“Sharing 20 years of experiences in integrated coastal cooperation is sharing our trust in long term, sustainable development of coastal resources and in finding resilient, adaptive responses to climate change for valuable and vulnerable coastal areas”

Robbert Misdorp – Editor

2011
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Joop Atsma
State Secretary of Infrastructure and the Environment, the Netherlands

More than sixty percent of the world’s population lives within 60 kilometers of the coast. The world’s coastal zones represent a precious resource. They are vital to international trade, habitation, wildlife, travel, recreation and energy capture. Economic development, social development and protection of the environment are equally important.

The management of coastal resources is quite a challenge. Many coastal zones are placed under intense pressures. Nations and communities must balance the benefits of short-term resource exploitation with long-term resilience. Adaptation to climate change has become a priority policy issue around the world.

As State Secretary of Infrastructure and the Environment, I am responsible for water policy in the Netherlands. A fascinating job! The Netherlands is a dynamic and densely-populated delta. It has a long tradition of water management; our ancestors have been ‘water managers’ for almost one thousand years. Given its vulnerable position in a low-lying delta, coastal zone management and flood protection are of the utmost importance to the Netherlands. We have chosen an adaptation strategy in which we look one hundred years into the future. Our Delta Programme identifies appropriate policies to protect the country from high water and secure its freshwater supply for today and the future.

We have learned how to keep our feet dry with infrastructure and engineering. And we have learned to find solutions in which Mother Nature lends a helping hand. An eye-catching example is the so-called Sand-Engine (see photo). We are depositing millions of cubic meters of sand in the shape of a large hook, extending from our coast. Wind and waves will spread this sand along the coast, making it stronger. With this approach, the Netherlands is a front runner.

Together delta countries can find better answers to the great challenges they are facing. We recognise the need to share information, experiences and knowledge. Therefore, we are a driving force behind intensifying international cooperation. Important in this respect are:

- The Netherlands Water Partnership. An umbrella organization for the public sector, companies, knowledge institutions and non-governmental organizations that aims to increase international exchange of knowledge and technology.
- The Delta Alliance. An international knowledge-driven network aiming to improve the resilience of the world’s deltas.

This ‘Climate of Coastal Cooperation’-publication is meant for anyone interested in coastal zone management. It contains a wealth of experience on coastal processes obtained through programmes and projects in Asia and Europe. Many of these projects were planned and executed with the support of the Dutch government and Dutch companies and universities.

I hope this production will strengthen the exchange of experience and will encourage the planning of adaptive measures to address the strongly changing conditions in the world’s coastal zones.
The Netherlands is a fertile, highly productive, densely populated, low lying coastal country, which serves as a gateway to Europe and the world. Located at the confluence of four major rivers and the sea, the Netherlands is an important hub for the worldwide transport of goods as well as a key centre of international commerce. Our rivers are vital axes of transport and providers of water for agriculture, industry, nature and drinking. The western part of the Netherlands is extremely low lying, with some areas more than six metres below present sea level. These conditions pose major challenges for survival. To survive, during the last millennium, our nation developed an almost inborn alertness to combat the forces of the rivers and the sea. The Delta Works (1953 – 1998), a series of hydraulic constructions in the south-western part of the Netherlands was created after the great flood in 1953. This post-disaster reaction was based on the advice of the first Delta State Committee.

The Netherlands is safe for now, but can become more vulnerable to the impact of future global changes such as climate change. We measure and predict that both temperature and sea water levels are rising and that our soil is subsiding. We expect that wet –and dry – extremes will increase further. We are already observing increasing extremes in precipitation. Consequently, we must improve our coastal and river defences against flooding in order to prevent future disaster.

Effective responses in advance of future developments are now being formulated on a global level. The Netherlands’ government, following the advice of the second Delta State Committee (2008), has started the Delta Programme not as a reaction to a disaster but to avoid one and to be prepared for the future. A Government Delta Commissioner was mandated to direct the implementation of this long term Delta Programme with all relevant Ministries, regional authorities, non-governmental organisations and local stakeholders. The Delta Commissioner is assigned for the national coordination of the Delta Programme, securing the cooperation and integration of all relevant parties involved. This programme, our Delta Works of the future, aims to protect the Netherlands and its future generations against flooding and to safeguard a sufficient fresh water supply.

Based on our long tradition of enabling life in a delta where four rivers continuously interact with the North Sea, we have learned how to adapt to ever changing circumstances. Building with nature has become an important lesson, and we apply this concept wherever possible to make the Netherlands safe and attractive, now and in the future. We seek flexible solutions, for instance, by adding sand to our coast to maintain and expand natural sand budgets. Moreover, we prepare for greater financial investments that may be needed in the future if critical stages regarding the impacts of climate change are reached.

In its continuous fight with the forces of nature, the Netherlands has developed a vast amount of knowledge and experience in the field of coastal zone management and flood protection and water management. In the last decades, the Netherlands has been actively supporting the cooperation with other countries and will continue to do so, particularly in the field of adaptive measures, preparing for the near future.

I wish the “Climate of Coastal Cooperation” all the success in the world on its path to promoting international exchange of knowledge and experiences, in order to deal effectively with the coastal challenges…. empowering our children to cope with their future challenges.
Foreword

Ursula Schaefer-Preuss

Vice-President for Knowledge Management and Sustainable Development, Asian Development Bank

The inherent high productivity of coastal zones means that they have become home to the majority of the Earth’s population – centers for trade, commerce and food production from the sea. Much of the world's economy, therefore, is at least partly dependent upon the health and integrity of coastal resources.

Highly dynamic coastal systems, however, face growing pressures from urbanization and resource mismanagement, including wetlands loss, coral reef destruction, urban and industrial pollution, and over-fishing. These stresses are now being exacerbated by the adverse impacts of climate change, with coastal zones among the most vulnerable due to the combined effects of increased ocean levels, temperature and acidity and more intense storm events. These development and climate strains are putting coastal populations, infrastructure and environments at risk around the world.

Nowhere are these trends more apparent than in Asia and the Pacific, where more people live and work in proximity to the sea than in any other region. Moreover, the hundreds of millions who live in low-lying coastal areas of this region often face a range of other vulnerabilities due to their poverty, vulnerability to natural disasters, and lack of access to clean water and other services. The rapid pace of development along Asia’s coasts – often with inadequate attention to environmental sustainability – further strains both coastal systems and their inhabitants. In the Pacific, the survival of entire nations is being put at stake by these forces.

The Asian Development Bank (ADB) is well aware of these trends, and is working closely with countries around the Asia and Pacific region and partners including the Government of the Netherlands to establish policies, institutions, management systems and the infrastructure needed to ensure that the region’s coastal resources will meet both current and future environmental and economic demands.

In the People’s Republic of China, for example, ADB has worked with the City of Shanghai to restore its main waterway – Suzhou Creek – from a murky and essentially dead river that polluted not only the City but the shore at its delta. It is now the cornerstone of a coastal ecosystem rehabilitation program. ADB is also a founding partner of the Coral Triangle Initiative, supporting Indonesia, Malaysia, Philippines, Papua New Guinea, Solomon Islands and Timor Leste in improving coastal and marine resources management across the most highly productive and biologically diverse marine region in the world.

Integrated approaches like those applied in Suzhou Creek and the Coral Triangle are the wave of the future, and ADB will continue to work with its many partners to support such by providing policy advice, building institutional capacity and investing in well planned coastal infrastructure.

The main message of this Climate of Coastal Cooperation publication is that a holistic perspective is needed to devise effective and sustainable coastal management systems, and the report provides an important knowledge resource for those seeking to understand and employ such integrated approaches to coastal management.

I am certain that it will contribute to improving the quality of life for coastal inhabitants and the integrity of coastal resources upon which we all depend.
The Dutch take the impact of climate change seriously. We cannot do otherwise; we are living in a vulnerable low-lying deltaic country:

- Our deepest polder with human settlements lies 6.5 m below mean sea level,
- Our national airport (fourth largest of Europe) is located 4.5 m below mean sea level,
- Several trillion Euros of capital investments in flood prone areas are at risk.

Our reference points are two large flooding disasters in the last century: 1916 and 1953. The recovery from these two events took several decades. Nowadays, we assess the impacts of climate change and we realise that responding needs extra vigilance, additional overarching, integrating institutional arrangements and the creation of reserve funds.

Is this acute, no, is it urgent, yes.
This need of urgency must be shared with the inhabitants of one of the most densely populated coastal countries.

As Chairman of the 'Second Delta State Committee – Outlook for the Netherlands in 2100: safe and sustainable' I choose to include a worst-case climate change scenario of 1.3 m sea level rise in the 21st century - why? Because we, in the Netherlands, know that preparing long-term measures takes many years, whilst their execution takes many decades. Dutch society needs to know, whether there is a need to change fundamentally our present strategy for dealing with the risks associated with living in a flood prone delta. The good news is that even the worst-case scenario can be handled, both technically and economically.

We propose mostly no-regret, win-win adaptive responses. Implementation should begin immediately and intensified as soon as the signals for an accelerated, irrevocable change are clear.

One of the examples of a no-regret, resilient measure, is to defend our coast from sea level rise and increased storminess, by using the flexible approach of sand nourishment on our sandy coasts. We have been gaining experience with this economically viable and effective coastal engineering method since the 1990s.

An example of a win-win solution is to increase significantly the storage-capacity of our largest fresh water Lake IJsselmeer, by raising the water level and the surrounding dikes with 1.5 m. This will improve the supply of fresh water, and help counteract the much drier summer seasons anticipated in the future. Raising these dikes, including the 1932 Afsluit Dijk (Enclosure Dam) also provides a higher level of security against the increased risk of flooding.

Some of the proposed solutions are required anyway, for other reasons. Strong economic growth, increase in capital investment and population necessitates a thorough review of risks and new safety standards for our dune and dike systems.

We have gained experience over many centuries how to cope with the sea and the rivers, which are often a friend but sometimes, a foe. We are preparing for the impacts of climate change and are learning how to plan and implement timely adaptive measures. Our experiences have been shared with other low-lying countries. We have seen that international cooperation is mutually beneficial. We look forward to exchanging our practical experiences with you, through this “Climate of Coastal Cooperation” publication.
CCC Statement
Getting the most out of coastal cooperation : sharing knowledge

Jeroen van der Sommen
Director Netherlands Water Partnership

The world’s coastal population is at risk. Expanding economies, urbanisation and climate change force us to act. This CCC publication on coastal cooperation stresses the complexity of coastal zones. At the same time, it underlines the opportunities change may offer.

In the Netherlands, we know all about living by the sea, which has always been a source of life and prosperity. Our two thousand years of habitation in a delta area close to mean sea level have produced an ambivalent relationship: we both love the sea and fear it. Living in a delta comes at a price. Such heavily populated areas are often favoured places for building industrial infrastructure and housing putting a great deal of pressure on the environment. More recently, climate change has created new challenges. Our permanent battle to control the sea and rivers has made us experts in water management. The experience has taught us two fundamental truths: that water management is a process of continuous innovation and that water management has to be a team effort.

That is why the Netherlands possesses both technological expertise and a deep-rooted willingness to cooperate. We have well-known research institutes in the field of water innovation, earth surveying, and dredging firms that operate world-wide, front-ranking hydraulic engineering companies and market leaders in the field of water purification technology. However, that is not all. We also have government bodies that deal specifically with water management, a relevant knowledge infrastructure and, last but not least, a strong public awareness of the issue. By combining expertise and experience at all levels, we are equipped to devise appropriate solutions to complex problems. Challenges in the field of water policy development include hydraulic engineering and design; construction, implementation and maintenance; water supply and sanitation; flood control; environmental protection, and integrated water and coastal management.

Illustrative of our willingness to cooperate is the number of Dutch that have contributed to “Climate of Coastal Cooperation” together with their colleagues from all over Asia and Europe. Together, these 100 contributors to this book – and those who did not make it to the list of authors – form a network of experts. Added to them are the future readers of the CCC book and its internet production. This results in a large number of experts cooperating and learning from each other, helping to change our approach to the management of vulnerable coastal areas. The key lies in networking.

