commonly perceived as being part of a distinct social group, typically among the poorest and most deprived (as demonstrated by reviews of the literature by Allison and Ellis 2001; Béné 2003), and engaged only in fishing. In contrast, people whose livelihoods involve fishing, but not as their primary or income-defining activity, account for the largest share of inland fisheries catches. Well over 90 percent of the catch in Laos, for example (Lorenzen et al. 2000), and even in the lower Amazon, where there is a well-developed commercial fishery, part-time subsistence fishing still accounts for at least two-thirds of the fisheries production (Almeida et al. 2002).

According to net return flows, irrigation is a consumptive use of water, and as it is the largest use of water by volume in most developing countries, it impacts on ecosystems and the fisheries they support more strongly than most other human activities. Irrigation intentionally disturbs the natural hydrological system to increase agricultural production and can have multiple direct and indirect effects on the natural and socioeconomic environment in the catchment area. Inland fisheries can be affected positively or negatively, and through complex and varied means. By changing the overall availability and ecological connectivity of natural aquatic habitats in the river basin, irrigation systems (particularly, dams) affect the productivity and diversity of inland aquatic resources (FAP17 1995; Petr 1998; Halls et al. 1999; Lorenzen et al. 2000; WCD 2000, Nguyen-Khoa et al. 2003; Arthington et al. 2004). Impacts on the role of fishing in rural livelihoods may arise as a consequence of these changes, or as a result of changes in physical accessibility or rights of access to water bodies (fishing grounds), and in economic opportunities (Lorenzen et al. 2000; Smith et al. 2001).

Although recognition of the importance of inland fisheries has grown and knowledge about them is improving (for example, that compiled by the World Commission on Dams, WCD 2000), many gaps remain, and a lack of location-specific baseline data is likely to be a constraint to the improved planning and implementation of irrigation projects. Similarly, the availability of information to guide the assessment of the mechanisms and magnitudes of possible impacts of irrigation development is limited. Rigorous and quantified impact assessments are available only for a few systems, notably flood control and irrigation schemes in Bangladesh (Halls et al. 1999) and small/medium-scale irrigation schemes in Laos (Lorenzen et al. 2000; Nguyen-Khoa et al. 2003). Apart from these exceptions, most assessments conducted to date have focused on biophysical and ecological impacts (see for example, Larinier 2000; Bizer 2000; Jackson and Marmulla 2001), and there have been few attempts at a more integrated assessment that takes into account the full range of impacts on production and the socioeconomy in addition to biophysical impacts. This dearth has prompted research in this area to improve the contributions it will make to the understanding of fisheries and possible changes wrought upon them by the development of irrigation.

Approach and Methodology

Principles

Clearly, impacts on inland fisheries should be considered in the planning and management of irrigation, but the diversity and complexity of impacts makes this difficult. This research focused on the relationship between irrigation and fisheries and how it impacts on fish production and livelihoods, whereas most existing studies have concentrated only on impacts on fish ecology. A range of approaches have been used, mostly focusing on the ecological impacts of modifications to river flows and longitudinal habitat connectivity (Bizer 2000; Jackson and Marmulla 2001; Arthington et al. 2003), but while useful for addressing issues of biodiversity conservation and ecological integrity, these rarely adequately capture the impacts on production and livelihoods. Indeed, direct inferences for production and livelihoods cannot always be made as the loss of certain habitat types or habitat connectivity can cause a loss of biodiversity or ecological integrity without strongly affecting overall production levels. Conversely a quantitative reduction in the extent of habitat may cause a proportional decline in fisheries production without great loss of diversity. Similarly, impacts on livelihoods can be varied and difficult to predict, and the existing knowledge of livelihoods impacts is relatively weak (e.g., Adams 2000; Smith et al. 2001). In livelihood terms, access to fisheries resources at critical times of the year, close to the dwelling or in times of hardship, may be more important than overall levels of production or the species composition of catches.

As noted the cost of impact assessment must be kept within appropriate limits. Ideally, rigorous assessment of the production and livelihood impacts of irrigation development requires “before versus after” and/or “impacted versus control area” studies, with adequate replication of sites and/or sampling of affected households. Data from such studies are available for only a few systems, notably flood control and irrigation schemes in Bangladesh (Halls et al. 1999) and small- and medium-scale irrigation schemes in Laos (Lorenzen et al. 2000; Nguyen-Khoa et al. 2003). The time and resources needed for such investigations are significant, and in the context of planning it is almost always necessary to appraise impacts before such rigorous assessments are available.

As a result, even though location-specific data will usually be lacking, inland fisheries impact assessments will have to rely on relatively simple methods and limited primary data collection. To address this, emphasis was placed on the judicious use of comparative empirical information and the understanding of mechanisms, within a process based on expert judgment, local knowledge and stakeholder participation. The aim was an integrated assessment of physical, socioeconomic and other causal factors of impacts, and capture of the local knowledge, perspectives and validation that can be derived from genuine participation by stakeholders. This enabled a relatively rapid assessment of gross production and livelihoods impacts to be made, leading to the identification of opportunities for the mitigation of negative, or the enhancement of positive impacts.

This corresponds to the principles and practice of Environmental Impact Assessment (EIA)—(Wood 1995) and this provided a framework for the work reported here. Distinctive features included the emphasis placed on: i) a holistic and integrated assessment (hydrology, ecology, institutions, socioeconomics and livelihoods); ii) the genuine participation of stakeholders; and iii) adaptation and iteration within a sequential process. Given the participatory and adaptive nature of the approach, the identification of key issues and selection of means for their assessment emerged from a deliberately iterative process rather than as elements of a detailed prior research design.

The approach adopted is further documented in a "Guidance Manual for the Management of Impacts of Irrigation Development on Fisheries" (Lorenzen et al. 2004), and is also described and evaluated in greater detail in Nguyen-Khoa et al. (2005). It was considered appropriate for the appraisal of irrigation projects of the scale considered here. Much larger projects may be exceptions, for which substantial primary data collection and the use of more elaborate analytical models may be justified. In addition direct and representative stakeholder participation may be more difficult to achieve at larger scales or may require a different approach.

Stages of the Process

The impact assessments involved distinct stages of screening, scoping, assessment, and identification of mitigation or enhancement options. Decisions to implement a project, and/or impact mitigation and enhancement measures, would be followed by the implementation of the project and thereafter, monitoring and evaluation of its operation.

The assessments were carried out in this sequential process, built around a series of stakeholder workshops. These workshops were interspersed with periods of fieldwork including the collection and review of secondary information, rapid surveys and consultation with key informants. For each assessment, a knowledge base was assembled by a multi-disciplinary team of specialists (fisheries ecology and management, irrigation engineering and management, agricultural economics, and institutional analysis) and these were used to support the analyses conducted with stakeholders at the workshops.

Screening and scoping

Initial screening and scoping were carried out to assess whether impacts on fisheries were likely, and what the character of such impacts might be. For this a preliminary assessment was made based on a review of existing information, reconnaissance surveys, interviews with key informants (government officers, local researchers and community leaders) and initial workshops with stakeholders. "Screening" then involved the determination of whether an impact assessment was justified, based on identification of the nature and potential importance of possible impacts on fish production, livelihoods and biodiversity. This was followed by "scoping," which aimed to define what needed to be measured and how it would be measured given available resources (time, budget and human resources). Scoping primarily relied on the results of the preliminary assessment, but continued throughout the process, so that the scope of the impact assessment could be adjusted to take account of new information or changing circumstances.

Impact Assessment

The impact assessment focused on the key issues identified during scoping, and involved four activities.

i). The description of the project.

ii). The description of the current (baseline) situation. Analysis was mainly descriptive and summative as the aim was to document and understand the current situation as a basis for evaluating project impacts.

iii). The assessment of project impacts. This requires a comparison of the “with” versus the “without” irrigation scenarios over a specified period of time for a given intervention or investment. In the case of the ex-ante assessment this took the form of a comparison between the current pre-project situation with a predicted post-project situation. In the case of the ex-post assessment, a comparison was made between the current post-project situation and a reconstructed pre-project situation. In both cases the main attributes of the system were described and their interrelationships were examined in order to identify possible interactions and impacts. Observable changes and identifiable trajectories of change were assessed for the key variables of concern.

iv). Identification of mitigation and enhancement measures. An important element of any impact assessment is the identification of options to mitigate the negative and enhance the positive impacts of a scheme.

Specific Methodologies

Logistics and Stakeholder Participation

In Laos, the impact assessment was carried out during the early construction phase of the scheme, which was over 10 weeks from October to December 2001. A sequence of eight workshops was arranged, corresponding to the stages of the assessment process described above. An initial list of stakeholders was defined in consultation with local partner organizations (the Regional Development Committee and the Agricultural and Forestry Division). This included villages benefiting directly from or affected by the irrigation scheme, drawn from across the project area. It also included District and Provincial level officers (for planning, irrigation, livestock and fisheries, agriculture and forestry), and the engineering company responsible for project design and construction. One or two representatives of each group of stakeholders were invited to the first workshop, where a formal stakeholder analysis was carried out. This aimed to validate the selection, identify any non-represented groups, and to rank the interests, importance and influence of each group. In addition stakeholder groups such as villagers were interviewed during field visits as described below, and these results were reported during the workshops. The conduct of the workshop and the outcomes were continually monitored and evaluated through the use of individual post-workshop participant questionnaires and direct observation by the research team.

In Sri Lanka, the assessment was carried out over 9 weeks from February to April 2002, 16 years after the completion of the irrigation and settlement scheme. The method of selection and validation of stakeholder participants for a sequence of five workshops followed a similar process to that used in Laos, but included local participation from the entire river basin in order to ensure better coverage of all possible impacts. Eight villages were represented, one from each of the following zones: above the head reservoir; close to the reservoir and within the new command area; downstream on the banks of the Kirindi Oya; and two each from the old command areas and the coastal zone close to the lagoons. Stakeholders from relevant national, provincial and district agencies also participated.

Secondary Data Sources

In Laos, key sources of secondary data included the results of a quantitative, and replicated fisheries impact assessment of small- to medium-scale dam irrigation schemes (Lorenzen et al. 2000; Nguyen-Khoa et al. 2003), and detailed analyses of the role of fisheries in livelihoods (Garaway 1999; Smith et al. 2001). Each of these studies was carried out in the Savannakhet plain near the case study site, providing quantitative information based on long-term and spatially replicated surveys. Specific information for the project site and concerned villages was drawn from district and provincial records (e.g., population, rainfall, planned irrigated area, crop area and production per village and per household) and cross-checked with data from the technical feasibility report of the Huay Thouat project (Anon 2000).

In Sri Lanka, key sources included quantitative estimates of reservoir and lagoon fisheries production (De Silva 1988; Amarasinghe 1998; Joyeux and Ward 1998), aspects of fishers' livelihoods in the 1990s (post-project)—(Renwick 2001; Jayakody 1993; Kularatne 1999) and pre-project studies (Senanayake and Wijetunga 1987; Chandrasiri 1986). Information on hydrology and irrigated agriculture was provided by project assessment studies carried out since the implementation of KOISP (e.g., IIMI 1995), and supplemented by interviews with IWMI field officers and researchers.

