A New Approach for Analyzing and Comparing Coastal Resource Systems*

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Introduction

A large fraction of the world's populations lives "close" to coastlines, however "close" is defined. The bulk of the world's fish catch is taken in the nearshore half of the coastal shelves.

These features alone would justify a strong research effort on the world's coastal zone. The juxtaposition, along coastal zones, of large human populations and of extractive systems relying on natural production implies, moreover, numerous intersectoral conflicts, because of the pollution generated by these large human populations, and the requirement of the fisheries and other extractive industries that the coastal resource systems continue to generate usable biomass.

These conflicts are exacerbated by developments such as coastal aquaculture, which directly leads to destruction of wetlands, and reclamation of coastal lagoons for agriculture or urban use.

These processes and conflicts, many of which have strongly increased in recent decades, have led to an upsurge of research on coastal systems in many areas of the world by practitioners from many disciplines, ranging from geology and physical oceanography to aquatic biology, fisheries science, economics, sociology and maritime anthropology.

This wide range of disciplines, while generating an extraordinary wide array of brilliant results, has also prevented the emergence of a common language for the sharing and evaluation of conceptual advances, and especially for constructing qualitative models of coastal processes which would integrate elements from these various disciplines.

ICLARM recently developed a Strategic Plan for International Research on Living Aquatic Resources Management** which identifies (tropical) coastal resource systems as one of its areas of research emphasis. ICLARM will be only one of many players in the worldwide "coastal scene", and can do only a small fraction of the worldwide research that is needed.

A catalytic role that ICLARM could play would include:

(i) conducting interdisciplinary, yet highly focused research that can serve as an example for other groups, and more specifically;

(ii) providing a conceptual framework for integrating and comparing the results of research conducted by different disciplinary groups.

Here we present a rudimentary conceptual framework for research which we will develop over the next years to integrate into our own research, and for communication with our colleagues.

The Coastal Cross-Section Concept

Two fairly recent lines of scientific enquiry provided us with the basis for the concept of Coastal Cross-Sections. They are agroecosystems analysis and farming systems research.

Agroecosystems analysis was initiated about a decade ago, when Gordon Conway[1] elaborated a framework for understanding agricultural ecosystems. His transects of land types, which went beyond soil types, used multiple criteria to define land types. In the intervening period, however, this potentially powerful analytic tool has not been used for more than descriptive purposes, although its power for comparative work is evident (Fig. 1).

More than two decades ago David Norman and others[2] formulated the concepts and procedures for *farming systems research* (FSR). This ushered in systems perspectives and farmer participation. FSR has since been widely used by commodity-oriented agronomists but not for natural resource management. The farmer participation idea has become an explosion of "participatory methods", centered on qualitative methods of rapid appraisal, as popularized by Robert Chambers.[3]

ICLARM has further developed these lines of enquiry, mainly by expressing land types as indigenous categories for resource systems that include aquatic resources. Such transects provide us with a common language to compare different systems in different areas (Fig. 1). The common language also extends to farmers because indigenous categories are used to define resource systems. With more tests over coastal, coral reef and more diverse inland areas, wider generalizations may be possible; and these would involve fishers and other coastal resources users.

Furthermore, we have gone beyond transects and developed resource flow models to examine biological, human (disaggregated by gender), and cash flows within and between resource systems (Fig. 2). Such models not only provide new insights on resource deployment, depletion and regeneration, but more importantly, they stimulate households

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***The Strategic Plan is available free of charge upon request from ICLARM.*

to improve the way they manage resources available to them.[4] Thus, a direct, immediate and meaningful interchange between scientists and resource managers ensues. With more tests over time and location, general principles for resource management, especially regarding biodiversity, may emerge.

What does this imply for research on coastal systems?

The fact that the inshore/offshore axis conveys far more information on the structure and process affecting coastlines than the alongshore axis needs little arguing.*** This also implies that *maps*, which always include both the alongshore and the inshore/offshore axes will often "dilute" information on coastal systems and make intersystem comparisons difficult. We argue here, in analogy with Figs. 1 and 2B, that coastal cross-sections schematically representing the offshore/inshore axis of a studied coast should be, for most disciplines concerned with coastal processes, the key tools for presenting results.