The Netherlands Water Partnership (NWP) is itself a comprehensive network that unites Dutch water expertise. The partnership consists of private companies, government, knowledge institutes and NGOs, acts as a centre of information and cooperation on water expertise, policy developments and opportunities. The knowledge available in the Netherlands is broad as well as deep and covers a great many areas, including drinking water, floating construction techniques, wastewater purification, mobile dams, storm surge barriers and water-related spatial planning and development. In the Netherlands as well as abroad, the NWP is the gateway to what you need to know about the Dutch Water Sector and its solutions to global water related challenges.

Now more than ever, sharing and exchanging knowledge has become vital for us all. Join the network! Only by working closely together, can we ensure a safe and sustainable future for the deltas of the world. The Netherlands Water Partnership therefore warmly endorses and supports this CCC publication.

We are happy to exchange and make accessible our knowledge and experiences with others elsewhere in the world. Do not hesitate to contact us: www.nwp.nl, www.dutchwatersector.com and info@nwp.nl.
Early coastal concerns in Europe
In Europe, the Council of Europe raised the coastal environment as an issue of concern by as early as 1974. The Council issued a number of studies, documenting the decline of coastal environments, as well as recommendations and ministerial resolutions.

Since the end of the 1980s an increasing number of integrated planning and management initiatives began in NW Europe at local and regional level. Many of the bottom-up and fruitful coastal partnerships originated around estuarine water bodies. Some of these early concerns can be considered as the start of integrated coastal management in Europe. However, the Mediterranean Action Plan and UNEP launched the only ‘official’ international ICZM programme in the Mediterranean region, during the 1990s.

Emergence of a European coastal network
International contacts between coastal experts, practitioners and planners increased as a result of the European integration process. An awareness developed that multidisciplinary networking would be important to solve planning problems, involving both governmental and non-governmental practitioners. At a European coastal conference in Leiden in 1987, delegates from 12 countries agreed to establish a coastal network, resulting in the establishment of the EUCC in 1989.

The emergence of EUCC has led to a considerable boost for ICZM throughout Europe. In 1991 the EUCC organised the European Coastal Conference, in close cooperation with the Dutch government that was President of the European Union at the time. A month later, the European Council of Ministers unanimously adopted a Resolution inviting "the Commission to propose for consideration a Community strategy for ICZM". The result of this initiative was twofold: the ‘official’ and the ‘informal’ ICZM programme.

Official and informal ICZM programme
The informal programme developed as a patchwork of local initiatives, running as a process in a climate of cooperation ("the more partners the better"). Most could not meet the rules and criteria of EC-funding. Because of their dependence upon local funding, they developed very slowly but often steadily.

The official programme developed later in the form of the EC Demonstration Programme for ICZM (1997-‘99), in a climate of competition for funds ("only the best project is a winner"). This programme consisted of 35 projects with EU co-funding. However, because of EC-regulations for open competition and tendering, this programme could not be connected to the EUCC’s practitioners network nor to the informal ICZM programme.

The Commission realised, after some time, the value of networks of coastal practitioners and invited EUCC to act as a representative of the European ICZM community.

Interface
Over the last couple of years EUCC has been involved in an increasing number of coastal projects including very large ones: the EU’s EUROSION study, the Coastal Practice Network and the ENCOGRA, SPICOSA and OURCOAST providing interfaces between the European Union and the coastal experts, practitioners and stakeholders community. EUCC’s first role is to ensure the input from the stakeholders in the fields of planning, management, conservation, and industry. This task
is implemented through its international staff and office network and its ability to communicate in 15 languages. The second role is to provide external communication mechanisms and media to Europe and the large English speaking countries in the world. This relies on the presence of a range of electronic newsletters, magazines, and websites in 7 languages, reaching more than a million people a year.
In this way the Coastal & Marine Union (EUCC) became the largest European organisation of coastal and marine professionals: experts, practitioners and policy makers.

Concluding
After more than a decade at the forefront of European coastal management, many achievements of the informal international networking by the EUCC can be mentioned. It has been particularly successful in delivering studies, promoting integrated approaches in planning, implementing ICZM-focused projects, and developing information and communication tools.
Some examples of the important role of international and national NGOs at the threshold between formal and informal ICZM activities in Europe as well as in Asian countries such as Bangladesh, India and Vietnam, are described in the CCC publication.
Executive Summary

1. Coastal zones: valuable and vulnerable
The coastal zone incorporates one of the world’s most diverse and productive ecosystems. It provides a significant proportion of global food production and supports many major economic activities. Half of the world population lives here even though it encompasses only about 15% of the land surface. Economic activity provides more than half of the world Gross Domestic Product. At the same time, it is under increasing pressure from rapid population growth and major coastal urbanisation. The natural resources and habitats suffer from eutrophication, pollution by waste and litter, from sediment depletion and over-fishing.

The anticipated impacts of climate change will exacerbate these terrestrial pressures and may adversely influence fresh water availability, affecting the livelihood of coastal inhabitants. Anticipated impacts of climate change on the marine side of the coastal zone will include sea level rise, increased sea surface temperature, storm surges and typhoons, increasing flood risks, coastal erosion and saltwater intrusion. As these pressures intensify, deterioration of marine habitats, water quality and resource depletion will increase in case no adaptive, sustainable measures are taken.

Finding the balance between exploitation for short-term profit and developing long term, environmentally sustainable approaches to resource use is difficult. This book seeks to help find that balance.

2. Audience and action
This book is for coastal stakeholders and professionals who are or will be responsible for physical planning, applied research and management of their countries’ coastal resources. In particular, the target group includes:

The coastal zone: Triple squeezed

The coastal zone is triple squeezed: from the land and sea, and the development in time. The coastal zone is in urgent need of adaptive, ‘no-regret’ measures, planned and implemented within an integrated framework (source: R. Misdorp and H. van Reeken).
• Applied scientists;  
• Policymakers;  
• Non Governmental Organisations;  
• Decision makers.

It aims to aid cooperation and show decision makers that integrated coastal management provides a means of achieving development that is economic profitable and environmentally sustainable.

Sustainable development of the coastal zone is an important topic in Europe. This is especially true for the Netherlands, where more than half of the densely populated and highly developed country lies below sea level. In order to protect this area from flooding, coastal erosion and salt water intrusion, coastal protection is an important component of management. In recent decades this approach has broadened to include integrated spatial planning, which together help define an Integrated approach to Coastal Zone Management (ICZM). The European Commission (EC) actively supports coastal member states in improving the Governance component of ICZM by providing integrated frameworks, institutional arrangements and legal provisions. Romania has similar problems and, as a new member of the European Union (EU), is developing within an EU framework ambitious ICZM programmes.

The low lying and deltaic coastal zones of many Asian countries and island states are also critically vulnerable to the impacts of rapid socio-economic growth and climate change, including accelerated sea level rise when compared to other areas of the world. The number of people at risk to flooding and the potential loss of rice production, for example, are amongst the highest in the world. In order to address these vulnerabilities, a number of Asian coastal countries have embarked on a holistic approach, started ICZM programmes and intensified (inter)national coastal cooperation.

3. Structure

The book is structured in the following way:
• Introductory words and statements;
• Case summaries of coastal cooperation in EU, the Netherlands and Romania (Part I);
• Case summaries of coastal cooperation programmes and projects in eight Asian coastal countries and island states (Part II);
• Concepts, ICZM planning tools, adaptive coastal measures and training manuals - the ‘What, Why and How’ to plan and implement ICZM programmes (Part III);
• Summary of the book, include learning experiences and recommendations for future cooperation (Part IV);
• Lists of free-of-charge downloadable demos of ICZM planning tools, training manuals, and an alphabetic list of the 101 CCC authors and acknowledgements (Part V).

The full chapters of each of the case studies, the tools and training manuals can be found on the Climate of Coastal Cooperation (CCC) website: www.coastalcooperation.net
This book is based on actual project experiences and shows the benefit of ICZM in practice over the last decades.

4. Integrated Coastal Zone Management (ICZM), as a tool for addressing both short and long term coastal management issues is not new. It was adopted by the:

- Rio de Janeiro Declaration (UNCED – Agenda 21, Chapter 17, 1992);
- United Nations Framework Conventions on Climate Change and Biodiversity (1992) ratified by the governments of almost all countries of the world. The assistance from so-called developed countries to developing countries is called for in these ratified UN Conventions;
- UN-Intergovernmental Panel on Climate Change (IPCC - First Assessment, 1990) and confirmed during
- the 1993 World Coast Conference in the Netherlands organised under auspices of the IPCC;
- The EU - ICZM Recommendations (2002).

The European Commission (EC) promotes coastal cooperation among other things between European regions by enlarging and exchanging scientific research on coastal processes relating to ICZM tasks. These tasks range from problem analysis to planning and implementation of coastal actions and an evaluation of their effectiveness. Monitoring the natural and socio-economic coastal system is an essential element in all phases of an ICZM programme.

5. The international Coastal Zone Management Centre (CZM-C, 1993 – 2006) was created as a response to the call for action during the 1993 World Coast Conference (WCC). Its aim was to help developing sustainable policies for coastal resources in the face of the potential adverse impacts of climate change. It did this by facilitating international cooperation through coastal networks, promoting integrated planning and the adoption of adaptive management. The Centre was situated in the Netherlands, generously supported by the Ministry of Transport, Public Works and Water Management (V&W), and five other Ministries including the Ministry of Foreign Affairs, which also provided funding and guidance through its Embassies.

Reorganisation of the tasks within the ministry (V&W), led to phasing out the CZM-C's activities. Parts of these activities now lie within the newly created Centre for Water Management and the Directorate General Waters of new Ministry Infrastructure and the Environment (former V&W). Some of the other tasks have been taken on by the Coastal & Marine Union - EUCC practising ICZM since 1991 also beyond the borders of Europe. It is therefore appropriate that the EUCC is publishing this CCC publication.

Quite a number of chapters are based on CZM-C's activities, thereby reflecting some of their valuable work.

6. Coastal Vulnerability Assessment a first step to ICZM
ICZM encompasses a wide range of disciplines, any of which may identify the need for an ICZM programme. Climate and climate change can have a profound impact on densely populated coastal zones and is one such trigger. A first stage of an ICZM programme may include a Vulnerability Assessment (VA). Following a request from the UN-Intergovernmental Panel on Climate Change the Netherlands assisted the production of a Common Methodology for such an assessment in 1991. It was adopted and provides guidance for coastal nations in estimating their coastal vulnerabilities to a 1m sea level rise and socio-economic development in relation to the present
situation. Two illustrative examples of this approach: “From VA to ICZM”, are found in the CCC chapters on Bangladesh and Vietnam.

More than 90 nations reported on and discussed their Vulnerability Assessments during the WCC’93. A Global Vulnerability Assessment (GVA) was also carried out, taking into account 179 coastal countries and using a selected number of Vulnerability indicators. This revealed that many Asian countries and island states are critically vulnerable to a 1m sea level rise, not least because of the rapid socio-economic development in their coastal zones. Because of this Asia has a prominent place in this publication.

7. Coastal cooperation and ICZM
Not all examples of successful integrated coastal cooperation follow the ICZM approach. Good examples of such cooperation are the integrated planning of the innovative Chinese coastal Eco-cities, involving many national and international partners. The Rotterdam harbour development is another, which includes many elements of an ICZM programme, but without the label. The main thrust of this CCC-Publication is to demonstrate that coastal cooperation pays off, with or without a formal ICZM framework.