Reconnaissance Surveys

Initial field visits contributed to the preliminary assessment and provided information for the screening stage of the impact assessment. In Laos, four villages were visited, purposively selected to be spatially representative by distance from the dam site. During each visit field walks and direct observations were made, and semi-structured group and key informant interviews guided by pre-prepared checklists were conducted. These checklists prompted explicit investigation of the identity and conditions of the poorest and most marginalized members of the selected communities, as well as a wide range of livelihood functions performed by those who engage in fishing. In Sri Lanka, a purposive selection of 11 villages spatially representative of zones within the river basin was visited and similarly surveyed. This was subsequently reduced to a selection of eight villages judged to adequately represent the main issues of concern, and these provided stakeholders' representatives and locations for more detailed investigation of impacts.

Impacts on the Biophysical Environment

For both schemes a baseline situation map of aquatic habitats and land use was constructed using information from topographic maps as well as participatory mapping exercises (initially prepared through group interviews in selected villages, with cross-comparison and validation at the workshops). Relevant features of the potentially impacted area and the wider catchment were identified and mapped, e.g., water resources (streams, rivers by category order, lakes, ponds, etc.,) and land use types (forests, agricultural, urban, etc.). Known modifications to the natural river course, such as reservoirs, embankments, weirs, etc., were indicated on the map. As a second step, a map of the predicted (ex-ante assessment) or reconstructed (ex-post assessment) situation was produced by adding or highlighting changes related to the project such as new reservoirs, canals, and irrigated fields. This allowed identification of aquatic habitats lost or gained, as well as possible effects on the ecological connectivity of habitats (i.e., changes that would impede or facilitate migrations of aquatic organisms).

Fisheries Production

Information on fisheries production from the habitats identified on the pre- and post-irrigation project maps was derived from local surveys where possible. Given the seasonality of fisheries and their dispersed and inconspicuous nature, it is often impractical to estimate production during short impact studies. However, comparative empirical data on fisheries production are available for most habitat types and geographical areas, and may be used in impact assessments where location-specific data are lacking. Empirical data relevant to the case studies are summarized in table 1. Productivity of river-floodplain systems has been broken down into river and floodplain (including natural floodplain and rain-fed rice fields) components based on a comparison of yields achieved from river basins with different levels of floodplain development. In the impact assessments, all production estimates were cross-checked with consumption and market estimates and discussed with stakeholders.

Impacts on Rural Livelihoods

The Sustainable Livelihoods Approach (DFID 1999) and a categorization of livelihood functions that can be provided by fishing within livelihood strategies (Smith et al. 2005) provided a conceptual framework for the assessment.

In Laos, the reconnaissance surveys had shown the area and affected population to be relatively homogeneous and comparable to those investigated by prior studies in the same province as listed above. Given the predicted outcomes for the post project biophysical and fish production impacts, this secondary information was used as the basis for predictions of the most likely livelihood impacts of the yet to be completed scheme. These predictions were validated through presentation, discussion and refinement at the stakeholder workshops. Additional field visits covering the selected villages were carried out by district officers to further assess specific issues (e.g., main aquatic species caught by fishers and traditional knowledge on fish migration).

In Sri Lanka, it was decided that a rapid appraisal of livelihood impacts completed mainly through an informal village survey would be the appropriate means of investigation. The economic and social importance of inland fisheries in the area indicated that some primary and location-specific data collection should be conducted for key variables, while the quality of stakeholder's prior knowledge about the situation and the availability of relevant secondary information supported the choice of rapid and informal survey methods. In the analysis emphasis was placed on triangulation of information from these varied sources.

The primary data collection for impact assessment consisted of the following activities. Key informant interviews were conducted in the eight selected villages. The respondent was a community leader and in most cases the president or other office bearer in the village Fishing Society. Information was collected about the village economy, including: natural, social and physical capital; financial capital (in terms of

TABLE 1.
Empirical estimates of fisheries productivity (mean and range) of different aquatic habitats.

Habitat	Area measure	Productivity (kg/ha)	Reference
River without floodplains	Catchment area	0.3 [0.06–0.57]	Welcomme 1976
River-floodplain	Maximum flooded area	80 [7–186]	Bayley 1988
Rain-fed rice fields (Laos)	Rice field area	60 [4–230]	Lorenzen et al. 2000
Estuaries and lagoons	Average water area	100 [4–2,200]	Joyeux and Ward 1998
Reservoirs (Sri Lanka)	Average water area	220 [40–500]	De Silva 1988
Small reservoirs (Laos)	Average water area		Garaway 1999
Non-managed		100 [36–176]	
Enhanced and managed		250 [50–550]	

Source: Lorenzen et al. 2004

Note: Different area measures have been used for different habitats access to credit and main income/employment sources); the local labor market and relative labor surplus or scarcity. Attention focused on the proportion of households engaged in fishing and its relative importance compared to other livelihoods. In addition ad hoc interviews of fish traders and fishers were conducted during early morning visits to sites when fish catches were commonly being returned to the shore.

From the eight villages surveyed in this way, five were identified as representative of the areas within the river basin that had the most important fisheries and/or the most significant project impacts. These areas were the scheme head and ancient reservoirs (three villages) and coastal lagoons impacted by scheme drainage inflows (two villages). In each of these five villages household interviews were conducted to inform a more disaggregated assessment of the role of fishing in livelihoods and to provide detailed household case studies. Two poor, two middle-income and two rich households were interviewed in each of the five villages. Households were selected by asking the key informant to nominate two households for whom fishing was a significant full-time or part-time activity in each of the three wealth categories. Clearly, this was based on a subjective assessment, and the wealth categories were considered only indicative. However, observation of assets, economic opportunities and housing conditions during the interviews suggests that the selections were generally appropriate. Progression from relatively poor to relatively rich was consistent for the six households in each village, although cross comparisons by wealth category across villages would not necessarily be consistent. The household interviews focused on household composition, productive assets, income sources and diversity, the livelihood role played by fishing and the impact of both the irrigation scheme and a recent drought on fishing.

Observations and the key informant interviews revealed that project impacts on fisheries in two of the remaining villages (and thus zones within the basin) were not significant. These were the upper catchment and river-floodplain, upstream and downstream of the head reservoir, respectively. Given time constraints just two fisher household interviews were conducted in each of these villages. These provided household level perspectives and confirmed the relative lack of importance of fishing in these zones. The final village was located near the coastal lagoons and was not surveyed further because of time constraints, and also because the coverage provided by the two “lagoon villages” referred to above was deemed adequate.

Secondary data collection and analysis was based on a review of existing project evaluation reports, other relevant studies and available statistics (see section above and literature cited). Information was also gained from meetings with local officers of the Divisional Secretariat, Wildlife Department, Fisheries Department and Irrigation Department, and from their participation in the workshops.

Results of the Impact Assessments

Huay Thouat Irrigation Project, Laos

Background

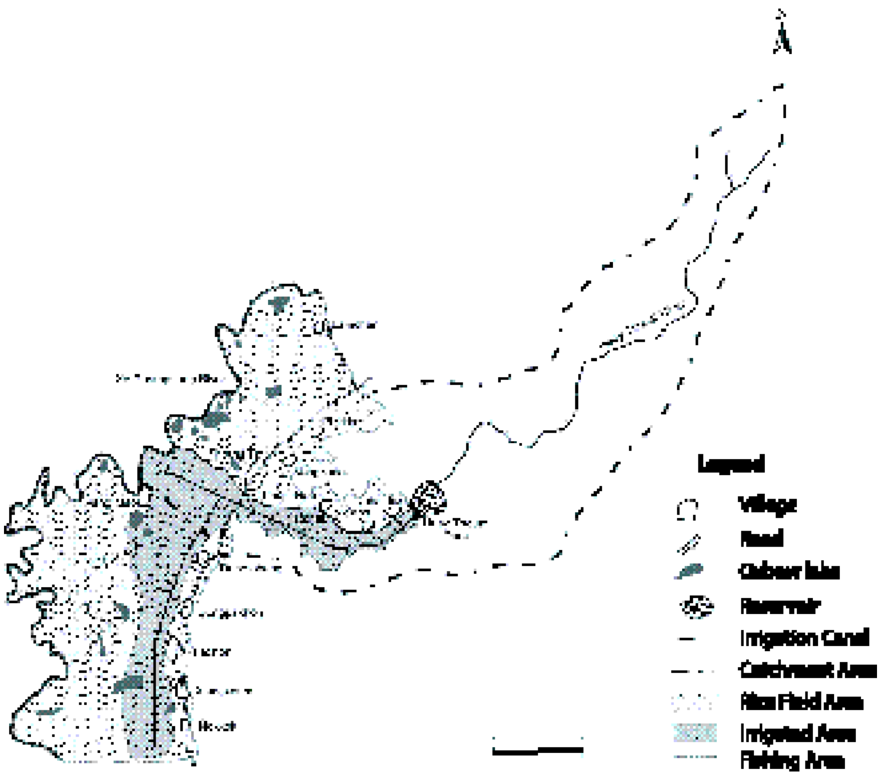
With an estimated GNP (gross national product) per capita of US$320 in 2001 (World Bank 2003a), Laos is the poorest and least developed country in the East Asia region. More than three-quarters of the population live on less than US$2 per day and social indicators are among the worst in the region (World Bank 2003b). Landlocked, the country covers 236,800 km^2 with a population of 5.4 million, and with a growing rate of 2.6 percent annually. Agriculture remains the major driver of the economy, contributing 53 percent of gross domestic product and employing over 80 percent of the labor force. In the year 2000, rice accounted for about 84 percent of the total cultivated area of approximately 820,000 ha per year, and about 16 percent of the rice area was irrigated (National Statistical Centre 2000).

The case study was conducted in Savannakhet province (southern Laos), one of the six plateau provinces adjacent to the river Mekong. Relatively low lying (elevation from 50 m to 200 m above sea level), the area is fertile and suitable for a variety of crops including rice, vegetables, maize, and cassava.

The site of the proposed project was Huay Thouat, a small watershed at the edge of the Xe Champhone wetland area (Claridge 1996). Pre-project, there were 1,240 hectares of farmed land within the project area, of which 990 ha were used for wet season rice cultivation with yields of 1.9 to 2.5 tonnes per hectare. There was little dry season cropping. Surplus labor was considered to be available in the area and able to contribute to the development of irrigated agriculture.

The irrigation system was designed for a command area of 1,020 ha, distributed over 15 villages. It will serve 880 households, with a total population of 5,830. The catchment of the Thouat river has a total area of 63 km^2 including 43 km^2 above the dam, which will be located upstream from the confluence with the Champhone river. The reservoir was designed to retain 13 million m^3 (about 70 percent of the total available volume of water) and to have a surface area of 474 ha at full storage level (Anon 2000). The aim of the proposed project was to increase agricultural production by extending the farmed area and by developing a dry season crop. Construction commenced in late 2000 and was in progress during the impact assessment.

