UNITED NATIONS UNIVERSITY

UNU-INWEH

IW:Science

Enhancing the use of Science in International Waters projects to improve project results

ANALYSIS REPORT

LAND-BASED POLLUTION SOURCES

A global Analysis of **Land-Based Pollution Sources** science and transboundary management

UNEP

GLOBAL ENVIRONMENT FACILITY 20 YEARS INVESTING IN OUR PLANET

GEF IW:Science Project

Analysis Report of the Land-based Pollution Sources Working Group

IW:Science

IW: Science, or *Enhancing the Use of Science in International Waters Projects to Improve Project Results* is a medium-sized project of the Global Environment Facility (GEF) International Waters (IW) focal area, implemented by the United Nations Environment Program (UNEP) and executed by the United Nations University Institute for Water, Environment and Health (UNU-INWEH). GEF ID Number: 3343.

UNEP

GLOBAL ENVIRONMENT FACILITY 20 YEARS INVESTING IN OUR PLANET

UNITED NATIONS UNIVERSITY
UNU-INWEH
Institute for Water, Environment and Health

CORE PARTNERS

SCOTTISH ASSOCIATION for MARINE SCIENCE

UNESCO

UNEP

LOICZ

ELME European Lifestyles Marine Ecosystems

UNITED NATIONS UNIVERSITY
UNU-EHS
Institute for Environment and Human Security

CANADIAN WATER NETWORK
RÉSEAU CANADIEN DE L'EAU

The UNIVERSITY of PLYMOUTH

UNITED NATIONS UNIVERSITY
UNW-DPC

WATER FOR LIFE 2005-2015

UN WATER

Analysis Report of the Land-based Pollution Sources Working Group

March 2012

This report is written as part of the IW:Science series of reports comprising a Synopsis and Analysis for each of five classes of global transboundary water system: River Basin, Lake, Groundwater, Land-based Pollution Sources, and Large Marine Ecosystems and Open Oceans. The findings and content of the Synopsis and Analysis Reports are then integrated into two IW:Science Synthesis Reports to provide a global water view with regard to *Emerging Science Issues and Research Needs for Targeted Intervention in the IW Focal Area*, and *Application of Science for Adaptive Management & Development and use of Indicators to support IW Projects*. All reports can be found on the IW:Science, UNU-INWEH, IW:LEARN and GEF websites.

This report was prepared under the responsibility of the IW:Science Core Partner and Lead Institution of the Land-based Poluttion Sources Working Group:

Through the dedication, input and authorship of the Land-based Pollution Sources Working Group Co-chairs:

Hartwig Kremer	Chief Executive Officer – LOICZ
Ramesh Ramachandran	Institute for Ocean Management, Anna University

and the IW:Science Land-based Pollution Sources Working Group members:

Anil Arga	National Institute of Oceanography, India
Andrés Carsen	UNDP – Consultant, Argentina
Michelle Etienne	Green Islands Foundation, Seychelles
Virginie Hart	UNEP/MAP, Greece
Kem Lowry	University of Hawaii, United States of America
Purvaja Ramachandran	Institute for Ocean Management, Anna University, India
Juan Restrepo	Department of Geological Sciences, EAFIT University, Colombia
Jan Vermaat	Institute for Environmental Studies, VU University, Amsterdam
Christoph Zoeckler	Consultant, UNEP – World Conservation Monitoring Centre

Available from:
United Nations University Institute for Water, Environment and Health (UNU-INWEH)
175 Longwood Road South, Suite 204
Hamilton, Ontario CANADA L8P OA1
Tel: + 1-905-667-5511 Fax: + 1-905-667-5510
Email: contact.inweh@unu.edu Web: www.inweh.unu.edu
IW:Science Project Manager: Andrew Dansie

ISBN 92-808-6024-0

Cover photo: Catching fish in the coral triangle, Timor-Leste / *UN Photo, M. Perret*

List of Acronyms and Abbreviations

ACRONYM	MEANING
AMF	ADAPTIVE MANAGEMENT FRAMEWORK
CSDMS	COMMUNITY SURFACE DYNAMICS MODELING SYSTEM
DPSIR	DRIVER, PRESSURE, STATE, IMPACT, RESPONSE (FRAMEWORK)
ELME	EUROPEAN LIFESTYLES AND MARINE ECOSYSTEMS
EMP	ENVIRONMENTAL MANAGEMENT PLAN
EQO	ENVIRONMENT QUALITY OBJECTIVE
GEOHAB	MARINE GEOLOGICAL AND BIOLOGICAL HABITAT MONITORING
GESAMP	JOINT GROUP OF EXPERTS ON THE SCIENTIFIC ASPECTS OF MARINE ENVIRONMENTAL PROTECTION
GIWA	GLOBAL INTERNATIONAL WATERS ASSESSMENT
GLOBALLAST	GLOBAL BALLAST WATER MANAGEMENT PROGRAMME
GPA	GLOBAL PROGRAMME OF ACTION FOR THE PROTECTION OF THE MARINE ENVIRONMENT
ICM	INTEGRATED COASTAL MANAGEMENT
ICSU	INTERNATIONAL COUNCIL OF SCIENCES
ICZM	INTEGRATED COASTAL ZONE MANAGEMENT
IPCC	INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
IPY	INTERNATIONAL POLAR YEAR
IWRM	INTEGRATED WATERS RESOURCE MANAGEMENT
LBP	LAND BASED POLLUTION
LME	LARGE MARINE ECOSYSTEMS

ACRONYM	MEANING
LMMA	LOCALLY MANAGED MARINE AREA
LOICZ	LAND-OCEAN INTERACTIONS IN THE COASTAL ZONE
MEG	MULTIDISCIPLINARY EXPERT GROUP
MOA	MEMORANDUM OF AGREEMENT
MPA	MARINE PROTECTED AREA
MPPI	MAJOR PERCEIVED PROBLEMS AND ISSUES
MUM	MEANINGFUL, USEFUL, MEASUREABLE
NAP	NATIONAL ACTION PLAN
NGO	NON-GOVERNMENT ORGANIZATION
NOAA	NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NRM	NATURAL RESOURCE MANAGEMENT
OAS	ORGANIZATION OF AMERICAN STATES
OECD	ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT
PEMSEA	PARTNERSHIPS IN ENVIRONMENTAL MANAGEMENT FOR THE SEAS OF EAST ASIA
RA	RISK ASSESSMENT
RM	RISK MANAGEMENT
SAP	STRATEGIC ACTION PLAN
TDA	TRANSBOUNDARY DIAGNOSTIC ANALYSIS
TOT	TRAINING OF TRAINERS
TWAP	TRANSBOUNDARY WATERS ASSESSMENT PROGRAMME
WIOLAB	WESTERN INDIAN OCEAN LAND-BASED ACTIVITIES

Table of Contents

List of Tables and Figures

Appendices listing

The appendices for this report are available electronically from the IW:Science, UNU-INWEH, IW:LEARN and GEF websites

CHAPTER ONE

Critical emerging science issues

A. *What are the critical science challenges "on the horizon" specific to each ecosystem type?*

B. *What is the significance of regional/global scale drivers in particular climate change in the genesis of transboundary problems?*

C. *Describe how understanding and managing multiple causality in transboundary water context is undertaken.*

D. *How have variable spatial and temporal scales in IW projects accounted for?*

E. *What approaches were used to understand/assess the coupling of socio ecological systems?*

F. *What scientific knowledge is available and/or used to evaluate tradeoffs between the response options developed by IW Projects?*

To arrive at a comprehensive analysis of critical emerging science issues, the Land-based Pollution Sources Working Group decided, as a first step, to consider the discussion on emerging challenges in the earth system and global change context, organized by the International Council of Sciences (ICSU), and based on an open forum consultation that invited some 10,000 comments from global interdisciplinary scientific experts and culminated in a set of five major challenges and related sub questions of major societal concern. These challenges and questions are considered as likely to populate priority agendas of the global science community in the coming decades. During the group discussion around the analysis of the synopsis, it was realized that most of these questions and challenges are directly relevant to the IW projects examined in this project.

The ICSU challenges and related core scientific questions are outlined in detail by Reid et al., (2010)[1], and summarized below:

1. ***Forecasting*: Improve the usefulness of forecasts of future environmental conditions and their consequences for people.**

Priority Research Questions:

- What **"significant environmental changes"** are likely to result from human actions? How would those changes affect **"human well-being"**, and how are people likely to **respond**?
- What threats do **"global environmental changes"** pose for **"vulnerable communities"** and groups and what responses could be most effective in reducing harm to those communities?

2. ***Observing*: Develop, enhance and integrate the observation systems needed to manage global and regional environmental change.**

Priority Research Questions:

- What do we need to observe in coupled social-environmental systems, and at what scales, in order to respond to, adapt to, and influence global change?

- What are the characteristics of an adequate system for observing and communicating this information?

1 W. V. Reid, D. Chen, L. Goldfarb, H. Hackmann, Y. T. Lee, K. Mokhele, E. Ostrom, K. Raivio, J. Rockström, H. J. Schellnhuber and A. Whyte (2010): Earth System Science for Global Sustainability: Grand Challenges; Science, Vol 330, 916-917

3. ***Confining*: Determine how to anticipate, avoid and manage disruptive global environmental change.**

Priority Research Questions:

- Which aspects of the coupled social-environmental system pose significant risks of positive feedback with harmful consequences?
- How can we identify, analyze and track our proximity to thresholds and discontinuities in coupled social-environmental systems? When can thresholds not be determined?
- What strategies for avoidance, adaptation and transformation are effective for coping with abrupt changes, including massive cascading environmental shocks?
- How can improved scientific knowledge of the risks of global change and options for response most effectively catalyse and support appropriate actions by citizens and decision-makers?

4. ***Responding:* Determine what institutional, economic and behavioural changes can enable effective steps toward global sustainability.**

Priority Research Questions:

- What institutions and organizational structures are effective in balancing the trade-offs inherent in social-environmental systems at and across local, regional and global scales and how can they be achieved?
- What changes in economic systems would contribute most to improving global sustainability and how could they be achieved?
- What changes in behaviour or lifestyle, if adopted by multiple societies, would contribute most to improving global sustainability and how could they be achieved?
- How can institutional arrangements prioritize and mobilize resources to alleviate poverty, address social injustice and meet development needs under rapidly changing and diverse local environmental conditions and growing pressures on the global environment?
- How can the need to curb global environmental change be integrated with the demands of other inter-connected global policy challenges, particularly those related to poverty, conflict, justice and human security?
- How can effective, legitimate, accountable and just collective environmental solutions be mobilized at multiple scales? What is needed to catalyze the adoption of appropriate institutional, economic, or behavioural changes?

5. Innovating: Encourage innovation (and mechanisms for evaluation) in technological, policy, and social responses to achieve global sustainability.

Priority Research Questions:

1. What incentives are needed to strengthen systems for technology, policy and institutional innovation to respond to global environmental change and what good models exist?

2. How can pressing needs for innovation and evaluation be met in the following key sectors?

    a. How can global energy security be provided entirely by sources that are renewable and that have neutral impacts on other aspects of global sustainability, and in what time frame?
    b. How can competing demands for scarce land and water be met over the next half century while dramatically reducing land-use greenhouse gas emissions, protecting biodiversity,

and maintaining or enhancing other ecosystem services?

c. How can ecosystem services meet the needs for improving the lives of the world's poorest peoples and those of developing regions (such as safe drinking water and waste disposal, food security and increased energy use) within a framework of global sustainability?

d. What changes in communication patterns are needed to increase feedback and learning processes to increase the capacity of citizens and officials, as well as to provide rapid and effective feedback to scientists regarding the applicability and reliability of broad findings and theoretical insights to what is observed in the field?

e. What are the potentials and risks of geo-engineering strategies to address climate change, and what local or global institutional arrangements would be needed to oversee them, if implemented?