8. Concepts and Cases
The coastal zone is subject to a multitude of complex functions with ICZM acting as a cyclical process involving the following concepts derived from the CCC cases:
- Increasing coastal resilience, which decreases vulnerability;
- Using soft solutions for coastal protection where possible and hard ones only where needed (Working with Nature concept);
- Increasing the area of valuable wetlands such as mangrove systems;
- Using innovative sustainable applied technology e.g. decentralised solar energy and sanitation techniques;
- Addressing both short and long term problems: Simultaneously the creation of short term adaptive solutions and drafting long term strategies in one project;
- Integrating the input of international and national authorities and experts in the analyses of coastal problems and the identification of sustainable solutions by the local authorities, NGOs and applied scientists. An example of successful application of vertical integration is found in Vietnam.

The setting of each coastal area is different requiring different ICZM approaches. This is clearly illustrated by the European and Asian cases included in this publication. The opportunities to exchange information on common problems and pressures, and the different ICZM approaches to solving these problems are considerable.

9. Tools and measures
GIS tools can support the planning phase of an ICZM programme. The tools described here by the developers simulate the effects of alternative spatial planning options and functional uses in the face of climate change. These include principles of 'Environmental Impact Assessment' and 'Decision Support Systems' such as those applied in India.

The tools to support policy preparation were developed whilst undertaking ICZM tasks, with emphasis on training and capacity building. The reader can explore these interactive tools.

The Netherlands - Oosterschelde: nature building - man made dunes and the Storm Surge Barrier in the background. (photo: //beeldbank.rws.nl, Rijkswaterstaat)
This publication provides examples of adaptive, innovative, 'no-regret' measures based on the precautionary principle. Capacity building, awareness raising and education have also been adopted as essential elements in ICZM development programmes. There are four training manuals including subjects ranging from improving the management of Marine Protected Areas, experiences with Thai Aquaculture, a Coastal Defence Guide and Teaching Material on water and coastal management for primary and secondary school teachers. These manuals can also be downloaded.

10. Benefits of ICZM, coastal cooperation and adaptive, no-regret measures

Although pressures on the coastal zone may trigger an ICZM programme, probably the most convincing argument is that it can be both economically and environmentally beneficial. The secret lies in creating multiple-use, win-win, resilient and 'no-regret' solutions. Examples with a high benefit – cost ratio are shown in this publication and include several of the evaluated European Commission – ICZM projects, the Rotterdam sustainable harbour development, the large-scale mangrove planting in Vietnam and the conservation of habitats from mountain to the sea in the Seychelles.

The combined, active and supportive participation of donor Ministries, consultancies and knowledge institutes is also important, safeguarding the quality of work and providing the deliverables as specified in contracts with the recipient countries.

11. What makes this CCC-Publication unique?

There are many books written on ICZM. The 2002 worldwide review by Jens Sorensen identified more than 700 ICZM projects. He concluded that lack of communication between coastal stakeholders was one of the key issues, which hampered progress in achieving sustainable development of the coastal zone!

This CCC-Publication aims to exchange and transfer coastal management experiences. It promotes the exchange of information between you the reader and the CCC-authors and developers engaged in planning and implementing coastal activities. It provides information on the experiences gained from the many different coastal projects and programmes described. It is different in three ways from many of other ICZM publications:

   Firstly, it provides conclusive evidence of the feasibility and the effectiveness of coastal cooperation.

Secondly, it presents practical background information on coastal cooperation and the 'What', 'Why' and 'How' of ICZM. It is based on actual project experiences and shows the benefit of learning from ICZM in practice over the last few decades.

Thirdly, it is not just a book for reading quietly in a library. The CCC Book offers a summary of the cases of Part I and II, while the “Climate of Coastal Cooperation” website provides background information and more detailed project results of theses CCC cases in the full Chapters. Furthermore, this website also gives the user access to the ICZM planning tools described by the developers. The demos of these tools and the training manuals can be downloaded free-of-charge. They provide a common platform for discussion, stimulating participation by the coastal stakeholders, NGOs and local authorities. Examples of coastal measures described range from ‘low’ to ‘high tech’ solutions and come from a wide variety of coastal situations making this CCC publication particularly valuable.

The List of Contents provides an overview of each contribution. The alphabetic List of Authors then facilitates the required communication, strengthening international cooperation. You are invited to explore the CCC website with its extended, full chapters, tools, training manuals and to forward your questions and views to the authors.

12. The CCC authors – a coastal community in the making

This Executive Summary presents an overview of the relevant steps of ICZM as well as results of coastal cooperation in practice. The authors come from many different fields of experience and expertise. These range from (former) Ministers and permanent secretaries, executive directors of international organisations and funding institutions, to representatives of many different NGOs, educators, coastal experts and stakeholders, governmental officials and university professors. They offered quite some time making this CCC publication possible. Their contributions are much appreciated and can be regarded as a demonstration of coastal cooperation in practice. It also shows that cooperation can make a difference.

The authors hope that the lessons from the case studies, the tools, manuals and measures prove to be valuable in their applicability to the reader.
Coastal zones are valuable and highly productive areas in economic and environmental sense. The coastal zones are however also vulnerable to non sustainable uses and impacts of climate change. Integrated coastal zone management is directed towards sustainable development and is addressing these challenges in a comprehensive way. Managing the coastal zones requires knowledge of the socio-economic and natural, coastal processes.

Good management is the base for well balanced and informed decision making.

It is the mandate of the EEA to assist European Commission and the NGO community, in: "Making informed decisions about improving the environment, integrating environmental considerations into economic policies and moving towards sustainability". Increasing the knowledge base of coastal systems is especially important in addressing the serious challenges dealing with the functioning of ecosystems and their resources. We strive to build up profound insight on the coastal dynamics, to decrease its vulnerability, to increase its flexibility and its resilience.

The EEA facilitates this building up of knowledge through assisting in monitoring capabilities of member states, to assist in data base management, to disseminate information in Europe and in EU related countries. Our support to the Asia-Europe Environment Forum shows that we also reach out to Asian countries, many of which have strongly developing coastal zones. We facilitate countries in their efforts to manage the narrow and densely populated and economic vibrant coastal zones in a sustainable manner.

The present day challenges are complex. The future challenges will be more pressing. Increased knowledge on impacts of global climate change for planning and designing measures to mitigate and to adapt is highly needed, as illustrated by our participation in: “One degree matters” (www.eea.europa.eu/cop15/bend-the-trend/one-degree-matters-movie).

Collecting data and transferring into information are essential activities. It is important to ensure proper data management and dissemination of knowledge to international, national, provincial and local authorities and coastal stakeholders and managers. The EEA facilitates monitoring of coastal processes and assists in creating information systems: example EUROSION data base can be consulted even after this valuable EU project finished. The EEA's hosting of such important data base provides continuation in data gathering, and data storage and information dissemination for EU coastal countries and beyond. Thus, it brings together key aspects of national and international research outputs including those from the Global Monitoring for Environment and Security (GMES) initiative in order to strengthen the link between science and policy.

EEA is an open structured organisation and will also in the future facilitate such important services directed at analysing the functioning of ecosystem and natural resources. The European Commission and EEA strongly support integrated coastal management approaches as can be read in the following chapters of this “Climate on Coastal Cooperation” publication.
Integrated Coastal Zone Management in the European Union

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Niels Roode & Hugo Niesing (RWS/Ministry of Infrastructure and the Environment, The Hague)

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1. Introduction
2. ICZM in EU Policy
3. Looking ahead
4. ICZM supporting projects
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Summary
Since the early 1990s, both the UN and EU have specifically addressed problems related to the state of the coast and seas. The EU institutions supported the development of Integrated Coastal Zone Management (ICZM) programmes, profitable in economic and environmental sense. Since 2002, most EU countries have adopted the principles of ICZM in their national coastal strategies or spatial planning process. Many coastal initiatives and projects related to exchanging information and sharing best practice have emerged. The future trend suggests greater emphasis on climate change adaptation, cooperation at regional sea level and coherence between plans, programmes and management of the maritime and terrestrial parts of the coastal zones.

* Article written in a personal capacity. The opinions expressed do not commit the European Commission and do not necessarily represent the official position of the European Commission.
1. Introduction

Integrated coastal zone management (ICZM) has been defined as a dynamic, continuous and iterative process designed to promote sustainable management of coastal zones. ICZM seeks, over the long-term to balance economic development and human use, with the benefits derived from protecting, preserving and restoring coastal zones, minimising loss of life and property and promoting public access and enjoyment, all within the limits set by natural dynamics and carrying capacity.

In the past 40 years, ICZM has become fundamental to good management of the world’s coastal resources. In the 1970s concern for the coastal and marine environments prompted the US Government to enact the Coastal Zone Management Act (1972). In 1973 the Council of Europe adopted a resolution on the protection of coastal areas (including the promotion of integrated coastal planning), and in 1981 the European Coastal Charter. In the 1980s a number of ICZM programmes began in a number of developing countries. The UN Conference on Environment and Development held in Rio de Janeiro in 1992 agreed a programme of action known as Agenda 21, when 178 governments committed themselves to “integrated management and sustainable development of coastal areas and the marine environment under their national jurisdiction”. Other UN conventions (e.g. Biodiversity and Climate Change) have reaffirmed the importance of ICZM, as did the World Coast Conference in the Netherlands (1993).

2. ICZM in EU Policy

In the EU, following inclusion of coasts as sensitive areas in the first "European Community programmes on the environment” and the development of a European Coastal Charter by the Conference of Peripheral Maritime Regions, two Council Resolutions, in 1992 and 1994, underlined the need for a European strategy for the coastal zone. In response, the European Commission (EC) worked to identify and promote measures to halt the deterioration and to improve the quality of our coastal zones.

Multiple functional uses (shipping, fishing, coastal protection, recreation, nature, urbanisation) demand an integrated management approach for long term, sustainable development of coastal zones. (photo: EUROSION)

Demonstration Programme on ICZM

From 1996 to 1999, the Commission’s ‘Demonstration Programme on ICZM’, included 35 demonstration projects and 6 thematic studies. This provided technical information about sustainable coastal zone management, stimulating a broad debate among those involved in planning, management and use of Europe’s coastal zones. In 2000, an assessment of the socio-economic costs and benefits of 21 demonstration projects revealed significant monetary benefits (costs: € 127 to benefits: € 660 million) and non-monetary benefits of ICZM (EC, 2000). The Demonstration Programme identified a wide range of environmental and social issues such as habitat destruction, loss of fish stocks and biodiversity, pollution, economic decline and social deprivation. Further investigation traced the causes to several underlying problems:

- Lack of a vision for management due to limited understanding of coastal dynamics and lack of dissemination of research results to end-users;
• Inadequate involvement of the stakeholders in formulating and implementing solutions to coastal problems;
• Inappropriate and uncoordinated sectoral legislation and policy, often working against the long-term interests of sustainable management of coastal zones;
• Rigid bureaucratic systems and the lack of coordination between relevant administrative bodies, limiting local creativity and adaptability and
• Local initiatives in sustainable coastal management lacking adequate resources and support from higher administrative levels.

**European ICZM Recommendation**

In 2000, following completion of the Demonstration Programme, the European Commission presented a ‘strategy for Europe’ to the European Parliament and Council, which became the European ICZM Recommendation.

The Recommendation invited member states to take a strategic approach to coastal management while following a number of ICZM principles (see box 1). Based on analysis of the national situation (national stocktaking), member states should develop an ICZM strategy, co-operate with each other and report on implementation to the Commission in 2006. To support this, the Commission facilitated an expert ICZM group that meets annually.