FIGURE 1.
Sketch of the proposed irrigation system and impacted area, Huay Thouat, Laos.



Screening and Scoping

It was known from previous work in the Xe Champhone wetland area (Garaway 1999; Lorenzen et al. 2000) that fisheries contributed very significantly to livelihoods, and this was confirmed by the reconnaissance surveys. Analysis of the comparative data from the region (sources described above), reviewed and validated by the initial stakeholder workshops, concluded that the impacts of the project on fisheries would be positive in aggregate, mainly because the scheme would increase dry season water availability and, thereby, provide better opportunities to fish in the reservoir, river and canals. This would outweigh the possible negative impacts from reduced wet season flows and obstruction of fish migration. The overall benefits from irrigation development would be positive for people's livelihoods and few concerns about possible negative impacts were expressed. Losses of paddy land to irrigation infrastructure were mainly mentioned. Nonetheless the stakeholders supported a full assessment of fisheries impacts, largely with a view to identifying measures that could further enhance the expected benefits. The resulting assessment maintained a broad scope and appraised impacts of the project on aquatic habitats, their productivity, fishing practices and effort, and labor use and livelihood opportunities within the affected area.

Baseline Situation

The Natural Resource System. Participatory mapping and direct observation showed that much of the upper Huay Thouat catchment is forested, while the area immediately above and below the dam is agricultural land. Water resources in the area are extensive but highly seasonal. In the wet season, the water resources include 990 ha of rain-fed paddy fields, the Thouat river, and the much larger Champhone river and its associated oxbow lakes and depressions. In the dry season, only the Champhone river and its oxbow lakes retain water and thus provide fishing opportunities. Villages and cultivated land are concentrated in the lower Thouat catchment, and are within easy reach of these fisheries.

Rain-fed rice fields play a major role in fisheries production. In rain-fed or flood recession type rice farming systems, rice fields can store water and create aquatic ecosystems with many similarities to natural floodplains (Heckman 1979; Welcomme 1985; Lawler 2001). They can often dominate the overall aquatic habitat and fisheries production (Gregory and Guttman 2002), and this may be maintained as long as farming practices that store water in rice fields for extended periods are continued, and the ecological connectivity with perennial habitats is sufficient to allow colonization by fish.

Livelihoods. The local economy was characterized by a relatively homogeneous population of households, clustered in largely independent villages engaged primarily in subsistence agricultural production. The activities were centered on paddy rice cultivation but hunting, fishing, and gathering of non-timber forest products were also playing an important role in their livelihood. Occupational specialization in villages was low, and income from farming is usually supplemented by other productive activities such as micro-enterprise, casual labor, and permanent or part-time government employment (Smith et al. 2001). Women bear a significant burden of agricultural work as well as other household tasks. Wealth ranking exercises conducted in the same area found that land ownership, adequate household labor to cultivate that land and achievement of a secure level of rice self-sufficiency or surplus were regarded by villagers as the most important determinants of "wealth" and vulnerability (Smith et al. 2001). Drought or floods and their impacts on the wet season rice crop are the main sources of vulnerability for households, with the effects of disease for livestock and the human labor force next in importance (Hopkins 1995; Smith et al. 2001). Table 2 summarizes the status of household livelihood assets.

TABLE 2.
Household livelihood assets in the Huay Thouat catchment.

Assets	Status and key issues
Natural	• land variously developed as rice paddy and swidden fields (shifting cultivation), or maintained as forest for gathering wild plants and animals, fuelwood, and occasionally timber • fisheries provided by streams and rivers, seasonally flooded rice fields and depressions and perennial ponds and lakes • comprehensive assessment of how wider trends in population growth, agricultural development and commercial logging are affecting sustainability of land use, forests and livelihood security is lacking
Physical	• access to infrastructure and public services is highly variable but generally poor • in Champone district 57% of villages have year round road access, 25% have only dry season access, and 17% have no road access; 54% have an improved water source (UNDP/ILO 1999)
Human	• levels of health and education are poor, particularly for women (World Bank 2003b) • nationally, the rural literacy rate for those 15 years and older is 79% for men and 49% for women; in rural areas the average number of years of schooling for those aged 15-49 is 5 for men and 4 for women (National Statistical Centre 1999) • in Champhone district 57% of villages have a permanent health volunteer and 3% a permanent doctor; 28% have a complete primary school; 70% receive visits from agricultural extension workers and 14% from veterinarians (UNDP/ILO 1999) • significant indigenous technical knowledge of fisheries as well as of other wild foods and non-timber products from forest areas
Social	• strong inter-household cooperation and support, especially within kinship groups and in reciprocal labor exchange for peak farm tasks (Randall Ireson 1995) • customary access and ownership rights usually exist for fisheries and forests, although disputes and uncertainty over rights may exist • relatively low socioeconomic differentiation between households and common reliance on shared fisheries and forests creates the potential for effective community management of these (Garaway 1999)
Financial	• low household savings • limited access to credit • sale of surplus fish catches can be one of few readily available sources of cash income for poor households

Source: Smith et al. 2001

Ninety percent of rural households in the region regularly engaged in fishing, obtaining an average catch of 60 kg/household/year (Lorenzen et al. 2000, Nguyen Khoa 2003). Fishing was second in importance to rice production as a livelihood activity, providing approximately 15 percent of total household income on average. Fishing thus formed an element of a traditional diversified subsistence livelihood strategy. Households fished throughout the year, with food security being primarily based on one's own rice production and catch of fish. Rice and fish are also purchased in times of need. The poorest often received some as participants in village social support networks, or in exchange for labor. Sale of fish is also a source of income for some households, though lower and less regular than that the income generated by the sale of surplus in rice production. Thus, the sale of fish tends to be most important for poor households with inadequate land to meet subsistence needs, but with sufficient manpower to be used for fishing, and acquire more skills through experience in the trade. In the same region Garaway (1999) found that time invested in fishing and the catch obtained were relatively similar for all social groups, but declined slightly with increasing wealth status. Availability and characteristics of fisheries within walking distance of the village, and/or restrictions on use, were important influences on the catch of fish and are much more important than the socioeconomic differences between groups.

In the project area fishing activity was concentrated in the Xe Champhone floodplain (below the Huay Thouat catchment) and in rain-fed rice fields. Wet season fishing was mainly in rice paddies or nearby drainage channels or depressions. Dry season fishing was limited to perennial streams or ponds, and thus often involved greater traveling and was more practiced by men. Fishing was not otherwise gender-specific and was widely practiced by men, women and children. The available fisheries were well suited for households who were also farmers. For such households fishing was a regular (often daily) activity, carried out in association with farm work or when traveling to and from the fields. This particularly applied to the use of passive fishing methods such as gill nets or fish traps.

Most fisheries were open access although local communities have "de facto" ownership and may choose to restrict access either on a communal basis or by renting out water bodies to private interests (Lorenzen and Garaway 1998; Garaway 1999). Such management measures are usually applied in only a small proportion of water bodies available for fishing. In rice fields, stationary fishing gears such as traps are deployed only in the farmer's own fields while mobile gears such as harpoons may be used anywhere. Aquaculture was little developed in the area, contributing less than 10 percent of the total fish production.

Predicted Project Impacts

Impacts on aquatic habitats and their connectivity. Changes in aquatic habitat availability and connectivity were assessed on the basis of the aquatic habitat and irrigation system map, and workshop discussions. The main changes predicted were:

i). Overall reduction in annual discharge of the dammed river due to evapotranspiration of irrigation water, and seasonal redistribution of flows resulting in lower wet season and higher dry season flows (from irrigation return flows and seepage).

ii). Relatively little change in the seasonally flooded area comprised of rain-fed rice fields (990 ha) and river Thouat floodplain (about 48 ha). This is contingent on the continuation of rain-fed paddy cultivation in the wet season, as any reduction in paddy water storage would reduce their value as aquatic habitat.

iii). Creation of a new dry season aquatic habitat in the form of a reservoir and irrigated rice fields.

iv). The Xe Champhone river and associated wetlands, which dominate the current dry season habitat, will be largely unaffected. The contribution of the Huay Thouat river to Xe Champhone discharge below the confluence was estimated as less than 2 percent based on relative catchment areas.

v). Loss of longitudinal connectivity of the Huay Thouat river at the dam site. Possibly a reduction in lateral connectivity due to raised irrigation canals, which may create barriers to fish migration into paddies situated above the command area, and a reduction of the wet season river flow.

Fisheries production. Projections of impacts on fisheries production were obtained by multiplying pre- and post-project aquatic habitat areas with empirical productivity estimates (table 3).

Fisheries production in the Huay Thouat catchment as estimated from habitat and empirical productivity data is comparable to the expected consumption by local households (53 t/year, 880 households x 60 kg/ha/year). Overall habitat and production are dominated by rain-fed rice fields, and this production is likely to be sustained unless connectivity is lost between perennial habitats and rice fields, or water retention in the wet season is reduced. Fisheries productivity of dry season irrigated rice fields is assumed to be negligible, due to low water levels and lack of natural "up migration" of fish from perennial water bodies.

While it is unclear to what extent the change in river flows and longitudinal connectivity will

TABLE 3.
Estimated impact on fish production in the Huay Thouat catchment, assuming maintenance of rain-fed rice cultivation in the wet season and complete loss of mainstream river and associated floodplain production. See table 1 for origin of productivity estimates.

Habitat	Catchment Area (ha)	Before Project			After Project		
		Area (ha)	Productivity (kg/ha/year)	Production (t/year)	Area (ha)	Productivity (kg/ha/year)	Production (t/year)
Rice fields*		990	60	59	990	60	59
Thouat River	6,300	0	0	2	0	0	0
Floodplain		48	80	4	0	60	0
Reservoir		0	100	0	200	100	20
Total		1,038		65	1,190		79
Change					152		14

Note: * Rice fields contribute to fish production only during the wet season since water levels are low and natural recruitment onto this area is negligible (no migration) during the dry season.

reduce fisheries production from the river and its seasonal floodplain, estimation shows that production from the river itself is only about 6 t/year in total. Thus, even a complete loss is likely to be outweighed by a gain of about 20 t/year from the new reservoir. The net effect of irrigation development on production of fish is thus likely to be slightly positive.

Sustaining natural fish production in the Huay Thouat catchment on the current scale is thus highly dependent on the continued role of rice fields as seasonal fish habitat. The main threats to this role of rice fields are changes in agricultural practices that reduce water retention, and loss of ecological connectivity of these fields with permanent water bodies. Availability of irrigation water reduces the need to store water in rice fields, and allows intensification of wet season rice production with concomitant increase in the use of agrochemicals. Reduction in rice field water storage and/or extensive use of pesticides will drastically reduce, if not eliminate fisheries production from rice fields. A sensitivity analysis shows that the net effect of irrigation could be strongly negative incurring a loss of production up to 45 t/year in the worst case scenario where rice field habitats would not support any fish production anymore. Hence, expected agricultural productivity gains from these practices must offset the concomitant loss of fisheries production to be beneficial overall.

