Chapter 5
Synthesis of Main Findings and Conclusions

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5.1 Global Change and Sustainable Use of Earth’s Coastal Zones

It is clear that global change to the environment is having a major influence on the functioning of coastal systems and their ability to sustain human development. A key outcome of the first 10 years of LOICZ is that, although major river systems have a profound influence on coastal and nearshore marine systems at a regional level, the mounting pressures from human development and their effects on coastal systems are felt most acutely at small to medium individual catchment scales. Furthermore, it is becoming increasingly evident from the LOICZ studies that the cumulative effects of human-induced changes in small- to medium-scale river systems may well be greater than those attributed to major river systems.

The LOICZ research described in the preceding chapters has demonstrated the importance of biogeochemical fluxes, nutrients and sediments from river catchments in the coastal zone for the availability of living and non-living resources for human society. The outcomes from LOICZ research have demonstrated that investigation of changes to coastal systems cannot be confined within administrative boundaries. Instead, studies need to be oriented towards watershed- and catchment-based perspectives to study coastal dynamics and to integrate the results with management of human activities. This reinforces the emerging concepts of integrated coastal management where the “coastal zone” is treated as part of a dynamic continuum linking terrestrial and marine components, rather than as an isolated “zone” that can be managed without reference to natural and human-induced changes to hydrology, or fluxes of materials in upland and oceanic systems.

The river basins or catchments (LOICZ-Basins) studies have helped to integrate the human dimensions to global environmental change by identifying the major social and economic drivers that lead to pressures with a direct or indirect influence on the state of ecosystems and corresponding impacts on biological, chemical, geo-physical, social and economic conditions. These studies demonstrated common as well as unique features concerning the rate and scale of change in human pressures among the different bio-climatic regions.

Integration of natural and social science dimensions in the LOICZ programme has clarified the principal problems and issues associated with global environmental change and consequent sustainability of human uses of coastal systems, including:

- eutrophication;
- pollution;
- changing erosion/sedimentation equilibrium;
- mounting impoverishment in the biodiversity of estuarine waters and coastal seas through a reduction in river-borne nutrients and organic matter;
- loss of ecosystem goods and services that help to sustain food security, economic development and improvements in social welfare; and
- increasing vulnerability of human societies to natural coastal hazards affecting settlements, public and private investment, property and lives.

Given the pivotal role that coastal areas and resources play in sustaining the social and economic welfare of up to 50% of Earth’s population, the major challenge that humans face today is to recognise and manage the consequences of adverse impacts from both natural and human-induced changes to coastal systems. History has shown how difficult it is to motivate nations to work together in addressing these issues at a global scale. However, much can be achieved at regional, nation-state and local levels to sustain human use of coastal systems. This can be done through initiating improvements in the management of human activities within catchments as well as within the marine and terrestrial components of the “coastal zone.” LOICZ methodologies have allowed up-scaling of local information to a global scale that can

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2 For the purposes here, a definition of human dimensions is “the effects of human activity on large physical and biological systems, the impacts of environmental change on people and societies, the responses of social systems to actual or anticipated environmental change, and the interactions among all these processes” (US NRC Committee on the Human Dimensions of Global Change).
then be down-scaled and applied to other local areas where there is a paucity of information. A major benefit from the LOICZ thematic studies is the provision of scientific evidence that could strengthen information available for policy, planning and management initiatives at small to medium to large scales. At the same time, LOICZ studies have greatly enhanced our understanding of the responses of coastal systems at a global scale.

### 5.2 Progress in Meeting IGBP-LOICZ Goals

During the past 10 years, the scientific effort of the LOICZ project has been directed towards answering the generic question:

*How will changes in land use, sea level and climate alter coastal ecosystems, and what are the wider consequences?*

The broad goals of LOICZ in addressing this question have been:

1. **Determination at global and regional scales:**
   a. fluxes of materials between land, sea and atmosphere through the coastal zone;
   b. capacity of coastal systems to transform and store particulate and dissolved matter;
   c. effect of changes in external forcing conditions on the structure and functioning of coastal ecosystems.

2. **Determination of how changes in land use, climate, sea level and human activities alter the fluxes and retention of particulate matter in the coastal zone and affect coastal morphodynamics.**

3. **Determination of how changes in coastal systems, including responses to varying terrestrial and oceanic inputs of organic matter and nutrients, will affect the global carbon cycle and the trace gas composition of the atmosphere.**

4. **Assessment of how responses of coastal systems to global change will affect the habitation and usage by humans of coastal environments, and to develop further the scientific and socio-economic bases for the integrated management of coastal environments.**

These goals and objectives have been addressed by a global network of scientists in which the active and collaborative participation of scientists from developed and developing countries has been vital to the successful conduct of the research and dissemination of results of the LOICZ programme. This network has compiled many local case studies, which form the data and information base that has been up-scaled for construction of the global synthesis.

Progress has been made in generating a comprehensive overview of the changes in Earth system processes affecting the coastal zone, the role of coastal systems in global change and the current state of coastal metabolism. This includes identifying simple proxies in the form of demographic and hydrological parameters, that can support the prediction of the state of coastal systems. Typology approaches supported by analytical and visualisation software have been developed to assist in the interpolation of these results for remote areas where primary information is lacking, thus enabling a first order up-scaling to a global synthesis.

Important scientific questions have been answered. For example, estimates of carbon fluxes and their modification by natural systems and human activities in coastal regions have been developed through the up-scaling of local nutrient budget data collated and analysed by LOICZ. Another success is the identification and analyses of nutrient loads transmitted to coast systems and an evaluation of the global increase in nutrients over recent decades. The LOICZ research has also provided new insights into the influence of global climate change on the dynamics of coastal systems with respect to sediments, groundwater and sea-level and how these may influence the long-term habitation of coastal areas and sustainable use of natural resources.

The main findings from the thematic studies produced new information of value in broadening our understanding of global systems and addressing management challenges at various scales, centring upon three areas of investigation:

1. **The Material Fluxes effort** relied more heavily on scientific evaluation of fluxes, measurements and models. Although most of the results stemmed from paper studies and scientific workshops, new data were assembled through the publication of compilations of information and model results and a series of field measurements and experiments. The latter activity was a joint LOICZ/SCOR working group on submarine groundwater discharge. The results of the overall effort consist primarily of an enhanced understanding of the issues involved in coastal zone fluxes, of the variety of forcing functions controlling them, and in the development of an inventory of relevant tools and the understanding of where and how they may best be applied.

2. **The Biogeochemical Budget effort** pursued a course that was in many ways intermediate between, and conceptually linking, the other two – using local expertise to assess the nature and status of biogeochemical fluxes in coastal waters in a quantitative, inter-comparable fashion. The systematic classification of budgets and associated flux data, and the terrestrial and marine systems they represent, provided a basis for identifying potential functional similarities among measured and similar unstudied systems – the typological up-scaling approach.

3. **The River Basins effort** used a standardised approach to identify and assemble regional “expert judgment”