*One dune ridge separates the low lying, capital intensive infrastructure: greenhouses, towns, (air) ports from the sea, Delfland, Holland.*

*(photo: //beeldbank.rws.nl, Rijkswaterstaat)*

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**Box 1: Eight Principles of good ICZM**

1. A broad perspective (thematic and geographic) taking into account the interdependence and range of natural systems and human activities impacting on coastal areas.
2. A long-term perspective taking into account the precautionary principle and the needs of present and future generations.
3. Adaptive management facilitating a gradual process of adjustment as problems and knowledge develop. This implies the need for a sound understanding of the evolution of the coastal zone.
4. Solutions need to be specific to local situations and respond flexibly to the great diversity of European coastal zone issues.
5. Working with natural processes and respecting the carrying capacity of ecosystems, will make human activities more environmentally friendly, socially responsible and economically sound in the long run.
6. Involving everyone with an interest or responsibility for management e.g. by agreement and shared responsibility.
7. Obtaining support and involvement of relevant administrative bodies in partnerships at national, regional and local levels. Establish and maintain appropriate links to improved coordination between existing policies.
8. Use a combination of instruments to facilitate coherence between sectoral policy objectives, and coherence between planning and management.
Touristic facilities so close by the sea provides short term economic benefits, but make the low lying coast vulnerable to climate change impacts such as accelerated sea level rise. (photo: Villa Joli, Koksijde, Belgium)

Evaluation of national reports

In 2007, the European Commission (EC, 2007) evaluated the national reports on the implementation of ICZM. This showed a large variation in the progress, both between member states and regional seas. The national reports covered: newly developed strategies, new phases in implementing on-going ICZM, stocktaking results and initial proposals for a coastal strategy. Research indicates that all coastal EU Member States regulate coastal use and development in some form. The period 2000-2005 marked progress towards a more integrated planning and management approach, but a mature and well-functioning ICZM involving all relevant levels of governance is rare. The evaluation identified reasons for success and failure in progressing ICZM. Recognising the relative importance of the coast, proper allocation of competences between administrative levels and leadership were important factors in successful ICZM implementation. Unclear distribution of functions between administrative levels led to failure. The analysis has shown that overall the EU ICZM Recommendation has been beneficial to coastal management in Europe by:

- Creating a new awareness of long-term challenges;
- Moving from traditional sectoral planning approaches towards more integrated spatial planning of the coastal zone and its sustainable development;
- Creating a strong pressure to increase participation in decision-making;
- Recognising and creating awareness of:
  1) The importance of land and sea interactions;
  2) The human dimension in coastal processes;
  3) The need to integrate different sectors and stakeholders in order to avoid the type of conflict, which leads to unsustainable development.

3. Looking ahead

When presenting the results of the evaluation, the European Commission encouraged coastal Member States to implement or develop ICZM strategies. Ambitions for the future are:

- To achieve a more coherent understanding and implementation of ICZM across Member States, develop guidance to clarify the principles underlying sound implementation;
- To ensure close co-ordination and co-operation with the Marine Strategy Directive and the related work of regional seas conventions such as the ICZM Protocol to the Barcelona convention (Mediterranean Sea basin). By doing so, ICZM will become an important component of the recent Maritime Policy of the European Union;
Within the context of support for ICZM, improve cooperation at the level of regional seas, including coherence between plans, programmes and management across the terrestrial and marine interface. The proposed Marine Strategy Directive and the related work of regional seas conventions will provide important instruments to take this forward;

- Given the high vulnerability of coastal zones to risks related to climate change, develop adaptive strategies that comply with ICZM principles;
- To promote the exchange of information on good ICZM practice, especially between coastal regions. This includes gathering relevant data and effective information sharing for use in policy and decision-making. Continue development, application and evaluation of common indicators as a framework for assessing the effectiveness and efficiency of ICZM.

The European Commission launched the project OURCOAST (2009-2012), to ensure sharing of the lessons learned from coastal management experiences. A dedicated budget resource voted by the European Parliament in favour of sustainable coastal management made this possible. OURCOAST focuses on adaptation to risks and the impacts of climate change, information and communication systems, planning and land management instruments, and institutional coordination mechanisms.

4. ICZM supporting projects

To support the implementation of ICZM within the EU, there are funding opportunities through the Cohesion Policy, the European Fisheries Fund and as part of the Research Framework Programme. Many initiatives related to exchanging knowledge and sharing best practice have emerged in the last decades. Examples of ICZM related Interreg projects in NW Europe are shown in Table 1.

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<td>science &amp; policy integration</td>
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(*) Service contract with EC; (**) Interreg 3a project

Table 1: Non-exhaustive list of ICZM related Interreg projects in NW Europe (with hyperlinks to websites).
Some illustrative projects are here described in more detail:

EUROSION (Coastal erosion management in Europe)
The EUROSION project initiated in 2001 by the European Parliament, aimed to evaluate the social, economic and ecological impact of coastal erosion on European coasts and assess the need for action. The results of this two and a half year study, steered by the Directorate General of Environment of the European Commission, were published in May 2004.

Severe cliff erosion
Happisburgh, UK (photo: EUROSION)

Coastal erosion threatening the transition zone between the centuries old sea dike (in the background) and the retreating dunes, Camperduin, Holland (photo: //beeldbank.rws.nl, Rijkswaterstaat)

The results provided the basis for policy recommendations to improve coastal erosion management at European, national, regional and local levels. The European Commission announced these results during a European conference and press release. The valuable EUROSION database is hosted by the European Environmental Agency and is publicly accessible (EEA-website).

EUROSION project products (see its website) are:
- A comprehensive and consistent map of the coast covering all coastal EU member states showing relevant parameters for vulnerability assessment;
- Cartographic assessment of exposure to erosion, based on spatial data and GIS analysis (elevation, geology, tidal range etc.);
- Introduction to the concept of sediment cells;
- A review of best practice in coastal erosion management as undertaken by local and regional authorities.
- A set of guidelines to help incorporate coastal erosion issues in environmental assessment procedures, spatial planning and coastal hazard prevention, and into regional and local information decision-support systems;
- A Shoreline Management Guide (SMG) to provide coastal managers especially at regional and municipal levels with state-of-the-art tools for coastal erosion management based on 60 case studies/pilot sites (Figure 1).
ENCORA (Coordinating coastal networks in Europe)

Lack of communication has hampered the implementation of ICZM in the past. ENCORA is a European network with new mechanisms for communication on shared problems within and between the communities of coastal science, policy and practice. In 13 European countries, National Coastal Networks have been established, or are anticipated. Ten trans-national, cross-disciplinary thematic networks led by institutions with outstanding expertise, address major ICZM issues. They include participants from all EU countries, including those where a national network is not yet established. There are operational nodes between the National and Thematic networks and other coastal networks (see website).

Figure 2: Cooperating coastal nations – ENCORA network
SAFECOAST (Coastal Flood and Erosion Risks in 2050)
The Safecost Project shares knowledge and information on coastal flood and erosion risk management between coastal management authorities in five North Sea countries: Denmark, Germany, Netherlands, Belgium and United Kingdom. In recent years, climate change, in particular sea level rise and its effects on low-lying coastal areas have generated renewed interest. Although uncertain in terms of magnitude and frequency, there are likely to be more intense storms and extreme events in the future increasing the potential for coastal erosion and flooding.

Despite the storm surge disasters of 1953 (Netherlands, Flanders and England) and 1962 (Germany), the North Sea countries continue to build in flood prone areas. The population is expected to continue to grow until 2050 and it seems likely further development in flood prone and coastal areas will take place. This will increase vulnerability to and damage from flooding. Therefore, Safecost has compared scenarios for climate change and spatial planning to 2050. Based on the results, the project gives recommendations on the management of the coast in 2050 (see website).

COMCOAST (Multifunctional Coastal Defence Zones)
ComCoast is a joint European project investigating different forms of land use with opportunities for creating a wider coastal zone for water storage during storm events (Figure 4). One essential feature of this is that the first line of defence against flooding is resistant to overtopping by waves. There are several techniques under review, see website. Another field of investigation is the stability of inner slopes of existing dikes during overflow or wave overtopping. For dikes under severe wave attack, large-scale tests, for example in Lelystad and Zeeland (both in the Netherlands) with grass-clay cover layers suggest a considerable crest height reduction is achievable, without failure of the dyke.

Figure 3: Transnational flood risk assessment and mapping for the North Sea Region

Figure 4: Combining safety with different functional uses – COMCOAST.
EU-PlanCoast (an INTERREG IIIIB NP CADSESproject (2006 – 2008)

The coastal zones of the Adriatic, Baltic and Black Sea face severe pressures from development. Multiple sea and coast-based activities such as tourism, transport, fishery, aquaculture and energy generation continue to grow.

Experiences in integrated spatial planning of the maritime and terrestrial part of coastal zones in these three regional seas were exchanged. This showed that spatial planning is one of the legal mechanisms for putting ICZM concepts into practice and furthermore:

- PlanCoast developed tools and capacities for effective integrated coastal planning in the region;
- Introduced the completely new spatial planning instrument Maritime Planning;
- Linked Integrated Coastal Zone Management (ICZM) and Maritime Planning with the processes of statutory spatial planning in selected pilot projects;
- Spread the use of modern Geographical Information Systems (GIS) for effective transnational planning;
- Contributed to the creation and implementation of EU policy on coastal zones and maritime areas, such as the Green Book and Blue Book, and led to the creation of numerous national laws and strategies.

PlanCoast had 16 partners representing the spatial planning departments or responsible regional authorities in the three regional seas. Among the many products were a handbook on Integrated Maritime Spatial Planning published by the PlanCoast project in 2008 (see Figure 5 and project website).

5. Conclusions

In the past, the lack of overall coordination of coastal zone responsibilities at national and international scales became evident. This led to the development of the concept of Integrated Coastal Zone Management (ICZM). The EU institutions strongly support the development of the ICZM programmes. The integrated approach to policy-making for the recent EU Maritime Policy and its environmental pillar the EU Marine Strategy Framework Directive, will allow the EU to take further important steps towards implementing ICZM.

The EU will increase its efforts to support the ICZM application also in the associated and non-member states when requested. The EU ICZM principles and efforts could help the sustainable development of the Asian coastal zone, increasing the economic and environmental benefits for future generations.

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Examples of ICZM practices in Europe from a NGO point of view

Albert Salman & Alan Pickaver (Coastal & Marine Union – EUCC, the Netherlands)

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2. ICZM contributions in the EU
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Summary
The role of NGOs, such as Coastal & Marine Union - EUCC, in the process of ICZM is manifold: stimulating and initiating ICZM programming at different levels, ensuring stakeholder participation, disseminating experiences in sustainable coastal development and daily management of coastal areas. These efforts have helped implementation of successful ICZM programmes in many parts of Europe. Some examples are highlighted below.

Hoisting the QualityCoast flags a recognition for sustainable development. (photo: Carlo della Libera)
1. Introduction

The Coastal & Marine Union – EUCC specialises in promoting ICZM theory and putting it into practice in many parts of Europe. As mentioned in the CCC Statements, the EUCC has been particularly successful in delivering studies, promoting integrated approaches in planning, implementing ICZM-focused projects and developing information and communication tools.

As a truly international NGO, the EUCC mobilises the expertise of its 2700 members and member organisations from all European coastal states. With its 13 active National Branches and seven offices the organisation tries to bridges the gap between research, planning and policy. It promotes integrated approaches to conservation, planning and sustainable development of coastal resources.

The EUCC became one of the key advisory bodies to the European Union and several regional seas programmes in the field of Integrated Marine and Coastal Management (IMCAM).

The EUCC has also been directly involved in the implementation of projects involved with integrated approaches to coastal planning and management, mostly in Russia, Estonia, Latvia, Lithuania, Poland, Bulgaria, Romania, Moldova, and Ukraine, but also in the Netherlands. This chapter illustrates some examples of ICZM efforts in practice.

2. ICZM contributions in the EU

In 2002 the European Union and its member states agreed that ICZM would provide an important policy framework to improve the effectiveness of existing legislation, financial and planning tools and better management of the diverse pressures on the coastal zone and sustainably develop its resources (see CCC I-2-1). ICZM, when operational should lead to sustainability of human uses at the coast. Several EU countries have issued an ICZM strategy for the future. They are developing tools to measure the progress of ICZM implementation using an ICZM Indicator Set together with other indicators to measure the state of the coast and evaluate the ICZM efforts.