Irrigation infrastructure and water management may restrict fish migrations from permanent water bodies to rice fields, due to low water availability in critical habitats along the migration routes, or physical obstacles to migration such as raised canals. Both negative impacts can be mitigated (see below). An extensive survey of impacts on fisheries in irrigation schemes was carried out, where a traditional wet season rice crop was maintained. No evidence was found of the effects on the yield beyond those explained by changes in flooded area and fishing effort (Lorenzen et al. 2000; Nguyen-Khoa et al. 2003). This suggests that impacts on connectivity are not generally severe.

The aforementioned impact study in Laos indicated slightly lower (by 10–20%) fishing effort and yields in irrigated areas as compared to non-irrigated controls. Returns to fishing effort were slightly, but not significantly higher in irrigated areas. This suggests that fishing in irrigated areas declines slightly as a result of socioeconomic rather than biophysical actors. Also, fishing effort was partially redistributed from river-floodplain and rice field locations to the reservoir. Estimated effects of irrigation schemes on fishing effort and catch showed a significant reduction of the fishing effort (-60%) and catches (-53%) in the floodplain and rice field areas. These effects were partially compensated by the increase of fishing effort and catches in other water bodies and particularly in the newly created reservoir.

Impacts on fisheries production outside the Huay Thouat catchment are likely to be insignificant given the low contribution of the Huay Thouat to overall habitat and discharge in the Xe Champhone basin (2–3%). However, irrigation schemes are being developed in many locations of the basin and cumulative impacts may be significant in the future and should be assessed.

Livelihood Impacts. Impacts for individual households will depend on a range of variables including the location and fishing characteristics of water bodies visited, the fishing methods used, the importance of fishing in a livelihood strategy, household resource endowments, and the level of social and economic development of the area. The lack of specific data for the project area made detailed prediction of livelihood impacts difficult, but it follows from the relative homogeneity of the rural population and, generally, positive changes in production potential discussed above that, damaging livelihood impacts were not expected for the majority of households.

The majority of households in the project area practiced fishing as part of a diversified subsistence livelihood and were expected to benefit from irrigation development overall. As farmers or farm laborers they would gain the benefits of irrigation, and as fishers most would benefit from the new reservoir fishery and other improved opportunities for fishing in the dry season. In aggregate, fishing effort was expected to decline (as observed by Lorenzen et al. 2000 and Smith et al. 2001), because of the increased labor requirements of irrigated farming and increased wage rates and demand for labor in local farm and non-farm labor markets.

Increased access to new and more perennial water bodies would compensate for the reduction of floodplain area, although there will be differentiation in this result between locations and households. Overall, access will be improved, particularly during the dry season, and importantly access to fisheries for the landless and marginalized should be maintained. Smith et al. (2001) suggested that travel to reservoir fisheries can be facilitated by service roads constructed along irrigation canals, but as men are generally more mobile than women this impact may be differentiated along gender lines. Reduction of time spent traveling, and/or concentrations of migrating fish created by the irrigation infrastructure, will improve the efficiency of the fishing effort, particularly for households situated in close proximity to the reservoir. Irrigation return flows and seepage will also facilitate dry season access to fisheries for women who generally fish nearer their homes.

Opportunities for Mitigation and Enhancement

A range of mitigation measures were considered in the assessment workshops:

- Maintenance of a rain-fed wet season rice crop is likely to be most critical for sustaining fisheries production in the area.
- Maintenance of lateral connectivity through design of “fish-friendly” cross-drainage culverts is a simple and potentially important measure. Cross-drainage culverts of Huay Thouat irrigation system had been designed for a flow of 1–2 meters per second which exceeded the maximum short-term swimming speed of most fish species (mostly below 0.5 m/s, Clay 1995) when migrating upstream at times of high rainfall and flow. Larger culverts would reduce flow velocity and improve connectivity, but are more expensive and require regular maintenance to remove debris.
- Maintenance of longitudinal connectivity across the 9 meter high dam is difficult to achieve. It is also doubtful whether this would provide significant production benefits as many species are likely to maintain

separate self-sustaining populations above and below the dam. This was regarded as a low priority. However, there may be trade-offs between maintaining water for reservoir fish populations and releasing water for maintaining habitats in the river downstream the dam.

- Augmentation of river flow with "environmental" releases during key migratory periods may be required to allow fish migration into rice field habitats. This issue should be assessed once the scheme is operational.
- Drainage channels may become key migratory pathways within the irrigated rice field system, as long as channels are designed without fall structures. In addition, fishponds for private aquaculture are likely to be created in the command area and will provide additional dry season habitat for wild fish, unless they are drained completely.

Summary of the Lao Case Study

The case is an example where irrigation is being introduced in an area with rich fishery resources, and where fishing plays an important role in the livelihoods of most rural households. The net impact of the irrigation project on fisheries production was predicted to be slightly positive. This unexpected and perhaps counter-intuitive result is the result of two main factors.

i). Natural fish production is to a large extent derived from rain-fed rice fields, and can be sustained within the irrigated system provided that the rain-fed wet season rice crop is maintained.

ii). The reservoir fishery that will be created should be sufficient to at least compensate for production losses arising downstream in the river and its associated floodplain.

The overall impact on the livelihoods of people living in the project area is also predicted to be positive. The majority will gain benefits from irrigated farming and the stimulus this provides to the local economy, while fishing, which is their second most important activity, will not be adversely affected in aggregate and may be enhanced. However, these aggregated positive results hide possible differentiation of the impacts among sections of the communities affected. If the project proceeds, such differentiation by location in the catchment, socioeconomic status and gender should be monitored to ensure that the interests of vulnerable groups are safeguarded. Most at risk will be the landless or land-deficient households, who are more heavily dependent on fishing but are a long distance away from the reservoir, particularly if they are less able to exploit new labor market opportunities.

Although irrigation development may help to stimulate the rural economy leading to new livelihood opportunities, the subsistence and backward nature of the rural economy will persist for some time, making it essential that the livelihood contributions of fishing are sustained. Indeed fishing can continue to be part of the diversified livelihoods of most rural households, while also playing the role of a "safety-net" (Jul-Larsen and van Zwieten 2002; Béné 2003) for the poorest sections of the rural population.

Kirindi Oya Irrigation and Settlement Project (KOISP), Sri Lanka

Background

Since liberalization of the economy from 1977, economic growth in Sri Lanka has been relatively strong (on average 5 percent per annum from 1990 to 2000, Central Bank of Sri Lanka 2001) apart from frequent slow-downs resulting from the internal conflict or international economic shocks. In 2001 the GDP reached US$898 billion, equivalent to US$536 per capita, but unemployment remained a persistent problem. The agricultural sector, including forestry and fisheries, was the mainstay of the national economy, contributing 20 percent of the GNP in 2001, providing direct employment to 35 percent of the workforce, and remaining an important source of income for about 70 percent of the population (Central Bank of Sri Lanka 2001). Despite strong growth in some sectors, a growing middle income class in urban areas and good progress on social indicators at the national level, much poverty remained in rural areas, particularly in the north-west and the south-east dry zone of the country.

In this context, both marine and inland fisheries have played an important role in supporting the livelihoods of a significant number of rural households, and as a source of animal protein, despite their modest share in the GNP (2.7 percent, Central Bank of Sri Lanka 2002). Coastal, deep sea and offshore, and inland fisheries contributed 57, 30 and 13 percent, respectively, of total fisheries production (Central Bank of Sri Lanka 2002). Although inland fisheries were less important than marine fisheries in terms of contribution to the GDP and employment at the national level, this does not diminish their importance as a source of livelihood for rural households, many of whom are among the poorest in rural areas, nor their importance as a source of protein in rural diets.

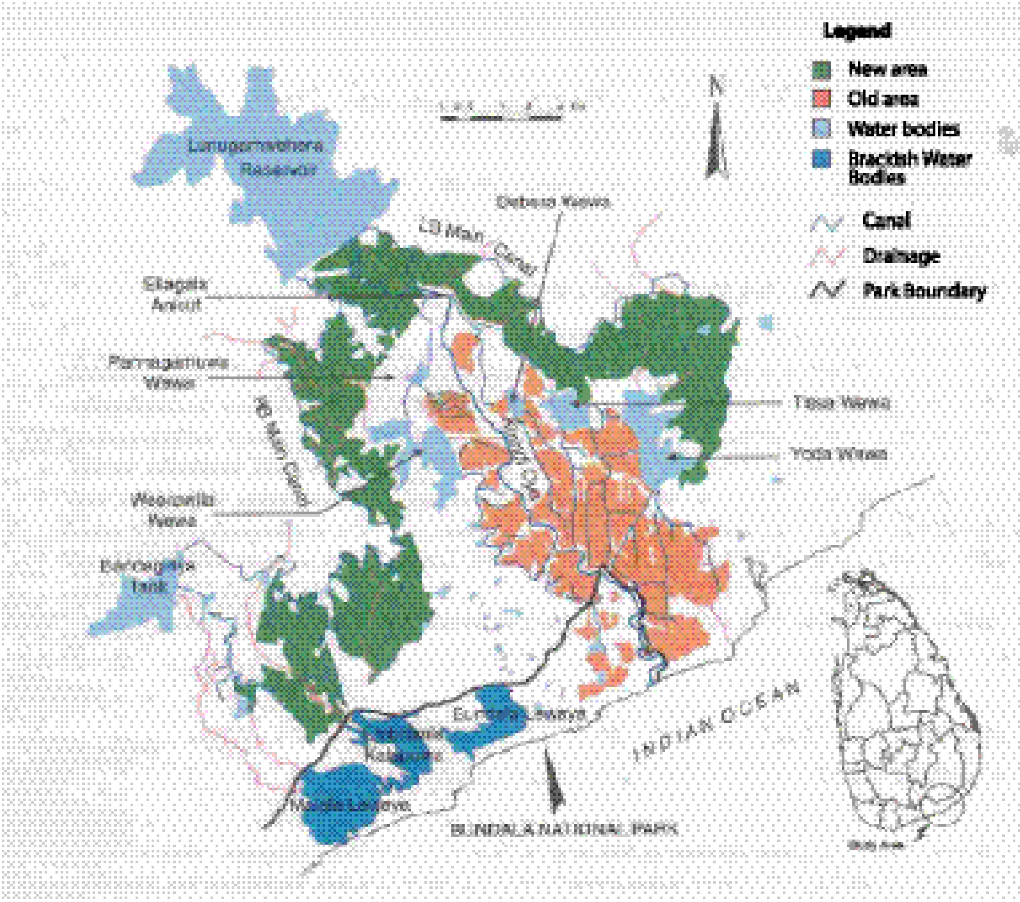
Fisheries were believed to directly support the livelihoods of over 10 percent of the population in many coastal areas, but no precise figures existed for the inland sector (Murray et al. 2000). An estimated 96 percent of the population regularly consumed some form of fish, while in 1996 fish products constituted an estimated 59 percent of the nation's total non-vegetable protein consumption (NARA 1997). Inland fisheries are mostly concentrated in perennial reservoirs where the activity has been promoted since 1952 through the introduction of exotic tilapia species (*Oreochromis mossambicus and O. niloticus*) and the government programs subsidizing fishing craft and gear (Amarasinghe 1998). The reservoir fisheries are managed mostly for the introduced tilapias, because fishers and consumers prefer them. However, tilapias still account for only about 10 percent of the fish biomass in these reservoirs, and native fish species remain important in both production and biodiversity terms (Pet et al. 1996).

