Assessment and Management of Irrigation Impacts on Tropical Inland Fisheries:

A Case Study from Sri Lanka

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Short title: Assessing irrigation impacts on fisheries.

Key words: impact assessment, fisheries, irrigation, lagoons, livelihoods.

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Abstract

Inland fisheries make an important contribution to rural livelihoods in many developing countries. Water resources development for irrigated agric ulture often has significant and complex impacts on inland fisheries, either negative or positive. The assessment and management of such impacts is important in order to minimize undesirable outcomes of irrigation development in terms of livelihoods and/or aquatic biodiversity. This paper outlines the application of a holistic and participatory approach to fisheries impact assessment of the Kirindi Oya irrigation scheme in Sri Lanka. The overall impact of irrigation development on fisheries production in the watershed has been assessed as moderately positive, with production from reservoir fisheries outweighing the estimated loss of production from river-floodplain fisheries. Stakeholders identified increased drawdown in reservoirs due to very high irrigation demand, and drainage water inflow into coastal lagoons as the main physical impacts of irrigation development on fisheries. These impacts led to conflicts between farmers and fishers regarding water management in the reservoirs and lagoons. Underlying these impacts and conflicts are weak linkages between irrigation and fisheries institutions. Stakeholders identified rehabilitation of irrigation infrastructure and increased water productivity in agriculture as key measures to reduce both, drawdown of reservoirs and drainage flows into the lagoons. Improvement of institutional arrangements for water management is crucial to resolving conflicts and ensuring an equitable allocation of water between agriculture and fisheries.

1. Introduction

Impacts of irrigation on natural and social environments have been widely recognized recently (WCD, 2000). In tropical socio-ecosystems, inland fisheries can be positively or negatively affected by irrigation through complex, multiple and varied means. This makes the assessment of impacts difficult, whilst a lack of data is generally perceived as the main constraint to valuation and inclusion of such impacts in the cost-benefit analysis of irrigation projects. However, this

cannot justify the neglect of fisheries considerations in irrigation planning, or underestimation of their importance to livelihoods and biodiversity.

Experience from Sri Lanka, presented in this paper will demonstrate that a holistic assessment of impacts within a process of informed decision-making, can help mitigate and/or enhance irrigation impacts on fisheries and thus increase the overall benefit of irrigation development. The fieldwork drew on, and contributed to, the preparation of a guidance manual that provides a framework for assessing irrigation impacts on hydrology, fish ecology, livelihoods and institutional arrangements (Lorenzen *et al*, 2002). This is relevant to all stages of irrigation development including conception, design and planning, construction, implementation, and rehabilitation. Participatory and consultative approaches are used throughout the process, from problem identification and assessment, to trade-off analyses and selection of appropriate options, so that a consensus between stakeholders is sought in formulation of recommendations at policy level.

This process was tested on the Kirindi Oya Irrigation and Settlement Project (KOISP) that was implemented in 1986 in the southeast dry zone of Sri Lanka. The case study is an example of an ex-post evaluation of an existing scheme that focused on the identification of scheme impacts on fisheries, on identification of feasible measures to mitigate or enhance impacts on aquatic habitats and local livelihoods, and on identification of the knowledge gaps and potential areas of conflict requiring further research and resolution[3].

2. Materials and Methods

2.1 Background

[3] Another case study has been undertaken in Laos applying the guidance manual as part of a an ex-ante appraisal of a planned medium scale irrigation scheme.

The KOISP rehabilitated and incorporated an ancient tank-based irrigation system (over 1000 years old). The new open cascade irrigation system consists of the headwaters Lunugamwehera reservoir of 200 MCM and five ancient tanks - Debera Wewa, Tissa Wewa, Yoda Wewa, Pannegamuwa and Wirawila (Figure 1) – ultimately draining into the India Ocean.

The main fisheries of importance are the reservoir, the five medium-scale ancient tanks and coastal lagoons that are within the scheme catchment, and receive drainage flows from the right bank command areas (Figure 2). Fisheries can be considered as an economic activity in a few small isolated tanks within the Kirindi Oya basin and the river itself, although they are of much less economic and social importance.

It must be noted that this study was conducted during the period February to April 2002, when the effects of a severe and prolonged drought that had been affecting the area since 1999 were still prevalent.