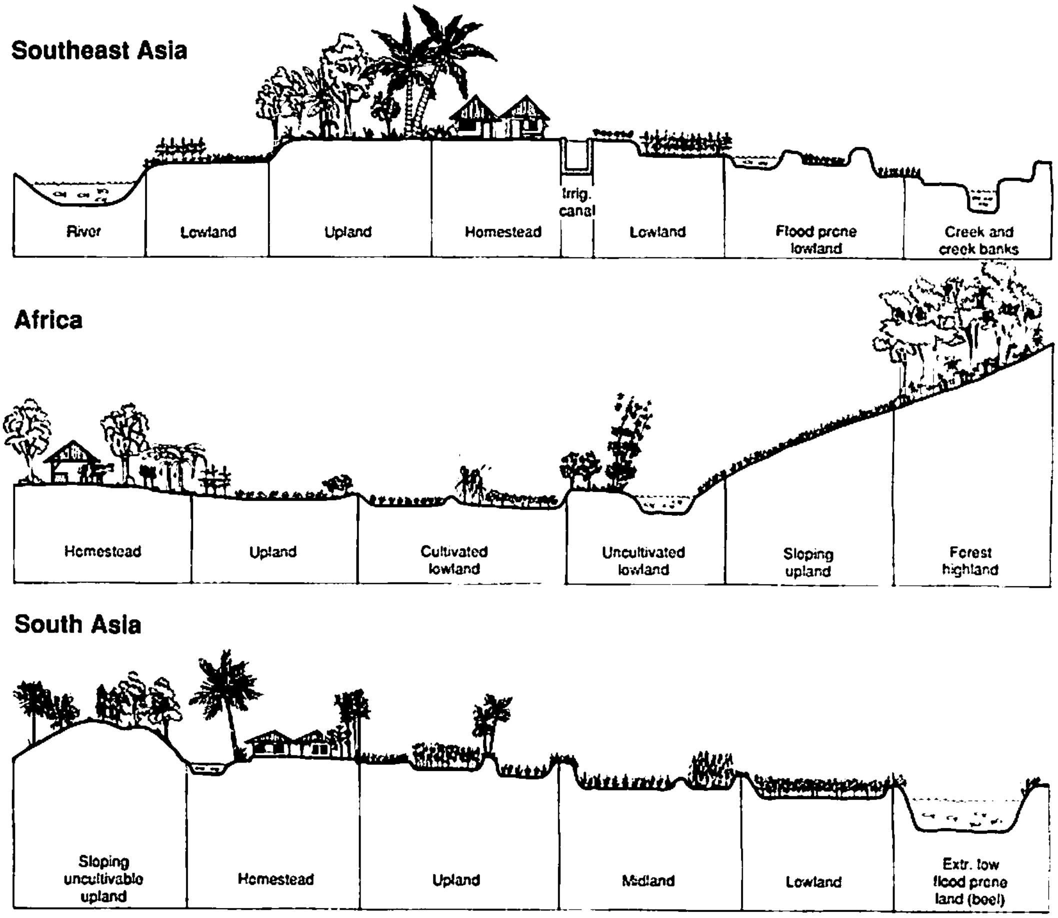


Fig. 1. ***Global comparison of resource systems, made possible by the standardization of their components, and the inherently low dimensionality of graphs representing transects (cross-sections).***

One practical advantage of low dimensional plots such as the proposed coastal cross-section (Fig. 3) is that they allow:

1) representation of most crucial processes affecting coastlines through a suitable set of icons; and
2) comparison of different coastal systems at a glance, using the best information processor there is: the human eye/brain system.