Reservoir fisheries have provided significant income, employment and dietary benefits. In Sri Lanka, for rural and urban populations in general, dried fish has long been an important component of the diet, due to advantages in handling and storage. However, recent data shows an increase in freshwater fish consumption plus higher levels of consumption in the irrigated (or dry) zone. The irrigated areas are mostly inland and often lack transport facilities. Thus, it can be expected that consumption of freshwater fish is high relative to marine fish consumption, with prices relatively more affordable for the poorest households. This has been reinforced by the security problems in the north and east, which reduced supplies of marine, fresh and dried fish, contributing to higher prices. Freshwater fish have thus been important as a source of protein for low-income households, being relatively abundant and affordable within irrigation districts where there are productive reservoir fisheries (Weligamage 2001).

The Kirindi Oya Irrigation and Settlement Project (KOISP) is a major agricultural development project, which was implemented in 1986 in the eastern part of the southern province and dry zone (figure 2). The project rehabilitated and incorporated an ancient reservoir-based irrigation system (also called "tank"[1] system), which was replaced by an open cascade irrigation system draining into the Indian Ocean through a network consisting of a headwater reservoir of 200 million cubic metres, five ancient reservoirs and command areas. The ancient reservoir system supplied a command area of 4,200 ha, which has been supplemented by a new command area of 5,400 ha, in which a substantial population was resettled. The new right bank command area extends and drains into a neighboring watershed. The project was designed for a diversified cropping pattern but since

[1]In Sri Lanka, "tanks" refer to irrigation schemes with small-scale (below 200 acres or 81 ha) and medium- scale (between 200–1,000 acres or 81–405 ha) command areas.

FIGURE 2.
Map of the Kirindi Oya watershed and the Kirinda Oya Irrigation and Settlement Project (KOISP) irrigation system.



Source: Matsuno et al. 1998

operation commenced, rice has been the main crop (IIMI 1995). As a result the demand for irrigation water has been higher than expected, and overall economic performance somewhat lower. Nonetheless, the project is considered to make an important contribution to the economy of the Southern Province (IIMI 1995).

Screening and Scoping

The reconnaissance survey and review of secondary information revealed that there was a significant inland fishery in the Kirindi Oya basin, with fishing predominantly practiced in the reservoirs and in coastal lagoons.

Stakeholders considered that the KOISP had impacted on fisheries and identified the following key issues:

1) Reduction in river flow and flooding
2) Declining dry season water retention in small- and medium-scale reservoirs
3) Inflow of drainage water into the lagoons
4) Conflicts between fishers and farmers
5) Weak linkages between fisheries institutions and irrigation institutions

Issue 1 (reduction in river flow) was raised by scientists at the workshop, while issues 2 to 5 were identified by local stakeholders. While all issues identified were related to irrigation-fisheries interactions, most had also been influenced by drought conditions prevailing for 3 years at the time of study and, which had led to a general water scarcity, increased rural underemployment, and recession in the regional economy. This implied a need to differentiate between current (drought-influenced) and more “normal” post-project conditions in the assessment, and that a complete separation of irrigation and drought impacts might not be possible.

Impact assessment involved characterization of the current (post-project) situation, identification of current fisheries problems related to irrigation development, and an assessment of the overall impact based on a reconstruction of the pre-project situation.

Baseline Situation

The baseline situation consisted of the post-project conditions as observed during the investigations described above.

Natural resource system. Land use in the Kirindi Oya catchment is predominantly agricultural, although the upper catchment is partially forested and an area of the lower catchment is set aside as a National Park. Water resources include the Kirindi Oya river itself, the large Lunugamwehera reservoir constructed by the KOISP, a number of large ancient reservoirs, and coastal lagoons. All rice fields in both the “old” and the “new” area are irrigated, as the catchment is too dry to support rain-fed rice culture. Consequently water levels in the rice fields are low on average and typically fluctuate between 0 and 10 cm over short time scales (days).

Fisheries production is almost entirely concentrated in the reservoirs and lagoons. The Kirindi Oya river itself has an innately low production potential due to steep gradients and rapid and seasonal river flows, with flooding limited in duration and extent (De Silva 1988, Arthington et al. 2004). Likewise, the irrigated rice fields support little fisheries production. Of the total inland (including lagoon) fisheries production in the watershed (see table 6 for details), the river, floodplain and rice fields were estimated to contribute less than 160 t/year (10–20%). Lagoon fisheries have been most drastically affected by the recent drought, and had virtually ceased at the time of impact assessment. Reservoir fisheries were based mostly on introduced tilapia, but also some native species. Lagoon fisheries were dominated by tilapias (which can tolerate brackish water), but had previously included a large harvest of shrimp.

Livelihoods. Agriculture, forestry and fisheries dominated the local economy. Apart from a minority who specialized in fishing, most communities depended on agriculture as the main source of income. Other than farming, the main skills and experience in the area were in fishing, and in other natural resource-based activities (e.g., shell mining, firewood collection, lime making), government servants (school teachers, clerks, etc.) and other occupations such as drivers, carpenters, and masons. Statistics by district showed that unemployment, and the proportion of employment in agriculture and fisheries for both men and women, were significantly higher in the region than national averages (Department of Census and Statistics 1999). One of the characteristics of the labor market in the region was the need for new jobs for the second generation of those households who migrated and settled in the dry zone, given the scarcity of land and water for farming. At the time of the assessment it was also evident that the regional economy was very depressed by the prolonged drought. This directly affected employment in agriculture, in reservoir and lagoon fisheries, and in the regional economy as demand from farming and fishing households for local goods and services slackened. Simultaneously Sri Lanka was suffering from a recession in tourism resulting from domestic and international security concerns.

The reservoir and lagoon fisheries were important as a source of livelihood for a significant number of rural households.

Approximately 1,230 households were engaged in fishing (7 % of the total), and the gross income from fishing was estimated at US$1.4 million/year, which represents 13 percent of total income in the area.

Fish catches from lagoons and ancient reservoirs were used by fishing households for their own consumption and also for sale. For fish from the reservoirs, the main markets were inland urban centers. Murray et al. (2000) reported that in rural inland areas of the dry zone demand was predominantly for cheaper, locally available inland fish, rather than for fresh or dried marine fish that had to be transported a long distance. Smaller seasonal reservoirs in the catchment were also used for fishing, but the activity was usually confined to occasional or subsistence fishing. Little et al. (2001) note that the poorest, most marginal members of communities gained benefits from consumption of fish caught in seasonal reservoirs.

Reservoir and lagoon fishing as a primary occupation formally requires membership of a Fishermen's Cooperative Society (FCS), but key informant interviews in all relevant locations indicated that this is rarely effectively enforced. Membership of a FCS is generally open only to those living in the vicinity of the water body, but this often leads to conflicts and in most cases others continue to fish without being members of the FCS. There are also government regulations on gill net mesh size for reservoir fisheries, but again enforcement is ineffective. The methods used in reservoir fisheries are simple and vary little. Fishers resident near the reservoir for whom fishing is the main economic activity (usually FCS members) almost exclusively use gill nets set from narrow fibreglass outrigger canoes. Nets are predominantly set in the early evening and the catch is hauled in at early morning. The fishers remain present all night where there is a risk of theft or damage to nets from crocodiles. The normal practice is to have two fishers in each boat—the "owner" and a regular "crew-member"—proceeds being shared after setting aside a certain proportion as rent of the boat and nets (typically 20–30 %)—(Chandrasiri 1986). Fishers in both ancient reservoirs and lagoons can thus be categorized as: i) owner-operators of boats and gear, ii) hirers (paying a share of the catch for the use of boats and gear), and iii) crewmembers working for a share of the catch. Generally, the latter are a low-income group, with the greatest uncertainty of employment (Kularatne 1999). Women usually have little direct involvement in inland fishing apart from assisting with the mending of fishing gear e.g., gill nets. Alongside such full-time fishing a wider spectrum of other fishers and fishing methods can be observed, particularly in smaller and more accessible reservoirs. Day fishing with cast-nets or hook and line is common, for own consumption or "part-time" to supplement farm or other income. Again this is predominantly a male activity, and farmers and farm laborers can engage in this activity mainly in the slack period between paddy sowing and harvest.

The village surveys conducted as part of the impact assessment found that 5 to 15 percent of households in villages, which are in close proximity to the reservoirs regularly fished for their own consumption and to generate an additional income by way of selling (table 4). Although a minority, over half of these were landless or marginal farming households, for whom fishing was the primary source of livelihood (as also observed by Chandrasiri 1986; Renwick 2001), for others such as farmers and fishers, for whom farming was the main livelihood, fishing was an important supplementary source of food and income. It was notable that a significant number of reservoir fishers were young men and that they belong to the second generation of settlers under the KOISP scheme. Without direct access to irrigated land for farming and with limited alternative employment opportunities, these young men relied on fishing and other activities such as casual laboring, and the renting or share-cropping of small plots when available. Overall in the KOISP catchment, most inland fishing is carried out either as a full-time specialization, or as an opportunist activity by the poor and landless who also engage in other

TABLE 4.
Proportion of households engaged in fishing, in the surveyed villages in 2002.

Village	Location in catchment	Fishery	Number of households	No. of fisher households (full and part-time)	% of households engaged in fishing
Ranawaranewewa	upper catchment	small reservoirs	196	15	8%
Kudagama 1	new command area	new reservoir	240	15	6%
Bandagiriya	old command area	ancient reservoir	1,500 approx.	200 approx.	15%
Malakapupathana	old command area	ancient reservoir	282	17	6%
Nadiganwila	banks of Kirindi Oya	ancient reservoirs and river downstream of reservoir	265	30 approx.*	11%
Pallemalala	near coast	lagoon	350–388	102 **	25%
Udamalala	near coast	lagoon	435	30	7%
Sippikulama	near coast	lagoon	450	140 **	30%

Source: Village survey, February 2002

Notes: *Mainly opportunistic and "leisure" fishing in the river

**Less fishing during the prevailing drought.

irregular activities such as firewood collection, laboring and share-cropping when able. Part-time supplementary fishing by farming households also occurs as described above, but it is much less common than in Laos, where the practice is almost universal.

At the time of the impact assessment reported incomes from fishing compared poorly to other non-skilled employment, and most fishing households, particularly those fishing full-time, were among the lowest income groups in the region (table 5). However, fishing households reported that prior to the recent drought reservoir fisheries had provided higher incomes than other available non-skilled employment. This is supported by the inflation-adjusted estimates in table 5. Renwick (2001) similarly reports average pre-drought incomes for reservoir fishing is approximately Rs 300 per day and estimates that the annual income from full-time fishing would exceed the annual income from irrigated agriculture. Incomes from fishing are, however, inevitably variable and dependent on experience and access to boats and fishing gear.

