Specifying User Needs for Global Change Science in Coastal Zones

by

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Abstract

Coastal areas are getting continuously under increasing pressure for human settlement, use of natural resources and spilling waste. There is no other type of ecosystems that undergoes such dynamic and hardly to forecast changes than coastal areas do. One expects that currently more than 60 per cent of the world population are sustained by the coastal zone (Lange, 1999). With a view on spatial, food and material resources provided by the earth coastal zone environments this seems to be a rather conservative estimate. However, no matter what the exact figure is the pressure on this global domain continuously increases due to growing demands first of all caused by a growing world's population. This development will obviously cause substantial changes in the structure of coastal areas and their functioning. The increasing pressures will cause changes in environmental as well as social states of both the environmental as well as the social system. These changes are related to a magnitude of foreseeable and unforeseeable impacts to the natural and social environment that will require appropriate response. Human response to such changes bases on decisions that should safeguard a development that eventually has to support sustainability. However, it is still quite the exception rather than the rule that humans use their environments in a sustainable way presently.

Moreover, the way indigenous people live in sustainable economies that base on a day-to-day subsistence not on market economy driven by individual interests may only serve as a model for a sustainable economy. The economy of indigenous people was determined by limited wants that offered unlimited means with regard to limits in population growth (Ponting, 1991; Gowdy, 1998). Social and economic pressures on coastal structures and ecosystem functioning are mainly related to drivers such as rise in population number or commercial use of resources such as fish, seaweed or gravel, land transformation, agriculture, transportation or industry including tourism. The concurrent development drives into an impasse that needs concerted action of analysis, science and spatial planning (Turner and Bower, 1999, Fig. 1.3), which in the sense of ICZM (Integrated Coastal Zone Management) leads to application of non-static management strategies and thus to sustainable delivery option for goods and services. In practice this IZCM implementation means to redirect economy, planning for urban and agrarian development, to mitigate environmental impacts, to safeguard social development and to involve stakeholders in decisions that may support sustainability.

Human's action bases on decisions. Humans do their decisions in a world that only allows in part foreseeing or predicting consequences of decisions. Uncertainty, unpredictability and surprise are constitutional parameters of decision-making systems therefore decisions call for

support systems that allows at least to reduce uncertainty (Köhn, 1997; Kremer, 1998a, van der Weide and de Vrees, 1999). Decision support systems mainly base on experience from past decisions but increasingly and complexity driven they rely on scientific advice. Social and biophysical sciences may ideally supply a set of different decision supporting systems that in one case more than another involves stakeholder experience. Big scientific programs like the IGBP/LOICZ (International Geosphere Biosphere Programme / Land Ocean Interaction of Coastal Zones Programme) and ELOISE (European Land Ocean Interaction StudiEs) are asked to put increasing effort in a user oriented synthesis. Not only should they cover those issues seeking scientific advice but also broker their respective deliverables to the various client groups continuously. Obviously a deliberate identification of users' needs against their different issues and the deliverables matching these needs is obligatory.

This paper will in particular reflect on the subset of potential deliverables of global and regional environmental change projects like LOICZ and ELOISE. It addresses questions such as: What are the issues, e.g. relevant uses that need decision support? Who are users involved in such decisions? What are their interests? What do users need to decide what? Why users should be involved in science and vice versa? When and how users should be involved in doing science? When and how should science be involved in decision-making? What are the user expectations from science and when is scientific advice required and for what purposes? What should science deliver to properly address the numerous physical, geographical, temporal and administrative scales of issues in overlapping systems? What are experiences that may be useful for ICZ? In conclusion we are trying to combine the scientific innovation cycle with decision-making by designing a perpetual information cycle that based on mutual interests and participation may support decision-making in coastal zone management.

Introduction

Science especially applied science is committed to assist understanding and managing regional and global programmes that are designed to deal with environmental, social and political change or to resolve conflicts. Therefore, science is asked to provide a better and systemic understanding of the earth systems functions and the role of humans in these processes. This is why we are trying to capture and synthesise increasing amounts of (scientific) knowledge for different guiding questions related to issues such as climate change, environmental vulnerability and diminishing biodiversity (Köhn, in prep.). At the same time, market economy progressively substitutes for subsistence based economy even in many pristine parts of the globe that are managed by local people in a way that bases on traditional rather than scientific knowledge (Keohane and Ostrom, 1995; Berkes and Folke, 1998).

Consequently pressures exerted on the earth systems increase continuously and information needs of those whose interests are at stake are changing as well. In order to meet the challenge of safeguarding a functional earth system dynamic socio-economic and political responses are required to handle respective state changes and to mitigate impacts to the environment and the socio-cultural systems. One response – the AGENDA 21 of the UNCED (United Nations Conference on Environment and Development) summit in Rio 1992 – pulls together a comprehensive package of potential measures, which on a scientific level can be summarised as a logical shift from curiosity driven to issue driven science. In other words, a 'sustainability science' emerges that underpins decisions necessary to implement integrated management systems. In our case it is integrated coastal zone or integrated coastal area management (ICZM or ICAM). Integration in this connection not only means to put together the different issues in a relevant areas. It also means to encompass the different stakeholders including sciences (for instance, in global/regional change programmes), resource users, the general public, the policy makers, NGOs (Non-Governmental Organisations) and coastal zone managers, e.g. land use planners and administration.

Needs of users

Introductory remarks about users/stakeholders

Identification of the respective multi-users involved in certain coastal zone management issues and their interests is very important for addressing the outcomes of research in a proper ‘language’, that is a language and argumentation every stakeholder can understand, follow and synthesise for plans or action, and levels of detail. Equally important for the mediation or brokering process between producers and users of knowledge and know how are tools and measures allowing for successful participatory approaches. Crossland and Jordao et al, elaborate on this topic in detail (this publication).

User interests – recent sociology uses the term stakeholder instead of users – are different in many aspects. Users such as scientists from pure and applied science, technology developers, public authorities and decision-makers, public and private households, tourists, fishermen, private firms, and military services use or consume coastal resources or functions directly or indirectly. In tendency the intensity of uses for market economies grows faster than for subsistence purposes. Thus, resource use today often has to ensure maximisation of deliveries for a spot or regional or even global market instead of assuring lifelong supply for those people depending on these or complementary resources of a specific coastal region only.

A question of scaling

Furthermore, considering pressures on coastal zone systems from a stakeholder perspective requires to distinguish between offsite and onsite uses of coastal resources, structures and functions (Köhn, 1996). Turner and Bower (1999) suggest three different areas of interest in the coastal zone to be considered for integrated management purposes

1. politically designated management areas,
2. ecological areas,
3. demand areas, which can exert distant pressures on local or regional resources.

All coastal areas are already naturally under high evolutionary pressures. Physical and biological processes and on top anthropogenic driving forces add in magnitude and number to coastal change processes that physical sciences just begin to understand to an increasing extend. Both, naturally and socially caused pressures frequently do not originate in the coastal zone itself but are results of processes in the respective drainage basin that affects a certain coastal strip (Costanza and Greer, 1995). This applies for example to nutrients and pollutants that had been accumulated upstream. Such offsite effects perturbate the ecological balance of the coastal zone, which is in an ‘end of the river catchment’ position receiving various impacts caused by distant system changes. ICZM therefore calls for concerted action not only addressing coastal zone but also integrating the catchment area into the management efforts to reduce runoffs. This was described by Odum (1969) and has recently been elaborated further in the context of impacts on Continental Aquatic Systems, **CAS**, by Meybeck (1998) who has summarised among others the coastal relevance of upstream processes (Tab. 1). IGBP in response recently established the ‘Water Group’, a cross programme initiative of the BAHC (Biospheric Aspects of the Hydrological Cycle), LOICZ, PAGES (Past Global Changes), LUCC (Land-Use/Cover Change) and GCTE (Global Change and Terrestrial Ecosystems) core projects indicating the transboundary character of coastal process changes and their links to the CAS. The table below summarises the state – impact relationships and lists the global issues involved.

The LOICZ project increasingly contributes to this IGBP approach through its ‘BASINS’ concept, which highlights the human dimensions of flux changes to the coastal sea. Addressed are for instance, drivers of change and residual production (C, N, P, sediments and pollutants) as well as environmental quality aspects in terms of capacity – load relationships. These projects also pay more and more attention to threshold theory (Salomons, 1998).

To employ integrated management in this process and to build up a broker function of organisations and institutions requires advisory scientific consultation in such a way that coastal managers and resource users including in particular communities and the private sector upstream may realise and own responsibility for a healthy coastal zone environment. However, the process of ICZM has to provide both, the broad scale options addressing the whole system of pressures, states and impacts as well as options to deal with individual conflicts to enable appropriate response for action on the various scales.

Table 1: Important global threats on Continental Aquatic Systems, CAS, and related issues (adapted and supplemented from Meybeck 1998).

Environmental State Changes	**Major impacts on the Coastal Zone**	**Global Issues**						
		Human Health	**Water Availability**	**Water Quality**	**Carbon Balance**	**Fluvial Morphology**	**Aquatic Biodiversity**	**Coastal Zone Impacts**
1 Climate Change	• Changes in Soil Erosion			4	4	4		4
	• Extreme Flow Events		4			4	4	4
	• Changes in Wetland Distribution	4	4	4	4		4	4
	• Changes in Chemical Weathering				4			4
	• Develop. of Non-Perennial Rivers		4	4	4	4	4	4
	• Salt Water Intrusion in Coastal Groundwater		4					4
2 River Damming	• Carbon and Nutrient Retention				4			4
	• Retention of Sediments and particulate Matter				4	4		4
	• Creation of new Wetlands	4		4	4		4	4
3 Land-Use Change	• Wetland Filling or Draining			4	4		4	4
	• Change in Sediment Transport			4	4	4		4
	• Nitrate and Phosphate Increase	4		4	4			4
4 Irrigation and Water Transfer	• Partial to Complete Decrease of River Fluxes					4	4	4
5 Release of Industrial and Mining Waste	• Persistent Organic Pollution	4		4			4	4
	• Salinisation	4		4			4	4
	• Heavy Metal Increase	4		4			4	4
6 Release of Urban, Agricultural, Domestic and Ship Waste (incl. Ballastwater)	• Eutrophication	4		4	4		4	4
	• Persistent Organic Pollution	4		4			4	4
	• Develop. of Waterborne Diseases, e.g. through transfer of pathogens and non-indigenous species in ballastwater (Gollasch 1996)	4					4	4

To give an example, long-distance transportation of nutrients along atmospheric trajectories reflects an additional potential for long-term and diffuse impacts originating from anthropogenic drivers as well as naturally caused global change. The Helsinki Commission (1996), for example, reports that 30 to 40 per cent nitrogen and ammonium input into the Baltic Sea originate from atmospheric deposition encompassing all sources in Western, Northern and Central Europe. Thus targeting a clean Baltic Sea environment requires concerted action in emission abatement strategies throughout Europe.

