Irrigation Impacts on Fisheries: the Need to Extend the Environmental Flow Paradigm

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International Water Management Institute

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Environmental Flows Definitions

1) EF are the quality, quantity and timing of water flows required to maintain the components, functions, processes and **resilience** of aquatic ecosystems which **provide goods and services to people**.

2) EF are additional intentional river flow releases **to benefit ecosystem goods and services including fisheries**.

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Issues challenging the EF paradigm

i) **Water flow rates**: not necessarily the most important variables driving fisheries production and exploitation esp. in tropical river floodplains

ii) **Use of aquatic resources** in particular the changes of fishing efficiency at different water levels

iii) **Major livelihood implications** of flow variations and possible conflicts with other water "users" including ecosystem needs

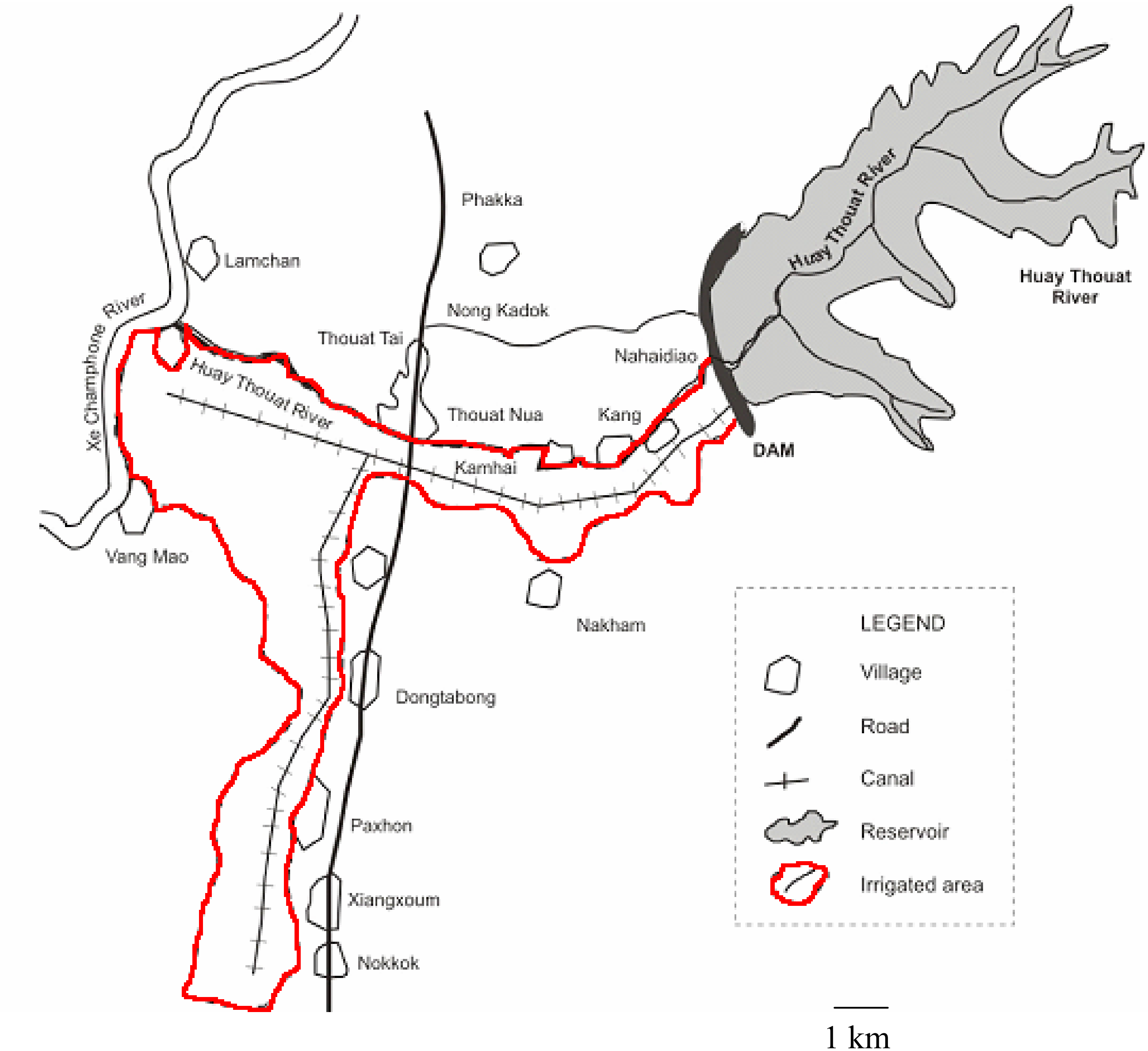
Assessment of Irrigation Impacts on Fisheries: Observational study in Lao PDR

Paired comparison of irrigated and control sites

Replicated at irrigation scheme level

10 paired sites each of **weir** and **dam** irrigation schemes

Medium-scale irrigation schemes in Southern Lao PDR



<u>Command areas</u>

17-515 ha

(av. 155 ha)