Eutrophication in Vembanad Lake / *IOM, Anna University*

These challenges and questions formulated by the global science community can assist in mapping the this analysis of GEF IW-Science projects in a globally-shared and forward-looking context. Two major adjustments may need to be applied to the traditional organization of GEF IW projects:

1. Overcoming the traditional divide of water bodies: i.e., the rather isolated consideration of rivers, aquifers, lakes, large marine ecosystems, and the open ocean;

2. Applying a socio-ecological system scale in the design and scientific analysis (including TDA and causal chain analysis) of future GEF projects to arrive at an issue-driven definition of system boundaries, including spatial, temporal and institutional scale of concern. These scales need to be properly defined and a standardized framework for assessing would be helpful.

As an example for the points made above, we elaborate here on deltas as a reflection of complex scale overlays and multiple drivers. Among the emerging science issues in coastal zones recently identified by the research funding community as a priority in the next decade, deltas are among the most vulnerable, which may justify particular attention in an IW context.

While the 2007 IPCC report highlighted the high risk of many river deltas being severely affected by sea level rise, recent studies indicate a whole set of human factors adding to this risk by causing deltas to sink significantly. The sinking of deltas is exacerbated by upstream trapping of sediments by reservoirs and dams, man-made channels and levees that whisk sediment into the oceans beyond coastal floodplains. Coastal urbanization further drives the accelerated compacting of floodplain sediment, due to extraction of groundwater and natural gas.

Researchers in the Community Surface Dynamics Modeling System (CSDMS) project in Boulder, Colorado conclude that 24 out of the world's 33 major deltas are sinking and that 85 per cent experienced severe flooding in recent years, resulting in a temporary submergence of roughly 250,000 km2 of land. About 500 million people in the world live on deltas. Considering that drivers of delta-coast vulnerability, and thus community vulnerability, can *be located along the whole water continuum from source to se, and include extreme events such as storm surges (some 10 million people affected every year, a holistic approach is needed.*

Assisting coastal communities and people in the contributing catchment to cope with and adapt to future delta change will require information about ecosystem goods and services of deltas in a social ecological system context. It will be a challenge for scientists to compile the necessary information and process it to support decision making across boundaries and on the appropriate spatial and temporal scales. Storm links and challenges may arise here also for a future transboundary waters assessment, as currently developed in GEF project TWAP.

Obviously, the scientific challenges addressed here also refer to generally low lying and/or highly dynamic coastal zones subject to rapid climate and anthropogenic pressure as well as extreme events: for example, islands, polar coastal zones such as the Arctic, etc.

When discussing critical emerging science issues in the GEF IW context, a few aspects need to be well understood. Thus, while there is substantial innovation needed to arrive at a solid system-based description of issues and scales, it is fair to say that “rocket”-science is not needed to inform IW projects. This is because they are first and foremost intended to secure a stronger political buy-in and institutional reforms needed for sustainable management. Most of the projects reviewed here relate to the “Response” part of a classical Driver, Pressure, State, Impact, Response (DPSIR) framework. They aim to provide the knowledge base and learning platform to enable better governance schemes for improved management of socio-ecological systems, and thus human welfare. From a perspective of the framework of the so called “orders of outcome” (see section 2) this is aimed at improving the enabling conditions for sustainable management of regional seas and their adjacent coastal zones. Based on better baseline conditions, the target is improved governance for increasing system resilience to cope with change, which is often driven by far distant processes. Ultimately, projects aim to influence societal behaviour: i.e., the way humans interact with nature and the resulting feedbacks.

In many cases, drivers and pressures are known, and state changes, such as changing material fluxes reaching the coasts through increasingly managed and engineered rivers, or effects generated by the pressure of rapidly growing urbanization, sea level rise, and increasing waste water loads, are reasonably well comprehended, but the step from knowledge to action is frequently the critical issue.

In conclusion, the future scientific challenges that GEF projects are likely to face are largely to be found in the context of institutionalizing applied sciences and in building constituency to promote changes in behaviour. This includes appreciating what knowledge is needed and where: i.e., in which group of actors it should sit. It requires a clear understanding of protocols for monitoring of the key parameters in a social ecological system scale; it needs transparent and peer-reviewed strategies for data assimilation and storage, including clearly defined responsibilities; and it requires a widely accepted understanding on how to deal with uncertainty and risk. In the future, responses to global change, be they on local, regional or global scales, and the decisions that must be made, should be scientifically informed whether or not knowledge is incomplete and forecasts uncertain.

Finally, a further three, rather complex conditions will be pivotal to the success of future projects:

A. A conceptualized learning strategy, addressing the information needs of different actors: i.e., concepts and language are commonly agreed to enable broad cross-sectoral ownership. This strategy should build on well-documented science;

B. Inclusion of scientifically sound and continuously evolving assessment of project accomplishments toward improved sustainable management. A promising concept here may be application of the so called “orders of outcome”, as developed from the management cycle concept promoted by GESAMP in 1996 and further developed by the scientific community (section 2 for detail);

C. Evaluation of the potential of the system of concern to cope with future global environmental including climate change. For this, the assessment of governance baselines and frameworks may be of assistance.

With all this in mind, mapping of the GEF analysis onto the future challenges identified by the earth system science community can be represented as follows:

GEF IW ANALYSIS QUESTIONS	ICSU EARTH SYSTEM SCIENCE GRAND CHALLENGES (CHALLENGE AND KEY ISSUES TO BE ADDRESSED)
What are the critical science challenges "on the horizon" specific to each ecosystem type?	All five challenges
What is the [current? future?] significance of regional and global-scale drivers, in particular climate change, in the genesis of transboundary problems? [Distinguish between temporal scales and consider individual characteristics of countries and regions]	1 Forecasting 2 Observing
Describe how understanding and managing multiple causality in a transboundary water context is undertaken?	3 Confining 4 Responding 5 Innovating
How are variable spatial and temporal scales in IW projects accounted for?	3 Confining 4 Responding
What approaches were used to understand/assess the coupling of social and ecological systems?	3 Confining 4 Responding
What scientific knowledge is available and/or used to evaluate trade-offs between the response options developed by IW projects? **New Question*	4 Responding 5 Innovating

When it comes to analysis of the projects, particularly as reflected in sections 2 and 3, discussion of indicators focuses on how best to gauge the interplay between environmental change and socio-political response. What are the best proxy indicators for what is ultimately needed to accomplish the projects goals: i.e., to enable and maintain sustainable development in international waters? It becomes evident that selection of the right indicators is a scientific challenge and includes conceptualizing social dimensions in complex systems. The traditional ecosystem-centred observation, with resulting monitoring strategies, will need to be complemented by thorough socio-economic observations. Incorporating valuations of changing ecosystem goods and services under different response options may encourage development of future scenarios with the potential to (a) deal with uncertainty and (b) assist in improving decision making. In some regions of the world, application of these concepts is now underway.

Reviewers discussed use of a standardized framework to assist in measuring project success, and we assume that in this context the debate around the best possible indicators and resulting project monitoring will enter a new round. Improvements in knowledge sharing across projects, and twinning between projects to share experiences, are among the most promising efforts in the IW project portfolio. Finally, a stronger collaboration with global and regional scientific networks may assist in supporting projects by providing access to up-to-date science knowledge.

1.1 What are the critical science challenges "on the horizon" specific to each ecosystem type?

Rather than focusing on certain ecosystem types, the science challenges seen by the group are located predominantly in the field of properly informing the application of scientific knowledge. In conceptualizing the application of science indication must be developed as to where, how and by whom the scientific knowledge shall be applied. Obviously there are implications for application of indicators and observation to be employed.

In order to lead this into the concept of informed adaptive management the projects are challenged to provide a platform for identifying and dealing with uncertainty. Information across the actor groups, including policy and management, is expected to inform decision making but be subject to continued revision that enables adaptation to new findings and conditions.

The changes in "system resilience" i.e. the human - nature interaction context as an outcome of the project implementation need to be thoroughly assessed and peer reviewed for which a gauging meter such as order of outcome need to be employed.

Future scenarios based on transparent and peer reviewed assumptions of societal preference may assist in informing social choice in the environment of different tradeoffs.

One final general recommendation is to be explicit in the terminology, i.e. the definitions of governance, adaptive management, social ecological systems to name a few.

In conclusion an overarching scientific challenge in the IW as well as other transboundary contexts will be to elucidate the still very visible barriers between scientific knowledge on the one hand and the steps towards application and better informed decision making on the other. Exploring the issues of hampered response and overcoming hesitation in policy implementation and enforcement are key scientific questions of the future (they are actually reflected in more than just one of the Erath system science challenges).

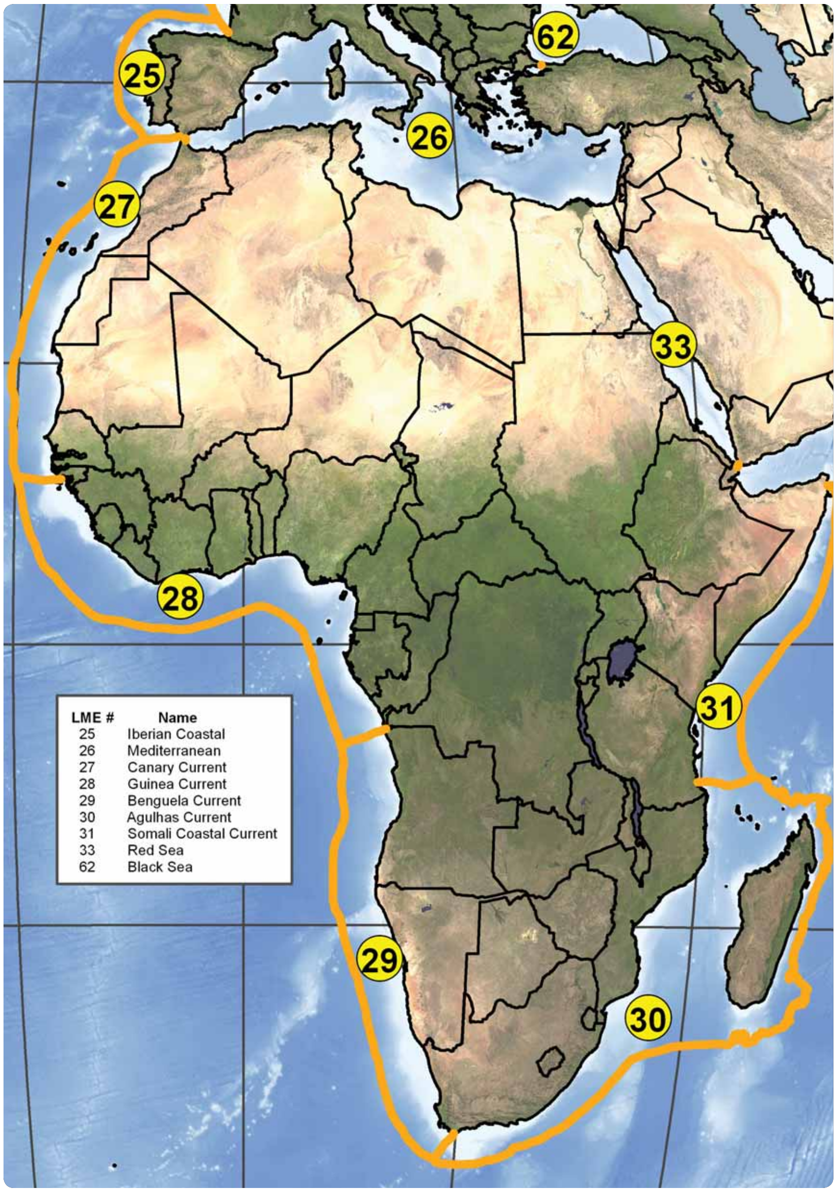
1.2 What is the significance of regional and global-scale drivers, in particular climate change, in the genesis of transboundary problems?

Regional drivers play a significant role in socio-ecological system functioning and change, as do global change drivers. The group emphasized that climate change is a central element but that issues such as pollution, subsidence/erosion, and anthropogenic forcing on catchment scales are strong pressures.