In the villages near to the lagoons approximately 25–30 percent of households had been regularly engaged in fishing (table 4). As the lagoon fisheries had virtually ceased under the prevailing drought the assessment of their contributions to livelihoods under more normal conditions were ascertained based on the information available -from the pre-drought surveys, which were conducted in early 1990 to mid-1990s, and also from other key informants. Between 250 and 400 households appear to have relied primarily on shrimp fishing in the lagoon in the early 1990s, reducing to 100–200 households by 1996 (IIMI 1995; Kularatne 1999). Fishing was the main source of income for 88 percent of all the fishing households in the relevant administrative district, i.e., Pallemalala *Grama Niladhari* Division, with agriculture and fish retailing being the main alternatives. In addition some households engaged in fishing on a part-time basis, and many "non-fishing" households fished in the lagoon for their own consumption only. The average monthly income in 1996/1997 for full-time lagoon fishing households was reported to be three times more

TABLE 5.
Income from fishing and alternative male employment, Rs per day (estimates from household interviews and village survey, February 2002).

Employment	Income per day, Rs	
	Before drought (late 1990s)	During drought (2002)
Reservoir fishing	200–800	50–150
Lagoon fishing (fish)	200–800	Nil
Lagoon fishing (shrimp)	700–5,000 *	Nil
Fish retailing (freshwater only)	300–1,000	100–200
Farm labor	145–180 **	200–250
Construction sector:		
Colombo	185 **	255
Locally	110–145 **	150–200
Salt pan	160 **	220

Source: Colombo Consumers' Food Price Index, Department of Census and Statistics

Notes: * Reported income range prior to decline of shrimp fishery

** Inflation adjusted estimates for 1997 from 2002

than that of non-fishing households in the same area (Kularatne 1999). Interviews with lagoon fishing households indicated that during the prevailing drought the most common alternatives to fishing engaged in by men were retailing (usually by bicycle) of marine and reservoir fish caught by others, collection of firewood and casual laboring in salt pans, which were also located in some of the coastal lagoons. Although relatively remunerative on a piece rate basis for those physically fit (table 5), the arduous nature of work in the salt pans meant that whenever available, most alternative activities were preferred. Changes in the shrimp fishery and their relation to irrigation are discussed in more detail in the following section.

Conflicts between fishers and farmers about water management issues were found to be common. In the ancient reservoirs these conflicts centred on levels of maximum drawdown, with fishers claiming that low water retention in the dry season reduced annual catches of fish. Although maximum irrigation releases were set at the beginning of each season, the needs of fisheries were not given weight in the planning process, and in practice farmers tended to demand and use more water than initially allocated. This conflict was especially severe under the ongoing drought conditions. In the lagoons, fisher-farmer conflicts centred on the opening of the coastal sand bar. Prior to the drought farmers opened the sand bar frequently to reduce water levels and avoid flooding of agricultural land, while fishers considered that this allowed shrimp to emigrate and thereby reduce the quantity of the catch and the income generated. Institutional arrangements to deal with fisheries and water management issues and related conflicts were weak, and this was seen as a major problem by the fishers.

Evaluation of Project Impacts

Evaluation of project impacts relied on the comparison of the baseline with a pre-project situation reconstructed on the basis of surveys conducted in the early 1980s, and also participatory assessment involving stakeholders who could compare pre- and post-project conditions. When assessing irrigation impacts it was thus important to consider that the pre- and post-project comparisons spanned a period of almost 20 years. During this period many social and economic changes are likely to have occurred that were not directly related to irrigation. Moreover, the KOISP itself has had impacts through its settlement program that exceeds by far those expected from its irrigation component alone. For example, population density in the Kirindi Oya watershed has increased by a factor of five from 42,304 in 1980 (Senanayake and Wijetunga 1987) to 201,710 in 1998 (Zhonping et al. 2001). This dramatic increase reflects the settlement of households in the new command area as well as the natural population growth.

Impacts on aquatic habitats and their connectivity. Changes in aquatic habitat availability and quality have been assessed using a comparison of pre- and post-project water resources maps, information from previous surveys and comparative data, and stakeholder consultations. The main physical changes were identified as:

- Reduction in river flow and the frequency and extent of floodplain inundation below the dam. Flooding has, however, always been a short-term phenomenon.
- A large (3,200 ha) and shallow headwater reservoir (Lunugamwehera) has been constructed, creating substantial and very biologically productive aquatic habitat. The reservoir has inundated about 2,000 ha of natural floodplain (which would have been inundated only for short periods and thus relatively unproductive) and some 100 ha of small ancient reservoirs.
- The project has reduced natural inflow into the ancient reservoirs in the Kirindi Oya basin, but offers the potential to recharge these water bodies from the headwater reservoir and reduce seasonal variation in water levels. The impact on ancient reservoirs is thus complex and dependent on water management decisions. This issue is further discussed below.
- The right bank command extends and partially drains into the neighboring Malala Oya catchment. Irrigation drainage flows enter the Malala and Embilikala lagoons, raising water levels and reducing salinity (from 10-41 ppt.,[2] in the mid-1980s to less than 7 ppt., a decade later). Rising water levels posed a flood risk to agricultural land and dwellings around the lagoon, forcing a need to breach the coastal sand bar more frequently than before to discharge excess water to the sea.
- Drainage flows can benefit the wildlife and livestock in the National Park (Bakker et al. 1999) as long as the quality of drainage water is maintained at safe levels for living organisms.

Fisheries production. A fisheries balance methodology was used to estimate the net effect (table 6). Recent estimates of fisheries productivity in Lunugamwehera and two of the ancient reservoirs (420–860 kg/ha/year) obtained by Renwick (2001) were substantially higher than the average (220 kg/ha/year) reported for Sri Lankan reservoirs by De Silva (1988). Two different balance tables were, therefore, drawn up to assess the sensitivity of net fisheries production changes to uncertainty in reservoir productivity. Fishers operating in ancient reservoirs consistently reported a decline in catches for recent years, and linked these to water management issues (see screening/ scoping and mitigation sections). It is not entirely clear to what extent these problems are linked to the construction of the KOISP, or to the recent drought. However, total catches of fish estimated in 1999 by Renwick (2001) compare favorably with values estimated in the mid-1980s by De Silva (1988), both on average and within specific ancient reservoirs covered in both studies. This suggests that recent productivity declines in the wake of low water retention are primarily linked to the drought rather than the KOISP per se.

[2]ppt: parts per thousand.

Therefore, the fisheries productivity of ancient reservoirs was assumed to be the same before and after KOISP. Sensitivity analysis shows that even if ancient reservoir fisheries had been lost completely, the impact of KOISP would remain positive or neutral (table 6).

The lagoons had been the location of a specialized shrimp fishery that had been very profitable in the past (table 5). Early juveniles recruited to the lagoon from the sea when the sand bar was naturally breached by seasonal tides and wave action, and remained trapped in the lagoon until a breach recurred about a year later. The shrimp fishery has declined drastically since the completion of the KOISP and as a result of a combination of environmental change and overexploitation. Increased freshwater inflow has reduced salinity and made the lagoons less suitable as habitat for marine *Penaeid* shrimp, while more frequent breaching of the sand bar for water level regulation allows shrimp to emigrate from the lagoon earlier and more frequently than before. At the same time, increased exploitation by much higher numbers of fishers operating with increasingly small-mesh nets was widely seen by other fishers as leading to overfishing and the consequent decline in catches of fish per fisher and also an overall decline. It appears that by the mid-1990s the shrimp fishery had been largely replaced by a finfish (mostly tilapia) fishery of similar productivity, but much lower in value. A comparative international study of yields from lagoon fisheries by Joyeux and Ward (1998) concluded that a lagoon's connectivity with the sea is the major determinant of its productivity, while salinity levels have little impact on total productivity. However, low salinity may reduce the proportion of marine shrimp (the most valuable species in this location) in total production. For lagoons of this type they estimated an average total fisheries yield of 100 kg/ha/year, including 25 kg/ha/year of shrimp. This average is comparable to an independent estimate of 120 kg/ha/year for these specific lagoons (Jayakody 1993). It was thus decided to assume constant overall productivity, but higher per unit value of lagoon catches in the pre-KOISP period (table 6).

There are no quantitative fisheries production estimates for the irrigated rice fields prior to the implementation of the KOISP, but it is clear that the production would have been far lower than the 60 kg/ha/year average for rain-fed rice fields (table 1). We assumed 20 kg/ha/year, but this is likely to be an overestimate given that virtually no fishing in or around rice fields was reported by stakeholders or in village surveys either before or after the implementation of the KOISP.

Overall results (table 6) suggest that the catchment-scale of fisheries production has increased by about 75 percent after the implementation of the KOISP. The value of fisheries production, however, has increased by only about 10–25 percent, due to the replacement of the particularly valuable shrimp fishery by a similarly productive but much less valuable tilapia fishery in the lagoons. Possible effects on coastal fisheries outside the lagoons have not been assessed (these may well be equivocal, given that freshwater outflows are lower overall but likely to be richer in nutrients as a result of agricultural intensification).

The catchment scale balance, of course, neglects distributional and livelihood impacts that may have arisen within the catchment. It is clear that the greatest benefits have been generated in the upper catchment around Lunugamwehera, while the greatest loss in economic value has occurred in lagoons outside the catchment as a result of increased drainage water inflow.

Livelihood Impacts. Prior to the implementation of the KOISP the area constituted a depressed region in the country, economically, socially and agro-ecologically (Senanayake and Wijetunga 1987), and about two-fifths of households were below the poverty line (Wanasinghe et al. 1983; Tudawe 1986). Senanayake and Wijetunga (1987) emphasized on the limited productive livelihood and employment opportunities, predominantly based on the local natural resources. They

TABLE 6: KOISP Fisheries balance table in terms of production and value.

TABLE 6. (A)
Reservoir productivity based on a recent survey.

			Before KOISP			
Water body	Catchment	Area	Productivity	Production	Value/kg	Total Value
Floodplain		6,200	20	124	0.4	50
Lagoons		1,500	100	150	1.5	225
Head reservoir		0	0	0	0.4	0
Ancient reservoirs		1,608	630	1,013	0.4	405
Small reservoirs		300	630	189	0.4	76
River	117,800		0.3	35	0.4	14
Total		9,608	1,380.3	1,511	3.5	770
			After KOISP			
Water body	Catchment	Area	Productivity	Production	Value/kg	Total Value
Floodplain		0	20	0	0.4	0
Lagoons		1,500	100	150	0.4	60
Head reservoir		3,200	420	1,344	0.4	538
Ancient reservoirs		1,608	630	1,013	0.4	405
Small reservoirs		200	630	126	0.4	50
River	117,800			0	0.4	0
Total		6,508		2,633		1,053
Change		-3,100		1,122		283

Source: Renwick 2001

TABLE 6. (B)
Reservoir productivity based on average for Sri Lankan reservoirs.