<u>Age of schemes</u>

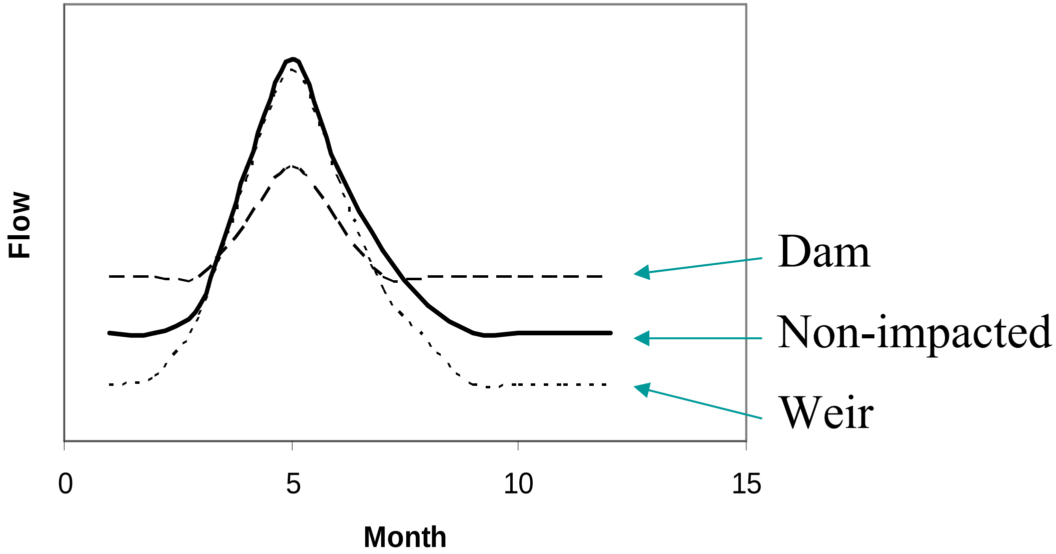
3-35 years

(av. 10 years)

Irrigation development modifies aquatic habitats

Weirs divert water

River flow pattern



Dams store water

Change of land and water use
in irrigation command

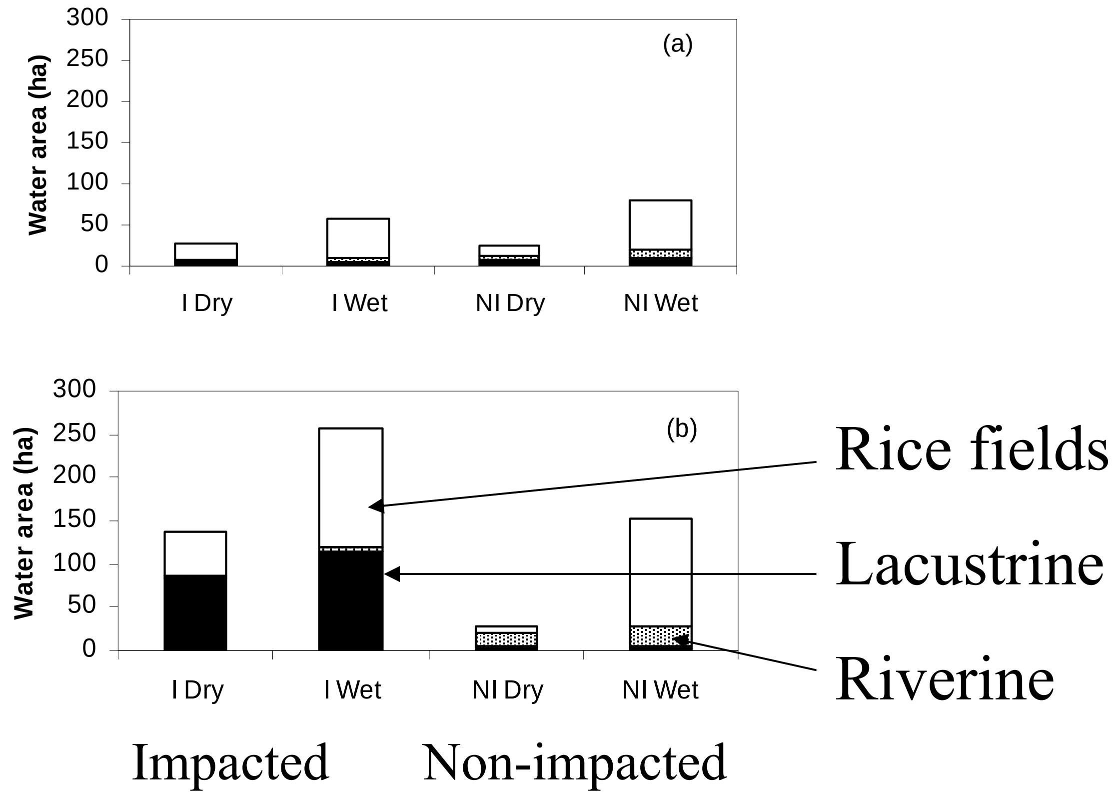
Aquatic Habitat Areas

Weir sites

Impacts: NS

Dam sites

Impacts: P<0.1



Lacustrine: reservoirs, lakes, and ponds

Riverine: streams and rivers

Village Level Catch Prediction

Regression model:

$$\ln Catch = \alpha_0 + \alpha_1 \ln Effort + \alpha_2 \ln \text{Permanent wetland area} + \alpha_3 \ln \text{Temporary wetland area} + \beta_1 \text{Impact}$$