Socio-political changes, such as the rapid oscillations in the global market, will very much dictate the extent to which sustainability concepts will affect future developments in resource exploration and exploitation. Larger scale, even global-scale, drivers can strongly influence regional and local development, leaving little room for communities to adapt. For example,

- Population growth – regional scale [PEMSEA];
- Urbanization – local/regional [PEMSEA];
- Economic development - global/regional [PEMSEA];
- Urban wastes including sewage - local/regional [PEMSEA];

Figure 1 Large Marine Ecosystems of Africa and the Mediterranean



Used with permission from the U.S. NOAA-LME Program Office 2011, http://www.lme.noaa.gov

- Material fluxes [natural plus human] urban runoff, agricultural runoff, natural fluxes and sediment retention by dams - across all scales (WIOLAB, DeltaAmericas, Role of the Coastal Ocean in the Disturbed and Undisturbed Nutrient and Carbon Cycles (by LOICZ), Sao Francisco);
- Tourism [African tourism] – local/regional;

- Rapid socio-political change triggering population movements, new institutions, etc. – regional [Danube GEF];
- Trading/sea transportation - all scales but drivers are global [ballast water, etc.] (ship waste project)
- Energy transport, storage, uses, etc. – global/regional; and
- Fisheries [algal blooms] including aquaculture – regional/local.

As mentioned above, the exploitation of energy resources, particularly in Arctic environments, the management of river systems in times of increasing water scarcity, and the development of global trade infrastructure and coastal urbanization may serve as examples. The concept of integrated management, whether it is coastal and/or including catchments or land-use and cover change, can thus be rather easily jeopardized, overrun by larger political and economic interests outside the system of concern.

Overall, it can be said that the overarching pressure on coastal systems is land-based pollution: for example, increasing land conversion for crop based bio-fuel production has undoubtedly had a strong significance for nutrient fluxes through international waters.

1.3 Describe how understanding and managing multiple causality in a transboundary water context is undertaken?

Multiple causality is recognized in many of the projects and managing it entails accepting certain tradeoffs and dealing with a level of uncertainty. This issue is, in general, considered to be an area where scientific input into IW projects may have a significant contribution to make.

On the project level, consideration of multiple causality is strongly evident, including multiple strategic priorities culminating in a variety of strategic plans (PEMSEA). Transboundary Diagnostic Analysis and legal instruments (e.g., WIOLAB) feature multiple causalities on a regional scale. However, there is rather limited consideration of the social side, and only minor considerations of governance aspects. As a means to improve knowledge transfer, including cross-system learning, the concept of twinning systems (e.g., catchments) across continental scale has been applied and promoted in projects in Latin America (DeltaAmericas) and Asia. As mentioned earlier, this is considered a valuable approach also in terms of enabling international learning about multiple causalities. Comparable concepts are promoted by research funders such as the European Commission.

1.4 How are variable spatial and temporal scales in IW projects accounted for?

There is an evident tendency within several of the IW projects to address issues along the water continuum. Notable examples can be found in PEMSEA, and individual cases are addressed in DeltaAmericas and those projects dealing with Caribbean systems. Particularly in Asia and partly in South America, institutions have been designed or reinforced to address variable spatial scales: for example, regional monitoring programmes, regional assessments, etc. The ecosystem approach is promoted as a vehicle for ensuring variable spatial scales are taken into account, for management purposes, and for encouraging establishment of the necessary institutions. Spatial scales range from local to regional n certain projects.

In terms of temporal scales the PEMSEA “follow up” project and the underlying fund are aimed at transferring into a long-term effort, and fostering sustainable development on regional sea scale. In terms of environmental quality targets, this includes securing national commitment and setting up programmes designed to reduce nutrient fluxes by 10-50 per cent by 2010 and increase ICM managed areas by 5-10 per cent until 2015. This is a target built on the concept of underlying variable temporal and spatial scales. Small-scale pilot projects demonstrating successful implementation of approaches may be used and scaled up in the future. Capitalizing on these pilot initiatives may generate added value far beyond the anticipated project lifetime.

1.5 What approaches were used to understand/assess the coupling of social and ecological systems?

The concept of a coupled social-ecological system approach is not explicitly used in the projects. However, features of this approach are visible in various projects examined. While the concept and its implications, particularly for indicators, are addressed more thoroughly in the sections to follow, we provide some examples here:

- Coupling of values and ecosystem goods and services with observed and anticipated environmental system change (PEMSEA);
- Arctic project – social aspect, indigenous peoples. WIOLAB also had a social aspect;
- Some of projects have problem statements that refer to a range of human behaviors and their impact on the environment;
- Proxy indicators – runoff and demographics – provide a link between demographic signals and coastal functioning;
- WIOLAB demonstration projects were considered a good example of local and cultural aspects.

1.6 What scientific knowledge is available and/or used to evaluate trade-offs between the response options developed by IW projects?

The whole area of tradeoffs in management of increasing pressures and response options in the coastal systems context is rather new to the scientific community. One result, reflecting evaluation of different options and likely changes in the socio-ecological system, can be seen in projects funded by the EU (e.g. KnowSeas and ELME). This, together with other observations made in the IW portfolio, allows the following summary of key aspects:

- Significant social-ecological-based scenarios are required to evaluate trade-offs (new concepts of integrated modelling and conceptualizing of social dimensions are critical);
- There are scientific tools to explore development and change of value systems that may influence social choice. Those should be addressed with high priority;
- Projects did not address climate change to any great extent and this needs to be changed, particularly as regards regional dimensions of hazards and risk;
- A body of tentative knowledge about climate change and long-term trends is available but has not been largely used.

Priority tools to be strongly emphasized include:

- Risk assessment; e.g., what is the probability of a storm surge/ storm surges over the next 12 months;
- What makes a coastal community resilient (resilience and risk research);
- Disaster management (community preparedness, humanities and the value of informal networks, prediction and forecasting.

These issues strongly overlap with the ICSU challenges, and also reflect the emphasis on regional scale currently discussed by major global research funders.

Below the surface, fishing village in Anilao, Batangas, Philippines / *Marine Photobank, P. Paleracio*

CHAPTER TWO

Development and use of indicators to support IW projects

An indicator is defined by Taal et al. (1998)[2] as:

> *"a parameter or a value derived from parameters, which points to, provides information about or describes the state of a phenomenon/ environment/ area."*

Indicators may also be described as qualitative or quantitative variables used to assess the type and rate of change observed in the environment. Burbridge (1997)[3], refers more specifically to management in his definition of indicators:

> *"as features which characterize well defined and designed management programmes."*

Guided by the OECD (1994) framework, three ICM indicators have been defined:

1. Pressure Indicators: describing stresses inflicted by human activities and imposed on the coastal zone environment;
2. State Indicators: describing the condition of the environment - be it chemical, geo-physical or biological. Natural resources are expressed in both a quantitative and qualitative manner;
3. Response Indicators: recording the choice of a policy as a response to an environmental problem.

The "Pressure-State-Impact-Response" (PSIR) Framework (Turner et al., 1998)[4] identifies four additional parameters:

1. Pressure Indicators;
2. State Indicators;
3. Impact Indicators: assessing the effects upon the health of the human population and ecosystems; and
4. Response Indicators.

Duda, (2002)[5] developed a provisional list of indicators, intended for measuring the success or otherwise of Environmental Management Plans (EMPs) and these were assessed in terms of several criteria:

- *Meaningful*: is the subject and theme of the indicator meaningful to the evaluation of EMP success? May it be deemed as important and relevant to the various processes of an EMP?
- *Useful*: will this indicator be useful and realistic as a tool for actively measuring specific EMP successes?
- *Measurable*: in practice, how easily would this indicator measure quantitatively and/or qualitatively?

A further key test is whether the benefits revealed by such indicators are attributable to environmental management plan initiatives. The value of these potential indicators against the MUM (Meaningful, Useful, Measureable) criteria was assessed qualitatively and/or quantitatively by seeking input by EMP Project Officers and members

2 Burbridge, P.R., 1997. A generic framework for measuring success in integrated coastal management. Ocean & Coastal Management, 37(2), 175-189.

3 Taal, M.D., de Koning, P., Werners, S., Zanting, H.A., van Buuren, J.T. and van der Valk, F., 1998. Framework on integrating models and indicators for European coastal zone management. Report for European Topic Centre for Consultation. Resource Analysis, The Netherlands.

4 OECD (Organisation for Economic Cooperation and Development), 1994. Environmental Indicators: OECD Core Set. OECD, Paris.

5 Turner, R.K., Lorenzoni, I., Beaumont, N., Bateman, I.J., Langford, I.H. and McDonald, A.L., 1998. Coastal Management for Sustainable Development: analysing environmental and socio-economic changes on the UK coast. The Geographical Journal 164(3), 269-281

of relevant authorities. Thus, indicators are quantitative/ qualitative statements or measured/ observed parameters that can be used to describe existing situations and to measure changes or trends over time (Duda, 2002)[6]. Indicators are often used as tools for monitoring and evaluation (M&E) plans to reflect changes in the state of coastal and marine environments, trends in socioeconomic pressures and conditions in coastal areas, and corresponding links among anthropogenic activities and ecological health. M&E plans are used for tracking the projects and for observing the changes over the lifetime of a project. Funders normally require indicators to assess the success of projects. Indicators are meaningless, however, without an established baseline from which change can be evaluated. It is with reference to these frameworks, ICM experiences, and the subsequent discussion on indicators, that indicators of the success of the projects are further considered and discussed.

2.1 How did the projects help build and implement sound indicators?

With one exception, most of the indicators focused on project outputs (e.g., number of plans produced, trainings held, etc.) and environmental outcomes (e.g., suspended solids, fecal coliform, per unit water etc.). There is a whole suite of indicators used in coastal management and Table 1 below provides a generic listing of core indicators under three major headings:

A. Governance,
B. Sustainable development aspects, and
C. Environmental issues.

6 Duda, A. 2002. Monitoring and Evaluation Indicators for GEF International Waters Projects. Monitoring and Evaluation Working Paper 10. Global Environment Facility. Washington, DC, USA.

The projects do not provide sufficient details, however, on protocols governing data collection, analysis, storage, access and dissemination of the accrued dataset during the course of the project. Indicators often focus on project tracking, but may not reflect the sophistication of the actual environmental monitoring occurring. These considerations lead into a core conceptual aspect of the use of indicators and the target audience. The rationale behind the development of indicators in projects includes:

- Who exactly are the "target audiences"?
- Who are the data users?
- To whom should the data be made available/ accessible, and
- At what scale/ level of detailing?

In designing an indicator system, identifying target audiences and their information needs is a critical task. Some questions include:

- Who will use the information?
- Will it be used for routine monitoring of management activities, assessing changes in environmental conditions or both?
- Is the primary intention evaluative so that managers can identify problems and adjust management activities?
- Is learning from experience an intention for gathering data? If so, what sorts of indicators need to be added to facilitate learning and adaptation?
- A more or less neglected question in the context of all projects reviewed is the one addressing the change of behaviour: i.e., do we observe adaptive management and changes in how people interact with nature. Indicators needed in this realm are to be based on thorough definition of a baseline of sys-

tem characteristics and governance (see Olsen et al 2009, LOICZ R&S volume 34)[7].
- As an exception, one may quote the indicators developed and applied in PEMSEA, which do, in fact, evaluate institutional dimensions and changing behaviour. Obviously, changes in value systems and preferences in social choice have a strong influence here. In the following discussion, this aspect is described in more detail.

The PEMSEA (Partnerships in Environmental Management for the Seas of East Asia) has developed "Project Performance Evaluation Indicators" in order to evaluate the success of the project from various perspectives. In PEMSEA practices, evaluation indicators are summarized in five major categories or levels[8,9]

- *Status indicators* – environmental or ecological, socio-economic and management features of the area where ICM is practiced, as the information basis for prioritizing environmental and resource problems and management issues to be addressed by the ICM efforts;
- *Stress or pressure indicators* – main forces influencing the state of the environment or ecosystems, particularly those forces of a transboundary nature;
- *Process indicators* – management interventions undertaken during the ICM process;
- *Response indicators* – outputs produced as a result of management interventions;
- *Sustainability indicator* – essential elements to keep ICM going in the long run;
- *Impact indicators* – environmental, economic and social outcomes of ICM practices, usually for measuring the physical, biological, or socio-economic changes resulting from ICM programme implementation against the baseline conditions before implementation.