2.2 Impact assessment process

The impact assessment process adopted (Figure 3) followed the protocol recommended in the guidance manual being prepared by the team (Lorenzen *et al.*, 2002). The study area extended from upstream of the main reservoir, downstream to the coast and the river mouth. Village representatives of fisheries in different types of water bodies - the reservoir, the tanks and the lagoons – and located in different zones within the Kirindi Oya watershed were selected. A stakeholder analysis identified stakeholders from the selected villages, and from district, provincial and national agencies relevant to the study area.

To promote and utilise stakeholder participation, a series of four workshops were held at local level in the Southern Province (Tissamaharama), and a final workshop was organised at national

level in Wadduwa, 30 km south of Colombo. Key representatives from each stakeholder group were invited to participate in the local workshops. Although it was anticipated that representatives of national level agencies would not be able to attend workshops at local level, they were invited and kept informed in the interests of building relationships with the agency concerned and for dissemination of information on the objectives and progress of the process.

Screening established whether the Kirindi Oya irrigation scheme was likely to have had any substantial impact on fisheries that justified an impact assessment. A preliminary assessment that included a brief field survey using methods of rapid appraisal and consultation of stakeholders at village and local level was completed. The level (i.e. depth and detail) of impact assessment required was selected through a scoping exercise, taking account of the available resources (time, budget and staff). The scope of the impact assessment was defined to focus on the known areas of most significant impact - key issues and knowledge gaps were identified - whilst leaving sufficient breadth and flexibility to allow for assessment of further issues if identified.

Impact assessment requires evaluation of change over time compared to a 'baseline' or 'benchmark' scenario, plus judgement of the causality of change based on comparison of observed or predicted events with a projected 'without change' or 'control' scenario to the extent that this is possible. This is difficult for an ex-post evaluation such as this for which it is not possible to observe either the baseline or control scenarios. Attention therefore concentrated on a descriptive and summative assessment of the current situation using available secondary data and observations from further fieldwork, and an assessment of past changes based on secondary sources and stakeholder consultation, and focused on the key issues identified during scoping. The situational assessment covered the water resources and hydrology of the basin, ecological changes, the socio-economic situation and role of fisheries in livelihoods, and the institutional environment (Figure 3). The information generated was used with stakeholders to predict future

change with or without implementation of measures for mitigation or enhancement of irrigation impacts, and taking account of possible linkages or interactions between measures. From this trade-offs between possible outcomes were considered and a consensus on provisional recommendations for mitigation of negative effects of the KOISP on fisheries sought.

Monitoring of the process was conducted through continuous observation and interaction by the study team and stakeholders. Regular evaluation of feedback allowed management of the process to be continually adapted and improved.

3. Results and Discussion

3.1 Screening

The preliminary assessment revealed that the KOISP appeared to have had a range of impacts on the actual and potential productivity of fisheries that are a livelihood option for a significant number of people, but could not conclusively isolate the specific impacts of irrigation from the effects of the prevailing drought (e.g. very low reservoir and lagoon water levels, high local under and unemployment, etc.). This, and the expectation that by modifying hydrology and the connectivity of aquatic habitats the project would have had a significant impact on the ecology of fisheries, warranted the implementation of an impact assessment.

3.2 Scoping

Workshop participants identified the following most important issues:

Issue 1: Loss of river flow and floodplain area downstream of the dam

Issue 2: Decreased water levels in the tanks and reservoir

Issue 3: Inflow of drainage water into the lagoons

Issue 4: Conflicts between fishers and farmers

Issue 5: Weak linkages between fisheries institutions and irrigation institutions.

Primary data collection was mainly restricted to a rapid appraisal of the role of fisheries in livelihoods that centred on key informant and household interviews in the selected villages. Some information relating to the water resources, ecological and institutional assessments was also sought and/or confirmed during these interviews and village visits.

3.3 Impact assessment

The impact assessment results were a combination of survey results, analysis of secondary information, workshop outputs and contributions from experts. Only the main results are summarised here (further detail can be found in Nguyen Khoa *et al.*, 2002).