In conclusion, environmental state changes in coastal zones, which are externally forced across numerous physical and social boundary conditions require increased consideration of response options covering various interest, spatial and temporal scales. Science must account for this demand and underpin the decision support needed through understandable and issue driven information for all levels of scales. This scaling exercise must be properly executed and applies to the formulation of the scientific issues, the respective cross-sector client questions as well as the research deliverables (Köhn, 1998). It is a crucial task for larger synthesising experiments like ELOISE and LOICZ if they really claim being responsive and thus acting as brokers.

Response to user needs requires holistic views

There is no doubt that geo- and biophysical sciences significantly contribute to improved understanding of environmental pressures on and states of ecosystems. However, applying holistic views for the description of certain local or regional demonstration sites needs strong efforts to further elaborate on impacts and responses on the level of human systems. Westley (1995) thus calls for enhanced integration of socio-economic science.

It is for sure that at present a lack of interdisciplinary understanding is a major obstacle to sustainability. Parson and Clark (1995) and Michael (1995), therefore, argue for designing processes of social learning in a turbulent human ecology. Their pleading applies very much to the socio-ecological, socio-economic and political economy of sustainability in coastal zones (Köhn, in prep). Designing interdisciplinarity and co-operation is the task ahead we are facing in the scientific community in order to provide tools for decision-making. It is also the key need in issue driven science that is expected to enable the translation processes needed to match individual client demands for scientific advice. Executed continuously from the beginning interdisciplinary and participatory science helps finding a common language that facilitates understanding and joint ownership of issues and actions during the process of transfer (see Crossland, this volume). In some cases of course, the more scientific discussion may stay with the scientific community to avoid confusing the public.

As a bottom-line for understanding and concerted action may serve an overall acceptance of the dynamic and interacting co-evolution of the two groups of – natural and human –systems (Turner and Bower, 1999). This is absolutely pivotal for generating a clear vision of the advisory demands of heterogeneous client groups, and how they may benefit best from scientific products. This is essential for successful ICZM implementation. Making a long story short: We are lacking holistic thinking and systemic scientific approaches (Cable and Cable, 1995) allowing for decision-making towards sustainability in terms of its advisory deliverables.

However, besides transferring information for a public or political understanding to initiate appropriate action science may not forget to recombine information for an (eco-) system-oriented handling. This is in many cases not as easy as it seems to be. Van Ierland and

Schiemann (1999), for instance, reported that reducing a single pollutant caused increasing impacts of another and therefore made the situation even worse. In summary benefits of options, gains and losses of different management strategies and trade-offs need to be highlighted from both the physical and social science perspective (Burbridge, 1999; Turner and Bower, 1999). This also is a major client expectation to holistic scientific approaches.

In order to cope with all these interdependent needs and expectations the application of a holistic descriptive framework to different coastal settings is a recommendable platform. Van der Weide and de Vrees (1999) and Turner and Bower (1999) give detailed insights on how such a scheme can be used. They illustrate a framework that enables understanding and acting from a systemic perspective. It includes socio-economic drivers and creates a link to state changes affecting the cycling and fluxes of carbon, nitrogen and phosphorous, sediment fluxes as well as stocks and resource use, goods and services.

The pressure-state-impact response, P-S-I-R, framework

The framework as outlined in more detail by Turner and Pirrone (this volume), Turner et al., 1998a; Scialabba, 1998; Turner and Bower, 1999; Van der Weide and de Vrees, 1999) tries to capture the variant aspects of external forcing of coastal change regimes comprehensively. Certainly this means natural changes caused by e.g. climate and sea-level change, vegetation cover etc. but equal effort is directed to include impacts of anthropogenic origin like land use and cover changes as for example urbanisation and aquaculture, expanded tourism or transport respectively.

Integrated modelling built on scenario descriptions that derive from PSIR framework application will allow both, future scenario building and reconstructing the interactions of drivers that caused past time events. Resulting peer reviewed scientific deliverables may prove beneficial when applied to management of coastal areas. By including those socio-economic '**drivers'** than referred to as **D-PSIR** framework solid answers against the major issues coming from coastal resource usage can be derived. Their inherent hind- and forecasting capacity D-PSIR site descriptions may lead to dynamic modelling that features the human dimension of coastal change and facilitates decision-making.

The D-PSIR framework is a tool that captures the different forcing functions and levels in coastal change regimes in a way that should allow appropriate scaling of scientific work. While **drivers** refer to the socio-economic forcing factors – sectoral pursuit of stakeholder interests through the exploitation of one or a limited number of environmental functions, goods and services –, **pressure** refers to forces and interactions that are likely to change the coastal system. The **state** parameters of the coastal system represent the boundary conditions of significant functions of the system that may be affected by these pressures. Changes to this state may lead to **impacts** that may affect both environmental and economic processes (the human system) within the coastal zone.

Combined information on pressure, state and impact forms a basis for potential trade-offs between conflicting interests. This is particularly achievable if indicator functions can be allocated to the parameters measured (for LOICZ these are mainly the bio-geochemical cycles and fluxes of C, N, P and sediments). Hence, **response** describes the policy and management action and opportunities that are or can be taken to mitigate the undesirable impacts of pressures imposed on the state of a specific system. Employed in scenario building these results may elucidate alternative management strategies and their enabling policy instruments, which need to be applied to facilitate trade-offs in the light of relevant policy goals. Thus current 'response-performance' may also face some scientific evaluation. LOICZ, is developing tools for this purpose to fulfil its commitment to make science useful for coastal management (Pernetta and Milliman, 1995) in particular through its focus 4 (see below).

The LOICZ approach and deliverables

This section again refers to the D-PSIR framework while introducing briefly the LOICZ Project and its relevant parts. LOICZ, which is one of eight IGBP core projects encompasses an array of natural and social science research to provide information on both anthropogenic and geocentric driving forces of coastal change to the global community. This information is designed to satisfy the needs of users like global decision-makers and coastal zone managers on different scales. The approach taken is to generate estimates of the fluxes of materials like C, N, P and sediments into, through, and from the world's coastal zone (Pernetta and Milliman, 1995). Increasing effort is being put on the human dimension of these flux changes i.e. how socio-economic **drivers** affect these fluxes through the coastal zone as a receiving body of transboundary transports.

In practice LOICZ supports the development of horizontal and, to a lesser extent, vertical material nutrient, pollutant and sediment **flux models,** which provide coastal sea bound budgets of nutrients, carbon and sediments. These models try to capture processes, which are influenced by or actively affect transboundary fluxes at the interface of the land/river drainage basin and the coastal environment as well as the atmosphere and ocean. They describe the **state** of the respective coastal compartment and doing so they consequently integrate material transportation throughout the whole water domain from the continental basins through estuaries and regional seas. Such biogeochemical process analysis and their time paths is fundamental for our understanding of coastal ecosystems and habitats.

Along with this biogeochemical approach LOICZ pays increasing importance to the human dimensions of fluxes (Kremer and Pirrone, 1999). The task is to identify those parts of biogeochemical flux changes in the coastal sea that can be attributed to peoples' activities referred to as **drivers** of change. Society **response** considers both types – the naturally and socially driven compartments – of changing regimes in system processes. This interplay makes the respective CZM process – if employed at all – look like an increasingly faster circling spiral, which ideally follows sustainable coastal zone management principles (Scialabba, 1998, part A). The difference between two "time shots" of D-PSIR scenario descriptions of a certain coastal site taken at T_0 and T_1 (see figure 1) may than be explained at least partly as management response(no matter whether effects seen are positive or negative at this stage).

If reviewed in the context of critical loads reaching the coastal environment (Salomons 1998 and Salomons et al., 1999) flux changes are indicators for the **pressures** exerted on the system and the level of **impacts.** Critical fluxes induce or may induce changes within environmental systems that may have unexpected feedback on the social system. The database used to develop models of fluxes, budgets and their changes over time generate a set of indicators that allow for monitoring and detecting for anthropogenic and non-anthropogenic **drivers** on different scales. Consequently, these LOICZ outcomes deliver options for abatement strategies and **response** options. In other words, LOICZ science delivers tools for ICZM, which can match different user expectations. The spatial and time scale applied for proper science exploitation depends on the issues coastal zone managers must address.

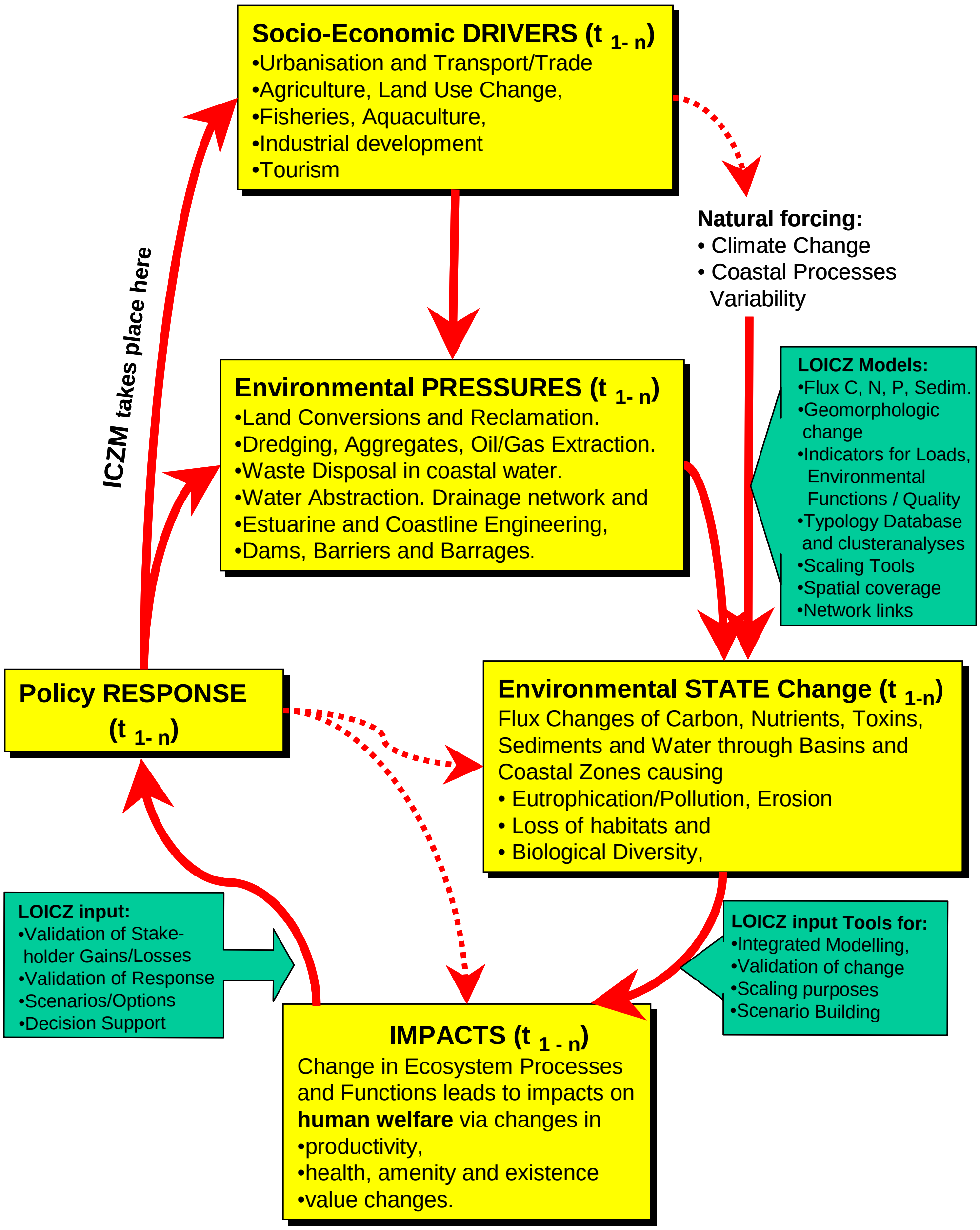

Figure 1. The D-PSIR framework adapted from OECD (1994), European Topic Center on Marine and Coastal Environment (1996) – Indicators for the environmental issues in the European coastal zone (Turner et al., 1998). Outlined are examples for the different elements, the dynamic interlinks and potential LOICZ contributions against the needs of the different stages.
The suffix (t $_{1-n}$) indicates the change (between investigation at time 1 and n) in the interrelations of the elements at one demonstration site, as consequence of natural effects and/or response action taken. This means that after one 'coastal management' action, no matter whether it is success or failure the driver – pressure – state –impact scenario may look different. The circle can be applied again. In fact it becomes a three-dimensional spiral rather than a single layer projection. Of course on e must be sure to be able to distinguish between natural from human forcing of change observed.