Effect		**Weirs**	**Dams sites overall**	**Dam sites outside reservoir**
Constant	α_0	-1.69	-3.07	-4.75
Effort	α_1	**0.48 (0.25)**	**1.06 (0.22)**	**1.21 (0.22)**
Permanent wetland area	α_2	0.15 (0.14)	-0.16 (0.19)	0.00 (0.15)
Temporary wetland	α_3	**0.61 (0.20)**	**0.46 (0.23)**	**0.54 (0.23)**
Irrigation imp.	β_1	-0.44 (0.45)	0.17 (0.39)	0.00 (0.41)

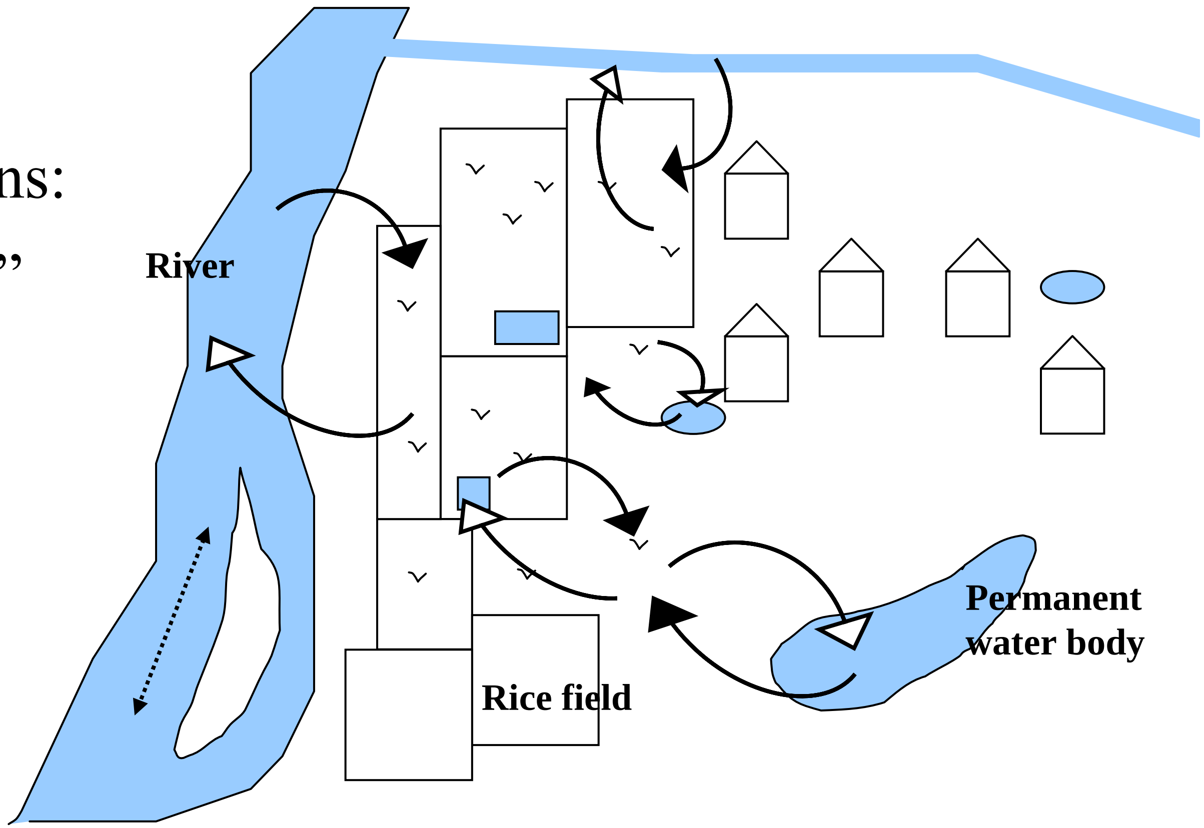
-> Maintaining temporary wetland area is key!

Rice Farming Landscapes:
Man-made Temporary Wetlands

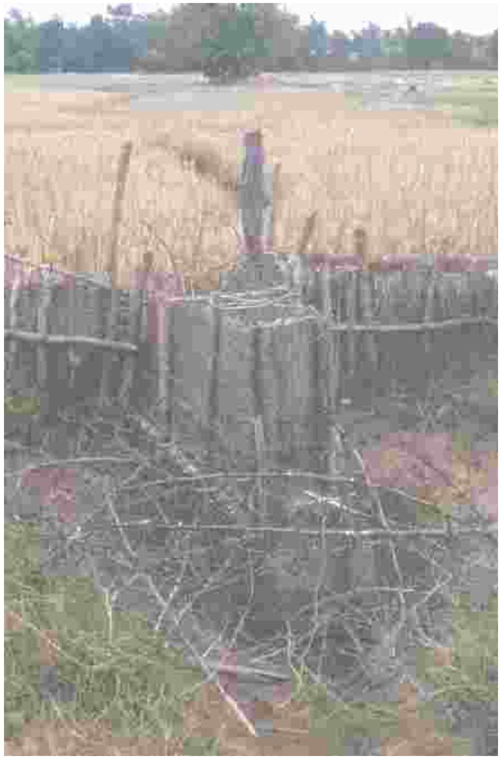
Fish migrations:

"Up & Down"

and Laterally



Source: Amilhat 2004



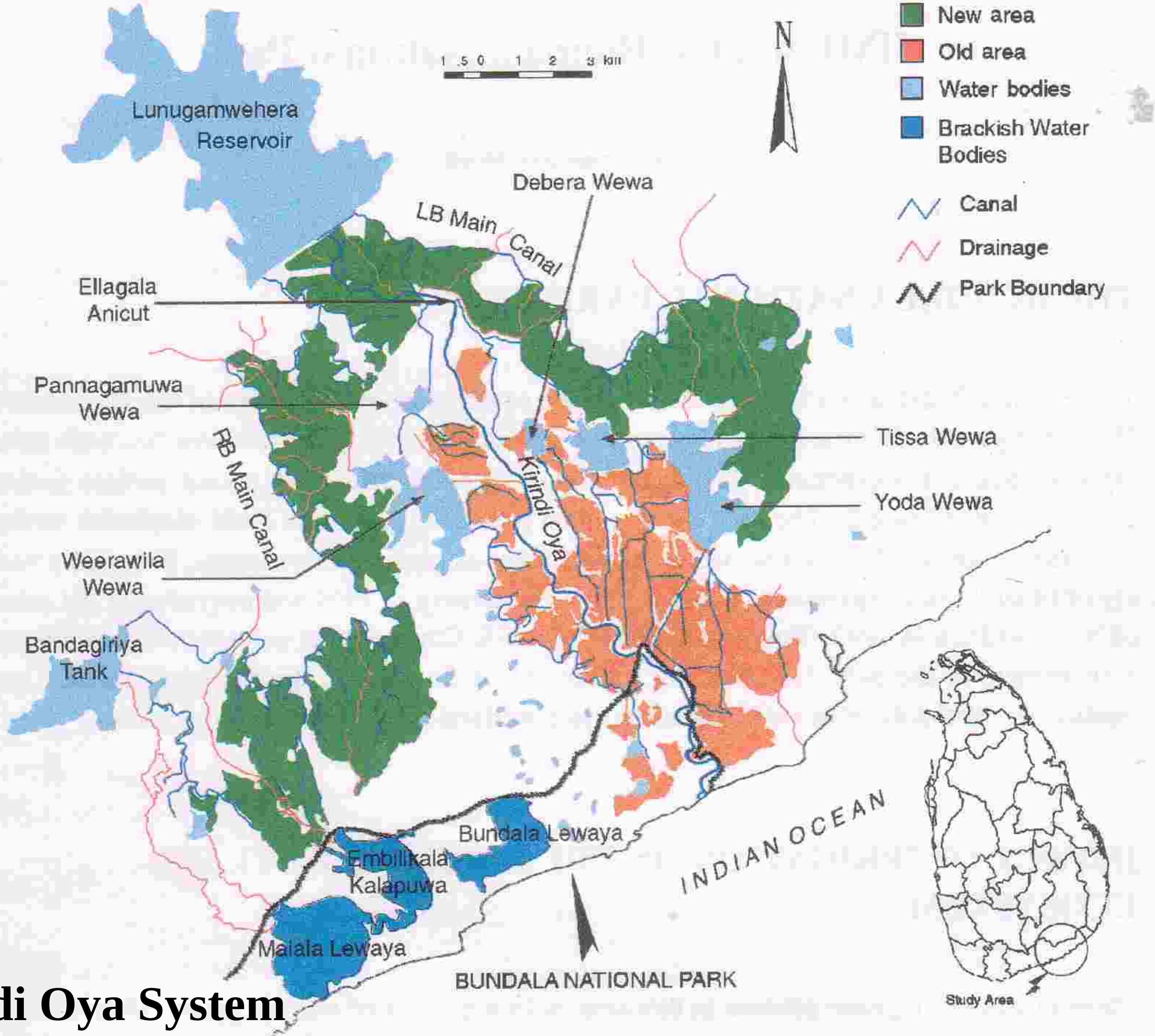
Fisheries in rice farming landscapes are inconspicuous...

Women and children fishing in a reservoir

Conclusions

1. Medium-scale irrigation schemes in rainfed rice farming landscapes had moderate impacts on fisheries, which remained productive and diverse.

