Catchment2Coast: making the link between coastal resource variability and river inputs

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AN INTERDISCIPLINARY, MULTI-INSTITUTIONAL modelling research project, which will help improve scientific understanding of the linkages between river catchments and their associated coastal environments, was started in October 2002. Named the Catchment2Coast Project, its overall goal is to investigate and validate an integrated river catchment coastal ecosystem framework that can support policy development and resource management, and is generic enough to be applied beyond the southern African region.

Although it has long been recognized that river catchment-based activities impact on riverine and coastal ecosystems downstream, their full consequences for socio-economically important 'ecosystem services' and coastal resources are poorly appreciated. It is not clear whether this is due to gaps in understanding of the linkages between catchment and coast, or to limitations of the historical data. These gaps pose particular obstacles in the furtherance of integrated ecosystem development policies, especially those that deal with transboundary consequences of management actions. Transboundary concerns apply to both national and ecosystem boundaries, including the traditional ones between river catchments and their adjacent coastal ecosystems.

The Catchment2Coast Project aims to address these gaps in knowledge using a combination of numerical modelling and field observations to understand the key biophysical linkages, followed by integration of biophysical and environmental resource economics models to provide the connections between ecosystem function and development drivers. This hypothesis-based approach will allow refinement of numerical modelling platforms, affording them the necessary degree of rigour and reliability for more generic usage as management and policy development support tools.

The project uses as a case study the Incomati River–Maputo Bay system in Mozambique (Fig. 1). The Incomati catchment, part of which falls within South Africa and Swaziland, is extensively affected by human activity, raising concerns that this may have a detrimental but unquantified effect on economically important coastal resources. Indeed, the Tri-Partite Technical Committee, which coordinates the regional water regulatory bodies in the Incomati catchment, recently recognized the need to integrate the inter-dependence of coastal function and livelihoods with catchment management.

In 1996 shrimping was Mozambique's biggest export earner, worth 35 per cent of total income from exports. In Maputo Bay, the shrimp industry provides livelihoods for about 3000 artisanal and semi-industrial fishers. The value of the annual catch of approximately 3000 tons was estimated to be US$3.5 million in the early 1990s. A case study of the Catchment2Coast Project focuses on this industry, in which the influence of runoff from the Incomati and Maputo river catchments on shrimp production in the bay will be specifically investigated.

The project comprises three phases, the first of which involves setting up numerical platforms using existing data sets to constrain model parameters, boundary conditions and process calibration. Each of the modelling platforms will then be used to undertake sensitivity analyses to identify the most important gaps in data and understanding.

The set-up phase will be followed by the implementation of a coordinated field measurement programme, together with the platforms using scenarios defined at a stakeholders' workshop. The data collected over three seasons will be used for verification purposes, and sensitivity analyses will be undertaken on the basic scenarios.

By the end of the third phase, in which all analytical exercises thus far will be integrated, the modelling platforms will be linked. It should then be possible to identify the most important forcing factors in the biophysical functioning of the catchment that have the greatest impact on the economics of shrimping in Maputo Bay.

Briefly, the modelling platforms to be developed in the project will involve the following aspects (Fig. 2).

River hydrology and water quality process dynamics

Available geographical information for the Incomati catchment, which will be delineated into approximately 200 sub-catchments, will be organized into a Geographical Information System. Existing data on land use, soils, rainfall, temperature, evaporation, runoff, abstraction, return flow, inter-basin transfer and dam releases will then be collated and formatted for modelling purposes. Aerial photography and field surveys will be conducted to investigate sedimentation and channel dynamics of the Incomati River. Data will be obtained for point source water quality, while non-point source pollutants will be inferred from an analysis of land-use and other field surveys. The refined and calibrated modelling system will be able to simulate the impacts of land-use changes and catchment management on hydrology and water quality for the entire Incomati system.

Groundwater hydrology and water quality processes in the Incomati estuary

This model aims to simulate the effects of changing groundwater quantity (flow) and quality (nutrients) on mangrove habitat. The development phase will include a literature review on current understanding of groundwater contributions to tropical estuarine and mangrove ecosystems. The model will use existing data on groundwater quality, water level, geology and recharge, as well as results from one annual cycle of field measurements, which will help develop local capacity in groundwater monitoring and geophysics.