Based on these different aspects LOICZ tries to employ the **pressure, state change, impact** and **response** scenario description to enable dynamic pictures of how natural and socio-economic forcing functions interact and impact coastal zone processes on various spatial and temporal scales. Relevant for users is to improve of the predictive capacities in the modelling approach. Thus while single models still remain approximations by capturing different scales and historical data one may continuously improve forecasting.

The LOICZ structure and research foci

The major topical LOICZ core projects, some of which will be elaborated further in examples in this paper include:

- **Regional Basins (currently planned on EU level as EUROBASIN, in Latin America - Latin Basin – and planned for Africa, South and South East Asia)**
- **Coastal Typology**
- **Biogeochemical Modelling**
- **Deltaic Processes**
- **Continental Margins Task Team**
- **South East Asia Project SARCS/WOTRO/LOICZ**
- **ELOISE (this project comprises 29 EU funded research projects)**

The LOICZ activities are organised along four scientific foci:

F 1: Effects of changes in external forcing or boundary conditions on coastal fluxes;
F 2: Coastal biogeomorphology and global change;
F 3: Carbon fluxes and trace gas emissions;
F 4: Economic and social impacts of global change in coastal systems.

The Foci bring together and integrate world wide and regional (e.g. ELOISE) research programmes and assessments dealing with fluxes of carbon (especially CO2, with consideration of trace gases), nitrogen, phosphorous and dissolved and particulate matter into and between coastal basins and coastal seas. They include the forcing functions and boundary aspects mentioned earlier. In order to illustrate the human dimension of coastal change LOICZ has outlined a modelling approach, which uses the 'currency' of biogeochemistry and relates these to monetary and societal figures (Turner et al., 1998). This is aimed to generate a combination of physical and socio-economic indicators. Underpinned by economic science valuation studies and measures to price environmental goods, services and amenities may assist decisions of policymakers. It will be an increasingly user oriented challenge for LOICZ and ELOISE to either put an economic value on biogeochemical fluxes or to find non-monetary indicators in biogeochemical parameters for the same purpose (Aguirre-Munoz et al., submitted). While the first may directly indicate sustainable or non-sustainable use of coastal resources (goods, services and amenities) the second tool provides indirectly for the same objective.

In addition LOICZ supports the development of coastal typology classification tools and methods. This research by setting up a natural and social science data set of 113 variables to one grade coastal squares tries to find a coherent approach and kit to resolve the up-scaling issue. Cluster and fractal analyses are employed to detect similarities and compare matching areas against different physical, biogeochemical or social sub-criteria, without necessarily starting new generic research everywhere. In this context LOICZ supports and contributes to the development of database-dependant key indicator monitoring programmes that particularly serve local and regional user needs (e.g. C-GOOS, the **C**oastal module of the **G**lobal **O**cean **O**bserving **S**ystem of the **I**ntergovernmental **O**ceanographic **C**ommission

IOC/UNESCO; see also section 6.1.4). Focus 4 tries to feed the indicators into the creation of if-then-scenarios superimposing the human dimension of changes along the D-PSIR framework for coastal zone management as a planning tool. If this effort results in a "D-PSIR" typology (Kremer, 1999) it may serve for developing coherent policy for clusters of coastal settings.

Addressing user needs – LOICZ & ELOISE brokering ICZM

When talking about ICZM as process planning science grows into a mediator role. Brokering the transfer of issues and related knowledge between the different groups involved will be needed to allow for joint ownership of issues and research action taken. This may foster extended peers discussions of users (Funtowicz and Ravetz, 1993) and eventually extended peers decisions. Extended peers are characterised by seeking consensus among stakeholders by exploiting best practise and best technological options to assure resilience for the decision-making and the succeeding implementation processes. Following Biesecker (1996) this only is possible when extended peers are designed to fulfil the following conditions:

(1) the inclusion of all those potentially affected (users, stakeholders, property owners)
(2) mutual acceptance to guarantee joint ownership of issues
(3) the equality of the rights of all participants
(4) the possibility of revising each position as well as the results
(5) the open-endedness of the discourse
(6) equal access to information
(7) the absence of power (formal equity).

No matter that science is one key player (and stakeholder) in this concept it can play an important role by assuring the equal access to information for all parties involved in a way everybody can participate through understanding and sharing information. Under these conditions and provided an early involvement of the general public management achievements like for example new fishery management schemes, coastal protection strategies and technologies, master plans or projects are realistic. While operational on few local and regional scales (e.g. the Barrier Reef Australia, see Crossland this volume) this kind of participation is still vision along most of the global coast line.

As many others, also the Global Change Science Community of IGBP recently picked up the issue of how best to address the transfer of its results to users. Different scales from global (e.g. the **I**nternational **F**ramework **C**onvention **C**limate **C**hange, IFCCC) to smaller regional scales are touched in a pilot project on 'results transfer' run by BAHC and GCTE, which also receives European Union support. Common understanding to the programmes is to address two ways of science–user interaction, which are

a) based on the application of already existing science or, in other words, have science in place and than streamline and apply the results against the clients' needs;
b) generate an early involvement of policy and resource management throughout the research process; (IGBP., 1999; briefing documents 7.1, 7.2 for the 14 SC IGBP Feb. 99 in Estoril, Portugal – IGBP Secretariat, Stockholm, Sweden)

Both ways have to be considered today. To step into successful results transfer careful identification of clients, their interests and issues and how their interests may be addressed by science and vice versa, i.e. what the users' expectations are and how they understand science is one of the major objectives for a broker. LOICZ and ELOISE may serve as brokers (see figure 2, modified from Kremer and Pirrone (1999) when i) they evaluate their past current and future outcomes against those needs and ii) when taking a neutral position between the stakeholder groups either as part of management dialogue groups or as part or moderator of a coastal forum. The latter for example has been engaged in some of the elements of the ICZM Demonstration Project of the European Commission (Directorate General DG) XI, (EU, 1999a, b) for example in the Dorset South UK part project.

Of course, following the outcomes of a recent conference on enhanced consultation between the EU research and development (R&D) administration (DG XII) and other executive parts of the Commission (Kremer 1999) this kind of brokering issue driven science to users has been accepted to be beneficial on the European scale for various users. The Commission itself should take the mandate and pursue this process actively. This also means for example to disseminate the findings made in course of the ICZM demonstration programme run by DG XI, link them to the science funded through R&D policy and provide for active involvement of advisory bodies such as the environmental management agencies like EEA. While a lot still needs to be done this discussion at least indicates increasing awareness to act towards the issue of science/user brokering in terms to enhance human welfare. Future will now have to show how this reflects in the practical willingness on different levels involved. However, besides serving as a mediator a crucial task of science remains to underpin the ICZM implementation through hard information, technology and prediction tools addressing functioning and interaction of natural and socio-economic systems, and to develop curricula for training and capacity building.

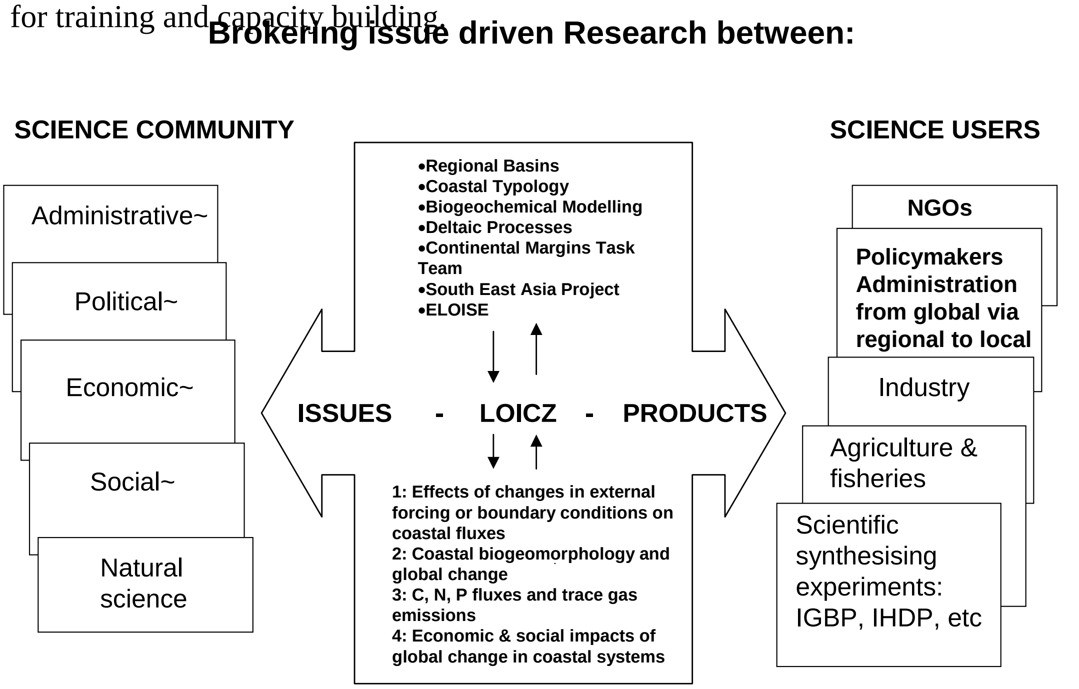

Figure 2. Projects like LOICZ aimed at global, regional, and local networking and synthesising to enhance multidisciplinary understanding of the coastal-catchment-ocean-atmosphere exchange processes and interaction in global change can take a vital role in brokering issues and deliverables between science and user groups.

The following chapter tries to enrol a first calibration of the contribution LOICZ and ELOISE might provide in form of science products to the decision-making and policy cycles related to coastal zone management. This will be outlined along examples for different clients making reference to the D-PSIR framework.