Issue 1: Loss of river flow and floodplain area downstream of the dam. Floodplain (including rice field) and river channel fisheries are, and have been historically insignificant apart from as a source of occasional recreation and dietary supplementation. A watershed-level fisheries balance based on current reservoir fish yields and comparative data on rice field fish production suggests that fisheries production from the irrigated watershed is higher than potential production from the non-modified watershed even when very high floodplain yields are assumed.

Issue 2: Decreased water levels in the tanks and reservoir. Reservoir and tank fisheries are a valuable economic resource and an important source of livelihood for small communities of full-time fishers who are generally landless, and often include second generation 'settlers' of the KOISP or wider dry zone, who lack both access to land and alternative employment. These fisheries are also a valuable additional source of income and protein for part-time or occasional fishers, who are mainly also farmers, although access by this group may need to be regulated to maintain sustainable productive fisheries.

Although reservoir and tank fisheries are not directly consuming water, sustainable production requires the retention of minimum water levels[4]. It has become increasingly common that during critical periods of the year (e.g. the peak dry season months) water levels have not been sufficient to satisfy the requirements of all water users, and in particular both farmers and fishers. Causal factors are that irrigators tend to use more water than planned and initially allocated, whilst fisheries' needs are not considered in the irrigation planning process[5].

Knowledge and analytical tools exist for management of reservoir levels for both irrigation and fish stocks (Lorenzen *et al*, 2002), so that there is potential to increase the aggregate economic and social benefits from the whole system. Requirements are that fishing interests are represented in seasonal water use plans in a way that resolves conflict between farmers and fishers, that the Irrigation Department has the willingness and capacity to adhere to the plan, and that farmers and other users act responsibly in the management and use of water.

Issue 3: Inflow of drainage water into the lagoons. The coastal lagoons were the location of a very profitable shrimp fishery in the past, although returns to individual fishers have been reduced progressively as more fishers were attracted to the lagoons. Lagoons serve as nursery areas for penaeid shrimp, with early juveniles recruiting from the sea during the monsoon when the sandbar separating the lagoon from the sea is breached. The sandbar normally remains closed throughout the rest of the year, so that shrimp are retained and harvested within the lagoon. Inflows of irrigation drainage during the dry season have reduced lagoon salinity to levels, and brackish aquatic resources (mainly high value shrimp) have been progressively replaced by less

[4] This may result in incremental evaporation losses and 'lost' seasonal storage capacity compared to full drawdown for irrigation. Water levels need to be sufficient to sustain a breeding population, and in the absence of adequate regulation of access, sufficient to inhibit complete catching of the stock.

[5] Reservoir inflows have also been consistently lower than predicted during the planning of the KOISP, and have shown a decline in recent years that results from increased abstraction from the river upstream, and possibly from climate change and land use changes in the upper catchment, though this has yet to be clearly established.

valuable freshwater resources (mainly fish), with a substantial reduction of revenue for fishers. Furthermore, drainage inflows and associated cumulative siltation and capacity reduction of the lagoons have increased water levels and flood risk to agricultural land. In response farmers frequently breached the sandbar to release excess water to the sea, thereby allowing shrimp to emigrate to the sea. Consequently the timing of sandbar opening has become a further source of conflict between farmers and fishers.

Issue 4: Conflicts between fishers and farmers. Conflicts between fishers and farmers have arisen over drawdown of the reservoirs and tanks, and the opening of the sand bar. These conflicts originate either in the quantity of water allocated for each activity, or in the timing/seasonality of water availability and its location in the catchment area. Underlying causes also arise from the institutional mechanisms through which water allocation issues are discussed and decisions made.

Issue 5: Weak linkages between fisheries institutions and irrigation institutions.

At lower levels, there is little if any influence by fishers on water resource management, which is mainly driven by irrigated agriculture. The present poor inter-sectoral coordination leads to increasing conflicts, both among institutions and among the various users of the resources. Institutions are seldom prepared for inter-sectoral harmonization of management measures and the lack of clear delineation of competence among institutions concerned with the management of water bodies is reflected in the legislation and regulations affecting fisheries. At higher levels, the government must establish a balance between the goals of economic development and environmental protection in order to prevent conflicts between the two. More specifically, the fisheries sector is still marginalized and does not feature as an issue in decision making processes on water resource management.