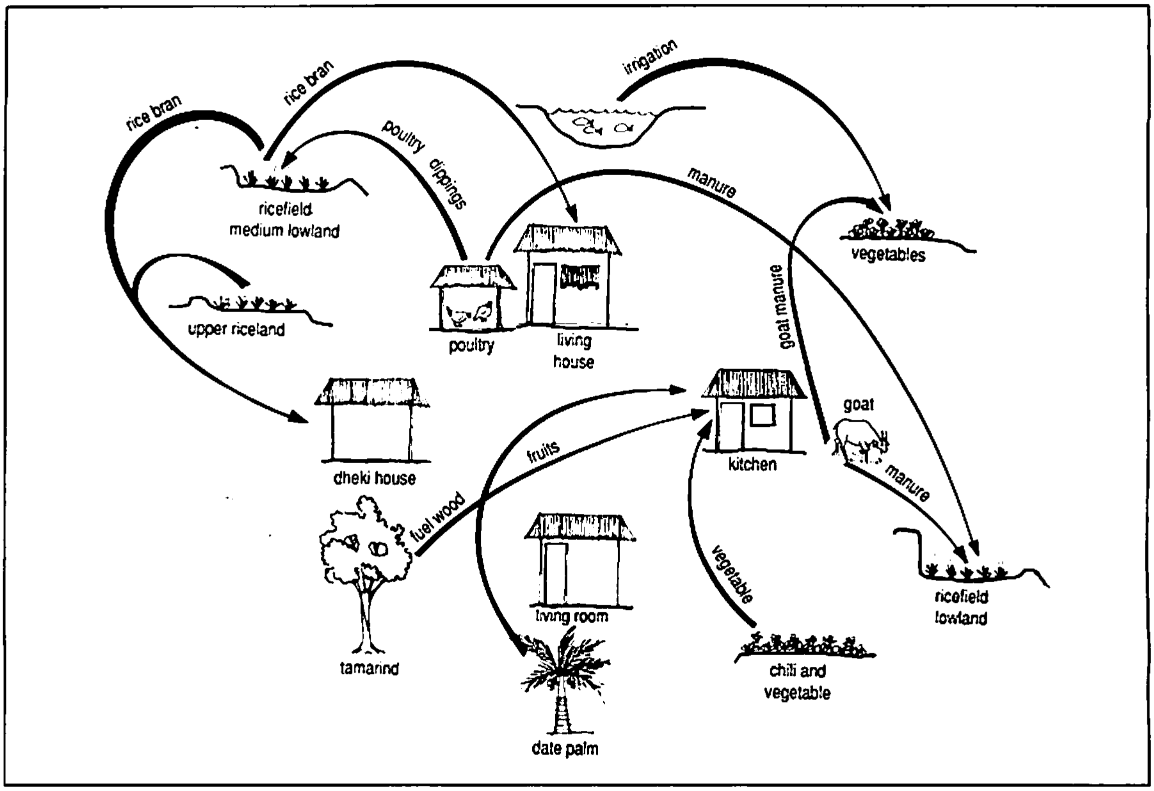
Representations of coastal cross-sections should put the point where land and water meet at the center of the graph (or screen in software representation), emphasizing the centrality of this interface. Suitable icons may be used to represent organisms (fish, shrimps, mangrove trees, etc.) and coastal industries (tourism, mariculture, fishing, fish processing and marketing, etc.) while arrows would represent the flow of biomass, labor or money between them. The size of the icons and arrows would express the relative importance of the objects or processes represented. Other key features of the coast represented in a coastal cross-section may be added to characterize physical and biological features and to describe the way humans have used or modified the coastline in question. These features would be represented through selective indices drawn both from the natural and social sciences (Table 1).

With the elements in Table 1, the stage would be set for adding fishes and other exploited organisms into the picture. This could be done via the icons mentioned above, each of which would represent a group of species. The flow linking these different species groups would be estimated mainly through trophic models, such as can be constructed using the ECOPATH II approach and software (see *Naga* April 1990, p. 9). The flows linking exploited species groups and the fisheries (including gleaning and beach-seining by women and children) would provide the strongest contribution to the visual impact of the coastal cross-section. Bioeconomic modelling has a strong role: the major cost factor for coastal fisheries is the distance fishers must travel offshore to encounter suitably high fish densities.[5] Thus, a bioeconomic model incorporating a suitably adapted form of yield-per-recruit analysis and the dependence of cost per unit of effort on fuel cost would enable coastal cross-sections to be used for simple simulation

****This was well understood by the ancient Hawaiians, as shown by Kimberly Smith and Mahealani Pai (see p. 11).*

Fig. 2. ***Illustrating the connection between farming systems research and agrosystem analysis: A: representation of village-level interactions based on villagers' input, as obtained during a rapid rural appraisal in the Mymensingh area, Bangladesh; B: the same system, represented as an agroecosystem transect.***