			Before KOISP			
Water body	Catchment	Area	Productivity	Production	Value/kg	Total Value
Floodplain		6,200	20	124	0.4	50
Lagoons		1,500	100	150	1.5	225
Head reservoir		0	220	0	0.4	0
Ancient reservoirs		1,608	220	353	0.4	141
Small reservoirs		300	250	75	0.4	30
River	117,800		0.3	35	0.4	14
Total		9,608		737		460
			After KOISP			
Water body	Catchment	Area	Productivity	Production	Value/kg	Total Value
Floodplain		0	20	0	0.4	0
Lagoons		1,500	100	150	0.4	60
Head reservoir		3,200	220	704	0.4	282
Ancient reservoirs		1,608	220	353	0.4	142
Small reservoirs		200	250	50	0.4	20
River	117,800			0	0.4	0
Total		6,508		1,257		504
Change		-3,100		520		44

Source: De Silva 1988

estimated unemployment to be about 20 percent of the labor force (among the highest in the country) and from the prevailing cropping patterns and intensities they deduced that the level of underemployment was also high.

The KOISP has increased overall agricultural and fisheries production in the catchment, but creation of new employment opportunities has not kept pace with the population growth. The industrial and service sectors have not expanded sufficiently to absorb surplus labor, while increase in agricultural employment has been constrained by the low availability of land and irrigation water. As a result, indicators of the overall socioeconomic status of households in the catchment continue to compare poorly with national averages.

Participation in fishing appears to have increased roughly in proportion to overall population growth. Number of boats estimated on Lunugamwehera and two ancient reservoirs in 1999 (Renwick 2001) is approximately four times higher than those estimated in the mid-1980s (De Silva 1988). Chandrasiri (1986) estimated that in 1986, 263 fishers from five ancient reservoirs (Ridiyagama, Bandagiriya, Wirawila, Tissa Wewa and Yoda Wewa) were members of the Fishermen's Cooperative Society, and that a substantial but non-quantified population of non-organized fishers also existed.

Despite a substantial increase in the number of fishers, total catches and catches per boat in the ancient reservoirs appear to have increased after the completion of the KOISP. This conclusion is supported independently by the KOISP evaluation study (IIMI 1995) and Renwick (2001). This suggests increasing contributions of reservoir fisheries to livelihoods in terms of both the number of beneficiaries and the average magnitude of benefits gained. By contrast, fishers operating in lagoons have suffered substantial reduction in income between 1987 and 1997, with the proportion of fishers earning more than US$26/month having declined from 52 percent to 35 percent (Kularatne 1999).

Virtually all fishers in the project area suffered from declining fisheries productivity during the period of the drought. Other natural resource-based activities such as shell mining, lime making, firewood collection, retailing of marine fish and laboring in the salt pans increasingly replaced fishing as a means of support for a significant number of the landless and unemployed who had previously engaged in fishing. The impact of the drought was most severe in the lagoons, where fishing became virtually unsustainable as a source of livelihood.

Of the fisher-farmer conflicts at the time of impact assessment, only those relating to water management and sand bar opening in the lagoons were directly attributable to implementation of the KOISP. Conflicts over reservoir water management arose from general water scarcity due to low rainfall and increasing irrigation demand. The KOISP has some potential to alleviate the problem through its ability to recharge the ancient reservoirs, but expansion of the command areas, little diversification away from rice cultivation and water allocation regimes dominated by farmer interests have tended to exacerbate it. Linkages between fisheries and irrigation institutions have never been strong in the project area, but increasing control over water resources has made this lack of linkages a more pressing problem.

Opportunities for Mitigation and Enhancement

While catchment scale impacts of the KOISP on fisheries production and related livelihoods opportunities have almost certainly been positive in aggregate, there are clearly issues that should be addressed by way of mitigation and enhancement. Improving reservoir water management with respect to fisheries is best described as an enhancement measure because it may further improve fisheries that owe their existence to irrigation development in the first place. Addressing the problems created by drainage water inflow into the lagoons on the other hand is clearly a mitigation measure. Both issues may be helped by more efficient use of irrigation water, and this was identified as an overall long-term priority.

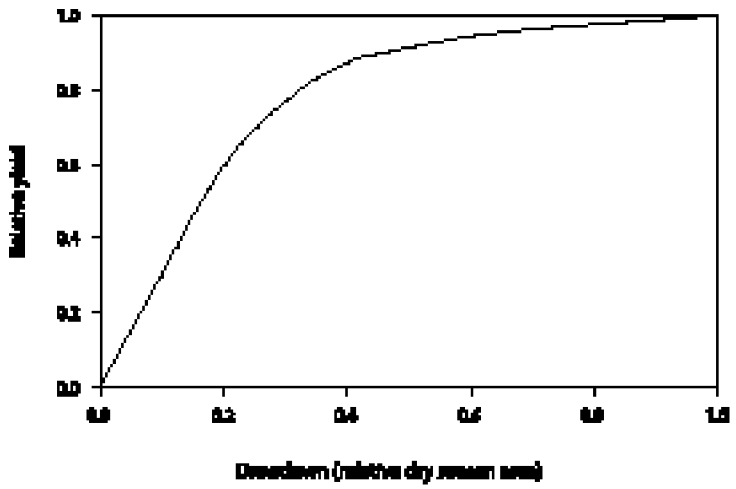
Improving Reservoir Water Management. Stakeholders identified that in the screening/scoping phase the recurrent, sometimes extreme drawdown of water level was causing overall decline in productivity and profitability of reservoir fisheries. Such episodes have become increasingly common during the peak dry season months when water levels were not sufficient to satisfy the needs of fishers and sustain the fishery.

The relationship between drawdown and fisheries production is complex and subject to considerable controversy. Drawdown concentrates fish stocks and thus increases the efficiency of fishing gear and effort. In addition periodic drying of the reservoir bottom may facilitate the breakdown of organic matter in sediments and increase biological productivity. These positive effects of drawdown on fisheries production are counteracted by reductions in stock abundance under conditions of high density resulting from natural factors as well as fishing. Dynamic models of fish populations in water bodies subject to large fluctuations in water level and area (Halls et al. 2001; Lorenzen et al. 2003) indicate a strongly non-linear relationship between long-term fisheries yield and drawdown of the form illustrated in figure 3. This suggests that the yield is fairly insensitive to moderate drawdown, but declines steeply as dry season area is reduced to a low proportion of full storage area. Location-specific empirical data (time series of fisheries and hydrological data) are required to quantify the relationship, which depends on characteristics of the reservoir and its fish population. It is not possible at present to give general “safe levels” of drawdown, but the general shape of the relationship is useful in that it focuses attention on the likelihood of rapid change at higher levels of drawdown.

Long-term recording of fishing effort and the resultant catch spanning a period of several years may be required to establish the precise relationship between drawdown and fisheries production. However, historical information may well allow a definition of approximate minimum water retention targets.

It can be seen that the issue is primarily a conflict of interests between competing water users—farmers and fishers—and though this may have occurred for the reservoir fisheries prior to the construction of the KOISP, neither the implementation of the scheme nor its subsequent operation have adequately resolved it.

FIGURE 3.
General relationship between relative dry season water area and fisheries yield.



Source: Lorenzen et al. 2004

Stakeholders at the workshop agreed that fisheries interests should be considered in irrigation water management policies. They also suggested that fishers should be represented in the seasonal planning meetings. Further awareness creation and accompanying institutional measures would be required to support this integration and to improve the planning, control and management of irrigation. Establishment of improved water management for fisheries in the reservoirs will also create opportunities and incentives for other fishery enhancement measures such as stocking and nursery habitat creation.

Drainage Management in the Lagoon Area. Three possible mitigation measures for drainage inflows to the lagoons were considered by stakeholders.

(1) Diversion of drainage water around the lagoons with the creation of a channel.

(2) Reduction of drainage flows through rehabilitation of irrigation infrastructure and reuse of drainage water.

(3) Better management of sand bar opening through the coordination of farmer and fishery interests.

Increasing Irrigation Efficiency. It was proposed that increased efficiency of irrigation water use would help to alleviate fisheries problems related to water management. The objective would be to increase the ratio between crop evapotranspiration and reservoir releases. An increase in crop evapotranspiration would reduce the drainage flows to the lagoons. A decrease in reservoir releases would help keep more water stored in the reservoirs to maintain fisheries.

Summary of the Sri Lankan Case Study

The KOISP had a modest positive impact on pre-existing fisheries in terms of aggregate productivity and actual production. As neither subsistence nor commercial fisheries developed in the river-floodplain system of the project area, the reduction of flow and flooding was not important in terms of fisheries and its livelihood functions. The large new reservoir created by the project substantially increased aggregate fish production from the catchment, compensating for losses downstream and in the lagoons.

However, while the impact of construction has been to increase the aggregate potential productivity of fisheries in the catchment, scheme operation and water management has had a negative impact on the actual production of fisheries in the pre-existing reservoirs and lagoons. In combination with failure to effectively enforce access restrictions, resulting in overfishing and also the effects of the recent drought has degraded fish stocks and driven fishing towards being a little more than an opportunistic and residual source of livelihood for households, which are left with few other alternatives. Given local population growth and unemployment rates, particularly among landless second generation settler households, this has provided an important "social safety net," albeit at low income levels. Alternative livelihoods for the economically marginalized, such as firewood collection, shell mining and lime making tend to be more environmentally damaging.

Improvements in water management across the KOISP catchment thus have the potential to deliver a range of environmental, social and economic benefits. Productive fisheries can be restored in reservoirs if savings can be made in the water needs of farming, and management regimes can take account of minimum levels needed to conserve sustainable fish stocks. The benefits of this will include contributions to national fish output, employment and improved nutrition for poor households. More research is needed on the ecology of the coastal lagoons, but similarly (though subject to wildlife conservation priorities given recent designation of the area as a National Park) a productive and valuable fishery can potentially be restored. Here, biodiversity and conservation objectives can potentially be realized, as well as social and economic benefits.

Impacts of Irrigation on Inland Fisheries Production and Rural Livelihoods: Lessons and New Perspectives

A number of improved insights and new perspectives can be drawn from these assessments of the impacts of the development of irrigation schemes in Laos and Sri Lanka. Transferable lessons for irrigation and water resource management are discussed first, and these highlight the potential benefits of integrated management of land use, irrigation and fisheries. This is followed by issues relevant to methods of impact assessment for inland fisheries, and final conclusions.

Benefits from Integrated Land and Water Management

Modified Aquatic Systems can Support Significant Fisheries Production

Irrigation development modifies aquatic habitats and hydrology and usually has a negative impact on at least some components of aquatic biodiversity. However, it is a misperception to assume that impacts on fisheries will necessarily be negative. Depending on local conditions and infrastructure design and operation, an irrigation scheme may enhance overall fisheries production levels. In the two cases reported here, irrigation development created new aquatic habitats without substantially affecting the extent or production capacity of the main existing fisheries: rain-fed rice fields in Laos and small ancient reservoirs in Sri Lanka.