3.4 Trade-off analysis and preliminary recommendations

The range of stakeholders involved in the impact assessment process had many conflicting interests, different ideas for improved resource management and varying priorities in the decision-making process. As a consequence the final workshops sought to focus on possible management scenarios that received the broadest support after consideration of the effectiveness of the measure and its potential outcomes.

Figure 4 was used to represent the main issues and their interactions. This representation is based on recognition that:

- "weak linkages between fisheries institutions and irrigation institutions" (Issue 5) are an attribute of the national institutional setting and not an outcome of irrigation impacts;
- "conflicts between fishers and farmers" (Issue 4) follow from Issues 2 and 3, i.e. they are a consequence of the issues and not a causal factor[6].

To increase the impact and efficiency of management measures attention should initially focus on causes rather than effects. The diagram indicates the issues that mitigation measures must target, acting at the origin of the chain of reaction (left side of the diagram). Reduction of conflicts (Issue 4) should follow, but if not, specific measures (e.g. means for conflict resolution) may have to be added. As a consequence, definition of water management scenarios started from Issues 2 and 3, with provision to include measures for Issues 4 and 5 if required.

The study team actively assisted stakeholders to formulate management scenarios for mitigation of the KOISP impacts on fisheries. The exercise was iterative as information was progressively fed into the scenario building activity. Imposing the need to consider the practicalities and

[6] Given the impact assessment results and priorities of stakeholders the loss of floodplain and river channel fisheries downstream of the dam (Issue 1) was not considered further.

consequences of implementation, and not just the measure itself, helped the participants filter out proposed measures or scenarios that were unrealistic or poorly matched to local conditions. At the end of this process, the scenarios had to be understandable by all stakeholders, distinct from each other, realistic and possible, and substantiated by known information (Brown *et al*., 2001).

Following discussion of management scenarios, stakeholder participants first ranked alternative options using evaluation criteria (Table 1) for feasibility of implementation (workshop 4 at local level), and then compared them using criteria defined for outcomes (workshop 5 at national level).

Key questions to be addressed in the trade-off analysis were as follows.

- Are fisheries significant enough to justify water retention in tanks and loss of irrigated area?
- Can negative irrigation impacts for the lagoon fishery be mitigated at acceptable cost?
- Can the livelihood opportunities provided by irrigated farming and fishing be sustained and enhanced without damaging biodiversity and wildlife conservation objectives?
- Can conflicts of interest be avoided or resolved?

Time and resource constraints during the final workshops meant that only an initial and limited attempt could be made to evaluate these questions. The exercise was still productive, however, demonstrating that collation and presentation of relevant information decreased uncertainty for decision making, and reduced controversy and misunderstandings between stakeholders. Although some potential conflicts over allocation of scarce water resources and in the management of the tanks, reservoir and lagoons remained, stakeholders were able to identify the options that gathered the widest support, and agreed to use these as the basis for preliminary recommendations.

To achieve retention of a minimum water level to sustain fisheries in tanks and reservoirs, stakeholders recommended a combination of the following measures: rehabilitation and improved maintenance of irrigation infrastructure to reduce water losses; and increased productivity of water use in agriculture through improved methods and diversification of cropping from rice to inclusion of less water intensive and higher value other field crops.

To achieve control of drainage water into the lagoons and restoration of the fishery, stakeholders preferred a combination of three measures: the rehabilitation of small tanks within the command area that could accept drainage flows, the diversion of drainage water away from the National Park and lagoons, and an improved management regime for cutting of the sandbar to release water from the lagoon.

Time constraints limited the depth of analysis and more detailed formulation of recommendations based on quantification of the costs and benefits of such alternative measures. It was also recognised that for both issues measures to strengthen fishery and irrigation management institutions, and the linkages between these, were essential. Despite this, the main objective of an assessment of irrigation impacts on fisheries in the KOISP project area had been achieved, and a process that could lead to effective mitigation and enhancement measures had been initiated.

4. Conclusion

Competing interests of water users lie at the heart of the main issues for inland fisheries revealed by this study, but the KOISP case shows that problems may lie more in the way issues are addressed and perceived by all stakeholders rather than in critical scarcity of the water resource itself (except during severe droughts). Here the potential for workable solutions exists because

there are good opportunities for improvement without need for radical changes in the system. The challenge remains considerable, however, as an integrated set of management measures is required, given that a failure to consider interactions between mitigating measures may impede effectiveness or generate new undesired outcomes or conflicts. More attention must also be given to the institutional arrangements needed for the sustainable management of water resources for farming, fishing, environmental conservation and other uses.