Users – examples for a multi-character group

Introductory remarks:

Stakeholders or users, we use the terms for simplification as synonyms here, in coastal zone management are individuals, groups, organisations or institutions claiming special interests in coastal zone issues. They may use coastal resources such as fish or minerals, draw benefits from space and functions such as the tourism industry (Sarda and Fluviá, 1999) or benefit indirectly from coastal zone economies by selling technologies for coastal protection etc. Users are also those who are engaged in nature protection, for spatial planning and decision-making in coastal zones. Eventually, the scientific community that focuses on coastal issues or working in basic science on coastal questions is a user. Along with the different user issues specific sets of questions can be identified, which seek advice needing targeted science exploitation.

The classical but partly paradox way for getting answers against current questions, as outlined by IGBP (see above), which is also valid for past and current LOICZ work, is trying to add value to already existing scientific results. This means to tailor available knowledge towards current and also future user needs, i.e. making '*old*' science responsive to future issues. However, new requirements of coastal zone management externally forced through for example global warming cannot rely on experience only. Therefore also new innovative ways of synthesising have to be designed for experiments like LOICZ and ELOISE, which respond to the user needs identified from the beginning in deliberate continuous consultation.

Relevant user groups and how LOICZ/ELOISE respond to their needs – A few examples

The science community

Slightly different from classical users not less important also the coastal science community comprising natural scientists, sociologists, economists, anthropologists and others is part of the heterogeneous group of coastal users. For example the disciplines and various institutes compete for limited funds. However, to gain a better understanding and explain the interrelationship between oceans, the coastal zone, the hinterland, the water regime and the climate as well as the spatial and time scales on which these compartments operate research programmes should communicate and interact as much as possible. For different science disciplines participating in one single programme it is in particular pivotal to accept that they are clients who mutually depend on each other results. Within LOICZ natural and socio-economic science may ideally interact across their special foci.

IGBP as an example:

A huge global synthesising effort like IGBP and its core programmes in fact use this kind of cross-discipline interaction as well. To fulfil its commitment to provide a comprehensive quantitative synthesis on global change issues in particular the biophysical processes that regulate the Earth's surface and its capacity to support life IGBP is the major client for the deliveries of its own core projects. Major motivation originates from questions around the risk of global warming or the related discussion on sea level rise and green house gas cycling searching for the missing one Gigaton of carbon (Smith et al., in prep.). How LOICZ on a global and ELOISE on a regional level may respond to this need is outlined here:

IGBP/LOICZ, and its core project ELOISE, provide science information to answer the generic question: “How will changes in land use, sea level and climate alter coastal ecosystems, and what are the wider consequences?” (see also http://www.igbp.kva.se/). LOICZ recognises that the coastal zone, the place where land, sea, and atmosphere meet is not a line boundary of interaction but a global three-dimensional compartment. It is a significant domain, not only for biogeochemical cycling and global matter fluxes but also for human habitation, which on the other hand strongly influences these processes. In the major LOICZ questions (Figure 3) addressing coastal issues on a global scale one may easily recognise the generic IGBP task and get a good grasp on the user-provider relationship between the two huge experiments.

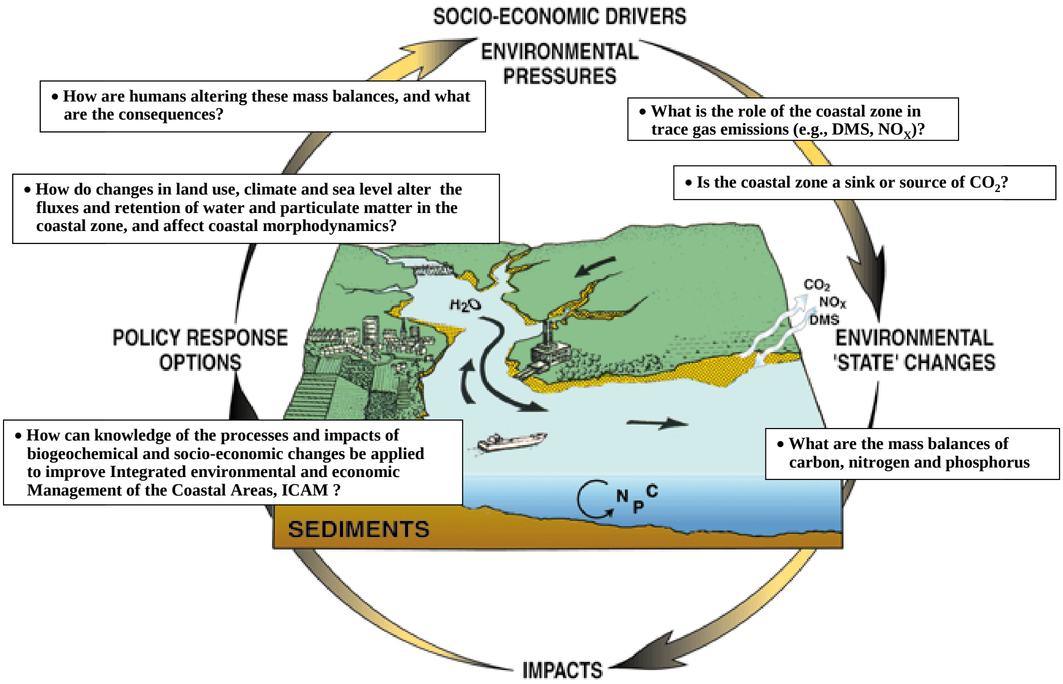

Figure 3. The six major LOICZ questions applied to the whole catchment-coastal sea-ocean margin water continuum. Transboundary modelling also covers exchange processes with atmosphere and bottom.

Products for the global change science community and IGBP

Evolving from the foci (Table 2) the own synthesis process LOICZ will provide different products, which also have high significance for the global IGBP syntheses.

Table 2: LOICZ deliverables against some key needs of global change synthesis (IGBP as a client).

<table>
<tr><th>LOICZ Focus</th><th>Deliverables</th><th>IGBP Needs</th></tr>
<tr><td>Focus 1:
The effects of changes in external forcing or boundary conditions on coastal fluxes</td><td>Regional synthesis estimating the catchment basin – coastal sea interaction including the critical link to drivers like land-use and cover change and climate change;
In co-operation with focus 3 and 4 quantifying models of anthropogenic residual C, N, P, sediment fluxes and change vital for use as indicators
Tools for global upscaling of the regional basins information captured here – feeding also in LOICZ focus 2</td><td>Scientific input to the global “Water Group” Initiative
Assessment of the contribution of changes in catchments (e.g. damming) to coastal material cycling and hence exchanges with atmosphere, ocean and bottom
Scaled models for the respective transboundary flux changes</td></tr>
<tr><td>Focus 2:
Coastal biogeomorphology and global change</td><td>A coastal typology (objective typology of discrete coastal units serving as a sampling framework and to determine the appropriate weighting for preparing global syntheses, scenarios and models on the basis of limited spatial and temporal research data)
Such a descriptive and dynamic system will allow grouping of the World's coastal zone into unit-clusters based on both natural and socio-economic features and processes. It will also serve as a basis for downscaling exercises needed in particular for management purposes.
In summary the typology based grouping of coastal areas and processes may serve the establishment of appropriate indicator monitoring schemes on various spatial and temporal scales (see also IOC-GOOS, 6.1.4)</td><td>Tool for global upscaling allowing the development of global scenarios and models based on clustering coastal zone areas of similar properties or against similar pressure state scenarios (without conducting empirical research everywhere)
Global picture of the ‘human dimension’ of coastal change (also serving the IHDP objectives) – see also Focus 4
Operational links and exchange between different elements of IGBP benefiting from standard modularised descriptions of coastal units (typology)</td></tr>
<tr><td>Focus 3:
Carbon fluxes and trace gas emissions</td><td>Horizontal and, to a lesser extent, vertical material flux models (budgets) of Nutrients and Carbon;
a characterisation of coastal areas as netto hetero- or autotrophic systems serving as indicator for environmental quality and vulnerability;
Estimates of the ocean basin – coastal sea interaction captured through the joint JGOFS/LOICZ CMTT (Continental Margins Task Team – also Focus 1);</td><td>Through respective up-scaling a global estimate of Carbon incl. CO2 and Nutrient fluxes through the coastal zone and respective changes
A comprehensive picture of coastal functioning as a sink or source of the respective chemicals/materials</td></tr>
<tr><td>Focus 4:
Economic and social impacts of global change in coastal systems</td><td>Integrated modelling tools linking anthropogenic drivers to respective flux changes through the coastal zone and also defining the loop back from flux changes on the socio-economic system (human dimensions of flux changes – C, N, P and sediment residual production as currency for human action)</td><td>Quantified description of the human dimension of global change, i.e. how economic action impacts the earth system and vice versa
Operational links and joint modelling efforts with LUCC and IHDP</td></tr>
</table>

Applied science / Technology developers

Basic science creates a pull- and push-effect to technological and tools development. On the one hand science needs equipment that industry may deliver, on the other hand, science detect resources, materials or methods that firms may be interested in or develop a new subject for entrepeneurship. It is a mutual dependence in a system that basic science, applied science and technology form or should form. Based upon scientific knowledge technology may create real innovation, instruments, materials and tools that can foster new market formation. Certainly some of these developments can lead to new direct or indirect (i.e. product and non product) pressures on the coastal environment (Van der Weide and de Vrees, 1999; fig. 4.4). New fishery technologies may serve as an example for affecting resources and the marine and coastal environment (Lindeboom and de Groot, 1998). Other technologies such as sewer management or farming that reduce erosion may assist coastal zone management schemes that protect the environment. It offers innovation and opportunities for using new materials and new technologies in agri- and aquaculture to mitigate impacts to the watershed and the coastal zone as a receiving body. In connection with global warming applied science responds to sea level rise and provides for coastal protection.

LOICZ and ELOISE combine an array of different scientific disciplines and approaches, which may provide for both the fundamental science and the more applied science and to both ends in form of data, guidelines for standardised investigations and modelling tools. A few examples are given in table 3.

Table 3: LOICZ/ELOISE approaches/products against the needs of some typical coastal management objectives, which seek to apply science; (compiled and supplemented from Salomons et al., 1999; Van der Weide and de Vrees, 1999; Scialabba, 1998).