7 http://www.loicz.org/imperia/md/content/loicz/print/rsreports/34_the_analysis_of_governance_responses_ to_ecosystem_change.pdf).

8 Chua, T.E., H. Yu and G. Chen. 1998. From sectoral to integrated coastal management: A case in Xiamen, China. Ocean and Coastal Management, 37(2): 233-251.

9 Chua, T.E., J. Lee, H. Yu and S.A. Ross. 2003. Measuring the performance of integrated coastal management programs. Paper presented at the East Asian Congress 2003, Putrajaya, Malaysia, 8-12 December 2003.

The selection of specific indicators will depend, in large part, on target audiences, usually project managers and funders. However, as part of the policy cycle, which builds on the management cycle as described by GESAMP (1996), Olsen et al., 1997 and 1999, political decision makers may also be targeted. All these target groups, including project managers and funders, require data to assess outcomes and to develop lessons from project implementation.

Conceptually, this policy cycle is a framework for examining the processes of ecosystem governance and for identifying repeated efforts to address critical issues (including actors involved). It can identify the presence or absence of learning, as a society works to achieve its goals over time. Past experiences in other comparably targeted projects demonstrate repeatedly, however, that even a sound processes, with appropriate participation, a technically competent program staff and sustained governmental support, may not necessarily deliver the desired outcomes. The Orders of Outcomes Framework (Olsen 2003[10]; UNEP/GPA 2006[11]; National Research Council 2008[12]) is designed to complement the policy cycle by focusing on the sequence of outcomes that must be achieved when working to realize desired societal and environmental conditions. This framework is featured in the figure below and one can see where indicators such as the ones mentioned above may feed in meaningfully.

Without these interim evaluations, the second order of outcomes (i.e. the change of behaviour in how humans interact with nature) diminishes. Strategic Action Plans (SAPs) usually include indicators useful for the implementing institutions. However, most SAPs do not have economic/social indicators incorporated [in the LBP projects]. So, what is missing?

- How are data stored and disseminated?
- Organization of databases by target audience — a kind of a *"click box"* for each target audience.

10 Olsen, S.B. (2003) Frameworks and indicators for assessing progress in integrated coastal management initiatives. Ocean & Coastal Management 46 (3-4): 347-361.

11 UNEP/GPA (2006) Ecosystem-Based Management: Markers for Assessing Progress. UNEP/ GPA, The Hague.

12 National Research Council. (2008). Increasing Capacity for Stewardship of Oceans and Coasts. Washington D.C.: The National Academies Press.

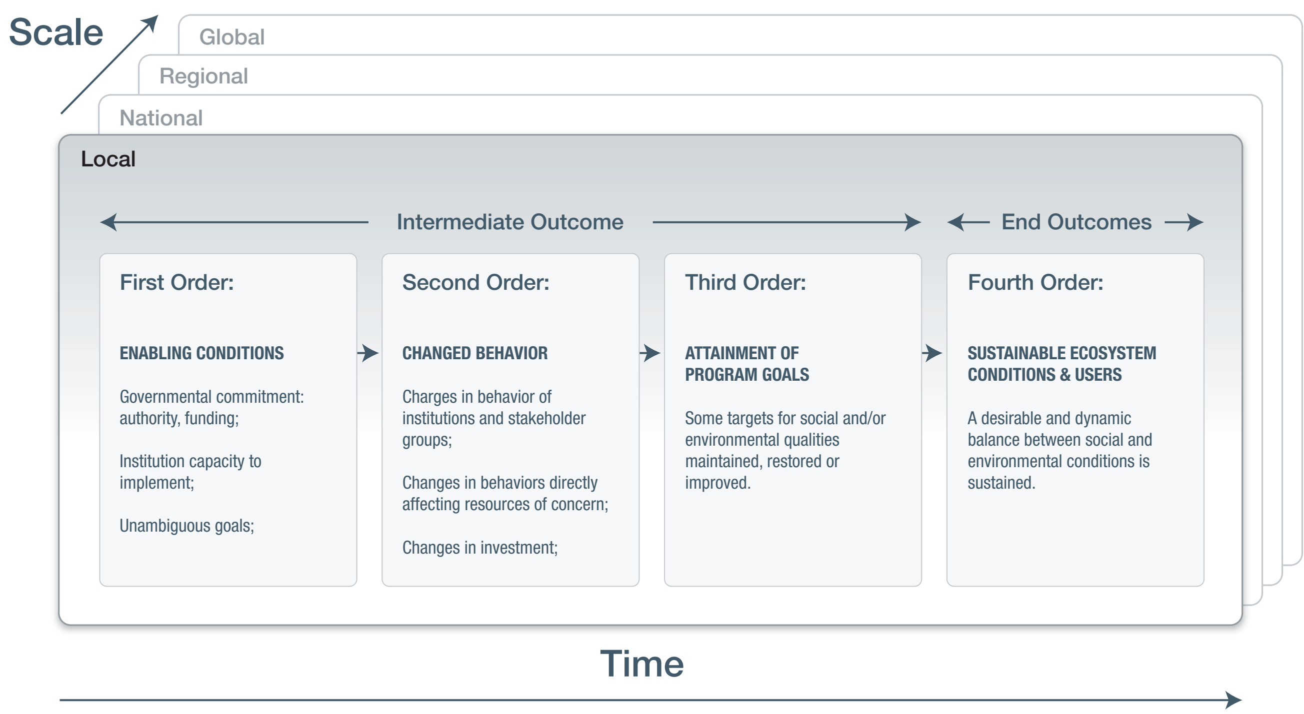
Figure 2 Large Marine Ecosystems of Latin America

Used with permission from the U.S. NOAA-LME Program Office 2011, http://www.lme.noaa.gov

- Emphasis on who the users are and how to make the indicators available.

Thus, indicators need to be useful tools for the implementing institutions, and they need to inform the assessment of system and governance baselines and change, particularly in societal response. This then leads to gauging success or need for improvement of the projects, which is an added value to a project, the investors and society as a whole. Obviously, this cannot be done without sound and solid science underpinnings across disciplines.

Figure 3 The Orders of Outcome Framework (from Olsen et al., 2006[13] and featured in Olsen et al 2009 LOICZ R&S Volume 34, GESAMP 1996; Olsen et al., 1997 and Olsen et al., 1999)[14 15 16 17]



13 Olsen, S.B., Sutinen, J.G., Juda, L., Hennessey, T.M. & Grigalunas, T.A. (2006): A Handbook on Governance and Socioeconomics of Large Marine Ecosystems. Coastal Resources Center, University of Rhode Island, Narragansett.

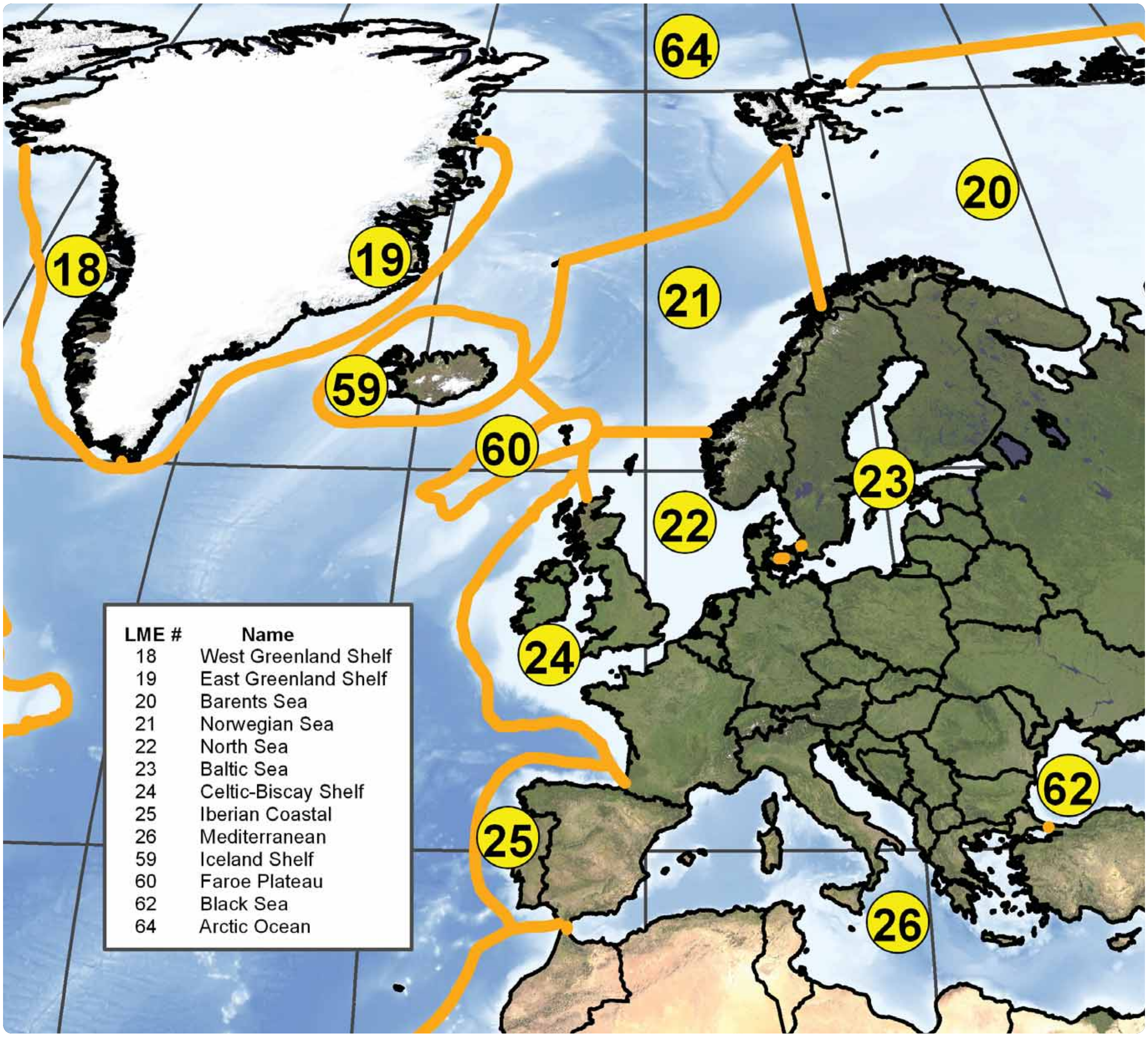
14 Olsen, S.B.; Page, G.G. & Ochoa, E. (2009): The Analysis of Governance Responses to Ecosystem Change: A Handbook for Assembling a Baseline. LOICZ Reports & Studies No. 34. GKSS Research Center, Geesthacht, 87 pages.

15 GESAMP (1996) The Contributions of Science to Integrated Coastal Management. Reports and studies No. 61. Food and Agriculture Organization of the United Nations, Rome.

16 Olsen, S.B., Tobey, J. & Kerr, M. (1997) A common framework for learning from ICM experience. Ocean and Coastal Management (37): 155-174.

17 Olsen, S.B., Lowry, K. & Tobey, J. (1999) A Manual for Assessing Progress in Coastal Management. Coastal Resources Center, University of Rhode Island, Narragansett.