The study has identified that deficiencies in irrigation management in the KOISP are a major constraint to achievement of improvements for fisheries and the environment. As a consequence, priority should be given to improved planning and management of irrigation with the aim of sustaining farm incomes whilst conserving water for other uses.

The impact assessment process undertaken was an iterative one, and evolved as continuous monitoring and evaluation fed back into improved understanding amongst stakeholders and the study team, and highlighted knowledge gaps or weaknesses in the process. Stakeholder participation was of great value in the process, both through contribution of local knowledge and establishment of consensual agreements on areas of conflicting interest. Although limited by time constraints and data inadequacies, the simple trade-off analyses completed demonstrated the potential for this process to lead to more informed decision making, and more sustainable implementation of selected resource management scenarios.

Further requirements

Subject to availability of resources a more detailed evaluation and cost benefit analysis of alternative management options should be completed, and national level irrigation and water resource managers should consider the preliminary recommendations produced by this process in more depth before adoption and integration in policy.

References

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Acknowledgments

This study was part of a research project on Management of Irrigation Development Impacts on Fisheries of the Department for International Development of the United Kingdom (KAR Project R7793), and this case study was completed in collaboration with the University of Kelaniya and the International Water Management Institute through the Comprehensive Assessment of Water Management in Agriculture. The results of the study will contribute to the Comprehensive Assessment: (http://www.cgiar.org/iwmi/Assessment).

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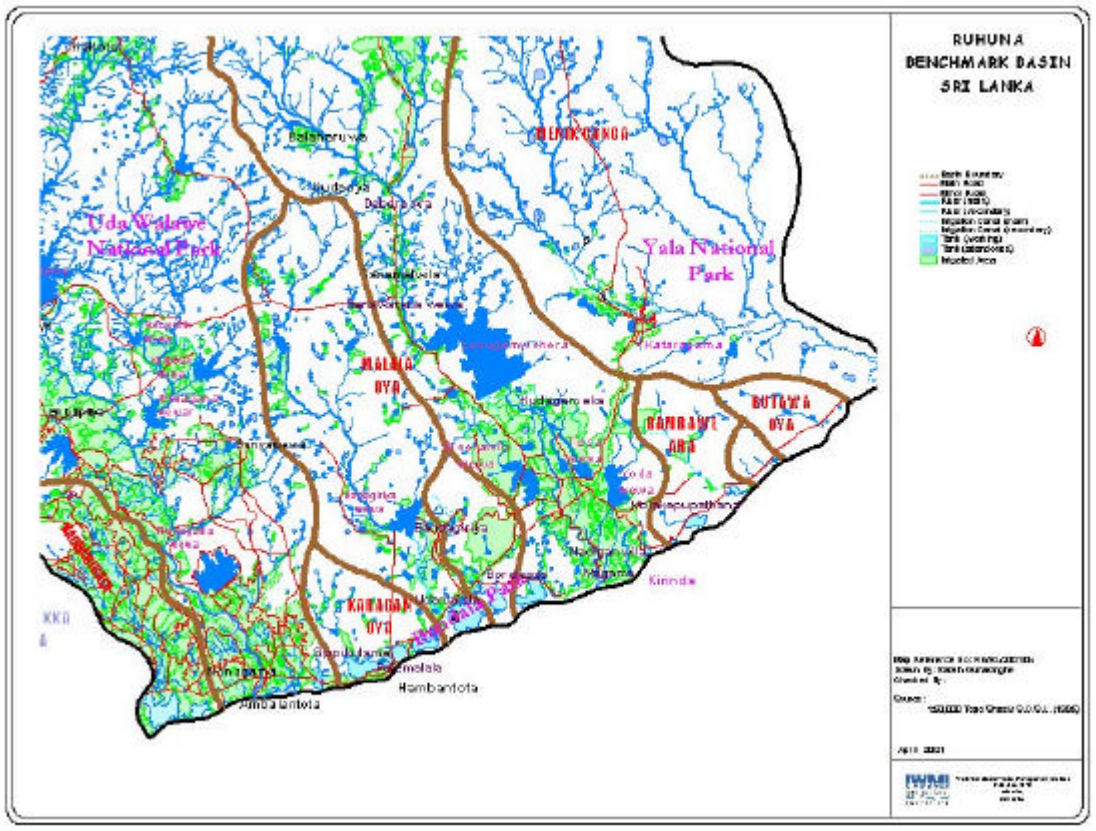