Coastal–estuarine hydrodynamics and physical processes in Maputo Bay

A validated hydrodynamic modelling system with two-way nesting of the estuary, mangrove, bay and coastal system at Maputo will not only facilitate an investigation of the influence of river flow on coastal stratification and transport, but also contribute to the water quality, and shrimp production and population models. At the same time, the modelling simulations will improve understanding of the dynamics of regions of freshwater influence in sub-tropical systems.

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Sediment and water column biogeochemistry in Maputo Bay

Coupled sediment and water column models will initially be set up for the mangrove ecosystem, and later extended into a three-dimensional model for the estuary–bay–coastal environment, with inputs from the hydrodynamic, river and groundwater models. This will allow dynamic simulation of water column production and remineralization, and provide the production input fluxes for the shrimp production and population model. The modelling platform also has potential for use in understanding and managing other more generalized water quality and human health concerns related to the influence of the city of Maputo, its surroundings and remote rural areas on the bay system.

Mangrove ecosystem — habitat health and function in the Incomati estuary

Mangrove swamps are important nursery areas for the main shrimp species in Maputo Bay. Shrimp production is therefore affected by the health of these ecosystems, which in turn is influenced by the quantity and quality of river, groundwater and tidal flows. Healthy and disturbed areas of the mangroves of the Incomati estuary will be sampled to gather information on macro- and meiofaunal communities and sediment and pore water characteristics. A model of mangrove ecosystem dynamics will then be developed and linked to other models to simulate the behaviour of the ecosystem in different river management scenarios, and the associated impact on shrimp production. A monitoring and management plan will also be established for the mangrove ecosystem.