Figure 4 Large Marine Ecosystems of Northern Europe



Used with permission from the U.S. NOAA-LME Program Office 2011, http://www.lme.noaa.gov

Table 1 Category of Proxy Indicators used in Coastal Management (modified from PEMSEA, 2008[18])

CATEGORY	RESPONSE[$]	PROXY INDICATOR
Governance		
Policy, strategies and plans	Coastal profile/ Environmental risk assessment	Per cent coastline for which profile has been done
	Coastal strategy and action plans	Area under ICZM, coastal plans including MPAs
	Local government development plan including coastal and marine areas	Use per cent of local plans (ICZM) that are graded/ rated, proportion of local government undertaking local governance
Institutional arrangements	Coordinating mechanism	Number of explicit MoA or informal mechanisms for coordinating between provincial and local government, percent of governance level (e.g., Philippines: number of local governments THAT have office of forestry management)
	Participation of stakeholders in the coordinating mechanism	Number of public debates, regular discourse/ consultations; whether there are legal procedures mandated for public hearings, number of litigations
Legislation	ICM/pollution enabling legislation	Number of violations and court cases for non-compliance
	Administration and monitoring of compliance to legislation	
	Environmental cases filed/resolved	
Information and public awareness	Public education and awareness	Right to information Act (RTI), frequency of information availability, number of events held concerning environment issues, number media stories and viewership
	Stakeholder participation and mobilization	Involvement of number of NGOs, percent local management budgets allocated to educational/ outreach activities
Capacity development	Availability/accessibility	Number of courses offered/ trainings/ workshops
	Human resource capacity	Proportion of staff who have advanced degrees in specialized management fields (mangrove specialists, marine biologists, social scientists etc), frequency of ToTs offered
Financing mechanisms	Budget for ICM/ pollution abatement	Proportion of budget that comes from designated revenue source, 5-year plans- municipal budget and does not require special allotment every year
	Sustainable financing mechanisms	
Sustainable Development Aspects		
Natural and man-made hazard prevention and management -	Level of preparedness for disasters	Designation of hazard zones, evacuation mechanisms, shelters, number of coastal protection of structures or other shields (bioshields), soft solution-inclusion of building codes, designated flood plains etc
State Indicators	*Degree of vulnerability to disasters - state indicator*	Proportion of community in designated hazard areas, in 100 year event, proportion of key facilities in the hazard zone
	Social and economic losses due to disasters	Number of lives/ property/ livelihood at risk
	Areal extent of habitats - System State	Number of Ecologically Sensitive Areas

18 Provincial Government of Batangas, Philippines and PEMSEA. 2008. State of the Coasts of Batangas Province. Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), Quezon City, Philippines. 119p.

$ Response here also links to the DPSIR framework

CATEGORY	RESPONSE[$]	PROXY INDICATOR
Habitat protection, restoration and management - Response Indicators	Habitat management plan and implementation - Response	Proportion of key habitats under the habitat management plan,
	Protected areas for coastal habitats and heritage - Response Indicator	Proportion of eligible areas under management, marine protection acts
	Reclamation and conversion	Proportion of reclaimed land conversion- e.g. identification of newly urbanized areas,
Water quality and quantity management	Water conservation and management	Proportion of reservoirs and existence of quality criteria, standards for number of days supply- amount of time the community exceeds expected reserves for water supply, environmental flows
	Incidences/deaths due to waterborne diseases	Proportion of population suffering from gastrointestinal problems- e.g. number of children with diarrhea
	Deforestation, floods and fluxes	Deforestation index, number of flood incidents per year, percent of the degree of forest cover annually, well used, land use change, sediment load, water discharge, soil type, vegetation cover
Food security and livelihood management	Fishery management plan and implementation	Specialized fisheries effort regulation (type of crafts and gears)
	Fisheries Production	Fishing effort (catch/ yr)
	Malnutrition	Proportion of population receiving basic calorie requirement per day; fish consumption in kg/ person (UNICEF/ FAO)
	Poverty, education and employment	Proportion of fishery resources availability, proportion of literacy
Environmental & Scientific		
Land-based Pollution and waste management - Impact Indicators	Management plans	Percent sale of fertilizers/ yr, tonnes of fertilizer/ ha/yr
	Water quality - impact indicators	Water quality index, number per area of sewage treatment under various categories (primary, secondary, tertiary)
	Air quality	Air quality index, number of coastal industries
	Sanitation and domestic sewerage	Number of sewage treatment plants, proportion of community served by sewage system
	Municipal solid waste	Proportion of waste ending up in landfills/ other technology
	Industrial, agricultural and hazardous wastes	Proportion of industry, agriculture, hazardous wastes in managed waste stream
	Bio-films for nutrient reduction	Percent of waste water subject to state of art treatment
	Suspended solids	Standards
	Fecal coliform	Number faecal coliform/ 100 ml
Sea-based Pollution and waste management	Ballast water pollution mitigation	International convention for ballast water management
	Treatment technology and management options	Response of the industry
Biogeochemical Functioning	*Nutrient loading - State Indicator*	*Number of people per catchment - Scientific Proxy indicator*
	Runoff	GDP as a controlling variable of runoff
	Trapping efficiency	Sediment load, number of dams in the catchment

Proxy indicators are "an indirect measure of a variable used when the variable of interest is difficult to measure" (Weiss, 1998) [19]. So development of an action plan is a proxy indicator for government action to indicate progress toward environmental change/improvement. Likewise, we sometimes *use number of community meetings or per cent of community residents attending planning meetings* as proxies for community participation.

Some key aspects highlighting availability of indicators in LBP projects include:

- Any best practices for transboundary issues and/or lessons learned;
- Effective institutions capable of dealing with transboundary issues;
- Services of the platform such as IWRN/OAS;
- Criteria for defining best practices; and
- Implementation of sustainable practices (with a few examples from case studies):
  - Enabling mechanisms to transition to long-term sustainable model on a regional scale;
  - Extensive logframe focusing on policy frameworks;
  - Target definition for sustainable coastal management – e.g., scaling up of integrated coastal zone management to 5 per cent of the coastline by 2010;
  - Reductions in nutrient loading by 10 – 15 per cent; and
  - Habitats identified as protected areas – restoration, increased biomass of 5 – 10% by 2015.

In many of the projects, SAPs do not indicate any social or economic dimension or value and, thus, the integration of human and environmental entities must still be conceptualized. Building on regional and local scale application of the socio-ecological system approach, Glaser and Glaeser *(accepted, ELSEVIER Treatise on Estuarine and Coastal Science volume 11, to be published in 2011)* mention five quality criteria and seven components for describing the social dimensions of managing social-ecological change (Fig. 2).

19 Weiss, C.H. (1998) Evaluation: Methods for Studying Programs & Policies 2nd edition. Prentice Hall

The five quality criteria include state characteristics:

1. Universal core and local specificity
2. Stakeholder resonance
3. Normative transparency
4. Comprehensive coverage
5. Appropriate scale.

The seven components include:

1. Population and resource use
2. Poverty, basic needs and wellbeing
3. Equity and justice
4. Social and human capital
5. Resilience, vulnerability and adaptive capacity
6. Participation, management and governance
7. Collaborative learning and reflectivity.

From these seven components, a set of practical and applicable indicators are derived that have proven to be of assistance in addressing the social dimension of socio-ecological system functions and feedbacks. Most of these indicators are proxy indicators. They may be useful to feed into an effective Orders of Outcome assessment. Obviously, the list provided does not claim to be universally applicable, but rather is developed from practical projects outside the GEF IW realm. However, the approach to conceptualize the "social" may be worth building in into future IW activities, along with the process of gauging success and failure based on thorough baseline descriptions.

The Mekong Delta supports a high density of human population and gateway for the effects of upstream and delta human activities to enter the marine environment / *A. Dansie*

Figure 5 Blue-print: 5 Quality criteria and seven components for describing the social dimension of managing social-ecological change – theory and testing [In blue – practical indicators for the social dimension of coastal management in the North Brazilian mangrove region of Bragança, Pará][20]

20 Glaser and Glaeser (accepted, ELSEVIER treatise on Estuarine and Coastal Science volume 11, to be published in 2011)

2.2 How can we identify effective proxy indicators for use in IW Science?

Examples of proxy indicators, as defined above, include:

- Economic valuation of ecosystems: i.e. ecosystem goods and services; and
- Livelihood status measurements - the proxy indicator for household income is number of electric appliances, cars, etc.

In an ideal situation, indicators should be incorporated during the early stages of management implementation, but this has not been the case for existing projects. Although there are 140 ICM efforts in 56 coastal nations adhering to the aspiring goals of ICM (Olsen et al., 1997)[21], harmonized indicators for evaluating the progress and success of ICM projects are still under development, and LOICZ has recently embarked on an initial proof of concept with coastal practitioners in Latin America (see comments on governance baselines above). As an integral part of coastlines, the potential for EMP indicators of success may be greatly influenced and guided by the lessons learned from and discussed for ICM. Three challenges have been identified in the process of developing meaningful indicators[22]:

21 Olsen, S., Tobey, J. and Kerr, M., 1997. A common framework for learning from ICM experience. Ocean & Coastal Management 37(2), 155-174.

22 Fry, V.E. & Jones, P.J.S. (2000) The development of meaningful indicators of Estuary Management Partnership success. Report from UCL to English Nature under the Estuaries Initiative Review.

For generations coastal communities in Asia have relied on a wide range of fish for their livelihoods. However, fish stocks in South-East Asia are being significantly depleted due to illegal fishing and overfishing / *UN Photo, M. Perret*

- A focus must be on process indicators, which will assist in generating a picture to map the project success against the orders of outcome (here largely the enabling conditions, and to some extent change in behaviour);
- Individual projects are diverse and unique in their locally orientated strategies; and
- Specific benefits and successes are difficult to demonstrate and attribute to the project.

Enabling conditions used to evaluate project implementation success include: plans completed, projects initiated, number of MOA signed, and those projects that identify a strategy, as well as a process for implementing a strategy, in response to an identified socio-economic or environmental issue. Some of the indicators for which proxies would be required in coastal management include:

- Ecosystem health
- Community empowerment (this can be a variable described by changes in institutional dimensions and the ways society may take influence in the major pillars of governance i.e. markets, civil society and policy)
- Reef health [a state]
- Ocean acidification
- Effective leadership – what is critical here is to be transparent about the question: at what point is this measured and what is the parameter that is the most meaningful (e.g., community satisfaction) with leadership? This is largely a matter of a proper social assessment concept and the right scales.
- Community commitment.

As an example: indicators for the "State of the Coasts" were determined based on PEMSEA's Framework for Sustainable Development of Coastal Areas through ICM to indicate current status, management responses, targets and impacts of management actions in each of the governance elements (policy, strategies and plans; institutional arrangements; legislation; information and public awareness; capacity development; and financing mechanisms) and the five sustainable development aspects (natural and man-made hazard prevention and management; habitat protection, restoration and management; water use and supply management; food security and livelihood management; and pollution reduction and waste management).

2.3 How to make better use of appropriate science and best practices for TDA?

The majority of coastal environmental problems are multicausal in origin so that exact causes are often difficult to specify. While incomplete knowledge leads to uncertainty in the decision-making process, coastal resources managers have tools for managing this uncertainty and for addressing major causes such as land-based sources of pollution. Science that provides insight into the causal impacts of interventions, and long-term trends in resource conditions, is at the heart of adaptive ocean and coastal management and policy-making. Based on a review of recent literature and interviews with coastal resource managers, five factors were considered [23] critical when integrating scientific knowledge into public policy-making. The factors are:

- The limitations of science;
- Scientific uncertainty;
- The importance of communication; (one may add here: …along agreed and understood concepts and terminology) and
- The role of politics and stakeholders.

23 Benoit, J and Lefebvre, C. (2005) Translating Science into Management: Challenges and Opportunities for the Coastal Community. Report Prepared for the Coastal States Organization 14pp.