2A



2B

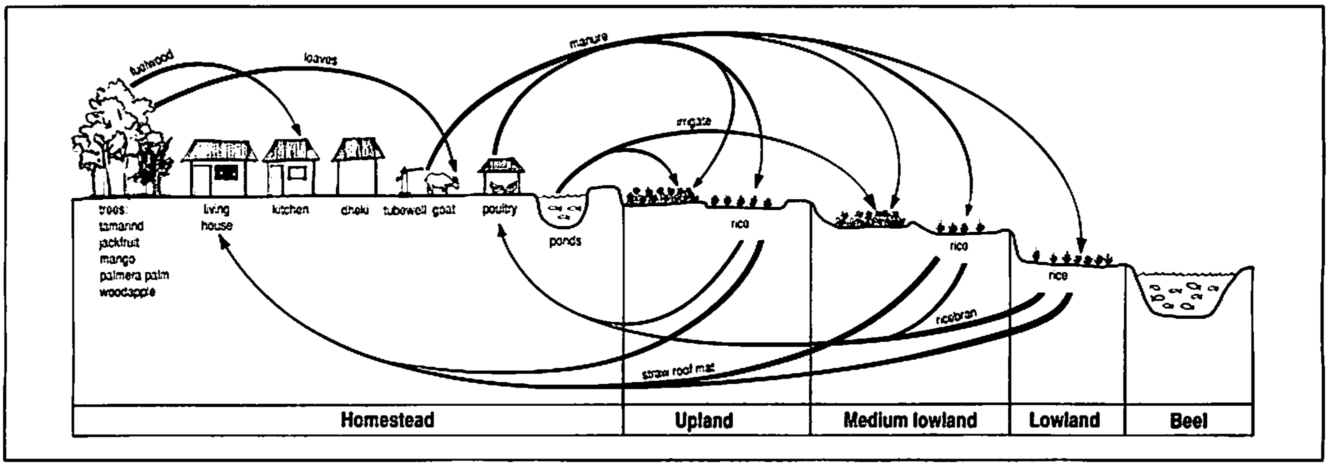


Table 1. Some structuring elements that may be included in coastal cross-sections and in software for representing and comparing them.

Discipline	Contribution to coastal plots	Use
Geomorphology	Land features, sea bottom features, slopes	Comparisons between areas
Meteorology/climatology	Frequency and timing of strong winds	Assessing risks for coastal industries (relevant for fishing, mariculture and coastal agriculture)
Physical oceanography Marine chemistry Pedology	Sea level changes (tidal and long term), nutrient levels and fluctuations, pollutants, coastal soil types and use for agriculture	Assessing risks and identifying opportunities for improved systems integration
Marine biology/botany	Plankton, primary production, distribution of macrophytes (algae, seagrass, mangroves), occurrences of noxious plankton blooms, etc.	Comparisons between areas, identification of critical habitats, risks
Economics	Bioeconomic modelling, resource valuation, marketing	Identification/quantification of management options
Sociology	Tenure and access rights, equity, benefit distribution, gender issues	Identification of possible constraints to or opportunities for management
Anthropology	Usufructory rights and customs, indigenous institutions and technical knowledge	Identification of possible constraints to or opportunities for management