Figure 1: Map of the Kirindi Oya watershed (IMWI, 2001)

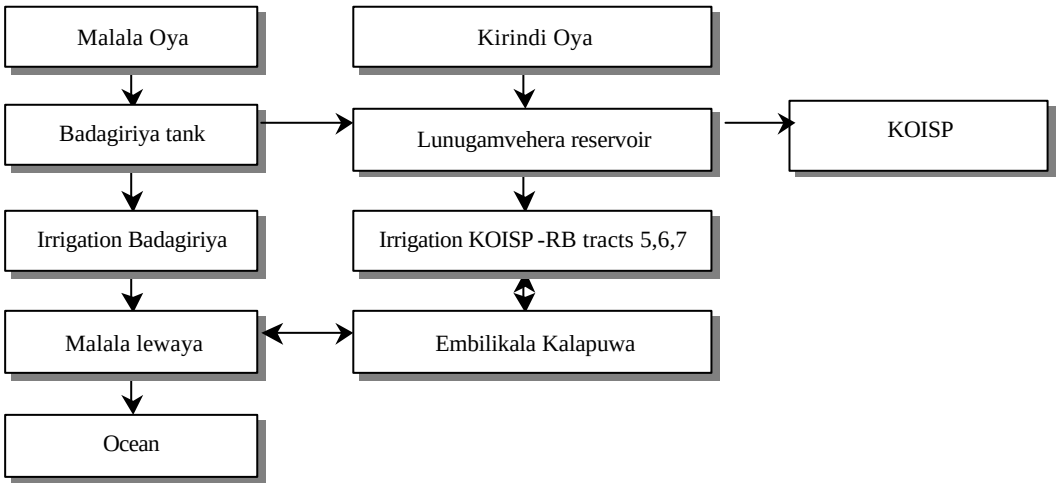


Figure 2: Lagoons water network (IWMI, 1998)