Popular perception is that science provides the best way to get at cause-and effect relationships so that we may understand the world well enough not only to make predictions about it, but to control and manipulate it (Steel et al 2004)[24]. Transferred to transboundary issues, there seems to be two ways of making better use of appropriate science and best practices for TDA that should be included at the start of related projects:

1. To look at "best practices" in the use of science and technical analysis; and
2. "Fact-finding" in appropriate appreciation of the underlying cause-effect relationships, the right scales to determine meaningful ecosystem and institutional boundaries of the issue under consideration, of the local, regional global and climate drivers involved and the level of uncertainty; fact finding should also be transparent in terms of identifying those aspects which may need to be attributed to surprises (e.g., unexpected socio-political and/or economic system changes)

The PEMSEA tools/strategies may be a good model in this context. PEMSEA focused on management through ICM, utilizing several tools and components: sciences; information and communication; civil society; regional collaborative arrangements; environmental investments, capacity building in a broad sense; coastal and marine policy specifications; and networking. On the contrary, the Global International Waters Assessment (GIWA) did not always make ideal use of appropriate science frameworks. There is a need to capitalize on existing knowledge outside the UN context, with appropriate use of traditional knowledge. Some of the projects that could be used in the context of making better use of appropriate science and best practices for TDA are listed below:

- Framework for addressing bio-invasion (in ballast water) where fisherfolk are encouraged to look for new species. This involves passive sampling by a larger population to identify marine bio-invasive species.
- Use of indigenous knowledge: for example,
    - MADAM - The Mangrove Dynamics and Management Program Project in Brazil. The MADAM program has two main objectives: i) to research the dynamics of mangrove ecosystems and ii) to support formulation of management recommendations based on traditional knowledge.
    - SPICE - Science for the Protection of Indonesian Coastal Environment project in the Indonesian Archipelago - provides significant information on the structure and functioning of coastal ecosystems covering mangroves, coral reefs, coastal pelagic systems and peat swamps, and on their alterations due to human interventions. These results have already found their way into management strategies being developed by the regional planning authorities. Phase II of the SPICE project is to focus on natural sciences, complemented by social science. The research cluster "Governance and Management

Mahabalipuram Coast shell sale / *IOM, Anna University*

24 Steel B, List P, Lach D, Shindler B. 2004. The role of scientists in the environmental policy process: a case study from the American west. Environmental Science & Policy 7: 1-13

of Coastal Social-Ecological Systems" has been added to the existing 5 clusters of Phase I.
  - CAVIAR - Community Adaptation and Vulnerability in the Arctic Regions - an International Polar Year (IPY 2007-2008) Project. The Arctic is experiencing rapid changes in environmental, societal and economic conditions. The particular conditions to which communities are sensitive are not well documented, nor have the conditions that might facilitate or constrain the adaptive capacity in the face of interacting climate and socio-economic changes been substantiated. Insights into the particular vulnerabilities of Arctic communities have not been compared across Arctic countries nor are these studies well connected to policy development. This project is designed to meet research gaps, and outlines a research strategy that develops a theoretical framework for community vulnerability assessment, refines a common methodology, establishes procedures for case studies, develops a process to compare and integrate results, and ensures direct application of research to policy.

- Continued training between science and managers.
- LME Projects - how do lifestyles and people's aspirations help govern regional seas? As an example, the European Lifestyle and Marine Ecosystems project (ELME) reflects the two key issues above and aims to establish innovative transdisciplinary modelling, assisting establishment of meaningful future scenarios for regional seas around Europe (http://www.elme-eu.org/).
- Develop and implement a flexible template for documentation and a "learning strategy" that includes "peer review".
- A good TDA/SAP needs guidance:
  - What are the steps?
  - Baseline data collection
  - Consultation of stakeholders
  - Identification of hotspots
  - Identification of experts.

- TDA must produce guidelines from the different steps.
- Some underlying principles behind TDA (Mee, pers. com.) are:
  - Improved stakeholder analysis;
  - Introduction of buy-ins by the multiple actors involved on the relevant temporal and spatial scales;
  - Adapting the TDA process to make it more inclusive and rigorous reflecting multiple geographic scales, scientifically rigorous documentation, socio-ecological systems and governance baselines (see also reference above to orders of outcome framework).

- TDAs are often too generic; they must lead into SAP (involving lessons learned) including economic/non-economic valuations that may illustrate the changes observed in ecosystem goods and services and may be complemented by indications of costs certain response options may bring.
- TDA *(according to Hart pers. Com.)* are characterized by the following:
  - Identifying issues of transboundary nature
  - Consultations and data gathering - methodology
  - Assessment of biodiversity degradation
  - Assessment of environmental impacts
  - Assessment of socio-economic impacts and
  - Causal chain analysis.

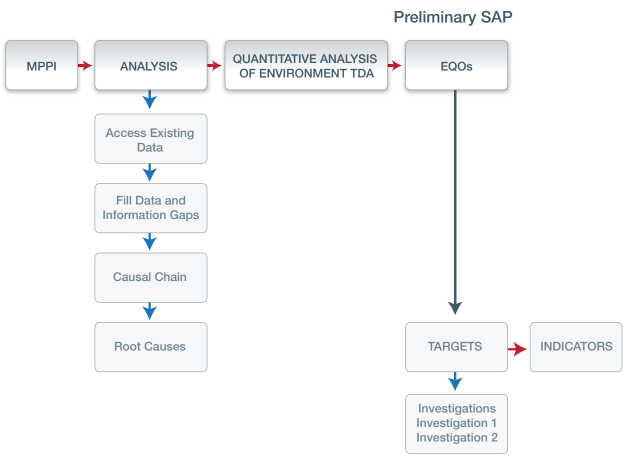
- Resulting Strategic Action Plans (SAP) are negotiated policy documents with clear priorities for action (e.g., the National Action Plan). It remains to be clarified, however, as to what level they may feed into legally binding policy and on which scale.
  - Ideally a SAP identifies i) policy; ii) legal and institutional reforms needed and iii) investments required to identify/ address the priority transboundary water problems.
  - The SAP is a cooperative process calling for ownership by key stakeholders in the countries of the region addressed.

The first step (Fig. 3) in the TDA process (featured is the one carried out for the Mediterranean Sea) is to identify major perceived problems and issues (MPPIs). This step was performed through a participatory process. These MPPIs were the basis for the analysis phase, during which time the MPPIs were investigated for validity.

- Do data support the MPPI as a priority concern?
- What data are necessary to evaluate the MPPI?
- What do the stakeholders think about the importance of the MPPI?

- What are the causes of the MPPI (causal chain analysis)?
- What are the environmental impacts of the MPPI?
- What are the socio-economic impacts of the MPPI?
- The analysis phase ends with a *de facto* ranking of the relative importance of the various MPPIs.

Figure 6 Flow Diagram for the TDA Process[25]



This is based on the perspective of the GEF/IW, as the TDA is a product of the GEF/IW process[13]. These steps lead to investigation of the quantitative understanding of the environment and its interaction with society, which is the TDA. This quantitative understanding by nature has uncertainties:

- *the data are not perfect,*
- *they are too infrequent,*
- *they are too sparsely located around the region,*
- *the analytical methods are imperfect, etc.*

However, the TDA is based on expert judgment of the best available data. The TDA then is followed by agreement of overarching regional quality objectives. If the TDA gives the present status of the environment, what is the common vision of the desired status? What environmental goals are desirable? These are environment quality objectives (EQOs). The root causes and the MPPIs generally "drive" the next step in the process: selection of specific targets and actions to move towards achievement of the EQOs. These targets must be realizable,

A. Dansie

transparent, have finite and defined duration, and be associated with definable and measurable indicators.

In summary, the TDA follows the general GEF Guidelines for International Waters projects. The EQOs naturally lead to identification of specific targets to be met within the desired time frame, and from there to identification of specific interventions and actions that can be considered in the framework of the NAPs and SAP. Critical elements that constitute the TDA documentation are:

- Executive Summary.
- Section 1 is the introduction
- Section 2 is the technical basis of the TDA, addressing the MPPIs.
- Section 3 is the legal and institutional framework analysis.
- Section 4 is the stakeholder analysis.
- Section 5 covers the environmental quality objectives.

The projects reviewed in the IW LBP portfolio, to a considerable extent, rely on TDAs. However, documentation in many cases is rather limited as to how this analysis has been considered in the projects and the underpinning science and data.

Coastal systems are complex, and their management takes place against a dynamic background where change is continuous and unpredictable. The adaptive manage-

25 UNEP/MAP/MED POL: Transboundary Diagnostic Analysis (TDA) for the Mediterranean Sea, UNEP/MAP, Athens, 2005.

CHAPTER THREE

Application of science for adaptive management

ment approach has become a useful alternative to deal with such systems. Walter and Holling (1990)[26] explain adaptive management as treating management[27] strategies, and policies as experiments conducted to learn more about the ecosystem's processes and structures. Adaptive managers, therefore, have the combined roles of defining desired realities, generating options, and applying measurements that allow adjustments to be made to the management strategy. The adaptive management process provides opportunities for "learning-by-doing". Such learning reveals how ecosystems respond, what the managers are doing, which strategies are successful, and whose interests are served (Lee, 1999)[28].

The concept of adaptive management was developed specifically to provide a framework for decision-making to help "reduce uncertainty". The principles of adaptive management can be applied at various scales and using various strategies. The most important element is to learn from the project. In fact, adaptive management has been called "learning by doing." Uncertainties are identified and acknowledged during the planning phase, and steps are taken to deal with these uncertainties. The framework developed by NOAA's Coastal Service Centre provides an important feedback loop and can be used to improve restoration success[29].

26 Walters, C. J., Holling, C. S., 1990. Large scale management experiments and learning by doing. Ecology 71: 2060-2068.

27 Zhang, X., (2010) Integration of Science and Coastal Management: a Case Study of Hong Kong, LEWI Working Paper Series # Paper # 101; http://www.hkbu.edu.hk/~lewi/publications.html

28 Lee, K. N., 1999. Appraising adaptive management. Conservation Ecology 3(2):3.

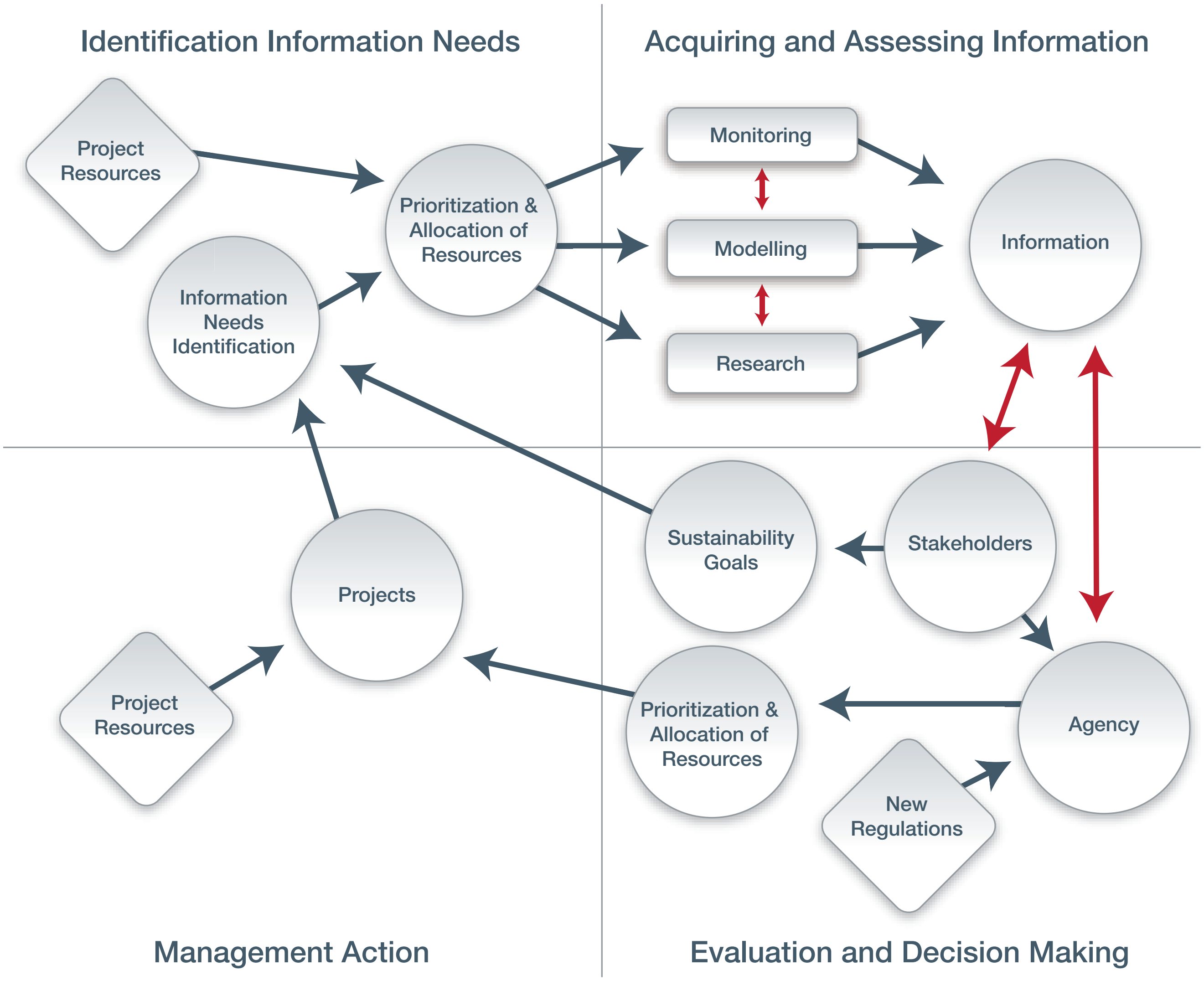
29 http://www.csc.noaa.gov/coastal/management/monitor.htm#ada

Figure 7 Applying the continual evaluation process of adaptive management leads to cost-effective, successful restoration projects[2]

The role of science in adaptive management is to provide information on changing parameters. Manley et al. (2000)[30] describe the cycle of adaptive management in four phases, as shown in Fig. 1. One of the most significant developments in project management has been the increased use of adaptive management principles to assess the success of a project at a particular point in time, based on monitoring-program results, and then to make adjustments that are likely to improve overall project success. The process can be repeated as many times as necessary to keep the project on track toward meeting all of its objectives. It is important to be able to modify management of an ongoing project, because it allows a manager to consider how such things as new knowledge from outside the project, new technology, inventories, and adjustments to performance goals could affect the project. The ultimate goal is to make a project *"work"* without wasting funds by attempting to adhere to inflexible and unrealistic goals.