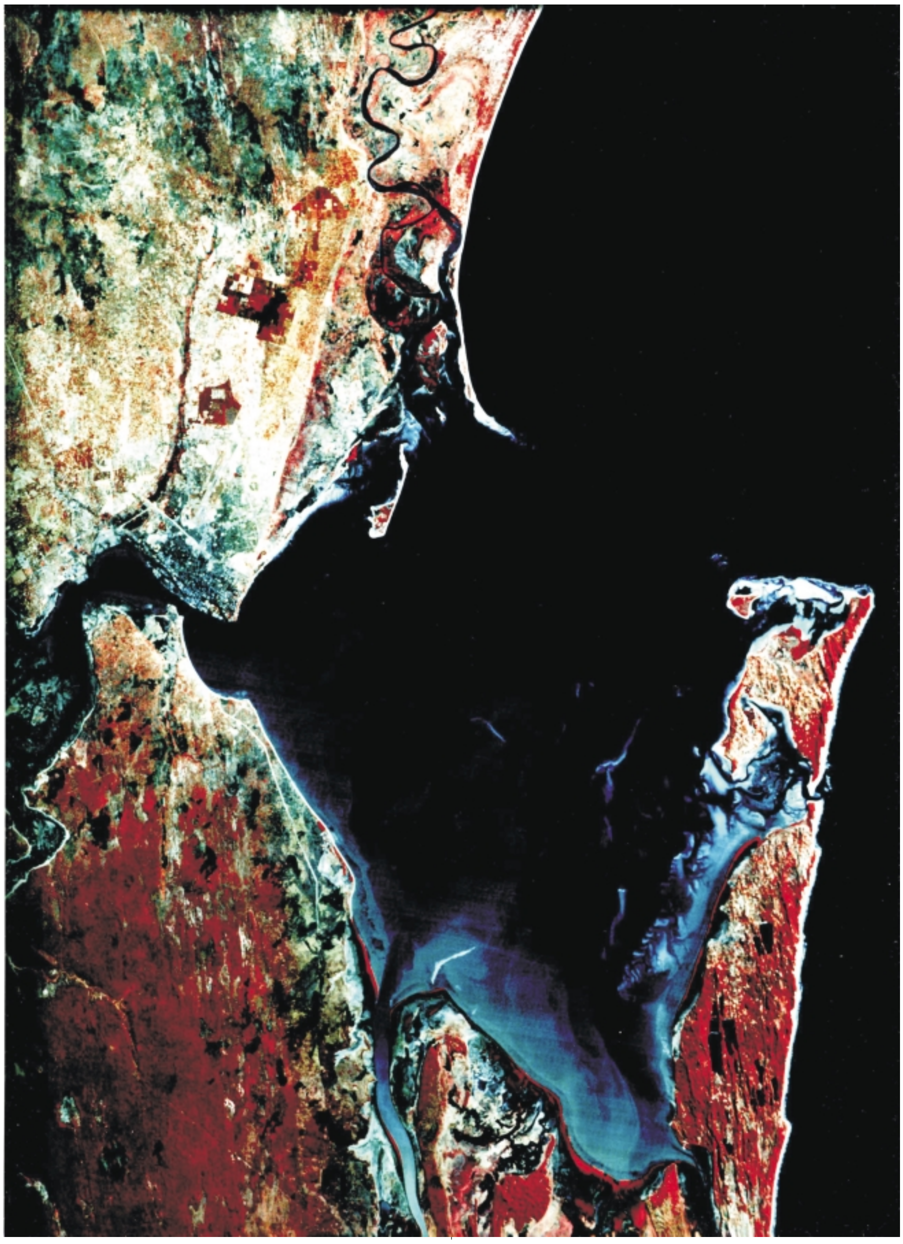

Fig. 1. A Landsat image of Maputo Bay showing the two major rivers — the Incomati to the north and the Maputo to the south — that drain into the bay. The city of Maputo surrounds the harbour area on the western boundary of the bay; Inhaca Island and Machangulu Peninsula form the eastern boundary. The bay is approximately 30 km wide.

The ecology of commercially exploited shrimp resources in Maputo Bay

Updated information on shrimp catches by the artisinal and semi-industrial fisheries in Maputo Bay will be analysed to estimate the maximum sustainable yield of the resource, and to recommend management measures for the fishery. Sampling will also be conducted to improve understanding of the recruitment of shrimp larvae into the bay and of the abundance and seasonality of post-larvae and juveniles in the Incomati estuary. An ecological model will then be developed and integrated with other models to elucidate the dependence of the shrimp life-cycle on the physical and biogeochemical characteristics of the system. This in turn will contribute to the overall catchment-to-coast modelling framework to simulate the effects of different management scenarios.

Resource economics modelling of shrimp production in Maputo Bay

The resource economics component of the project will use the shrimp industry in the bay as a case study. Shrimping's contribution to the broader economy will be quantified, and the driving forces governing supply and demand in the industry analysed. In addition, the 'goods and services' provided by the mangrove habitat to the shrimp industry will be identified and assigned a monetary value. This information will be used to establish a generic resource-economics model capable of translating the predicted variability in coastal ecosystem and resource production due to river catchment activities into an economic currency. The model will be used to inform policy recommendations.

Integration of models and systems analysis

An overall framework for analysis will be set up to provide a description of the linkages between the different models, including input and output requirements, time steps, boundary conditions and spatial resolution. However, it is not