Management Objectives Area/Sector	Applied Science User-needs	Science response (ref. to LOICZ & ELOISE)
• **Coastal Protection, Flood Prevention;** • **Large Scale Constructions and (Port Management)** • **Aquaculture**	• Geomorphological models; • Sea level change models; • Socio-economic modelling; • Indicators for water quality and health of the environment	• Flux-budgets and models including sediment transport and transboundary exchange processes; • Typology based on biogeochemical, geophysical and socio-economic parameters including rivers, fertiliser usage etc. • Tools for integrated modelling, hindnow and forecasting along PSIR, linking land and sea interaction to different pressures
• **Waste Water Treatment**	• Indicators for systems functions and health (state and performance) • Modelling tools for scenario simulation	• Basin Research (Integrated catchment/ coast) Approach incl. Load versus system capacity concepts • Flux-budgets; • Residual estimates of sectoral production of indicator fluxes (e.g. N, P)
• **Water/Ecosystem Quality Assessment, EIA and** • **Monitoring Schemes**	• Indicators for systems functions and health (state and performance) • Guidelines for standard comparable approaches at different locations	• Measurement Guidelines; • Critical fluxes/loads and change modelling; • Integrated modelling linking natural and social system components of coastal production processes; • Coastal typology to enable scaling of monitoring and CZM action against clusters of comparable coastal PSIR settings – not necessarily dependant on onsite generic research but allowing use of secondary data (see chapter 6.1.4)

Knowledge transfer, capacity building and networking

A crucial 'need' for successful science application has not been outlined explicitly in the table because it applies to all sectors and issues. What is meant here is the transfer of knowledge that is strongly dependant on interdisciplinary, multicultural learning and translation tools, which help to find common languages between the players and allow for the comparability of indicators (Kremer, 1998a,b; Mann-Borgese, 1997; Vallejo, 1996). Finally the effort of tool development and application has to be taken jointly by scientists and users in the field. Van der Weide and de Vrees (1999) distinguish four different phases of capacity building to be employed here:

1. Institute building,
2. Professional education,
3. Professional training,
4. Institutional support.

They have to be considered to various extends as in some cases institutions might already be in place whereas in others they are lacking. However, the levels described here are institutional (1,4) and individual (2,3), which are interacting complementary steps.

LOICZ tries to meet these needs through its active networking and co-operational links within the IGBP family and beyond with NGOs, IGOs (Intergovernmental Organisations) and regional institutions. Examples quoted in the same sequence are links to the LUCC (**L**and – **U**se and **C**over **C**hange) project focusing on integration of data on human drivers and the changes they induce in the socio-economic system more distant as well as close to the coast. The same applies to the joint participation of (among others) BAHC and LOICZ in the IGBP water group. Other operational links are with START (**Sys**t**em** for **A**nalysis, **R**esearch and **T**raining) as well as with the IOC (see section 6.1.4) and the regional Global Change Networks APN (**A**sia **P**acific **N**etwork), ENRICH (**E**uropean **N**etwork for **R**esearch **I**n **G**lobal **C**hange) and the IAI (**I**nter **A**merican **I**nstitute for Global Change).

LOICZ also currently employs continuous capacity building and training components in its global flux budgeting exercise funded by UNEP/GEF. Scholarship training for one of the participants allowing for deeper insights and capabilities to use the respective scientific tools will follow each regional workshop. Furthermore, in view of global up-scaling and synthesis LOICZ is committed to, the trainees are expected to function as regional mentors for future research and networking in their areas.

On the European level added value may certainly be generated through strong links to science users like DG XI and its Demonstration Programme on ICZM (European Commission, 1999a, b). Also other Directorates General like the **J**oint **R**esearch **C**entre, JRC, in Ispra (Italy), more classical users like the EEA (**E**uropean **E**nvironmental **A**gency) in Copenhagen and European monitoring programmes may benefit from enhancement of science transfer, capacity building and application. On the other hand a wide-ranging application of science also means an invaluable test and verification of the LOICZ deliverables. In this area there is still considerable space for strengthening the links and stimulate the exchange of LOICZ/ELOISE outcomes with science users.

The economic/private sector and general public

The **Private sector** (companies and households) including the **general public** is closely involved in the process of ICZM and partly depending on its results since ICZM may directly influence their interests. Relevant stakeholders are private business, fisheries, tourist industry, home owners, farmers, service industry, construction industry, harbour and shipping industry, vacationers, local people, etc.

It is worth considering where decisions may cause changes in the coastal zone and affect these interests – the scaling issue again has top priority. 'Upstream decisions' may have serious impacts on the coastal zone and cause changes in water or material budgets, affect the groundwater level or nutrient loads. ‘Downstream decisions’ on increased urbanisation, large scale constructions, harbour business, tourism, intensive aquaculture causing for example salt water intrusion, diminishing of mangroves, etc. will directly affect the coastal environment. In conesquence the scale of the “coastal decision area” is an integrating over the whole water continuum including the catchments and expanding down to the continental margins.

It is exactly this system in which according to various uses the spatial range of ‘coastal zones’ is often defined closely along the limits of influence of interest groups or stakeholders. This sets the stage not only for the enormous extension but also the complexity and range of participatory processes aiming at deliberate sustainable use. Knowing these limits helps to identify the issues and expectations towards science that concern the stakeholders involved. Scialabba (1998) and Salomons et al, (1999) provide comprehensive overviews of scientific needs for sustainable cross-sectoral management of agriculture, forestry and fishery, whereas Barg (1992) and Sarda and Fluviá (1999) reflect on sectoral demands of fisheries and tourism (Table 4).

The table here concentrates on scientific data and deliverables providing information about sector related impacts. This has been done in order to underline the deliverables of the two synthesising projects LOICZ/ELOISE against related user needs in a simple and visible manner. Impacts outlined are affecting the systems functioning on environmental as well as socio-economic levels. Implications for human health and welfare are inherent. Most obvious institutional information, the legal and administrative framework and strictly economic backgrounds like market conditions have to be equally considered no matter that they are not mentioned here. We reiterate that most likely mutual benefit will be generated here from operational information exchange with IHDP (**I**nt. **H**uman **D**imensions **P**rogramme on Global Environmental Change) and its subprojects.

Table 4: needs for scientific information (those, which will most probably find answers within LOICZ/ELOISE) of some sectoral socio-economic drivers (compiled and supplemented from Salomons et al., 1999; Sarda and Fluviá, 1999; Scialabba, 1998; Barg, 1992).

<table>
<tr><th>Sector</th><th>Scientific information needs for coastal management</th><th>Science response (ref. to LOICZ & ELOISE)</th></tr>
<tr><td>Agriculture</td><td>• Demography data;
• Land-use change data;
• Nutrient and pollutant losses from diffuse sources;
• Nutrient and pollutant losses from point sources;
• Agricultural sources of sediment load in surface water systems;
(further points see under forestry)</td><td rowspan="4">Since there are a couple of deliverables, which may serve all the sectors mentioned to various degrees they are no longer divided by single sectors here:

Obviously those are budget models of biogeochemical fluxes incl. sediments; fertiliser retention times; morphology and stability data of coastal land areas, and in particular again the coastal typology, which may also allow for clustering of information against comparable coastal settings of sectoral pressure;

• However, the BASIN approach, which tries to cluster LOICZ/ELOISE science against management objectives in the whole water continuum covers catchment – coast interaction, critical loads etc. as well as the LOICZ/SCOR working group on Groundwater fluxes. The resulting data, guidelines and tools provide information against the various sectoral needs outlined. Emphasis must be put on the integrated scientific work like e.g. in LOICZ focus 1/4 (see above):

Employing tools for integrated modelling to allow for involvement of socio-economic data aimed at:

• Valuation of state changes and impacts as well as response options. Critical here is for example the approach taken in the South East Asian LOICZ project SWOL (see respective box): Residual calculation of C, N, P fluxes generated through the sectoral activities mentioned here may finally allow for successful marriage of biogeochemical change data and socio-economic as well as monetary figures. This tool also serves to achieve decision supporting accounting systems through applying for instance IO (Input Output) modelling, which finally may feed into Natural Resource Accounting, NRA, (Lange, 1999) on different scales.</td></tr>
<tr><td>Forestry</td><td>• Demography data;
• Land-use change data;
• Interrelation between the aquatic system and the supply of leaf litter, detritus and some silvicultural practices;
• Effects of forest management on environmental quality of the coastal system (incl. other sectors like aquaculture, tourism etc.) and coastal geomorphologic stability;
• Cross – sector impacts by other uses like tourism, agriculture etc;
• Environmental impact on forest use strategies incl. land conversion;
• Human impact through households, industry, use of water etc.
• Impacts of changes in the catchment and/or coastal zone through large scale constructions (damming, filling or in general change in the horizontal flux characteristics)</td></tr>
<tr><td>Fisheries</td><td>• Demography;
• Land-use and cover change;
• Biogeochemical and physical data (sediment and nutrient cycles and changes; i.e. is the system likely to shift from benthic to pelagic driven or vice versa);
• Pollution;
• Interaction with other sectors incl. aquaculture;
• Hydrographical regimes and parameter changes incl. ENSO Events (El Niño Southern Oscillation);
• Climate change;</td></tr>
<tr><td>Tourism</td><td>• Demography;
• Land-use and cover change incl. large scale constructions;
• Biogeochemical and physical change data (in particular state changes of sediment and nutrient fluxes induced by waste production, land filling, dredging, water and sand extraction and changes);
• Pollution;
• Interaction with other sectors incl. aquaculture, fisheries, forestry, etc;
• Coastal vulnerability to Climate change, erosion etc.;</td></tr>
</table>

Intergovernmental bodies such as IOC/UNESCO

Intergovernmental organisations, IGOs, are clients since initiatives they conduct, mainly rely on existing scientific programmes in terms of pulling their results together to a new joint, often up-scaled approach. **GOOS** (IOC, 1998) may serve as an example. The major thrust for GOOS is in the fact, that since the majority of environmental processes are not simple cause – consequence processes, science has to enable proper monitoring of the systemic indicators and effects. Furthermore in service for coastal and ocean management this effort will have to be employed globally and to prove vitally applicable for policy and decision support. It may gain from standardised approaches, which translates into:

- pulling together fundamental science that is continuously conducted in most possible standardised manner without neglecting regional characteristics and with maximum global coverage to underpin the applied science on state of the art levels,
- setting up regional, system relevant indicator schemes for continuous monitoring; (Here in particular GOOS may act as a user of available indicative state and impact (critical loads!) parameters in existing research efforts like LOICZ. Consultation will also cover information exchange on upcoming new measuring systems. On the other hand LOICZ products receive invaluable validation through global application),
- employing a multidisciplinary coastal typology to gain maximum synergies in the implementation of coastal monitoring schemes also allowing similar approaches (including policy and management) for coastal pressure-state-impact clusters,
- underpinning this global effort through appropriate capacity building, and
- opening the outcomes and organisational links like for example to LOICZ for other GOOS modules like HOTO (**H**ealth **O**f **T**he **O**cean).

The enormous integrative force needed for getting such a programme off the ground is visible through the various international organisations involved such as IOC, WMO, UNEP and ICSU. GOOS in principle is targeted to advice a heterogeneous multi-user group in setting up individually issue driven measuring systems. Especially the efforts taken in the coastal module **C-GOOS,** which is committed to be strongly responsive to user needs, are direct clients for the synthesising experiments LOICZ/ELOISE.

The C-GOOS panel has divided the main client interests requiring scientific advice into four operational groups (GOOS Report No. 57, IOC-Paris in prep.):

1. Preserve healthy coasts,
2. Promote sustainable use of resources;
3. Mitigate coastal hazards;
4. Ensure safe and efficient marine operations.