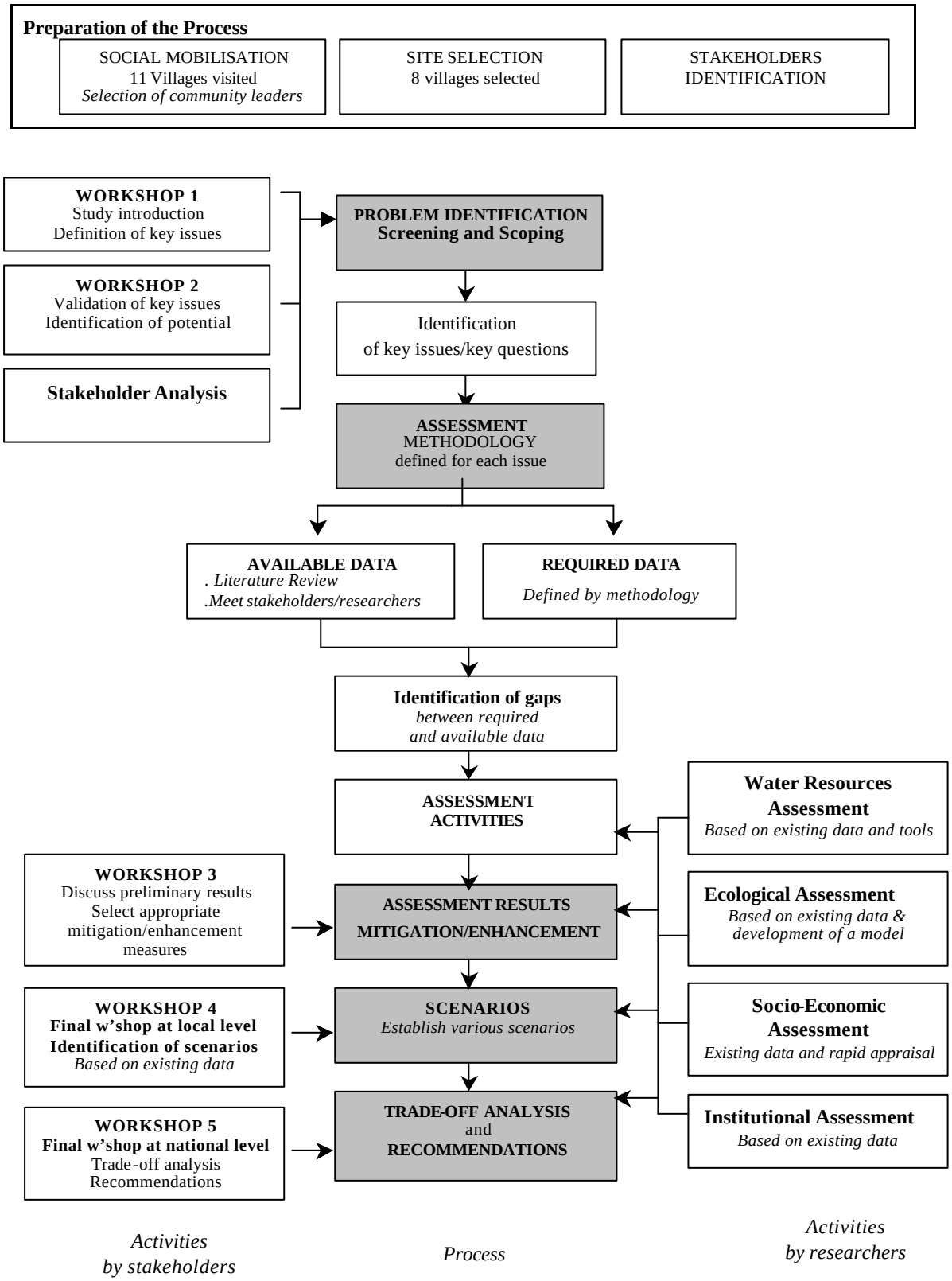
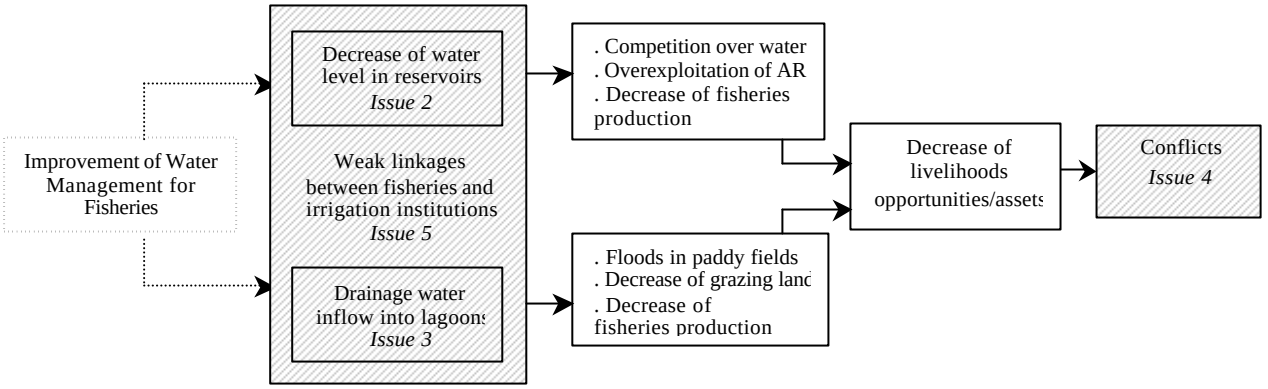


Figure 3: Implementation of the Impact Assessment Protocol



AR: Aquatic Resources

Figure 4: Presentation of issues and their main interactions

Feasibility of implementation	Outcomes
1) Effectiveness in achieving outcomes 2) Cost effectiveness 3) Time scale 4) Potential of conflicts 5) Potential for local level implementation	**1)** Economic benefits - Economic national revenue - Household income **2)** Social benefits - Creation of job opportunities - Benefits the poor/vulnerable **3)** Environment - impact on biota - impact on ecosystem integrity

Table 1: Evaluation criteria for trade-off analysis