ICZM indicators

EUCC has been instrumental in the development of the “ICZM Indicator Set” to show the progress that is being made in the implementation of ICZM in EU Member States (Pickaver et al 2004 and Pickaver 2008). This set analyses the complex, ICZM management cycle using a simplified comparative evaluation based on qualitative and semi-quantitative criteria. Thus, it recognises that the ICZM cycle can be broken down into a series of discrete, ranked actions. These actions, now 31 in total, are not completely exhaustive but are comprehensive enough to allow measurement of the progress in ICZM.

Extensive testing in Europe has made it even more user friendly, especially to those who do not have English as their first language. It has been accepted by the EU ICZM Group of Experts, formally introduced as a policy instrument and is now being implemented: at the time of writing, eight EU Member States are measuring the success of their national ICZM implementation using the Progress Indicator. Table 1 shows part of a typical response from the government of Greece (Greek Ministry of The Environment, Physical Planning and Public Works, 2006) which demonstrates the conclusions that can be drawn, underlining the added value of the methodology. Against each action a simple ‘yes’ (Y) or ‘no’ (N) or ‘don’t know’ (DK) has been entered for three governance levels: national, regional and local. However, because it is important to identify a trend through time, an extra layer of complexity can be added at each level asking respondents to consider the action in two periods, for the year 2000 and the year 2006. The table should be looked at both vertically and horizontally. Vertical use shows how far along the ICZM cycle implementation has taken place. The horizontal dimension reveals the degree of integration between the three governance levels. Used alongside sustainability indicators for the coast, it should also determine just how good ICZM is as a management tool.

QualityCoast

What has been lacking for many years, to ensure measurable sustainability, is a linking programme that can target specific elements for sustainability and set targets for improving the sustainability effort. QualityCoast (QC) has become such an over-arching programme for coastal towns, cities and small islands (see QC website). Since sectoral approaches to coastal development are no longer a sustainable option, coastal regions and local authorities are making efforts to use ICZM planning approaches to achieve sustainable economic development.
In the framework of the EU Interreg IIIC project, CoPraNet, led by EUCC (2004-’07), successful QualityCoast pilot projects have been implemented for southern Fuerteventura and Los Lobos island (Canary Isles, Spain), Calvià (Mallorca, Spain), Aveiro (Portugal), Cork Harbour (Ireland), Newcastle, Co Down (Northern Ireland), Sefton Coast (Merseyside, England), Zandvoort and Noordwijk (The Netherlands), Stockholm Ekoparken (Sweden), Usedom (Germany), and Stepnica (Poland).

QualityCoast programme linking a growing number of coastal towns, regions and islands in improving their performance of sustainability and tourism quality. (www.qualitycoast.info)

This was the start of a successful follow-up in 2008 -’09, which resulted in the presentation of twelve new awards to coastal towns in May 2009 (www.qualitycoast.info).
It is imperative that actions along the coast by responsible government authorities are required to improve their sustainability. However, in order to develop any successful plan of action, it is important to know in which field improvements are needed. The QualityCoast criteria that were developed in the CoPraNet project provide the management issues, which need to be addressed.
During 2009-2011, the partnership is planning to take the QualityCoast methodology a step further and improve the measurability of the criteria. In so doing the partners hope to collaborate with coastal communities all over the world.
Coastal towns and islands, which perform well in addressing the 20 QualityCoast criteria, in preparing and implementing improvement schemes and in producing appropriate information for the general public are eligible to apply for a QualityCoast Award. Only councils making a real contribution to sustainability receive these awards.
Table 1: An Indicator for Measuring Progress in the Implementation of ICZM in Greece (Extract: Greek Min. of E,PP&PW 2006)

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Aspects of coastal planning and management are in place</td>
<td>1</td>
<td>Decisions about planning and managing the coast are governed by general legal instruments.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>A framework exists for taking ICZM forward</td>
<td>6</td>
<td>Existing instruments are being adapted and combined to deal with coastal planning and management issues.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>Most aspects of an ICZM approach to planning and managing the coast are in place and functioning reasonably well</td>
<td>13</td>
<td>All relevant parties concerned in the ICZM decision-making process have been identified and are involved.</td>
<td>No</td>
<td>Yes</td>
<td>DK</td>
<td>DK</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>An efficient, adaptive and integrative process is embedded at all levels of governance and is delivering greater sustainable use of the coast</td>
<td>25</td>
<td>There is strong, constant and effective political support for the ICZM process.</td>
<td>Yes</td>
<td>Yes</td>
<td>DK</td>
<td>DK</td>
<td>DK</td>
<td>DK</td>
</tr>
</tbody>
</table>

Legend: ‘yes’ (Y), ‘no’ (N) and ‘don’t know’ (DK)

3. Management & development in the Baltic States and Russia

The Nemunas delta (24,000 ha) is situated on the Russian-Lithuanian border (Figure 1).

![Map of Europe highlighting the Nemunas delta and Oder Delta](image)

The delta is of a particular importance for breeding birds. Several species are internationally important e.g. White-tailed Eagle, Barnacle Goose, Aquatic Warbler, Dunlin and cranes. For migratory birds, the Nemunas delta is one of the most important stop-over areas in the northern part of the Western-Palaearctic migration route. Rusne Island, five square kilometres of grassland, fishponds, reed beds, and swampy areas, lies in the centre of the Nemunas delta. After the break-up of the USSR in 1989, the agricultural and social system collapsed and the protection and management of the natural values of the entire delta were at stake.

In 1993, EUCC became involved in a cooperative effort with Lithuanian ecologists (Lithuanian Fund for Nature), scientific experts and farmers in the Nemunas river delta.

Figure 1: Oder Delta (Poland) and Nemunas Delta (Russian-Lithuanian border).
One of the aims was to achieve a sustainable development of Rusne Island, especially in the field of agriculture and agrotourism, in combination with nature conservation. For this purpose farmers were encouraged to cooperate more closely, Dutch agricultural and management expertise was mobilised, training courses and stakeholder consultations organised and transfer of nature and agricultural management techniques introduced.

In this way, the EUCC helped to secure long-term support for an integrated approach (see also website of Ecocnet). The cooperation also resulted in the establishment of an EUCC Baltic Office in Klaipeda (Lithuania) to further ecological advancements in the area.

**Oder Delta Nature Park, NW Poland**

A particularly interesting approach was taken in the Polish Oder Delta. The Stettin lagoon, straddling the border between Poland and Germany, forms an important part of the delta (Figure 1 and photos).

![Aerial view of part of the Oder Delta: wetlands surrounded by the water of Stettin Lagoon. (photo: EUCC Poland)](image)

Like the Nemunas Delta, it is an important resting and feeding area on the Western-Palaearctic migration route and a crucial link for migratory birds between Russia and NW-Europe. The Polish side of the Oder Delta holds the highest density of White-tailed Eagle (see photo) in Europe. 150 breeding pairs nest in the Oder Delta, which is 25 percent of the total Polish population. In 1994, the difficult agricultural, social and management situations threatened the natural values as well as sustainable economic development. After ten years of Dutch-Polish cooperation, EUCC and EUCC Poland, with the help of Natuurmonumenten (NL), succeeded in establishing an Oder Delta Nature Park in October 2005 (see websites Oder Delta Nature Park).

The partners have been working for the last eight years in several strategic locations in the Delta, purchasing more than 1,000 hectares of the most important land and concluding management agreements for 4,000 hectares of land and water. The partners have furthermore incorporated the development of a management plan and vision for the entire Oder Delta, promoting sustainable agriculture and ecotourism. The entire Nature Park area has become an EU Natura 2000 site.

The involvement of local and regional stakeholders throughout this process has been vital to its success. One of the aims has always been to show to both government and local population that sound economic development and nature conservation can go hand in hand.
Aspects of both sustainable tourism and ecological farming have demonstrated that biodiversity conservation can also result in a sustainable rural development.

4. Conclusions

NGOs are important players on the international stage. They can both influence public opinion and provide reliable information and material for rational action. They are also in a position to initiate concrete actions which still have to be taken in order to achieve sustainable development and avoid destruction or degradation of natural resources. The role of NGOs, such as EUCf, in the process of ICZM are manifold: stimulating and initiating ICZM programming at different levels, ensuring stakeholder participation, disseminating experiences in sustainable coastal development and the daily management of coastal areas. Implementation and execution of coastal measures gives substance to the ICZM process.

5. References

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Websites:

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  www.qualitycoast.net (information for network partners)
- EUCf: www.eucc.net
- EECONET Action Fund: www.econet.org/eaf/projects
Conclusions -
ICZM efforts in the European Union

From the nineties onwards, the European Union has taken a strong leadership role in the development, application and promotion of ICZM. Starting with the UNCED – Agenda 21 (1992) as a trigger point, the EU has developed mechanisms for long-term support through the funding of ICZM programmes such as Interreg, Cadses and Cohesion, the development of legal and institutional frameworks and anchoring ICZM principles in the EU Water Framework Directive (WFD) and the EU Marine Strategy Framework Directive (MSFD).

The EU efforts cover a vast array of different ICZM activities, involving the whole spectrum of ICZM tasks from problem recognition to evaluation. Examples of the EU ICZM initiatives and efforts include:

• The EU Resolution (1992) emphasising the need for ICZM;
• Evaluation of the ICZM Demonstration Programme (1996-1999), which showed a positive benefit-cost ratio;
• The ICZM Recommendation (2002) on the application of ICZM programmes and drafting national reports on ICZM by participating EU countries;
• Development of indicators on the progress of ICZM implementation and their application in the evaluation of national country reports (2002-2007);
• The project OURCOAST (2008-2011): mechanism for sharing lessons from coastal management experience and practice.

From a top down perspective, the ICZM activities aimed to strengthen regional cooperation among EU member states and also beyond the borders of the EU. A range of supporting projects illustrates this, including:

• EUROSION (2001-2004) investigating the social, economic and ecological impact of coastal erosion on European coasts and the need for action;
• COMCOAST (2004-2007) investigating innovative concepts of flood protection systems allowing for multifunctional land use in coastal zones of five North Sea countries;
• SAFECOAST (2005-2008) providing a stimulating framework for regional cooperation between coastal countries around the North Sea on flood risk assessment, leading towards a common approach for coastal adaptation;
• PlanCoast (2006-2008) focusing on integrated spatial planning of the terrestrial and marine parts of the coastal zone as an important instrument for ICZM implementation and exchanging experiences between EU member states bordering the Baltic, Adriatic and Black Sea;
• ENCORA (2006-2009) on the development of a network for communication and exchange of coastal science, policy and practice in 18 countries within and outside Europe.

From a bottom up perspective, the EU has offered an ICZM platform to NGOs, stimulating NGO activity in the field of awareness raising, stakeholder consultation and information dissemination. The NGO efforts have focused on the execution of ICZM measures directed at sustainable development through integrated planning of local and regional Delta areas, such as:

• The EUCC’s projects Quality Coast and Coastal Practice Network (2004-2006) establishing the integration of tourism, coastal defence and environmental protection at town level and resulting into the QualityCoast Programme.
• The Nemunas Delta on the Russian-Lithuanian border (nature conservation, agriculture and agro-tourism) beneficial for other coastal areas in Latvia, Estonia, Russia and Poland;
• The Oder Delta Nature Park (2005) was established as a ten-year Dutch-Polish cooperation and its principles are carried forward in various EUCC-projects.

In these examples, the involvement of local and regional stakeholders throughout the process has been vital to their successful implementation.
Introduction

Over the centuries, dynamic coastal processes in and around the mouth of one of our rivers the Maas (Meuse) have formed a large system of sandbanks. The residential and working area of 'Delfland' located in the surrounding area, is a few metres below sea level and protected by natural sand dunes. However, a rising sea level and powerful hydrodynamic forces during storm tides poses a serious threat to the safety of the inhabitants.

Three centuries ago, 'De Beer' - as part of the sandbank in the mouth of the Maas was called - became a “Dangerous sea monster, which could destroy ships and annihilate all of Holland". Protecting land, property and people from such threats, became a common theme in the physical and geographic history of the low-lying Netherlands. It was the driving force behind the vision and ingenuity, with which much of the low-lying country, now referred to as the Netherlands, was created.