How parameters investigated by LOICZ and ELOISE may fit into environmental quality monitoring may be seen in the chapter on indicators and in the Phillippine LOICZ case study (outlined in section 6.1.5). In the following we elaborate in some detail on the LOICZ typology effort, which also has been identified to be of significant scientific relevance for C-GOOS (IOC, 1998 and respective C-GOOS panel meeting reports not listed individually):

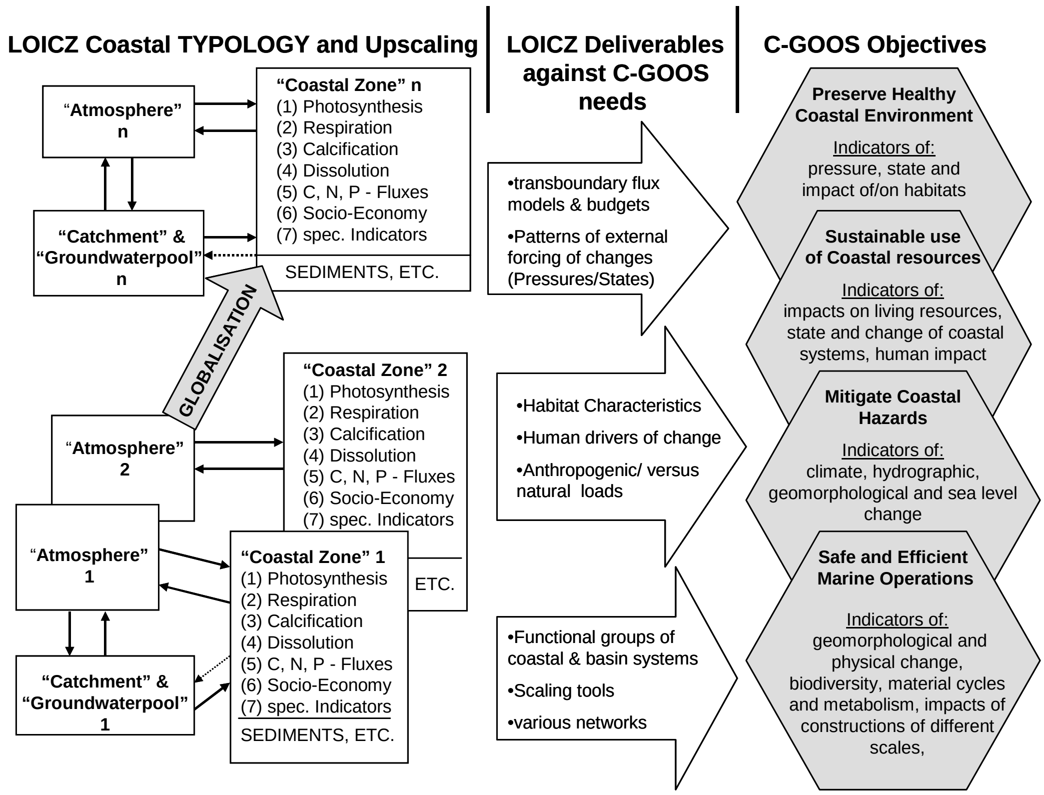

Figure 4. C-GOOS needs and deliverables from LOICZ research with special view on the LOICZ coastal typology core effort.

The LOICZ typology – a brief outline

All three C-GOOS panel meetings have identified the LOICZ typology to be a major need for the GOOS implementation phase. By mid 1998 the database comprises 113 physical, biological and socio-economic parameters at one degree pixel scale providing about 9600 coastal pixels in total. The typology database is a tool aiming to provide standardised scientific data allowing for analysis like clustering, scaling and modelling.

The sampling framework facilitates global syntheses through determining the appropriate weighting for, scenarios and models on the basis of limited spatial and temporal research data. A user including LOICZ itself can improve global up-scaling relying on the similarity patterns pulled out of the typology by cluster and fractal analysis while still keeping focused in key geographic coastal regions. To further enhance the applicability in particular for integrated modelling improvement of course will be needed for the partly still rudimentary subset of socio-economic parameters.

Furthermore a comprehensive global river basin database on e.g. river runoff, and catchment-size figures as well as one on fertiliser usage is available for investigation. All data are public domain and accessible through the LOICZ page (www.nioz.nl/loicz/). What is currently underway and interesting for a user like the C-GOOS?

Further work will continue to develop methodologies and tools for clustering and aggregating coastal descriptions, expanding and rationalising indicator parameters in the database, ways of linking to existing global data models, and seeking ways to link coastal with catchment typologies. The initial products are being posted to web-sites.

While there is still a lot to be done to refine a sound scientific and statistically proof approach for aggregating the pixels into a coastal classification the aim is to allow grouping of the World's coastal zone. Expected outcomes are clusters of discrete, scientifically valid units based on both natural and socio-economic features and processes. Similarities and differences can be pulled out easier and used to identify appropriate areas for comparative studies with secondary data. The LOICZ typology cells have already been used as spatial bases on top of which forecasting models of expected average temperature changes along the European coast until 2040-69 have been built. It was carried out by applying temperature models from the UK, Hadley Centre for Climate Prediction and Research, (www.kars.ukans.edu/mexico/coastal/hhgsdx50coast.htm; and LOICZ page for more information).

It remains a priority to search for finer-scale resolution as well as to pursue the linking efforts with other typologies including IGBP projects such as on Land Use and Cover Change and in particular the BAHC typology efforts on river catchments. The 4th LOICZ Open Science Meeting 15-18 November 1999, Bahia Blanca, Argentina, will pick up this issue in a joint BAHC/LOICZ working group and respective sessions (see proceedings for results). Clients beyond GOOS and the IGBP Water Group are most likely to be found on EU level (see below). Linking catchment – coastal sea typologies serves directly the objectives of the FP5 in particular its Energy, Environment and Sustainable Development programme providing a cross-cut over various key actions with significant importance for No. 1 on Sustainable Management and Quality of Water and No. 3 Sustainable Marine Ecosystems.

In summary the Coastal Typology and the networking provided through LOICZ globally and ELOISE on a regional scale will be important contributions against the needs of Coastal- and other GOOS modules as well as the IOC-ICAM objectives. But as outlined in IOC (1998) it is also the validation of numerical models, which have been developed along the respective LOICZ guidelines which will provide a sound scientific basis for GOOS. The major LOICZ key parameters describing the carbon and nutrient cycles (Focus 3), sediment fluxes and changes across the boundaries of catchments down to continental margins (e.g. Focus 1) will be put in the context of environmental change to serve as indicators. This will be complemented through taking the socio-economic component into account in terms of integrated modelling (Focus 4), which again serves the FP5 goals in their generic action focussing welfare and human dimensions of change.
The operational link with C-GOOS will drive the combination of the tools, guidelines and data made available through LOICZ and ELOISE to an integrative product. This product employed by the GOOS monitoring effort will reach various end users (policy makers, coastal communities, international agreements etc.), and contributing to operational and sustainable management of coastal zones. The integrative needs of GOOS will including application of the modelling deliverables for environmental impact assessment and the valuation of response options and their effects on availability, economic value ranking (see also Costanza et al., 1997) and sustainable use of the coastal domain.

Public sector - The European level

CZM is based on multi-sectoral policy and decision-making seeking and considering scientific consultation on different international, national, regional and local levels. On a European scale the hierarchically highest level of legislation is the council of ministers; on the administrative (executive) level the Commission and the expert organisations like the European Environmental Agency, EEA, takes responsibility. Research and Development as well as economic and social policy is made, co-ordinated and evaluated here and has to consider all aspects of scaling interacting sectors etc.

In order to adequately address the difficult and often conflicting issues and interests in coastal zones including the influencing land based economic and social settings the Parliament in the early 90ies called for an Integrated European Coastal Zones Strategy. The DG XI has therefore launched a Coastal Zone Management Demonstration Programme (European Commission, 1999a, b) and DG XII through different programmes like MAST (**Ma**rine **S**cience and **T**echnology) as well as Environment and Climate has addressed a variety of 'wet' issues through its Research and Development policy. The biggest synthesising experiment pulling different related projects together is ELOISE. However, both, the shift of objectives that is visible when comparing the first four and the 5th R&D Framework programmes as well as the CZM-Demonstration Programme indicate that there is still a lot to be done to

a) exploit the scientific know how successfully against the needs of various clients including the EU itself,
b) to establish operational user involvement in scientific work on different levels from local community levels up to the establishment of links and continuous exchange between the Commission DGs (e.g. XI, XII, XIV, XVI, JRC Ispra etc.) and their associated organisations like the EEA or the EUCC on the NGO level.

FP5 in principle takes into consideration the various requirements of the decision-making process, which seek sound scientific underpinning and access to response options. However, it remains with the Commission's evaluation whether or not these integrative and cross-cutting objectives will reflect adequately in the selection of forthcoming European funded research and networking. Burbridge (1999) points out that insight must be provided in the potential risks and benefits of coastal management and the trade-offs, which are inevitable in cross sector management. Here the PSIR while taking changing demographic and socio-economic conditions into account together with use of resources like water, natural hazards etc. can help facilitate the development of **If-Then-scenarios**. Those combine experience with new scientific knowledge to increase the scientific certainty on which to built decisions. The user need covered in this way is enhanced prediction capacity of scientific results aimed at now-, fore- and hind-casting.

In response to these needs and in particular to the scaling issues of transboundary environmental process changes the EU took action in manifold ways. Examples are the water framework directive mentioned earlier, the WAtER Science Plan and the new problem oriented key action on 'Sustainable Management and Quality of Water', which aim at improved understanding of the complexity and to cope with a system like the water continuum in continuous change. The manyfold interactions of this key action with the other elements of the FP5 have been addressed in detail by the Environment-Water Task Force in its respective Freshwater report (European Commission, 1998).

Links and exchange will be needed in particular with the global and climate change activities as well as with the sectoral efforts aimed at enhanced sustainability and environmental health issues. The coast and thus the key action on 'Sustainable Marine Ecosystems' comes into focus addressing the receiving domain of the impacted land based water continuum and as a generator and buffer for global change processes. This again underlines the importance of joining land and sea based typologies for cross-cutting synthesis along this domain.

As sees it is most obvious that the private sector is a key player in this context and has to be involved in future research to make sure that science is targeted by issues and contributes to human welfare. This is elaborated further through the R&D generic activity "Socio-Economic Aspects of Environmental Change in the Perspective of Sustainable Development" and will become a crucial part also for LOICZ/ELOISE work to meet the FP5 objective of improved user orientation and providing problem solutions. From a user perspective FP5 is a profound tool to direct science against the urgent needs of sustainability science and human welfare. However, hope has to be expressed here again that this will adequately reflect in a policy that pursues integrated issue driven research in the Framework Programme.