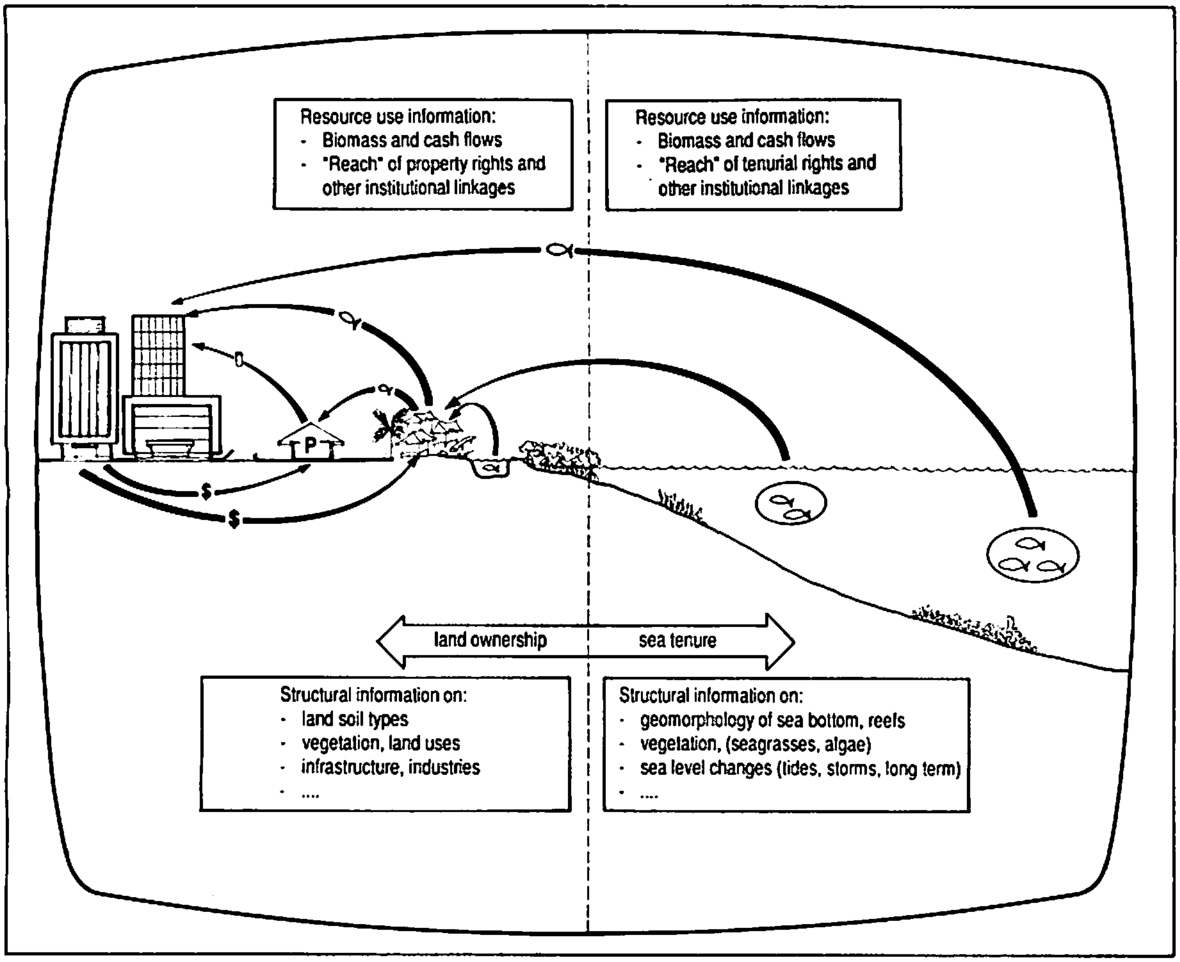


Fig. 3. ***A hypothetical coastal cross-section illustrating biomass and cash flows between a community of small-scale fishers (huts behind the coastal mangroves), processors/intermediaries (hut marked "P") and a nearby city (leftmost blocks); these arrows which may be quantified represent the (value of) catches taken either close inshore (by the small-scale fishers), or further offshore (through an industrial operation which bypasses the coastal communities). Separate panels allow for information on the structure of the land and aquatic resource systems, while arrows can be used to express the "reach" of various ownership patterns (on land) or of tenurial rights (over coastal waters).***

of the dynamics of coastal fisheries.

The economics of fish processing and marketing could also be represented through icons and flows and this would also allow visual and quantitative evaluation of the fraction of total benefits from coastal fisheries which accrue to coastal dwellers rather *vis-à-vis* those exported to urban dwellers or even abroad.

Further, right-pointing arrows could be used to express the offshore "reach" of various formal and informal tenural arrangements, and, where they overlap, the likely occurrence of resource access conflict.

On land, left-pointing arrows would, similarly, express the "reach" of property and use rights on coastal lands. Here, as for other land-based features of coastal systems, links would be created with ICLARM's FARMBASE, a database for integrated farming systems research developed by the Integrated Farming Systems Group at ICLARM in collaboration with the International Institute of Rural Reconstruction, in Silang, Cavite, Philippines.

ICLARM will use the opportunity provided from mid-1992 by the need to elaborate a mid-term (5-year) plan to contact researchers, in advanced scientific institutions and in national aquatic research institutions to identify appropriate qualitative or quantitative descriptors for the various coastal processes mentioned above.

Also, specialists will be consulted on how best to express the approach proposed here in form of an interactive software package that could be used as a stand alone product, but which also would be linked to various ICLARM and other software for the detailed disciplinary analysis of the components of coastal transects, e.g., Geographic Information Systems for mapping information, or ECOPATH II and FiSAT**** for fisheries/ecosystems research or FISHBASE (see *Naga*, October 1991, p. 10) for information on resources species.

Comments from readers on these ideas are more than welcome.

****FAO-ICLARM Stock Assessment Tools, available in early 1993.*

Further Reading

[1]Conway, G.R. 1985. Agroecosystem analysis. Agric. Admin. 20:31-55

[2]Norman, D.W. 1980. The farming systems approach: relevancy for the small farmer. MSU Rural Development Paper 5. Michigan State University, East Lansing, Michigan, USA.

[3]Chambers, R., A. Pacey, L.A. Thrupp, Editors. 1989. Farmer first, farmer innovation and agricultural research. Intermediate Technology Publications, London, UK.

[4]Lightfoot, C., S. Feldman and M.Z. Abedin. 1991. Households, agroecosystems and rural resources management. ICLARM Educ. Ser. 12, 86 p.

[5]Fox, P. 1986. A manual of rapid appraisal techniques for Philippine coastal fisheries. Research Division, Bureau of Fisheries and Aquatic Resources, Manila.

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