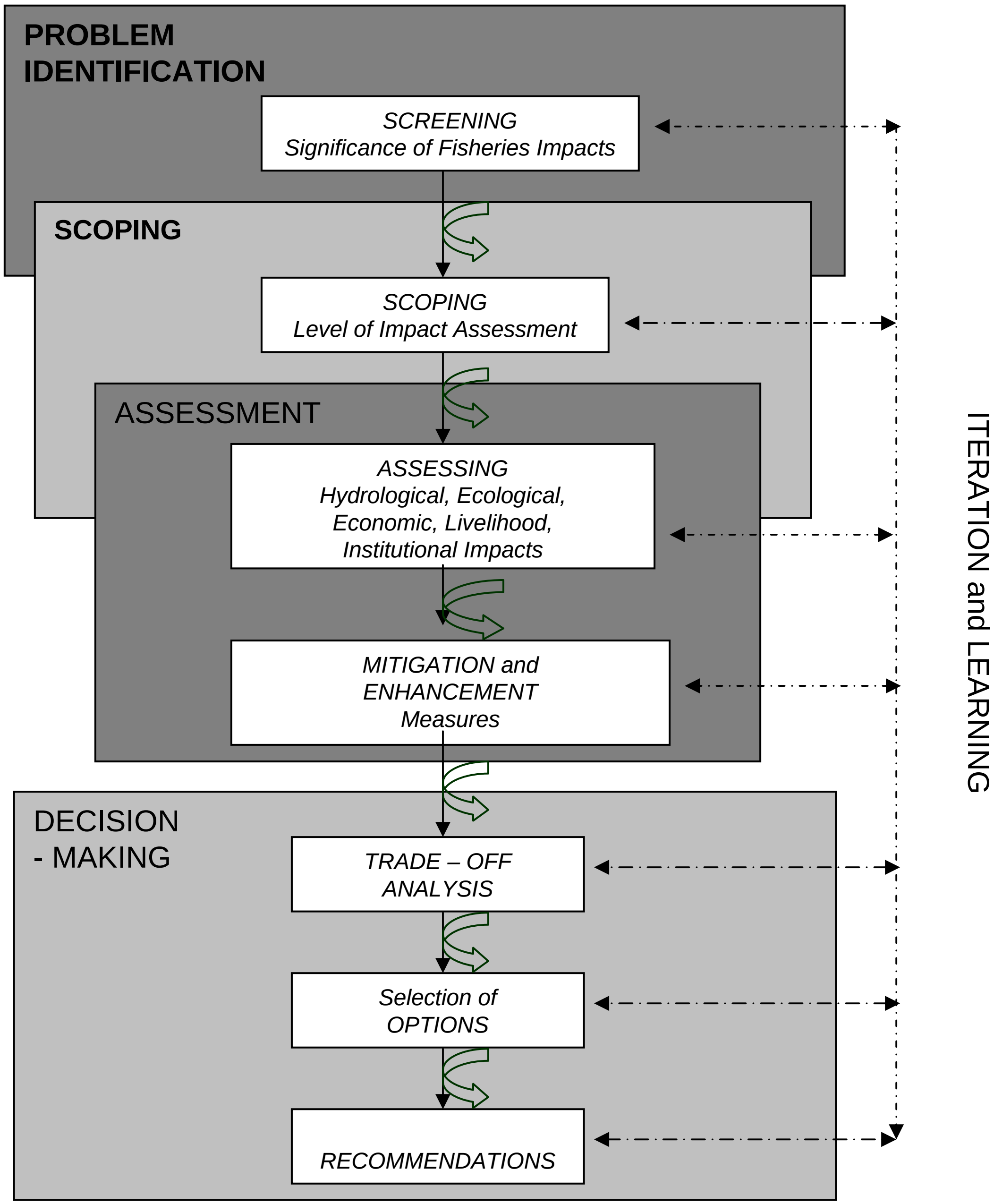
2. Agricultural practices in the wet season are likely to have greater effects on fisheries than irrigation *per se*.



Kirindi Oya System

APIA

Adaptive Participatory Integrated Assessment



Kirindi Oya Fisheries Balance

Waterbody	Area	Production	Tot. Value
	ha	tons	million Rs
Unaffected by KOISP	**2,350**	**996**	**39.8**
Lost by KOISP			
Tanks inundated	-100	-65	-2.6
Floodplain below dam	-4,200	0.05	-8.4
Floodplain inundated	-2,000	-100	-4.0
Lagoons		-200	-30.0
Total	**-6,300**	**-575**	**-45.0**
Gained by KOISP			
Lunugamwehera	3,200	1,355	54.2
Lagoons		200	8.0
Total	**3,200**	**1,555**	**62.2**
Balance	**-3,100**	**980**	**17.2**

Conflicts in the Irrigation System

2 Major Issues faced by Fisheries

1) Drawdown of reservoir water levels
2) Drainage inflows to the coastal lagoons

Common features of these conflicts

- Unequal allocation of water resources
- Fishers are under-represented in decision-making and management of water
- Overexploitation of common pool resources
- Relatively rapid decline of fisher livelihoods