30 Manley, P.N., Tracy, J.C. Murphy, D.D., Noon, B.R., Nechodom, M.A. and Knopp, C.M. (2000). "Elements of an Adaptive Management Strategy for the Lake Tahoe Basin". In Lake Tahoe Watershed Assessment: volume I (Technical Editors: Murphy, D.D.; Knopp, C.M., Gen. Tech. Rep. PSW-GTR-175. Albany, CA: Pacific Southwest Research Station, Forest Service, US Department of Agriculture; 753 p.

Figure 8 A schematic diagram of an adaptive management planning cycle (adapted from Manley et al., 2000)



The cycle of adaptive management can be described in five phases:

1. Identify information needs
2. Develop information acquisition and assessment strategy
3. Evaluate management options and choose management strategy
4. Implement management strategy, and
5. Evaluate management strategy. [Note: essential for adaptive management.]

The first two phases focus on the information acquisition and assessment phase of the cycle with a brief reference as to how information can best be transferred to the evaluation and decision-making phase. The other stages are critical to developing a fully functioning adaptive approach to the management of resources in the basin; however, they largely pertain to public policy development and participatory evaluation processes rather than to the direct relationships between scientific research and management. Coordination of scientific activities with management actions is at the core of an adaptive management approach. Adaptive management calls for new roles for science that lie outside the formal academic training of most scientists. Generating new information is only one of several important steps in adaptive management. McLain and Lee (1996)[31] posit that effective management requires societies not only to acquire knowledge but also to change their behavior in response to new information about the systems in which they live.

This is an emerging scientific issue to actually gauge the level to which a change of behavior can be observed (the governance baseline approach – see LOICZ R&S 34). Science can inform the establishment of the enabling conditions and adaptive socio-environmental monitoring, but stakeholders and practitioners themselves need to report on their changing value and preference systems to allow an assessment of changes in behavior. Orstom (2009)[32] for example explores a framework to assess the likelihood that behavior changes in the form of self-organization among resource users (A General Framework for Analyzing Sustainability of Social-Ecological Systems).

31 McLain, R. J., and R. G. Lee. 1996. Adaptive management: promises and pitfalls. Environmental Management 29(4):437-448

32 Ostrom, E. (2009) www.sciencemag.org SCIENCE VOL 325, 419-422 24 July 2009

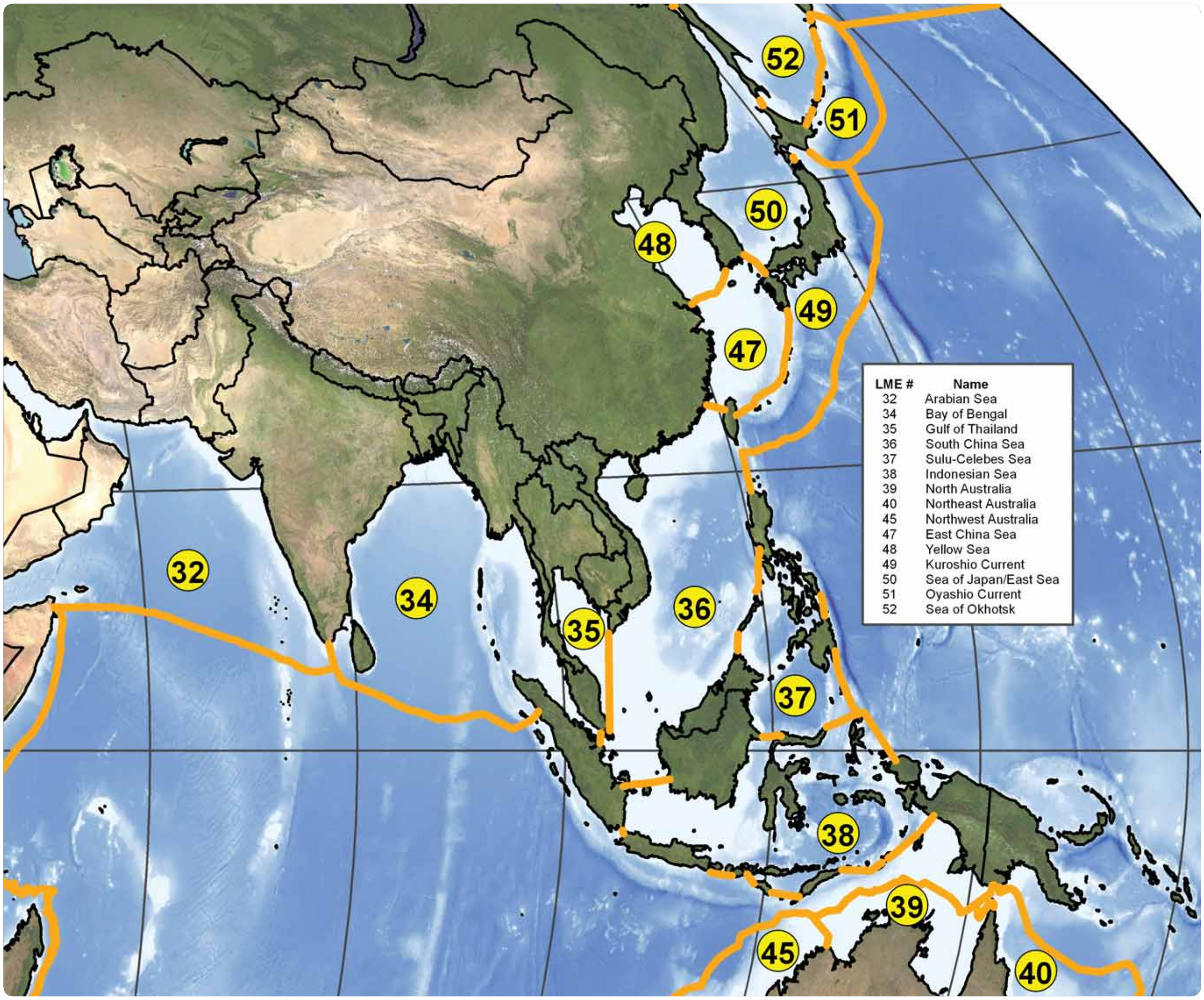
The following core questions were to be explored.

3.1 Was engagement of both local and wider science communities utilized in IW projects? If not, how can improvements be made?

Examples of engagement of local and wider science communities from IW projects are particularly evident in the following land-based sources of pollution projects:

- The project on the *Role of the Coastal Ocean in the Disturbed and Undisturbed Nutrient and Carbon Cycles* was a purely science driven project, which engaged local regional and global science communities to a large degree. Due to an inherent capacity building and training component building "regional mentors" for a specific research approach, this engagement has grown to a global network of scientists applying the methodology and engaging in evaluation and adaptation.
- GIWA is a key transboundary project dealing with global environmental problems and threats to transboundary water bodies. However, across the over 60 GIWA sites, the engagement with science communities has been rather variable. One lesson is that in such global assessment, there is potential to have an even larger effect by inventorying and involving existing scientific networks and research on appropriate scales from the beginning.
- European Regional Seas Program has proposed the generation of high quality data for accurate "modelling", providing computerized views of conditions, both existing and possible future scenarios. Again, links with complementing regional-scale research efforts and networks have potential to improve. Further progress requires tangible science management efforts to establish the links between the more policy-directed regional seas program and the research community, and it needs a broadly agreed platform for data sharing and maintaining databases. Currently, the situation in different regions is quite heterogeneous, and databases, research and monitoring, as well as observatory efforts, are still considerably fragmented.
- PEMSEA has developed a long-term, "adaptive management" approach to site-level ICM projects. Adaptive management encourages a problem-oriented approach to management and to capacity building. Engagement with the scientific community

Figure 9 Large Marine Ecosystems of South East Asia



Used with permission from the U.S. NOAA-LME Program Office 2011, http://www.lme.noaa.gov

has occurred on both specific issues and geographic areas. Discussions and updates on coastal management analytical needs and knowledge products were subjects of regional conferences. The broad buy-in from national, regional and local stakeholders and practitioners has been critical. Development of research networks comprised of high-ranking scholars has also been important.

- In the African tourism project, standard project monitoring and evaluation will be conducted in accordance with established UNEP and GEF procedures. Technical review teams have been established, but are constrained by the availability of data.
- Monitoring is a key component in the Guangdong-Pearl River Delta project. Engagement with the science community had defined the baseline of the system states and pressures.
- WIOLAB - the project has undergone some adaptive management, in particular in relation to the demonstrations, but has not gone beyond the scope of the original objective with its focus on pollution from land-based sources.

- Projects either with direct regional and/or global networks or implemented by organizations hat bring this capacity: PEMSEA, LOICZ, GEOHAB, and GLOBALLAST partnership.

How can improvements be made?

- There should be no hesitation and no perception of competing interests preventing the projects from engaging the broader scientific community.
- The manner in which current funding schemes operate in the UN shapes participation and outcomes.
- Twinning arrangements (i.e. across systems or site exchanges and learning) and other collaborative initiatives can broaden participation and build capacity, and scientific forums can reinforce dialogue. Examples are predominantly among those projects addressing the management of river catchments and effects on coastal seas.
- Attribution – more scientists could be drawn into UN activities. Ownership and attribution of knowledge needs to be clear from the beginning (i.e. the terms and conditions of this collaboration). Compensation creates incentives for scientists to participate, so in some cases, compensation may be required.
- Clear charter and clear expectations facilitate attribution of individual contributions.
    - In LBP projects, what is the charter of a scientific group? What are the expectations? What are the incentives to participate and how is participation acknowledged?
    - Do scientists regard this participation as useful both for their career and for the larger effort in which they are involved?

- Improvements could be achieved through the "training of trainers" concept
    - Capacity building, information sharing, training modules, enhanced knowledge
    - Institutionalization of "applied sciences".

3.2 Is scientific expertise and local knowledge well applied within the IW focal area?

The attitude of people, and their perceptions, beliefs, and knowledge, can have a profound effect on the success of coastal management initiatives. While science can serve as a rational foundation for management, in many cases it is the groups affected by coastal resource management decisions that determine how acceptable a decision is and influence how effective management will be. Experiences and culture, understanding of an issue, and support for an agency can each shape the level of public support for and compliance with coastal resource management decisions and policies[33]. In a few of the LBP projects, scientific expertise, formal training and education, and cognizance of local knowledge have aided in the decision-making process. Some of the shared knowledge includes:

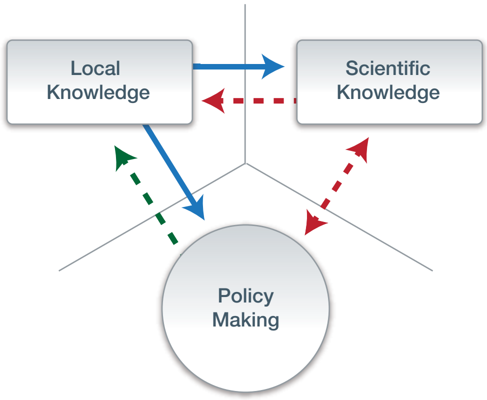
- Existing baseline information, -(e.g. PEMSEA);
- Coastal resource profiles;
- Developing or adapting analytic methodologies;
- Scientific insights/breakthroughs from local projects; and
- Scanning for emerging issues.