In 1731, a hydraulic engineer by the name of Nicolaas Cruquius launched a plan to dig a channel through the section called the “Hoek van Holland” and the sandbank in order to provide the Meuse River with a wide entrance to the North Sea. In his vision, the strong currents in the mouth of the river would remove the sandbank, strengthen the dikes and reduce the risk of flooding. Cruquius was far ahead of his time. His plan met a great deal of resistance and was not (yet) accepted. His proposal to “centralise the management of water flows and levels” in Holland met the same fate. In the 19th century, an engineer by the name of Pieter Caland put this plan on the table again. In 1858, in his role as secretary of the “Raad van Waterstaat” (Public Works Council), he proposed launching a daring project to dig a channel through the dunes to the “Hoek van Holland.” The primary aim of his proposal was an economic one: ensuring the free passage of ships from Rotterdam to the sea. In 1863, King Willem III signed a new law: “Den Nieuwen Waterweg” (The New Waterway), and in 1872, the first ship, a steamer of the Harwich line, sailed through the Nieuwe Waterweg to the sea (see the recent map of the Nieuwe Waterweg).
Rijkswaterstaat (Dutch Department of Water Management and Public Works)
In the 18th Century, there was an increasing awareness that the safety of the Netherlands was at risk. In 1770, the influential "Bataafsch Genootschap der proefondervindelijke wijsbegeerte" (Dutch Association for experimental philosophy) was established with its most important goal being to prevent the destruction of the Netherlands by catastrophic floods. Influential citizens, including the founder of the Rijkswaterstaat, Christiaan Bruning, were convinced that "unity in the administration and management of water" was needed to ensure the safety and welfare of the entire country - a concept, by the way, which also deserves attention today.

In 1798, the Rijkswaterstaat was established during the 'Bataafsche' Republic (1795 – 1801), a period of national and political change, characterised by a significant move to a central authority.

Rijkswaterstaat became responsible for managing and taking care of the coasts and rivers, all the inland public works, and the supervision of the lower government echelons responsible for public works and water related issues.

The significance of this was far-reaching. The decision and the manner in which the Rijkswaterstaat - worked with research institutes, engineering firms and dredging and construction companies - has transformed the low countries in the course of two centuries into a modern, safe and secure country.

The Dutch policy of integrated coastal management has received worldwide recognition. This was emphasised in 1993 when the first American National Oceanic and Atmospheric Administration: “Excellence Awards for Coastal and Ocean Resource Management” was given to the Netherlands (Van der Plas, 1993).


Vision of the Netherlands future
In the final decades of the 20th century, the focus has been on the economic infrastructure of the Netherlands. The Netherlands was busy preparing itself for the coming century. Its economic strength and potential had to be utilised to the full, but at the same time, there was an increasing focus on issues such as sustainability, quality of the spatial environment, and responsible ecological management. This resulted in an integrated approach to formulating policy, choosing investments, and preparing and implementing projects.

The vision of the economic future of the Netherlands was and still is, in large part, based on the strategic geographical location of the Netherlands as a “Gateway” for Europe, but with an additional focus on broadening the economy to include knowledge-intensive activities. In order to take advantage of the potential in terms of transport,
distribution, industry and services, it was necessary to invest in the main ports, the links to inland Europe and mobility in our own country. Preparations for major infrastructure projects, included separated railway links for goods and for people connected to the European networks, the Nieuwe Waterweg Storm Surge Barrier, the expansion of Schiphol Airport and the Port of Rotterdam. Most of these projects are complete, whilst others are ongoing.

The CCC-I-2-2 Chapter - "Rotterdam: Long-term sustainable harbour development" - which is presented below, is an excellent example of what can be realised via a modern and integrated project-based approach.

Climate change
The speed with which the world around us is changing, is both fascinating and at the same time frightening. As recently as the last decade of the previous century, the world seemed to be entering a long period of economic growth, but now it is going through a major financial and economic crisis. It is becoming increasingly clear that natural climate change is being accelerated by human intervention, raising the earth’s ambient temperature and leading to rising sea levels. One of the greatest challenges facing humanity is to ensure that the areas situated in deltas and along coastlines and rivers, where roughly three quarters of the world’s population is located, remain a safe place for their inhabitants to live. Successfully meeting this challenge will demand a high degree of international cooperation. The Netherlands, for its part, has started preparing adaptive measures based on worst-case climate change scenarios.

Concluding
The threat to the low-lying areas of the Netherlands from the sea, now exacerbated by the impacts of global warming, demand leadership from central government.

In view of the enormous scale and complexity of the challenges facing us, we will need vision and ingenuity to find solutions, make plans, and implement the projects to meet these challenges. In so doing, the Dutch treasure trove of knowledge and experience, gained over the centuries in the Dutch delta, will be an invaluable asset. However, to take advantage of this asset, the central government in the Netherlands will need to demonstrate the same type of leadership and vision as it did in the 18th century. The techniques for protecting life and property acquired during the long period of living in the Dutch Delta can be shared with other coastal areas in the world threatened with inundation from the sea.

References


The vision of the economic future of the Netherlands is, in large part, based on the strategic geographical location of the Netherlands as a “Gateway” for Europe; Rotterdam (largest harbour of Europe) and Schiphol International Airport contribute 12% to the GDP.
The Netherlands: flood, coastal erosion and management

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Tjark van Heuvel (RWS/Ministry of Infrastructure and the Environment, the Netherlands)
Robbert Misdorp

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2. Historical aspects
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Summary
The Netherlands is protected against flooding and coastal erosion by natural dunes, dikes, dams and storm surge barriers. Throughout its history, the Dutch have taken advantage of living in a low-lying delta and learned how to adapt to changing conditions. Population growth, coastal urbanisation, economic development and a changing climate increase pressures on the coastal zone. Designing and evaluating coastal defences, including the effectiveness of sand nourishment requires long term and frequent coastal process monitoring. Integrated planning addresses the increasing risk of flooding and coastal erosion and is a useful tool to help reduce the risk to the population and capital investments.

The low lying western part of the Netherlands, sensitive to flooding and coastal erosion, is protected by dunes, in places supported by additional coastal measures. Visible behind the single ridge dune are the capital-intensive industries, towns and horticulture in glass houses. (photo: //beeldbank.rws.nl, Rijkswaterstaat)
1. Introduction

The Netherlands, a low-lying deltaic country, is the product of interaction between natural and socio-economic processes. Water enters the lowlands from all directions: via the rivers Rhine, Meuse, Ems and Scheldt (river floods), from the North Sea (tides and storm surges), from precipitation and from subsoil seepage. Today, about two thirds of the country’s surface is below mean sea level and most of the landscape is man-made. The Netherlands is a prosperous, densely populated and above all dynamic country. Since 1950 the population has grown from 10 to 16 million people, while the Gross Domestic Product has increased exponentially to about € 600 billion (2008, see Figure 2). Most of this growth is concentrated in the low-lying western part of the country.

![Image: Urbanisation of coastal zone](image)

Figure 1: Increasing urbanisation (in red) of the sandy Holland coastal zone between Hoek van Holland and Den Helder. (source Min. V&W, Min. VROM, Min EZ, Min LNV, 2002)

The coastal zone has considerable economic value. Its sandy beaches and dune fields are both a natural habitat and natural sea defence. These are not the only functions of the coastal zone; many towns and cities are situated here, such as Rotterdam (largest harbour in Europe) and The Hague. Strong urbanisation in the Dutch coastal zone started at the end of the 19th Century (Figure 1).

Where beaches and dunes are absent, dikes, dams and storm surge barriers protect the hinterland from floods.

Flood risk and coastal erosion management in the Netherlands are the concern of public organisations, such as the Ministry of Infrastructure and the Environment (former Transport, Public Works and Water Management = Min. V&W) and the 26 water boards, some having been in existence for more than 800 years.

Today, flood risk and coastal erosion management occur within the legal framework of the Water Act (2008, enacted in December 2009), which incorporates amongst others the Flood Defence Act of 1996. This act holds statutory safety standards and divides responsibilities between national, regional and local governments (including the water boards) with respect to evaluation and reinforcement of flood defences.

2. Historical aspects

Up to the Middle Ages humans moved in response to changes in the coastal zone. People normally lived on the higher dunes and from the 5th century BC on ‘dwelling mounds’. Sedimentation from tidal waters allowed the land to keep pace with rising sea levels.

A rising population forced people to move to low-lying areas. Since about 1000 years ago, the Dutch started to structurally affect the coastal landscape (see IGU, 1996). Drainage for agriculture, peat excavation for fuel and salt production caused land subsidence and more serious flooding. Humans responded by constructing dikes improving drainage; first by windmills, later by mechanical means, which exacerbated land subsidence.

In the peat and clay areas of Holland, whereas 1000 years ago the land was almost three metres above mean sea level it now lies three metres below (Figure 2). For other low-lying areas, the situation is more favourable. The increasing flood risk from the sea led to the decision, in the 20th century, to shorten the coastline. This included the construction of the Zuiderzee Works (1932 - Closure Dam and large polders) and the Delta Works (1953 – 1997, dams, sluices, locks, dikes, and storm surge barriers).

Today, most infrastructure developments occur in low-lying polder areas. Although the probability of floods has decreased, the consequences should a flood occur would be far more serious than ever before.
Figure 2: Land subsidence largely by compaction of peat and clayey areas intensely drained, sea level rise and the rise of prosperity indicated by the Gross Domestic Product (GDP) of the Netherlands. NAP = Normal Amsterdam Water Level ~ Mean Sea Level. (source: TAW 1998, adapted)

3. Present flood risk management

Overview
The Netherlands has 3500 km of primary flood defences along the coast and rivers and around lakes. An additional 14,000 km of regional (secondary) dikes and embankments exist. The primary flood defences form dike rings. There are 57 larger and smaller dike rings, some are almost the size of a province, others just an island (Figure 3).

Safety standards
Standards for the design and safety of primary flood defences are based on analyses of the 1953 flood disaster. The First Delta Committee (1953) proposed safety standards for flood defences along the Dutch coast and in the estuaries. At a later stage, standards for river dikes based on the work of the Delta Committee were proposed. It was only in 1996 that standards for all primary defences became a legal part of the Flood Defence Act.
A safety standard, defined as the probability of exceeding water levels within a certain return period, range between 1/1,250 (upriver) and 1/10,000 (Holland coast) annually. A design and maintenance of a sea dike should be able to withstand a water level with a chance of occurring once in 10,000 years. For dunes, this means they should have a minimum volume (sand) capable of withstanding predicted storm conditions.
Figure 3: Dike rings and flood safety standards in the Netherlands. The western part (red) is most densely populated, with large capital investments, infrastructure, harbours and airport, has the highest safety standard. In this part, the coastal defences (such as dunes, dams and dikes) are designed to be able to withstand a sea level which occurs once in the 10,000 years.
Evaluation
Every 6 years, testing of compliance to statutory safety standards requires state-of-art information of the hydraulic conditions and geo-technical state of the primary flood defences. This information, provides the basis for a nation-wide inventory of the strength of flood defences. Water boards appraise this (legal) technical evaluation with their local judgement and report on the state of their primary flood defences. The reports pass to the provinces and from there to national government and parliament. This step-wise overview has a 6-yearly cycle and has been performed twice (2001 and 2006) since the Flood Defence Act of 1996 (Figure 4).

The most recent evaluation (2006) led to the conclusion that almost a quarter of the flood defences in The Netherlands did not yet comply with the new safety standards. The increase in capital investments and human settlements over the last decades are the main reasons for updating the safety standards in The Netherlands.

In the past, the disastrous floods (1916 and 1953), were the main catalysts for policy change and visionary decision-making regarding the construction of the Closure Dike (1932) and Delta Works (1953–1997).