Drawdown of Water Level in Reservoirs

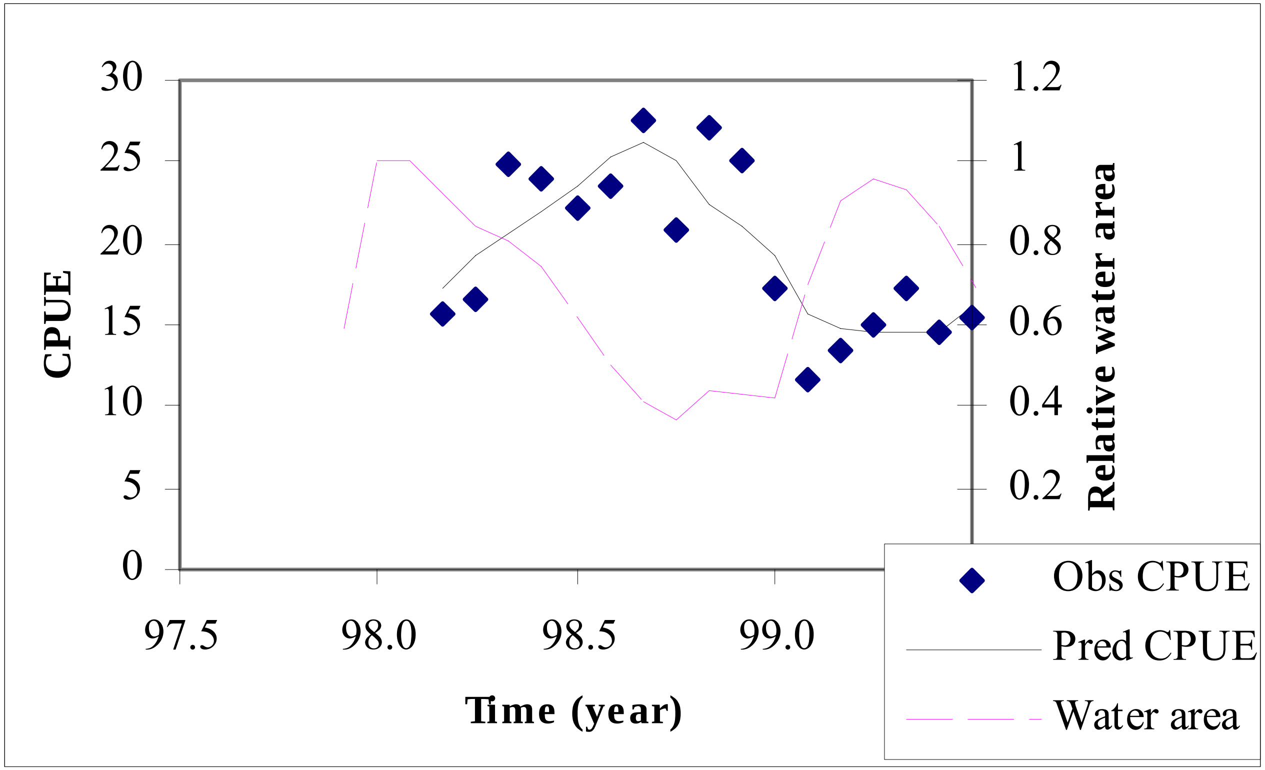
Reductions of reservoir water level/area/volume affect the dynamics of fisheries in 2 ways:

- Concentrate fish and therefore make them easier to catch (change in 'catchability')
- Reduce the biological productivity of the water body relative to the productivity at full area

The complex interactions between catchability and the long-term productivity effects of water drawdown require a Dynamic Model.