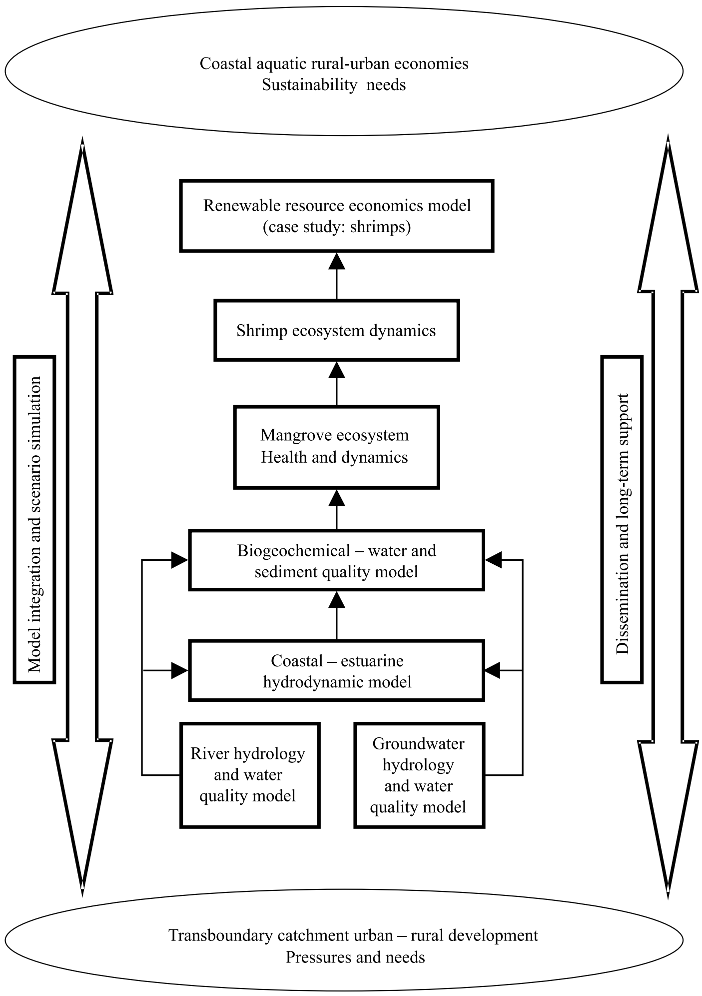

Fig. 2. Flow-chart illustrating the functional relationships between the biophysical and resource economics components of the Catchment2Coast Project.

intended to provide a fully integrated modelling system; instead a pragmatic and cost-effective solution will be developed with minimum software and maximum flexibility to run models separately. A number of scenarios for model runs will then be determined and the outcomes of these will be used to analyse the impacts of river flow on shrimp production, and to establish critical flow requirements. Based on enhanced understanding of the behaviour of the Incomati–Maputo Bay system, recommendations will be formulated for future catchment management here and in other tropical coastal regions.

The three-year Catchment2Coast project is a partnership between the EU-INCO Programme (part of the 5th Framework Programme), six institutions in southern Africa and three centres in Europe. The European Union is contributing half the funding (€1.2 million), with the rest being shared by the partner institutions. The southern African partners are the CSIR (Pedro Monteiro, Christine Colvin and Martin de Wit), University of Cape Town (Geoff Brundrit) and Natal University (Mike Savage) from South Africa; University Eduardo Mondlane (Antonio Hoguane, Adriano Macia and Diniz Juizo) and the Fisheries Research Institute-IIP (Rui Silva) from Mozambique; and the University of Swaziland (Jonathan Matondo). The European partners are Delft Hydraulics of the Netherlands (Marcel Marchand), the University of Wales' School of Ocean Sciences (John Simpson) in the United Kingdom, and the Institute of Marine Research (Joao G. Ferreira) in Portugal.

Most of the work will be undertaken by the southern African partners, with the European collaborators bringing to the project additional specialized capabilities in process understanding and in modelling tools. Interaction with the European partners is therefore expected to strengthen scientific capacity in the region, and this will be actively promoted through experience-based training of project members and postgraduate students. The project also aims to strengthen the links between aquatic scientists and resource economists, and to encourage institutional collaboration in the SADC region (Fig. 2). In the final stages of the project a legacy programme will be designed to ensure the continuation of capacity-building opportunities through, for example, scientific exchange visits, strengthening of graduate programmes and short courses for professional training.

A programme has also been started to raise awareness among interested parties of the project and its findings. Among the anticipated outcomes of this activity are media releases, brochures and the creation of a project website, www.catchment2coast.org. A simulation of river–coastal interactions will be used to demonstrate the benefits of the skills and tools developed in this project to the main regional stakeholders.

The Catchment2Coast project will provide a practical example of the need for high-quality biophysical understanding, at the correct scales, in developing ecosystem-based policy to manage the interaction of river catchments, coastal zones and their resources in a sustainable manner. It will also promote more equitable water allocation, taking account of renewable resources that depend on water flow and quality.

While the project will not provide all the answers for the management of Maputo Bay, we expect it to demonstrate a more effective approach to sustaining its resources through the integrated management of its catchment and coastal environment.

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AIDS: lessons from the front line

the world of street children, and the tools for survival they acquire there. For all but a few of them, the almost inevitable consequences are prostitution, petty crime, pregnancy, ostracism and, finally, HIV/AIDS. Understanding the plight of these children is simply a first step in just one of the many battles that need to be engaged and won in the fight against HIV/AIDS.

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