The Ministry of Infrastructure and the Environment (former Ministry of Transport, Public Works and Water Management - Min. V&W) is reviewing the safety standards and looking for alternative approaches (e.g. improved crisis management and spatial planning policy) and addressing the envisaged impacts of climate change. This national assessment includes cost-benefit analysis and a nationwide risk assessment on a 20-40 year cycle (Figure 4).

Flood defence reinforcements
Based on the evaluation of 2001 and 2006 many projects designed to improve flood defences to comply with the 2015 safety standards for rivers and coast, were launched. On average, total government spending on primary flood defences is about € 600 million annually (0.1% of Dutch GDP in 2008), while the protecting capital invested is reaching several times the GDP. This flood defence includes about € 120 million of operational maintenance costs funded (and locally taxed) by the water boards.

Figure 5: The coastal foundation and nourishment zone.
4. Present coastal erosion management

Overview
In addition to the system for flood risk management, in 1990 the Dutch government adopted a hold-the-line policy to combat structural (long-term) coastal erosion, and maintain the coastline at its 1990 position. Natural fluctuations are allowed but the management aim is to prevent landward movement of the coast caused by sea level rise.

Standards
For this ‘Dynamic Preservation’ policy (1990), there is a reference standard for each 250 meter wide coastal section, the ‘Base Coast Line’ (= reference coastline= BKL, Figure 5). This BKL is a function of the ten-year trend in sand volume for the centre of the profile (between 3 meter above and about 5 meter below Mean Sea Level). Averaging this linear trend over a decade provides a measure of structural, rather than erosion caused by a major storm event.

Monitoring
In the 1960s, an annual monitoring programme (JARKUS) was established to assess the evolution of the near shore zone along the entire, 350 km long Dutch coast. The JARKUS data set represents a key source of coastal information, particularly in combination with historical observations of Dutch coastal evolution dating back to 1840-1850.

JARKUS measures coastal depth profiles from the first dunes up to 1 kilometre offshore, with a profile spacing of 250 meters (see also CCC III-3-3-2). Based on these data a so-called Momentary Coastline (MCL) based on the volume (per unit length) of sand between two horizontal planes is calculated. If the trend of the Momentary Coastline is landward of the Basal Coastal Line this represents a signal to consider intervention (= compensation by sand nourishment).

Compensation
Based on the methodology above, coastline maintenance between 1990 and 2000 required 6 million m$^3$ of sand annually. Whilst this approach was successful in combating erosion in the short-term, it did not address morphological developments in the deeper parts of the coastal profile (CFZ) over longer time scales, such as those associated with sea level rise.

Therefore, in 2000, the Dutch government adopted a wider approach, which involves maintaining the sediment budget of the ‘Coastal Foundation Zone’ (CFZ = the area extended to the – 20 m depth contour). The primary method is sand nourishment, which led to an increase in volume of supplied sand from 6 to 12 million m$^3$ (see Figure 6), through beach nourishment and gradually more and more foreshore (underwater) replenishment, which is an cost effective way to nourish sand.

![Figure 6: Annual sand nourishment volumes along the Dutch coast to counteract the effects of structural coastal erosion.](image-url)
The structural erosion, expressed in % exceeding the BKL versus the total coastline, is significantly decreased. Since 2000, the volume doubled to compensate for sand losses in the ‘Coastal Foundation Zone’.

Managing the ‘Coastal Foundation Zone’ (CFZ) provides long-term safety, while maintaining the ‘Base Coast Line’ provides conditions to preserve the sand volume (‘rest strength’) of the higher parts of the coastal profiles and addresses smaller temporal and spatial scales.

5. Some ICZM experiences

Turning point in water management

The 1953 storm surge disaster triggered a huge hydraulic undertaking in the south: the Delta Project. At that time the only feasible solution to securing the area against similar extreme disasters seemed to be closure of all sea inlets, except for the Nieuwe Waterweg (entrance to the Port of Rotterdam) and the Westerschelde (entrance to the Port of Antwerp). In 1958, work began on the Delta Project to shorten the coastline by about 700 km.

During the 1970s, public pressure led to a revision of the Delta Project, reconciling safety with environmental issues. Parliament decided (1979) to abandon damming the Eastern Scheldt, and instead sought to preserve its tidal character with tidal currents, flats and salt marshes including their abundant flora, rich fauna and the high-yield shellfish fishery.

Figure 7: The Delta Project in SW Netherlands between the harbour areas of Rotterdam and Antwerp: the primary dams, sluice complex and storm surge barrier in the west - in the three mouths and three series of compartment dams in the east. (photo: //beeldbank.rws.nl, Rijkswaterstaat)

This was achieved by the constructing a storm surge barrier at the mouth of the Eastern Scheldt tidal basin marking a turning point in the history of Dutch water management (Koningsveld et al, 2008). After a millennium of protection
strategies, the completion of the Delta project represented an important step towards an integrated national water policy plan (Misdorp & Terwindt, 1997).

**Next steps towards ICZM**

The decision in 1990 to adopt a policy of ‘hold the line’, while preserving the dune habitats and natural coastal dynamics, represents another step towards integrated coastal and water management in the Netherlands. This policy, confirmed in the Third national Policy Document on Coastal Areas (2000), extended the coastal domain from the deep-water zone to the dune fields. The document also recognised weak links in coastal flood defences and the risk of increasing storm damage to seaford settlements. Integrated planning studies undertaken by relevant provincial authorities, not only looked at ways to strengthen the flood defences, but also to improve the quality of the areas. Environmental impact assessments helped predict the loss of natural values and hence compensation needs. Some of the issues related to increasing socio-economic developments and impacts of climate change are addressed in a new coastal zone policy. This included strengthening the integrated approach, focusing on ‘spatial quality’ and ‘sustainable safety’, in line with the European Commission’s Recommendation for ICZM, see the document: “Towards an Integrated Coastal Zone Policy” (Ministry V&W, Min. LNV, Min. VROM, and Min. EZ-2002).

**Present principles of ICZM in the Netherlands**


These policy documents contain four main principles of ICZM:
1. ‘Decentralisation’: Implementation of spatial policy “should be decentralised wherever possible and centralised only where necessary”.
2. Flood protection: “Soft wherever possible, hard only where necessary”.
3. Raising awareness: “Successful ICZM requires understanding by stakeholders, public support and the active involvement of NGOs (WWF, 1996)”.
4. Exchanging information: All EU coastal states face similar problems when developing ICZM strategies (CCC I-1-1). Regular regional information exchange is valuable.

**Spatial planning**

In the Netherlands providing protection from flooding and erosion management are priority areas. Other issues such as economic development, nature conservation, and recreation play a secondary role. Integrated spatial planning is the key to creating sustainable adaptive management of the densely populated coastal zone and play an important role in identifying emergency flooding locations along rivers and in spreading the population away from flood risk areas.

*Figure 8: Water as guiding principle in integrated spatial planning.*

**Legend**:
- Blue rivers: “Room for Rivers projects”;
- Black open squares: non-effectuated emergency flooding polders, upriver;
- Dark Yellow: protected dune zone: flood safety is first priority;
- Light Yellow: coastal foundation zone: area of nourishment: fore shore and deep water (unto 20 m below MSL) and reserve for sea ward extension;
- Red areas in the coastal zone: weak links areas reinforcement is being executed;
- Light Blue on land: area below sea level.

The decentralisation of spatial policy has become clear in the last few years. For example, the annual planning of sand nourishment was delegated from the national to the provincial level. The national government continues to provide most of the financial resources for the primary water and coastal defence schemes. Together with this decentralisation, the national government is scaling down the size of the ministries (J. van Alphen & Q. Lodder, 2006). Both developments occur during a period when crucial long-term adaptive coastal management decisions and preparations for measures must be made.

6. Conclusions

Annual sand nourishment is an efficient means of coastal defence. It is flexible, cost effective and based on decades of monitoring and knowledge of coastal dynamics. This experience provides also a firm basis for creating new land in the sea to combat lack of space and adapting to the impacts of climate change.

Integrated spatial planning can play an important role in identifying and implementing adaptive resilient measures. The Dutch experience has, over many centuries evolved into a coherent system of ICZM principles and practices, anchored in national legislation and national/regional planning. The Netherlands is willing to exchange its coastal and water management experience with other coastal countries.

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Rotterdam Harbour Development
Long-term sustainable development is actually good for economy and environment

Robbert Misdorp

Contents
1. Dilemmas for further development - 1990
2. Coastal cooperation in practice
3. Value of an integrated approach
   3.1. Economic success
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Summary
It became clear in the 1980s that the growth of Rotterdam Harbour could not continue without creating serious environmental problems. These in turn were having an adverse impact on the local population and economic growth. By bringing all the local stakeholders together and with a shared financial risk it has been possible to realise economic growth and environmental protection. Central to this was the development of an integrated and co-operative programme defined by regional spatial planning within a national legal framework. Mitigation of climate change is one of the future challenges currently being addressed.

The Port of Rotterdam: its geographic setting

The geographic setting: The Port of Rotterdam within the Greater Rotterdam Area (GRA) is a part of the delta formed by the rivers Rhine, Meuse, Scheldt and the North Sea. The Nieuwe Waterweg, the main navigation channel without sluices, connects Rotterdam with the North Sea. Even the biggest ocean-going vessels, have unrestricted access all year round with 24 hour maritime services providing rapid turnaround. (photo: Port of Rotterdam)

The Port of Rotterdam: its economic position

The European market is accessible via Rotterdam by many forms of transport. Goods arriving through the port in the morning can be delivered in Germany, Belgium, France or Great Britain the following day. Improved connections include a new freight train line – the Betuwe line – linking Rotterdam with Germany and an inter-European, high-speed rail passenger transport links Amsterdam, The Hague, Rotterdam, Brussels, Paris and London. Rotterdam the largest harbour of Europe grows more steadily than the rapidly expanding Asian seaports.

In 2010 Rotterdam, with 430 million metric tons of throughput of goods, was the fourth largest harbour of the world behind Shanghai, Ningbo & Zhoushan and Singapore.

The strong economic development in Asia is reflected by the quickly increasing numbers of large Asian harbours during the last decade. Rotterdam was in 2010, the only non-Asian harbour of the ten largest harbours of the world, seven were Chinese.

(source: Port of Rotterdam Statistics.)

1. Dilemmas for further development – around 1990

During the 1980s it became clear that further unhindered exploitation of Holland’s densely populated coastal zone (more than 700 inhabitants/km²) was unsustainable.

Environmental problems for example had a serious effect on the economics of Rotterdam Harbour and its surroundings, which were intensively used for industrial activities. People working and living there also suffered from air, noise and water pollution and lacked areas for recreation.

Further economic growth would imply even more pollution. At the same time, it became clear that Rotterdam harbour needed more space to expand and to secure future employment.

These complex, interwoven issues demanded integrated, holistic and sustainable management.

In 1988 the Netherlands Ministry of Housing, Spatial Planning and Environment introduced the innovative Spatial Planning and Environment programme (ROM) for ten specific Dutch areas with serious spatial and environmental problems. ROM-programmes use integrated spatial planning, sustainable development of resources and sound environmental policies, in order to reach a balanced exploitation of resources, bringing economy and ecology into harmony.
This ROM Program was preceding the principles of co-developing economy and environment laid down during the UNCED 1992 World Summit. Years later and experience gained, it was taken as leading example by EU/Eurocities – PEGASUS= Planning, Environment, Governance and Sustainability (see PEGASUS 2004).

For the Rijnmond (= Greater Rotterdam Area = GRA = Rotterdam and surroundings) with 1.2 million inhabitants, the challenges of the ROM programme for the near future were clear:

1) To combat pollution of air, water, soil/sediments, and
2) To use space in an efficient way preventing loss of land by coastal erosion and to find space for further expansion and
3) To increase efficiency in mobility reducing transport and traffic congestion.

These became the three principle pillars for sustainable development of the harbour.

In the long term it was necessary to take into account the effects of climate change. Accelerated sea level rise, more storms, greater fluctuations in river discharges, increased risks of flooding and erosion and salt-water intrusion will effect the functioning of the Rotterdam harbour.