For LOICZ and ELOISE to address properly the manifold demands for scientific deliverables arising from these needs is quite a challenge. However, this already takes place to various extents in the course of for instance:

- The joint **LOICZ/SCOR** (**S**cientific **C**ommittee of **O**cean **R**esearch) **working group on ground water**. Here answers will be searched to the overall importance of groundwater fluxes as part of horizontal transports for the state and state changes of coastal systems. Methods will be developed and applied to model respective nutrient fluxes and their influence on the net biogeochemical behaviour of the adjacent systems (i.e. auto- or heterotrophic, pelagic or benthic driven) considering also the implications these characteristics might have for the coastal community and the aquatic resources.
- Other core projects like the South East Asian **SARCS/WOTRO/LOICZ** project that contributes considerably to create links between biogeochemical cycles and their states as systems characteristics and the anthropogenic driven production of residuals through for example agriculture, forestry etc. The box below gives a summary of the respective Philippine case study (adapted from McManus et al., 1999). It is most obvious that results produced here will touch the needs of policy makers directly. They seek and develop systemic indicator functions by taking bigeochemistry as a '**currency**' for human action. In view of the PSIR (see above) this may allow, at least in a later stage, for monetary and non-monetary valuation of change, scenario building and thus generating management or response options.
- The **Regional Basin (like EUROBASIN)** approach (Salomons, 1998), which aims at modelling the link between anthropogenic pressures on the catchment and the coastal zone, related state changes impact and response options. The main objectives are to derive from horizontal and vertical fluxes the loads, which have indicator functions that allow for appropriate decision support locally and upstream. Thus LOICZ by providing the respective Modelling guidelines (Gordon et al., 1996; Turner et al., 1998) adds value to the review of ongoing science as well as for the design of future action. Projects like MONERIS (Behrendt, 1999) and various ELOISE activities like METROMED, EROS etc. may thus provide directly against the needs of the EU for policy making on DG as well as subordinated levels like the EEA, or NGO level e.g. EUCC. It directly contributes to the outlines in FP5 and if put into a broader European synthesis may allow for input and valuation of the implementation of the water framework directive including coastal zones.
- The **LOICZ typology** effort, outlined earlier, which can deliver against the needs of monitoring approaches on various European scales and which could also be extended to a typology of coastal pressure – state – impact scenarios. Clustering "coastal zones" through standardised scientific data assessment, and along different scales of for example management areas can provide a sound foundation for science – user interaction groups as coastal fora or cross sector user dialogue groups (see the Dorset Forum UK as part of the EU Demonstration Programme) or similar constructions. This helps to facilitate policy

making and thus coastal management in a climate of joint ownership of issues and action taken by the different players including NGOs. Furthermore the typology if properly fed with socio-economic data on drivers and impacts will most probably allow finally the clustering of comparable D-PSIR scenarios on different locations (Kremer, 1999). A step in this direction even if not detailed enough yet for detailed scaling can be seen in the list of drivers as given in the report on lessons learnt from the Demonstration Program (European Commission, 1999b), which provides a simple 'driver typology' for European regions.

The following table summarises the outcomes of the recent review of various needs taken from observations made in the EU Demonstration Programme and potential deliverables and responses from the ELOISE/LOICZ side. The compilation strongly focuses on the needs for effective Integrated Coastal Zone Management:

Table 5: Information (i.e. processed data against certain issues) requirements as developed in the EU DG XI Coastal Zone Management Demonstration Programme (after European Commission, 1999b) and potential deliverables. The table concentrates on those requierements, which may already now or in the near future benefit from ELOISE/LOICZ achievements.

Issues and needs in the ICZM process	Available and recommended deliverables from LOICZ and ELOISE
Information Issues (information here means processed data)	
• Identifying and accessing available data	• Networking & brokering issue-led rather than curiosity driven science and transfer of products;
• Generating useful data to be turned into useful information;	• Data, modelling and tool products appropriate for temporal and spatial scaling and cross-discipline integration (holistic analysis) in a standardised manner
• Undertaking assessments;	• D-PSIR application allowing for impact assessment on different scales, valuation, accounting and benefit analysis (LOICZ-focus 4) and risk assessment based on standard natural – social science data and typologies
• Diffusion of information and knowledge;	• Networking with target groups and institutions on different levels and scales including science users; providing regular distribution tools, discussion fora and links to different data bases – all deliverables as public domain;
• Appropriate information management technology (improved communication between coastal managers and developers of information systems)	• Bridging the gap may be facilitated through the operational links LOICZ has to coastal management institutions, namely the Coastal Zone Management Centre, of RIKZ, The Hague; The Netherlands
Collaboration Issues	
• Identifying and ensuring the involvement of all relevant stakeholders;	• Improving regular links to clients on different levels either through programmes like in the Barrier Reef, Australia; • Generate respective workshops like the one treated in this monograph; • Strengthen institutional co-operation with science applicants (like IOC, EEA etc.); • Participating and supporting the steps taken by other parties like the EU DG XI/XII/XIV/XVI meeting on finding ways for a common strategy on coastal zones and management (July 1999);
• Cooperation across the land-sea boundary;	• Transboundary science as in the LOICZ BASINS concept and the IGBP Water Group delivers against the needs of transboundary users – enhanced stakeholder involvement will therefore automatically include institutions and authorities responsible for land and sea domains;
Legal Issues	• will have to be considered by both projects during science dissemination and communication as well as for proper scaling in the model-design
Assessing the effectiveness of ICZM initiatives incl. policy performance	• the production line of biogeochemical flux budgets, change indicators, river loads versus threshold loads, calculation of residuals from human activity and integrated modelling drawing upon socio- economic figures, land-use cover change and addressing the whole basin will allow to set up indicators for • human impact, • gains and losses (benefits of current and future scenarios) • state-and impact analysis will enable valuation of responses taken by the decision makers

	• indicators of environmental and human welfare in practice application of tools and appropriate synthesis from LOICZ and ELOISE projects for instance against the 'coastal' objectives of the Framework Directive-Water will generate a picture of both ecological and social systems functioning and performance including past and current policy; the same may apply to other CZM measures
Research and development to support ICZM among the various fields mentioned the two programmes have potential to respond in particular in terms of:	• developing methodologies and tools for integrated assessment (but they must improve the transfer into decision making and policy development) • deriving input conditions from observed concentrations (inverse modelling) – this is in particular addressed by the BASIN concept considering the loads of material in the coastal sea in relation to activities in the catchment – (this has been outlined earlier e.g. in the chapter reflecting on economic sector needs). Combined with **multidisciplinary indicators** this will provide the **human dimension of fluxes** taking the coastal sea as mirror for upstream processes; • to develop classification typologies, which will in particular be useful if clustering can rely on biogeochemical as well as socio economic settings – e.g. along the D-PSIR scheme;

Of course these are only some pieces of the jigsaw not claiming to provide a full picture. On top of the single aspects mentioned there is an evident need for both projects to pay increasing attention to user identification, participation and thus to generate and distribute useful scientific information. Improvement is also recommended in the area of co-operation and co-ordination first to avoid duplication of efforts and second to enable continuous channelling of information to the users. The Commission can play an important part her in particular if this is executed on a Common Strategy level as recommended by the Council already in the early 90ies.

The following box gives a practical example of current LOICZ related science and provide an impression on how this may serve coastal management needs for indicators, and integrated modelling. From the four SWOL demonstration sites in Malaysia, Thailand, Vietnam and the Philippines the latter one is summarised here.

The impact of economic activities on biogeochemical cycling in Lingayen Gulf, northern Philippines: A preliminary synthesis (after Talaue-McManus et al. 1999)

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Objective
This study attempts to determine how residuals derived from the waste production by land and water-based economic activities affects the cycling of materials and in consequence the health of the coastal environment in Lingayen Gulf, northern Philippines.

Study Area – Natural and Socio-Economic Structure
Lingayen Gulf is a u-shaped 2,100 km^2 wide and 160 km long embayment located on the northwest coast of Luzon, facing the South China Sea. The gulf has an average depth of 46 m, reaching a maximum of 110 m at its mouth. Its western section is dominated by about 200 km^2 of coral reefs and associated seagrass and algal beds. The bayhead has mostly a muddy substrate as it receives materials from the Agno River the biggest of six major river systems, which drain into the Gulf. Their total drainage area extends to 8,810 km^2 and annual aggregate freshwater discharge reaches 9,880 X 10^6 m^3. Agno River is the longest at 275 km, drains 70% of total catchment area and accounts for 70% of total discharge into the Gulf. Groundwater seepage into the Gulf was estimated to be 1 x 10^9 m^3/yr or 10% of total surface runoff. Flushing time is approx. 1.1 months.

From a total of 2.6 million people in 1990 in two adjacent provinces, population is expected to reach 4.6 million in 30 years at an annual growth rate of 1.45%, which is lower than the national growth rate of 2.3% per year. Inland areas are extensively used for agriculture and forestry and together with the fishery sector accounted for 43% of regional GDP while the service sector contributed 42%, and industry generated 15% in 1995. Most of the estuarine aquaculture areas with secondary stands of mangrove and nipa swamps are located here. The eastern section has a sandy substrate and its beaches provide for a moderately flourishing coastal tourism.

Approach
In this study, the contributions of nitrogen, N, and phosphorus, P, generated by economic activities were determined as major parameters in calculating nutrient budgets. Using the rapid assessment method developed by the World Health Organization (WHO, 1993), appropriate economic sectors were identified, and their respective residual production and environmental assimilation along its transport to coastal waters were calculated.

Estimates of waste loading were used in refining calculations of stoichiometrically linked water-salt-nutrient budgets. Preliminary budgets were made using the LOICZ Biogeochemical Modelling Guidelines (Gordon et al., 1995). Complete mixing of the water column was assumed and only annual means were considered. The influence of groundwater seepage was also taken into account.

Results and Ecosystem and Management Implications
Table 1 summarizes waste generation by each activity/sector. Household activities accounted for 32% of nitrogen and 52% of phosphorus estimated to reach coastal waters. Non-point agricultural runoff contributed 64% of total nitrogen, 45% of total phosphorus and 97% of suspended solids. These values show that population and agriculture significantly contribute to the loading of nutrients and suspended solids in Lingayen Gulf.

About 15,000 mt/yr (1 x 10^9 moles/yr) of N, mainly from agricultural run-off and household activities, enter the gulf. This estimated input was obtained using derived values of assimilation rates for different nitrogen sources, and which ranged from 60% for domestic sewage to 80% for agriculture and domestic solid waste (Valiela et al., 1997; Moffat, 1998). Because only 33% of total N were inorganic (San-Diego McGlone in press), DIN input from economic activities was estimated to be 360 x 10^6 moles/yr or 41% of ambient DIN concentration in the Gulf (Table 2).

The important sources of P in terms of economic activities include household activities and agricultural run-off. Estimated total P input assuming an average assimilation rate of 80% as for N, was 2,400 mt/yr (77 x 10^6 moles/yr). Of this input, only 50% or 39 x 10^6 moles/yr were inorganic (DIP) (San-Diego McGlone in press) accounting for 33% of ambient DIP concentration in the Gulf (Tab 2).

The calculated P budget indicated that the Gulf is a net DIP source with ΔDIP being +0.001 mol/m^2/yr. Assuming that organic matter entering the Gulf includes plankton with C:P = 106:1 as well as organic waste material with a C:P = 47:1 due to partial oxidation, (prod.-resp., p-r) was estimated to range from –0.07 to –0.03 mol/m^2/yr. Overall, the small DIP flux and correspondingly low (p-r) values suggest that the system is nearly in balance metabolically as it efficiently recycles organic matter. However, the slight heterotrophy and a high initial estimate of ΔDOP at +0.09 mol/m^2/yr (almost 2 orders of magnitude higher than ΔDIP), suggest that **an increase in organic pollution could lead to changes in recycling efficiency and perhaps to a likely greater metabolic imbalance**.