Managing Water for Irrigation and Fisheries

There can be scope for multi-use management of water resources for irrigation and fisheries, and impact assessments using the approach described here are capable of identifying and addressing opportunities for this purpose. Irrigation planners should consider opportunities to protect and sustain fisheries, or to develop them in new or modified habitats. Similarly, fisheries benefits can be enhanced, or negative impacts mitigated, in systems already operational, because water management and farming practices can have a greater impact on fisheries productivity than infrastructure construction. For example, in Laos, sustaining fisheries production depends on maintaining a rain-fed wet season rice crop. Any modification in the cropping cycle that reduces water retention in rice fields is likely to cause a drastic reduction in fisheries production. In Sri Lanka, extreme drawdown of reservoir levels for irrigation dramatically reduces fish production of reservoirs that are highly productive under conditions of moderate drawdown.

These results are similar to those obtained for flood control schemes in Bangladesh. Flood recession rice farming systems within flood control schemes can continue to support productive fisheries, and small adjustments in the design and operation of flood control structures, with the creation of some perennial aquatic habitat, can improve production (Sultana and Thompson 1997; Halls et al. 1999).

For all such situations, empirical information and analytical tools exist, or can be developed, for the evaluation and management of any trade-offs. The aim being to optimize the aggregate economic value of production (crops and fish) from the system, or enhance the livelihood and social benefits (for example, employment creation).

The Diverse Livelihood Functions of Fisheries

The impact assessments reported here also showed that it can be another misperception to regard fishing only as an activity of last resort, whereas it can range from this, through contributing to a diversified livelihood strategy, to a specialized and remunerative occupation. In Laos, the majority of rural households fished as part of a traditional and diversified livelihood strategy that also involved farming, collection of other wild foods and forest products, and occasional wage labor. In Sri Lanka, fishing had been either a specialized occupation or a means of diversification for farming households, but with increasing population pressure along with unemployment and degradation of fisheries it had become a residual activity for the poor and vulnerable (recognizing that many specialized fishers had been impoverished by the decline in productivity).

Irrigation development may raise the opportunity cost of fishing and draw labor away to farming or associated non-farm employment that has become more productive and more continuous throughout the year. Alternatively, it may disrupt traditional livelihood activities or reinforce existing patterns of economic, social and political inequity, further marginalizing the vulnerable and, often leading to increased reliance on fishing. Information is thus needed on the role played by fishing for different groups and how this is likely to change over time. Policy responses need to be well adapted to local conditions and to the range of livelihood functions performed by fisheries.

In cases such as Laos, planners should seek to avoid or mitigate negative impacts on fishing given its importance in the livelihoods of most rural people, and also its potential role as a "social safety net" for the socially and economically excluded. In Laos, fisheries are likely to decline in relative social and economic importance as the rural economy undergoes a transition to a more market-oriented production system. This is demonstrated at the household level, where fishing tends to decline in importance with increasing wealth. Despite this, fisheries will continue to provide an important means of support for land deficient and labor surplus rural households in the foreseeable future. They also have potential for some commercialized, though still small-scale, development.

In Sri Lanka, planners should seek to protect and sustain existing fisheries, while also developing new or modified habitats. The aim being to provide employment and incomes to landless or marginal farming households, as either a full-time or part-time activity. In a region depressed by recurrent droughts, a stagnant economy and high unemployment, productive fisheries would be valuable in both social and economic terms.

The Need for Integrated Land and Water Management

The studies reported here suggest that integration of land, water and fishery management can be crucial to achieving optimal use of water for farm and fish production and livelihoods. This is more likely to be achieved by an integrated, iterative and participatory management approach than the prevailing sectoral approach. In the latter responsibilities for farming, irrigation, and fisheries often lie with different agencies that have few, if any, institutional linkages. Holistic and integrated management is needed to sustain or enhance fisheries, adding to the benefits generated by an irrigation scheme, and often matching the needs of poor and vulnerable groups otherwise neglected or adversely affected. In turn, this must be set in the context of the multiple and often competing water uses within a river basin, as addressed in an integrated water resources management (IWRM) framework.

Planning and Impact Assessment for Fisheries

Biodiversity, Production and Livelihoods Objectives

Environmental impact assessments of irrigation development that have considered impacts on fisheries have tended to focus on issues of biodiversity and ecological integrity. While these can be closely linked with impacts on production and livelihoods, the studies reported here have confirmed that this is not necessarily the case in all respects. Indeed, in Laos, and in Sri Lanka, irrigation development was deemed to increase overall fisheries production and related livelihood opportunities for the local population, despite negative impacts on biodiversity and ecological integrity.

In both Laos and Sri Lanka, the ecological integrity of aquatic habitats had been heavily modified prior to modern irrigation development. As a result the river, the dominant aquatic habitat prior to human interference, accounted for only a small proportion of fisheries production (this particularly applied to Sri Lanka). In such cases, given an objective of preserving original aquatic biodiversity, restoration of the river's natural flow patterns and lateral connectivity would be the preferred option. But conserving or restoring the river may not be a priority of local stakeholders (as in Laos and Sri Lanka) and may not yield significant production and livelihood benefits. If these are the goals then managing the fisheries in the man-made or modified habitats to increase production and employment should be the priority.

Therefore, different perspectives and tools are needed to assess the impacts on biodiversity and livelihood, and different measures may be needed to mitigate any negative impacts of irrigation development. The approach taken to impact assessment must certainly be broader in scope than a conventional assessment of the ecological changes resulting from abstraction from, or diversion of a river, for irrigation or other uses.

Assessment of Livelihood Impacts

Impacts on livelihoods depend on the objectives of households that fish, the functions fishing performs in their livelihood strategies, their access to fisheries and their alternative livelihood opportunities. Assessments must look beyond incomes and consider the wider benefits provided by fishing as part of a diversified livelihood strategy. These can include buffering against shocks, managing income risk, and smoothing consumption and labor use. Fish are also valuable as a primary source of protein and micro-nutrients, and as an accessible cash income. Fishing can also form the basis for reciprocal exchange, participation in social networks or simply for recreation (Smith et al. 2005).

Fishing can play diverse but equally important roles for different groups. It can be a supplemental activity for a significant proportion of a community as well as a critical component in the livelihood strategies of some households (as in Sri Lanka), or it may be an integral part of the livelihoods of the whole community (as in Laos). Thus, even where aggregate net impacts on fisheries productivity are neutral or positive, it is important to make an assessment of impacts that is disaggregated spatially across a catchment and by socioeconomic group and gender. The distribution of impacts may not be equitable and any assessment, particularly in large-scale systems, must look beyond aggregate production changes and encompass physical, temporal and institutional determinants of the productivity and accessibility of fisheries for all affected groups.

The Value of Stakeholder Involvement

The approach to impact assessment adopted in Laos and Sri Lanka involved participation by all relevant stakeholders, and the use of simple and transparent tools such as mapping habitats and budgeting fisheries production on the basis of comparative yield information. At low cost the approach achieved rapid identification of key issues, estimation of the magnitude of likely impacts, and prioritization of responses. It demonstrated that involving stakeholders in the process can help scope the assessment by rapidly identifying key issues and priorities for mitigation or enhancement. This is particularly useful when funds and time are limited. Stakeholder involvement can also help address community concerns and potential conflicts, establish greater ownership and commitment to any measures ultimately agreed on, and create a foundation for an on-going dialogue and negotiation.

Representation from different stakeholder groups, including relevant civil society and government agencies, is necessary, not just from the standpoint of ownership and equity issues, but also because knowledge and perception of impacts differ between groups. There is a risk that stakeholders will introduce bias or misinformation into the assessment, but combining technical expertise with local knowledge from multiple stakeholder groups can help minimize this and ensure adequate and objective coverage of issues.

Limitations of Fisheries Impact Assessments

Despite the utility of the approach to impact assessment used in Laos and Sri Lanka, some uncertainty inevitably remains inherent in the prediction or evaluation of complex and variable phenomena. Gaps remain in our knowledge of freshwater fisheries and how they may respond to the range of changes introduced by irrigation development. For example, improved knowledge is needed of the ecology of coastal lagoons affected by drainage inflows, as in Sri Lanka, and of their management needs as both fisheries and wildlife reserves.

Where uncertainty exists, appropriate use of sensitivity analysis can be helpful, but overall it is important to respond with an iterative and adaptive approach to enhancement and mitigation measures, well informed by monitoring and evaluating their implementation. More time and resources would have facilitated more rigorous assessment of the nature, determinants and distribution of the key impacts in Laos and Sri Lanka, but the costs of such information must always be weighted against its incremental utility for decision making.

One further limitation of project-based impact assessments is that they may neglect important cumulative (or counteracting) impacts of irrigation or other water resource developments, on natural resources and livelihoods at the river-basin scale. Further study is needed of possible cumulative and synergistic impacts of irrigation schemes and other water resource developments within a river basin. This point is relevant to the level and extent of stakeholder participation. In Sri Lanka, possible impacts were identified across the whole river basin and this influenced the selection of stakeholders to participate in the impact assessment. In Laos, a sub-basin was studied for which downstream impacts on the main river were expected to be negligible. It is important to note that this may not always be the case, and a fishery could be adversely affected downstream where there is no possibility of compensating benefits from the irrigation scheme.

Conclusions

Assessments have been made of the impacts of irrigation development on fisheries for a new irrigation scheme in Laos and for an established scheme in Sri Lanka. These focused on impacts on fisheries production and rural livelihoods. The assessments were made through an inclusive participatory and iterative process that was holistic and interdisciplinary in its orientation. This sought to proceed from broad and rapid appraisal, through more in-depth technical analysis of key issues, to provision of information for decision making on project-specific enhancement or mitigation measures. The results have added a number of new perspectives to the limited existing literature on the impacts of irrigation on inland fisheries.

Dependent on conditions, productive fisheries can coexist with irrigation schemes, in many cases adding to the aggregate productivity of the system. In contrast impacts on the biodiversity of freshwater aquatic resources are almost always likely to be negative, because the characteristics and connectivity of natural habitats will inevitably be modified by irrigated agriculture and its infrastructure. Production and livelihood objectives may not, therefore, coincide with biodiversity concerns, requiring different approaches for impact assessment and water management. Impact assessments for irrigation projects and other developments that affect the hydrology of inland water bodies should consider the fisheries that exist in man-made and modified aquatic habitats as well as those still in their natural condition.

Farming practices and water management can have impacts on fisheries that are at least as significant, if not greater, than impacts arising from construction. An integrated water resources management approach is needed to optimize the productivity and livelihood contributions of fisheries and irrigation systems, in the context of multiple and competing water uses within a river basin. Processes of planning and implementation are needed that can recognize and resolve trade-offs between competing interest groups. These processes need to involve stakeholders and to improve on sectoral approaches, where irrigation and fisheries are managed by different agencies with weak institutional linkages, and which can fail to adequately recognize community interests and needs.

Fisheries can play diverse roles in livelihood strategies within communities and, to adequately capture livelihood issues, irrigation impact assessments must be disaggregated spatially (e.g., above and downstream of a dam), between different types of water bodies (e.g., river-floodplain, rice fields, reservoirs, and lagoons) and between different socioeconomic groups. It is important to go beyond stereotypes of fisheries as the last resort of the poorest, and for impact assessments to look in depth at the actual contributions made by fisheries to people's livelihoods.

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