CPUE and Relative Reservoir Water Area

Kaudulla Reservoir, Sri Lanka

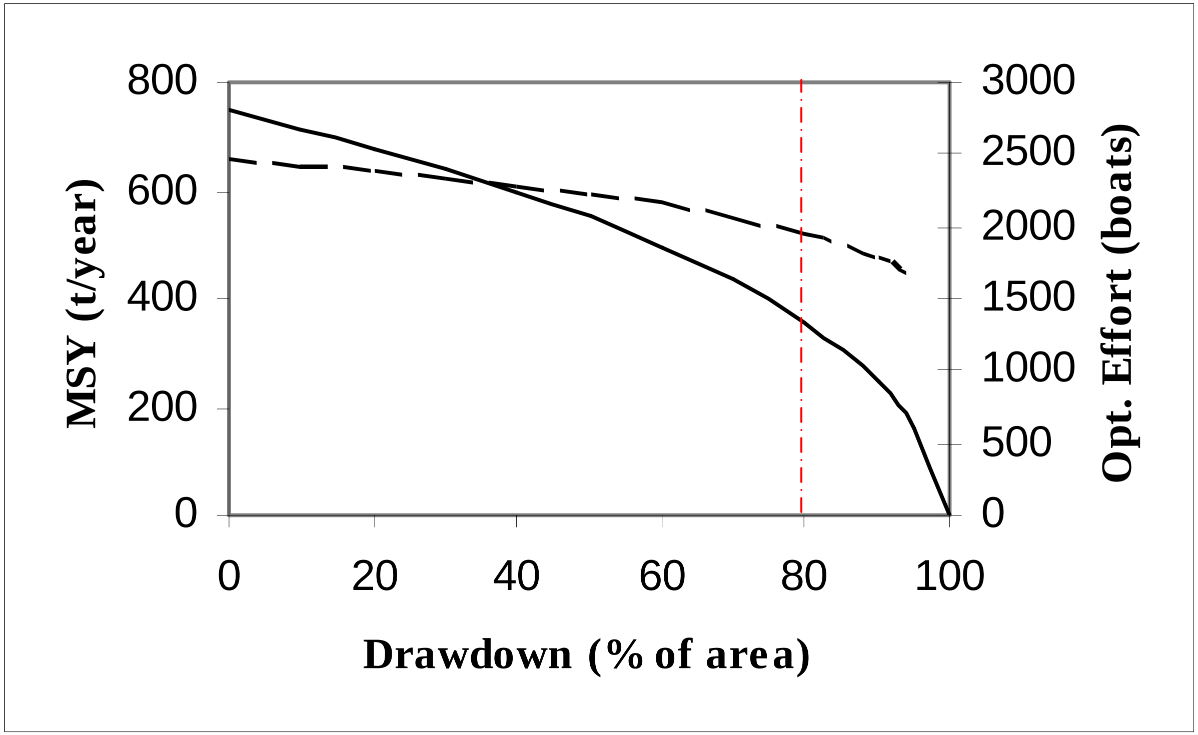


Observed and predicted catch per unit of effort (CPUE)

Data provided by Amarasinghe et al., University of Kelaniya

Reservoir Water Level & Fisheries Production

Biomass Dynamic Model



Predicted MSY (solid) and the corresponding optimal fishing effort (dashed) as a function of drawdown (% of water area at full storage level)

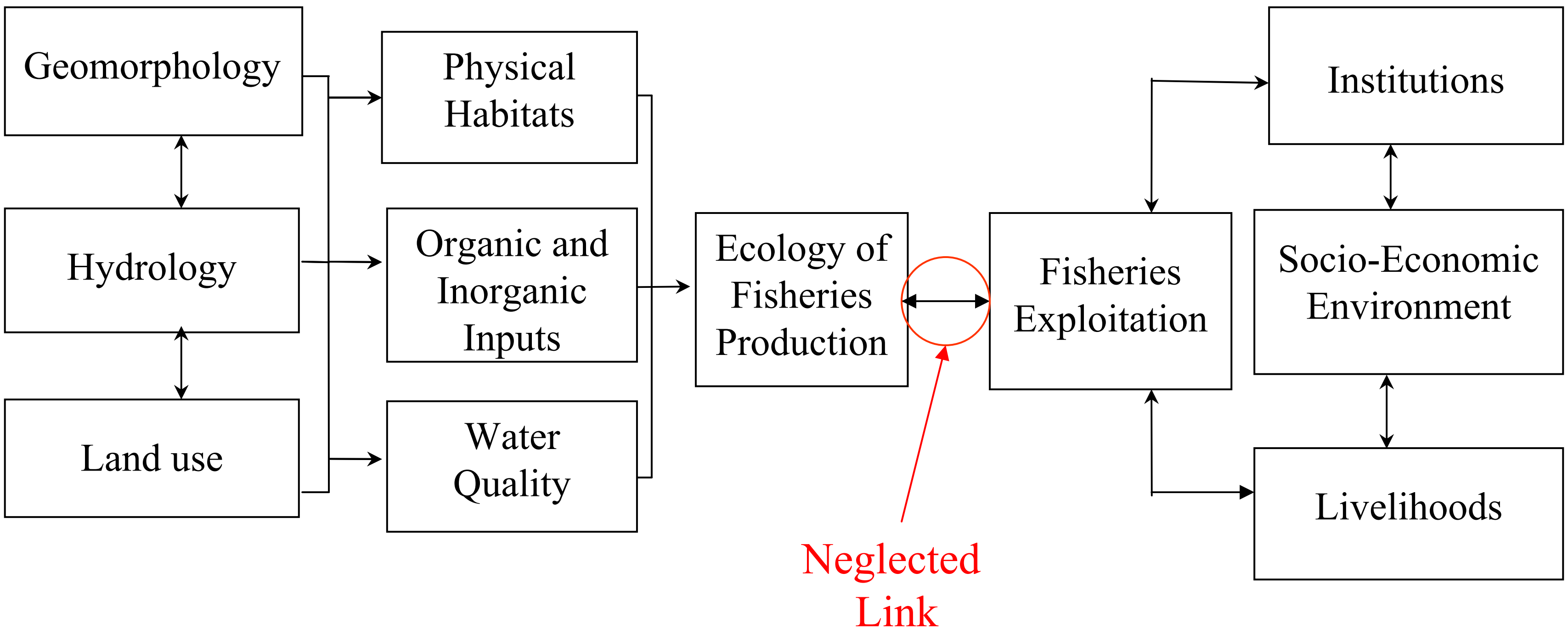
Source: Lorenzen, Smith, Nguyen Khoa et al. 2007

Interpretation of Results and Conclusions

- Fishing with extreme drawdown - temporarily or on a regular basis - should be more restricted than under conditions of moderate drawdown.