3.3 Identify lessons learned for linking science and policy implementation, including policy formulation and broader governance issues

In order to be effective, policy must be focused and practical, addressing priority and strategic coastal use and change issues. Lessons can be drawn from each aspect of the policy process (i.e., policy formulation, implementation, monitoring and evaluation and adaptive efforts). To draw useful lessons, it is necessary to engage meaningfully with the scientific community, the public, the private sector, and all levels of government.

33 NOAA (2007) Linking People, Information and Technology, Social Science Tools for |Coastal Programs, NOAA Coastal Services Centre, USA. www.csc.noaa.gov/cms/human_dimensions/focus_socialsci.html.

Figure 10 Depiction of ideal flow across boundaries in the context of cooperative research (modified from Johnson, 2007)[34]



Local (fishers) knowledge (blue lines) flows to scientists (due to collaboration) but not into policy-making (due to legal mandates). Scientists' knowledge (red dashed line) flows to local (fishers) knowledge (due to collaboration) and into policy-making (due to qualification as the best scientific information).

Key points important to consider when identifying lessons learned for linking science and policy include:

- Scientists need to understand how to conduct management-relevant applied science: i.e., scientists need to understand how their information can be transformed into knowledge products that can be applied in socio-ecological system management;
- The WIOLAB project demonstrates the application of policy–science links (see annex on WIOLAB Project);
- Science-policy collaboration is also explicit in the project that focuses on ballast water;
- The LOICZ project, in a final policy and management review of the *Role of the Coastal Ocean in the Disturbed and Undisturbed Nutrient and Carbon Cycles* (GEW IW project), provided information on how biogeochemical assessment of coastal ocean systems needs to be transformed to inform science-policy discourse and lead to decision support;
- The ICZM protocol for the Mediterranean (Madrid, 2008) is a protocol to the Barcelona Convention that indicates the influence of multiple coastal zone management projects and plans on a regional sea development;
- Community-based management often includes capacity building by foundations, universities, donor agencies, other projects. A cross-site training is the prime focus of the project, *Demonstration of Community-based Management of Seagrass Habitats in Trikora Beach East Bintan, Riau Archipelago Province, Indonesia;*
- PEMSEA has developed a substantial adaptive management strategy for the use of risk assessment and risk management (RA/RM), together with Integrated Coastal Management (ICM). By combining these frameworks, a comprehensive coverage of marine and coastal environments and the associated land-based and sea-based issues was obtained;
- At the local project level, the strategy for learning and adaptive management is often less clear. For example, pilot and demonstration projects are a feature of most site-level strategies. These specific projects should be thought of as mini-experiments from which lessons can be extracted as to whether to "scale-up" to additional, similar projects and, if so, to determine the requisite requirements for constructing successful projects. While these pilot projects and demonstration projects are often carefully and thoughtfully designed, procedures for learning from them are often not explicit.

At the regional level, the PEMSEA project aims at preparing a framework for establishing a sustainable regional collaborative mechanism that can generate a coastal and ocean governance regime. This effort will build on the experiences from all the other components. Several lessons learned can be identified from the PEMSEA Project:

- Success and sustainability hinges on the proper combination of key programme ingredients;
- Sustainability can be achieved through strong government action; supporting legal systems; sound science and capacity building;
- Partnerships must be inclusive and based on buy-in on all relevant scales;
- PEMSEA's combination of "top-down" and "bottom-up" impetus is effective in securing necessary political commitment; and
- Partnerships do not happen overnight.

34 Johnson, T. R. 2007. Integrating fishermen and their knowledge in the science policy process: case studies of cooperative research in the Northeastern U.S. Doctoral dissertation. Rutgers University. Rutgers, New Jersey

3.4 Is adaptive management happening? How to better understand and effectively communicate the scientific dimensions of adaptive management to different user groups?

Adaptive management encourages a problem-oriented approach to management and to capacity building. It is our notion that policy initiatives are undertaken as explicit experiments – and out of this emerges adaptation. For this purpose, deliberate and organized trial-and-error experiments are essential at several scales including:

- Project-scale adaptive management;
- Systematically gathered data- where interventions were changed; and
- Adaptive management across the portfolio: e.g. Xiamen – new paradigm in adaptive management.

PEMSEA has adopted the concept of ecosystem-based management for river basins, estuaries and coastal seas in the region through the application of integrated and adaptive management approaches in addressing pollution, loss of habitats and biodiversity, depletion of fisheries and marine resources, coastal reclamation, and other coastal and marine issues in the context of the socioeconomic, political, cultural and ecological characteristics of the region (PEMSEA, 2004)[35].

Adaptive Management Framework in coastal management:

An Adaptive Management Framework (AMF) is a systematic process for continually improving management policies and practices by learning from the outcomes of operations through careful monitoring and relevant research. There are many benefits to an adaptive management framework as it allows decision making to proceed, even when there are considerable gaps in knowledge and uncertainty, by specifying actions, monitoring and adjustment of visions, targets and associated management practices.

The Coastal Resources Center (2006)[36] study states that the Adaptive Management Framework (AMF) includes six basic components:

1. Information collation: where information from stakeholders and ongoing research is pooled and organized so it can be readily accessed and used to improve the common understanding of natural resource management (NRM) issues and opportunities.
2. Systems analysis and vision: where stakeholders come together to develop their NRM vision and aspirations for a particular location, catchment or region, and to develop a systems approach to their assets to enable exploration of differing perspectives, values, beliefs and linkages between understandings. Concepts are refined to provide a workable understanding of the ecological system and its expected responses.
3. Planning: where stakeholders collectively establish NRM goals and targets and negotiate a preferred strategy based on consideration of multiple and sometimes conflicting objectives and possible trade-offs that may be required.
4. Implementing actions: where stakeholders assign roles, responsibilities and resources to conduct the agreed actions for achieving goals and targets in the plan.
5. Monitoring and reviewing: where stakeholders evaluate progress towards the vision, goals, and implementation schedule and targets established at the start of the adaptive management process, modifying goals or practices as a result of emerging knowledge, using agreed review timelines.
6. Core components: comprising facilitation and management of the adaptive management process and the evolving knowledge whereby networking, learning, negotiation, conflict resolution and knowledge development processes are organized.

A few examples of Adaptive management from the LBP Projects:

Adaptive management also includes cross-site innovations and continued review within the DPSIR cycle:

35 PEMSEA, 2004.Sustaining Benefits. PEMSEA IEC Manual 1, 38p. Global Environmental Facility/ United Nations Development Programme/ International Maritime Organization Regional Programme for Building Partnerships for the Seas of East Asia (PEMSEA), Quezon City, Philippines.

36 CRC (2006) Enabling adaptive management for regional natural resource management, technical report 18, August 2008

- The project report that derived from the global biogeochemical assessment implemented by LOICZ provides graphics and feeds into follow-up activities aimed to address effective science communication, including reflection on how to deal with uncertainty;
- Addressing uncertainty at a regional seas scale or across portfolios could be of use in adaptive management; this is particularly the case if uncertainty is being quantified scientifically and involved in scenario simulation for likely futures of regional seas (this can be seen in recent EU projects outside the GEF portfolio);
- Changing technology: i.e., changing to collaborative management among agencies is a potential example of changing management principles;
- Changing ballast water technology;
- The LMMA network (http://www.lmmanetwork.org/), which is a network of marine conservation practitioners working in Asia and the Pacific who have joined together to increase the success of their efforts is an example of adaptive management.

3.5 How to better communicate newly synthesized science knowledge to stakeholders within and external to GEF

The approach must be to communicate information about coastal problems and solutions in ways that are relevant and actionable. As decision makers, natural resource managers should monitor scientific trends and connect with scientific experts who can answer questions relevant to the public policy debates in which they engage. Likewise, there is a growing need for scientists to present their research findings outside traditional publication pathways (which are nonetheless the one and only truly accepted scientific reward system!) and to target their research communication on specific public policy issues. Three common communication problems that can arise among scientists, resource managers, and the citizens they serve are outlined below:

1. *Concepts and language* – different concepts and language barriers (e.g., on the level of system descriptions or delineations of boundaries of drivers, impacts and institutional dimensions) can easily stymie or obstruct policy-science discussions;
2. *Relationships and partnerships* - applying knowledge can be a challenge for managers because it is not always clear what scientific findings are relevant to the problem at hand, or where and in what form the information might be available (Bosch et al 2003[37], Gregrich 2003[38]).
3. *Information Technology and data sharing* - one tool resource managers have identified to improve internet information exchange is a central source of reliable on-line information that combines what is known about particular topics both from public policy and scientific research standpoints. With such a resource, particular attention should be paid to issues surrounding the comparability of data, data records (metadata), how data is being used, and who is using it[39].

Some of the ways to better communicate newly synthesized science knowledge to stakeholders within and external to GEF as discussed within the LBP Working Group are delineated below.

- *Talk to them* - communicate to different stakeholders;
- Science conferences with information channels to other audiences and involvement of youth and early stage researchers/stakeholders;
- *Post-normal* science communication - *Silvio Funtowicz's[40] definition of "post-normal science", where "facts are uncertain, values in dispute, stakes high and decisions urgent". Ravez started discussion of post-normal science in the context of the debate over environmental issues: in this case, not all the factors are knowable, it is necessary to cope with uncertainties, but at the same time it is of great importance to find a way to cope with this knowledge and to continue with the decision-making pro-*

37 Bosch OJH, Ross AH, Beeton RJS. 2003. Integrating science and management through collaborative learning and better information management. Systems Research and Behavioral Science 20: 107 - 19

38 Gregrich RJ. 2003. A note to researchers: communicating science to policy makers and practitioners. Journal of Substance Abuse Treatment 25: 233-7

39 CSO (2005) Translating Science into Management: Challenges and Opportunities for the Coastal Community. Report Prepared by Jeff Benoit and Chantal Lefebvre of the Urban Harbors Institute – University of Massachusetts Boston for the Coastal States Organization

40 Funtowicz, S.O. and Ravetz, J. R. (1993) "Science for the post-normal age", Futures, vol. 25(7), pp.739-755

cess. A few examples of post-normal science include the following:

- Report card of status of coastal health
- Different communication strategies for outreach
- Communicating conceptualized diagrams to elucidate complex interplay and feedback in social ecological systems including effects of surprises and how they affect our world
- Visual media
- Targeting specific groups also outside the science community.

- Change incentives so that outreach and connections to management are reinforced;
  - Educate school children / youth (including youth for an educational curricula addressing issues of a changing earth system and human dimensions)
  - Develop language, stories, and images to communicate this new knowledge effectively and to communicate successes effectively.

- From the beginning of the process, make stakeholder analysis compulsory;
- Local language website, bottom-up approach (ownership); and
- Revitalize traditional knowledge: i.e. incorporate *traditional knowledge* such as water management in community-based management notions of 'kapu'/ taboo; restricted areas/species/harvesting seasons).

In conclusion.....

"All you gotta do is put your mind to it knuckle down, buckle down, do it, do it, do it"

— Roger Miller

A coral head provides refuge for many species of reef fish in South East Asia / *A. Dansie*

IW:Science

Enhancing the use of Science in International Waters projects to improve project results

UNITED NATIONS UNIVERSITY
UNU-INWEH

The United Nations Think Tank on Water

United Nations University
Institute for Water, Environment and Health
175 Longwood Road South, Suite 204
Hamilton, ON Canada L8P 0A1
1.905.667.5511 • www.inweh.unu.edu

ISBN: 92-808-6024-0