The ΔDIN estimated for the Gulf was –0.1 mol/m^2/yr and which translated to a (nfix-denit) of the same rate. A net denitrifying state of the Gulf could be sustained by significant concentrations of DON and decomposition of organic matter.

Suspended solids derived from economic activities and that reached the Gulf were estimated to be 2.8 million mt/yr, 97% of which came from agricultural run-off (Table 1). This delivery could account for 37 to 100% of measured ambient concentration (Table 2). **Given this level of anthropogenic influence on the flux of suspended solids into the Gulf, changes in economic activities that increase delivery rates can have profound impacts. These may include changes in carbon fixation by and in the species composition of autotrophs and changes in sediment dispersal patterns and their consequences on bathymetry and coastal geomorphology, among others.**

Future Objectives – Modelling Change and Impact

Future studies in Lingayen Gulf will include the empirical measurements of concentrations and fluxes of the dissolved organic forms of nitrogen and phosphorus along a distance gradient from river mouths and point sources. The nutrient characterization of groundwater will also be done. With these additional parameters, net metabolic rates can be established along a distance gradient using disaggregated box models to validate if net autotrophy dominates near river mouths, and if net heterotrophy increases with increasing distance from shore. Simulations of changes in demography and economic activities can be made to determine first-order changes in nutrient concentrations, and their consequences on net metabolism at various levels of the gulf's assimilative capacity.

Table 1. Residuals from economic activities entering coastal waters of Lingayen Gulf (in metric tons yr^{-1})

Economic Activity	Nitrogen	*Phosphorus*	Suspended solids
Household activities	4,912	1,252	-
• Domestic sewage	4,467	563	-
• Solid waste	445	69	-
• Detergents	-	620	-
Urban Runoff	354	29	66,253
Agricultural Runoff	9,706	1,081	2,743,592
• Crop fertilization	5,097	973	-
• Cropland erosion	4,607	108	2,743.592
Livestock	83	14	2,687
• Commercial piggery	71	14	2,194
• Poultry	12	-	493
Aquaculture	62	11	66
Mining	-	-	20,732
TOTAL	*15,117*	*2,387*	*2,833,329*

Table 2. Total material concentrations in Lingayen Gulf and those contributed by economic activities

Material	**Ambient Concentration**	**Concentration derived from economic activities (% contribution)**
DIN	0.81 µmol/L	0.33 µmol/L (41)
DIP	0.12 µmol/L	0.04 µmol/L (33)
TSS	2.5 ± 4.5 mg/L	2.6 mg/L (37-100)

Coastal zone managers – The need for indicators

All groups mentioned above are users for scientific information and frequently but to various extents they are each other's clients. However, in as much as they are involved in steering coastal resource usage or take other influence on resources or people they are actively involved in coastal management. Policy makers often are also considered to belong to the coastal managers but mostly on a more distant level setting the legal, administrative and institutional framework, which without any doubt is one of the major pre requisites for successful IZCM implementation (Kremer 1998b, fig 1; Scialabba, 1998). There is no argument that the information needs on the different levels where coastal managers are active vary considerably but the common link for successful planning and implementation control (monitoring) can be found in a reliable set of indicators. The following chapter tries to review in more detail the question on what kind of indicators do users need and again in reference to the PSIR framework. For more detailed analysis of Coastal Zone Management strategies and needs please refer to Scialabba (1998), Cicin-Sain and Knecht (1998), European Commission (1999a,b) and Salomons et al., (1999).

The role of indicators

From a user perspective projects like LOICZ/ELOISE are expected to determine indicators that provide a quantitative understanding of the most important interactions between coastal sub-systems (geomorphologic, biochemical and human or economic system) under changing external conditions. These interactions are steered by processes within the sub-systems, all of which can be characterised by a set of parameters. The challenge is to identify the triggers that mainly govern the processes and their characteristic features. Appropriate combinations of parameters may than serve as indicators for complex systems, the quality and (potential) development of coastal zones.

On the other hand generating a joint perspective of the issues among client-groups is depending on the identification of **user relevant indicators**. They form the bottom-line, from which clients will review the responsiveness of LOICZ products and from where more detailed discussions on issue driven science exploitation will depart. Indicators that sketch the human dimension of biogeochemical environmental change can be seen as the glue between the pressures and states description and the impact response side of the PSIR framework. In principle they can be seen as:

- parameters measuring the degree of sustainability in coastal uses and developments, which also help building bridges for the "public-private" partnership (clients are: public sector administration, private sector, coastal managers incl. advisory science (Kremer, 1998b), communities local people etc.),
- relevant for determining the state of environmental quality (clients are: EEA, EU-Commission, OSPAR, HELCOM, OECD, private sector, etc.),
- parameters relevant for modelling global change processes.

From the PSIR-framework as explained earlier three sets of indicators can be derived (OECD, 1994; Turner et al, 1998):

- **Indicators of environmental pressure**. They describe pressures from human activities on the environment e.g. energy, transport, industry, agriculture, fisheries, others.

- **Indicators of environmental conditions**. These indicators should be designed to give an overview of the situation (the State) of the environment and its development over time and not the pressures on it.
- **Response indicators.** Societal response indicators are measurements showing the extent to which society is responding to environmental changes and concerns.

In the framework of LOICZ these indicators are expressed in the form of

- Biogeochemical and physical fluxes of C, N, P, water and sediment (see the Philippine example above),
- Economic fluxes relating to changes in resource flows from coastal systems, their value and changes in economic activity,
- Social fluxes -e.g. food supply and price relating to food security, public health, welfare, flooding hazards.

The SARCS/WOTRO/LOICZ project as outlined in the box (section 6.1.5) gives a practical insight on how they can be investigated and linked to human activities. The major impetus which also poses the most complicated questions to the research teams involved comes from integrating science disciplines (natural and social and economic science). However, driven in particular through policy needs future developments will concentrate on this integration and economic modelling will receive increasing attention:

- putting values against biogeochemical flux changes and impacts;
- develop and apply appropriate indicators addressing the impact/response side within the PSIR framework;

These objectives already provide a major thrust for LOICZ but will need further consideration particularly in a review of past research and for the design of new work. They are also crucial for responding to the user needs as expressed in the 5th FP. It can be expected at least on the level of some demonstration sites that LOICZ will have such higher order modelling available within its lifetime (ending in 2002). However, since global synthesis required to that date can mostly be drawn out of simpler modelling exercises these higher order results will form a major legacy for future issue driven, management oriented coastal science to be run by either a new LOICZ period or a following successor experiment.

The role of science – Concluding remarks

Conflict management in coastal zones requires equal information access for all actors affected. The principle of mutuality also seeks all actors to supply to their information to the resolution process (Biesecker, 1996). However, the very specific processes governing coastal areas in terms of numerous cross-boundary forcing and therefore the complexity of decision-making users in coastal zones have to face put science in a challenging position.

Beside traditional knowledge, indigenous skills and experiences local people take from observation science is the main in many cases the only source of information. Nevertheless, the purpose of conflict resolution – the human – environment conflict as well as the 'between user conflict' is to foster equal and multidirectional exchange of information. This is to ameliorate situations perceived as being in conflict with user interests and which may in a short or long-term compromise future options for uses and living in the coastal zone by capturing a broader view of the players involved.

The sequence of deliberate advise and action science as a broker can support starts with identifying the issues and actors and their individual, joint economic and social interest in resolving the conflicts. Science as has been outlined has to engage its products and tools from its relatively neutral position to provide information on the gains and losses that may arise when users pursue their interests and to weigh them against environmental response. Hence, discourses, once set in motion, require various kinds of information and in order to resolve conflicts - a task also social scientists should be invited to assist at an early stage and contribute to the holistic thinking needed. However, it is principally important to get all stakeholders involved from the beginning. The initial step might be built up around:

- indigenous knowledge, skills and traditional practice of interacting with the environment
- local knowledge about the place and its development history
- experience acquired by trial and error before and during discursive processes (contextual learning)
- scientific knowledge

The following process of gathering and 'completing' information as well as sorting and applying tools for concerted action may do best if science sees its role in a dialogue procedure of mutual give and take. Positive as well less successful examples have been shown in the course of the European ICZM Demonstration Programme. The whole process needs interdisciplinary science and participation to generate joint ownership of issues through engagement of holistic views. This may assure that science speaks with in user oriented language to avoid confusion, which is pivotal for getting the process of ICZM going and keeping it alive. Moreover, this also assures that no scientist feels as appendix to another or that no user feels his interests being intruded in "wrong"directions by high flying scientific statements.

In designing future research programmes for resolution of coastal zone conflicts the complexity of the issues will no longer allow for separation in 'true' science and applied / social science. This means, concluding from the above, the main impetus for user involvement and responsiveness in projects like LOICZ and ELOISE must grow from engaging integrative research, analysis and modelling approaches. It also means to allow for appropriate capacity building and training in holistic, multidisciplinary scientific thinking, and science dissemination.

In other words the role of science in matching the needs of different clients mainly is to reduce the uncertainties involved in decision-making processes. However, there is no way to eliminate uncertainty completely. But since "(un)certainty reduction is costly and never fully accomplished" (Ostrom, 1990), dialogue strategies that see science as one player may reduce costs by forming or at least participating in dialogue relevant information (pools) involving all social players. The subsequent decision-making processes and the implementation of decisions into the social realm may also benefit from this.

Following Morgan (1993) the involvement of social science just from the starting point is even more important since "the only way to communicate risks reliably is to start by learning what people already know and what they need to know, then develop messages, test them and refine them until surveys demonstrate that the messages have conveyed the intended information". Morgan calls for informational support and assistance for discourses by science to overcome the fragmentation of knowledge. Although the social players involved will perceive and process information from and during the dialogue in their own ways. The dialogue however can keep scientists as well as users on track with the planning and implementation process of ICZM. This again comes down to a mediator or broker role of science in conflict resolution in IZCM, which can finally be summarised as follows:

- to assist the identification and dealing with the issues by analysing processes in natural and social systems (ecological, political, economic, technological, cultural, institutional change),
- to provide appropriate information and tools to deal with uncertainty,
- to offer options for action (scenario analyses),
- to contribute to and to communicate in discursive processes,
- to monitor implementation processes by means of appropriate indicator systems, and
- last but not less important to enable and provide for capacity building and training

In this paper we have tried to review the huge global change synthesising experiment LOICZ and its core project ELOISE on its current and future capacity to satisfy those needs. There is already a lot to be delivered against the various needs, which has to be pulled out of the bulk of information and transferred. But there is also quite an impetus needed to improve the responsiveness of the projects. The 5th Framework Programme of the European Union as well as the cross boundary initiatives like IGBP's Continental Aquatic Systems, the WAtER science plan (European Commission, 1996) as well as the water directive and, most recently, the huge UNEP/GEF effort GIWA (Global International Waters Assessment (GIWA, 1999) are examples for issue driven, cross boundary and resource (i.e. water) rather than spatial domain oriented approaches. One can expect that LOICZ and ELOISE through their efforts and syntheses will be able to generate significant contributions to these initiatives, while on the other hand they receive a comprehensive evaluation of their products through regional and global application by a large, multivariate user group.

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