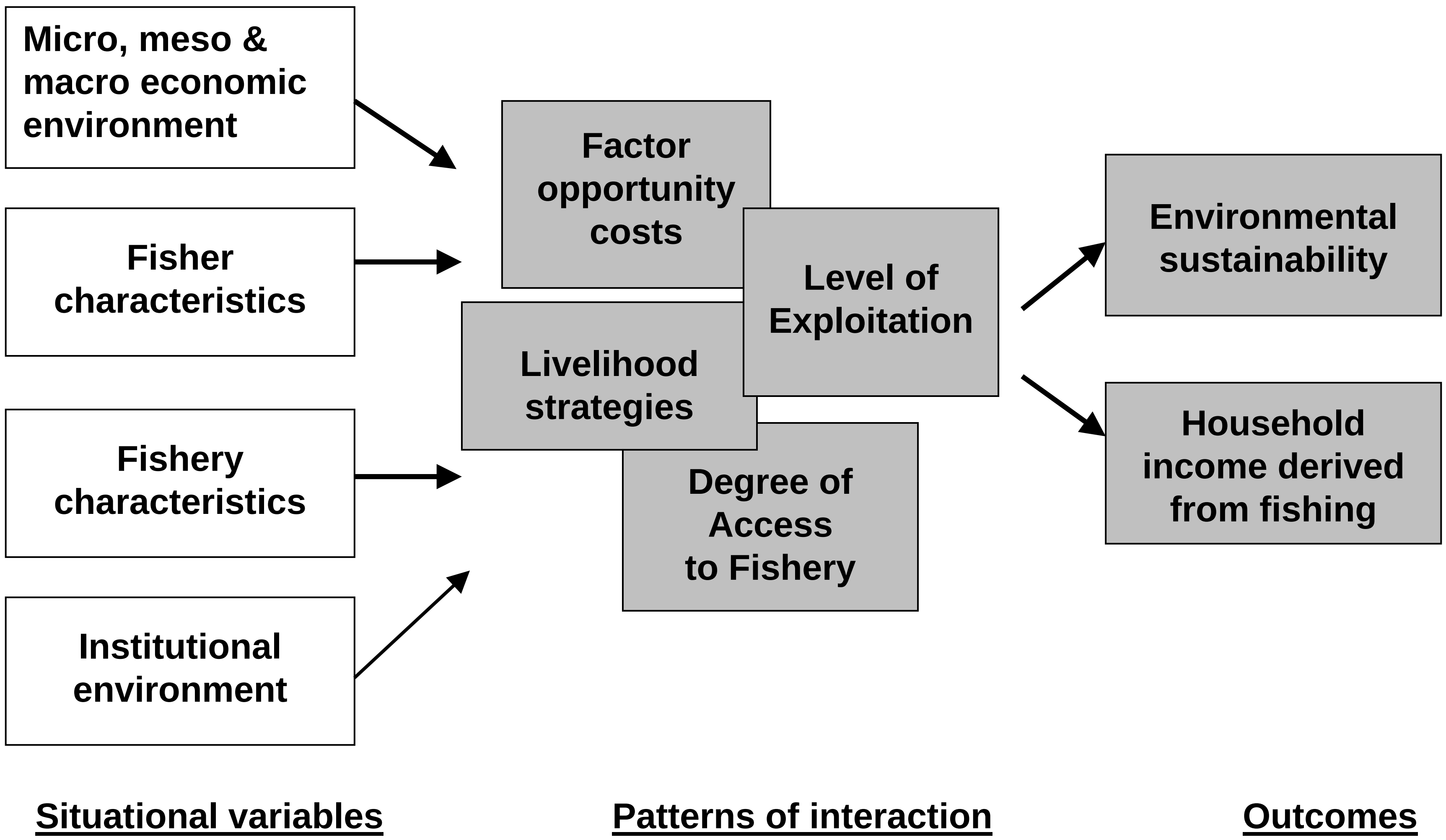
- Decisions of water allocation between downstream users and reservoir fisheries towards the end of the irrigation season will have a drastic effect on fisheries production on the long-term average.

The Fishery System



After: Nguyen Khoa 2005

Determinants of Livelihood Outcomes



Source: Smith, Nguyen Khoa, Lorenzen 2004

Livelihood strategy	Livelihood functions of fishing
'Survival'	• Subsistence: food production and income • Nutrition
'Semi-subsistence' diversification	• Own consumption • Complementarities in labour use with farming • Means for barter, or for participation in reciprocal exchange and social networks • Occasional cash source • Diversification for: o labour and consumption 'smoothing' o risk reduction o as a coping strategy/buffering against shocks.
'Specialisation'	• Market production and income • Accumulation
'Diversification for accumulation'	• Accumulation • Retention in a diversified accumulation strategy. • Recreation

Summary

- Objectives of ecosystem conservation, fish production and livelihood improvements are not necessarily co-terminous
- Causation pathways: generally not linear, a complex set of relationships and trade-offs
- Trade-offs within the fishery system, esp. between downstream and reservoir fisheries
- Need to manage water to meet multiple objectives

Extension of the EF paradigm

- Other key hydrological functions driving the ecology of fisheries production
- Changes in aquatic resource use and exploitation patterns with water resource fluctuations
- Livelihood implications (options, strategies, conflicts)

-> Need for a Holistic Social-Ecological Approach to Environmental Flows


THANK YOU!