2. Coastal Cooperation in practice 1993 – 2010

The ROM-Rijnmond program for the Greater Rotterdam Area began in 1993 with signing of the ROM-Rijnmond Covenant by all relevant parties:

- Four Dutch Ministers,
- The Governor of the South–Holland Province,
- The Rotterdam Port Authorities,
- The Chairman of the Chamber of Commerce Rotterdam,
- The Mayors of all 17 towns of the Rijnmond - greater Rotterdam area,
- The City Council of Rotterdam,
- The representatives of all the 600 Rotterdam Port companies (Deltalinqs) and
- Water and transport related NGOs.

The ROM-Rijnmond programme’s main goal is: To enlarge Rotterdam Harbour’s productivity in a sustainable way. The ROM-Rijnmond partners translated this into objectives based on the three principles of sustainable harbour development. They also recognised that improving the quality of life is a major stimulus for economic development. This recognition was shared by all stakeholders.

An Executive Council of the ROM-Rijnmond programme included high-level stakeholder representation, chaired by Rotterdam’s Alderman for Harbour Affairs and supported by a technical staff bureau. This council provided the framework for decision making and project implementation.

The partners raised about 7 billion Euro implementing 28 projects over 17 years: 1993-2010.

The partners carry out the projects in a decentralised manner but under the common umbrella.

3. Value of an integrated approach

Most of the environmental and economic goals have been achieved. Some projects, like the seaward extension of the Maasvlakte-2 are under construction (2008 – 2013). Improvements to institutional arrangements, the economy and environment of the Greater Rotterdam Area have been substantial.

Factors contributed to success:

1. The Ministry of Housing, Spatial Planning and the Environment took the initiative and coordinated the planning process. It provided a vision for the future innovative functioning of the harbour: “Combining the environment with long term development and profitability”!
2. **All parties**, including representatives of the 600 harbour companies, signed the 1993 Covenant and stuck to their financial promises, enabling the construction of the necessary infrastructure for expanding the harbour: creating work, increasing the inhabitants’ well-being and improving the environment.

3. **The Executive Council and the Technical Staff Bureau**, facilitated the planning and the execution of the long term, ROM-Rijnmond Covenant Programme.

4. **The Port of Rotterdam Authority** (a turnover of € 500 million and a staff of 1,200 employees) as the manager, operator and developer of Rotterdam’s harbour and industrial area with commercial, nautical and infrastructure-related responsibilities played an important role during the implementation of the Programme.

5. **Participation** many inhabitants of the Rijnmond area work directly in or indirectly for the harbour authority. They used the out-door recreation facilities and helped report urgent pollution incidents. This interaction between the inhabitants and the programme partners, was vital in planning and executing this integrated and complex programme. This interaction is facilitated by websites and newsletters and the dissemination of reports.

### 3.1. Economic success

Many of the socio-economic and environmental objectives, laid down in the 1993 Covenant were reached in 2008. The construction of the Maasvlakte-2 harbour extension started in 2008, the first phase will be completed in 2013, together with the creation of 750 ha recreation and nature area elsewhere in the GRA.

In total, about 7 billion Euro has been invested in the Rijnmond area and these investments can be divided into:
- ‘hard’ investments directed at improving the functioning of the port itself and its
- ‘soft’ investments aimed at improving the environment and the quality of life of its inhabitants.

The positive effects of these ‘hard’ investments can be deducted from the throughput of goods, based on harbour statistics (www.portofrotterdam.nl), see Figure 1. Analyses of these throughputs shows that two periods can be distinguished:
- Between 1975 and 1996, a linear trend can be observed with an annual, averaged growth rate of slightly more than 1 million metric ton goods per year, while
- Between 1996 and 2010 the annual, averaged growth rate of the throughput goods is strongly increased to almost 11 million metric tons goods/year. According to the Year Report 2010 of the Port of Rotterdam, the direct added value of the Rotterdam Harbour area is growing and reached a value of 155 billion € with a throughput of 421 million ton of goods in 2008. The direct added value of the Rotterdam Harbour area per ton throughput of goods almost doubled in the period 1996 – 2008.

It is tempting to conclude that the acceleration of increase in the throughput of goods, starting three years after signing the Covenant (1993), is related to implementation of the integrated programme. The accumulated extra transhipment of goods in the period 1996 – 2010 on top of the 1975 – 1996 throughput rate (Figure 1) amounts to 800 million metric tons, contributing to a direct added value of about 25 billion €. This extra added value of the Rotterdam Harbour area represents a good economic return if related to the total investment (‘hard’ and ‘soft’) of 7 billion Euro made between 1993 – 2010.

![Rotterdam: Throughput goods 1975 - 2010](image)

**Figure 1: Rotterdam: Throughput of total goods (mass-wet, mass-dry, packed goods) during the period 1975 - 1996 – 2010. (Source: R.Misdorp based on Port of Rotterdam Statistics)**
3.2. Environmental achievements

The DCMR - Environmental Protection Agency of Rijnmond area, is amongst other things monitoring the quality of the air and the level of noise, see the annual reports on the DCMR website.

Improved Air Quality:
Monitoring general air quality in Rijnmond area shows how it has improved over the last two decades, thanks to reductions in industrial emissions. The policy of reducing traffic emissions is also showing results, with lower levels of hydrocarbons, fine dust and nitrogen oxides.
Concentrations of most substances monitored, are under the EU Target Values.
However, Nitrogen Oxides (NO\textsubscript{x}) and particulate matter (MP10) exceeded the targets at some measuring stations, during a number hours and days in 2006. The year average NO\textsubscript{2} concentrations for Rijnmond is decreasing, reaching values just under the EU Target Value of 40 μg NO\textsubscript{2}/m\textsuperscript{3} air (Figure 3).
Far better results have been achieved for lead, cadmium and sulphur dioxide. Most of these substances met their targets before 2002. The year average concentration of cadmium (Cd) for the Rijnmond reached the EU Target value of 5 ngr Cd/m\textsuperscript{3} air already in 1990 and now fluctuates around 0.4 ngr/m\textsuperscript{3} air (Figure 4).

![Air monitoring stations – red dots. (source: DCMR)](image)

![Year average NO\textsubscript{2} concentration (μg/m\textsuperscript{3} = microgram/m\textsuperscript{3}) in the air of GRA 1973 – 2006; EU Target Value: 40 μg NO\textsubscript{2}/m\textsuperscript{3}. (source: DCMR)](image)
Noise mapping

In 2007, more than 22,000 complaints were sent to the Complaints Department of the DMCR (the Environmental Division of Rijnmond). About 70% of the complaints were about noise, about a quarter dealt with smell, while the rest concerned nuisance by fine dust, smog and black soot.

Most noise complaints were related to the airport and airplanes, less than half from road traffic, railways, industry, and – in city centers – cafes.

To combat noise pollution in the Rijnmond area, efforts were undertaken to map noise levels related to sources (traffic, rail, industry and air) and time of day. These noise maps covered most of Rijnmond, are modeled and based on extensive measurements using seven noise classes starting with < 50 dB (green) to > 75 dB (blue; Figure 5). These maps enable inhabitants to estimate the noise level at their front doors and help politicians to give priority to mitigation measures.

On 1 January 2007 the Noise Abatement Act came into force, urging the municipalities to submit action plans and noise level maps to the Netherlands Government. Ten Rijnmond municipalities did so, by June 2007.

Figure 4: Year averaged Cd concentration (ng/m³ = nanogram/m³) in the air of GRA 1986-2006; EU Target value: 5 ng Cd/m³. (source: DCMR)

Figure 5: Map of the noise distribution produced by traffic during daytime on 1st June 2007, see website: www.si2.nl/ru-kaarten/rdam/index.htm. (source: DCMR)
3.3 Win-win solutions

**Coastal sand nourishment using dredged material: a cost effective measure against coastal erosion**

Coastal erosion in the Rijnmond area occurs mainly north of the 5 km long, northern breakwater of the Nieuwe Waterweg, the main navigation channel. This erosion is compensated by near-shore and beach nourishments using sand dredged from the nearby ‘Nieuwe Waterweg’.

This coastal nourishment is a profitable, integrated win-win activity: the dredged sand is used for land reclamation and combating coastal erosion. It takes cooperation between the national, provincial and local authorities, dredging companies and local interest groups to plan such a successful operation. There were the challenges to integrating dredging activities and use of the new land in a sustainable and balanced way.

This new triangle land measures, about 2 km² and is located westwards - seawards - from the original N-S running dune ridge near Hoek van Holland (see yellow line, Figure 6). It not only acts as an extra coastal protection zone, but also serves a recreation and nature protection area. The so far limited settlements are connected to existing (road) infrastructure.

![Triangular land reclamation](image)

*Figure 6: Triangular land reclamation - Hoek van Holland (about 180 ha) with jetty and navigation channel, de Nieuwe Waterweg in front, sand nourishment used clean, marine dredged material from the navigation channels yellow lines mark the original coastline before nourishment (photo: www.kastfoto.nl - 1993; source map: Topografische Dienst Kadaster, Emmen, 2009)*

Such projects help provide addition land for densely populated Holland. Moreover, such solutions can be helpful in combating the impacts of climate change. The approach: working with rather than against nature, increases coastal resilience (see Waterman in CCCIII-3-3-1).

**Harbour extension coupled with creating green areas and a marine reserve**

The Rotterdam Mainport development Project (PMR) was launched at the end of the 1990s. Project Main Port Development Rotterdam is a collaboration between a number of authorities (see PMR website). The PMR dual objective is: land reclamation and simultaneously improving environmental quality. This large project has three main components with delegated responsibility to three partners:

1. Land reclamation for the new Maasvlakte-2 harbour by the Port of Rotterdam;
2. Creating of 750 ha recreation and nature areas by the Province of South Holland and a 25,000 ha sea bed protection area (marine reserve) by the National Government;
3. Series of small scale projects (BRG) to improving on noise pollution and creating city and river parks, bicycle and walking paths and upgrading 200 ha old harbour quays, by the City of Rotterdam.
A three layered approach was used during the planning, design and implementation of the Maasvlakte - 2 harbour extension:

1) Feasibility phase addressed the need for and the viability of an extension and the choice of best location. The Cost Benefit Analysis focussed on the direct and indirect effects of the construction of the Maasvlakte - 2 (= in ‘orange-colour’, see Figure 7) extension, including the societal values associated with more green space and the 25,000 ha sea bed protection area compensating the ecological values lost by the reclamation. This all is arranged in the Regional Development Plans (PKBs, including Key Physical Decisions) enacted by the national government. The PKBs deal with permits for extraction, exemption from flora and fauna laws, permits under nature protection and adjustments to existing local spatial plans, all detailed in EIAs.

2) The Environmental Impact Assessment (EIA) for Maasvlakte -2 is the most elaborated (6000 pages), ever made in the Netherlands. It contains two EIAs, one for the construction, including sand extraction and one for the future sustainable use of the created harbour.

3) The third level deals with permits for construction and testing whether these comply with the overall permit.

The construction of the, started in September 2008. Costs are estimated at about three billion Euro. The first container ships will be welcomed in 2013. It will provide 1000 hectares of industrial sites and quays. The new land will emerge after the construction of hard (rubble or concrete blocks) and soft (beach and dunes) sea defences are created in the North Sea. The total Maasvlakte – 2 area will encompass about 2000 hectares, including sea defences, railways, roads and port basins (see NASA images above).

The nature compensation measures include a 25,000 ha sea bed protection area and the enlargement of a dune area by about 100 ha providing extra resting areas for protected bird species and will be carried out in accordance with Dutch and European legislation, such as the EU Birds and Habitats Directive.

This all will have positive effects on nature and human inhabitants of the Greater Rotterdam Area.

![Figure 7: Maasvlakte-2, 2008 - 2013: 2000 ha seaward harbour extension in orange. (Source: Rotterdam Port Authority)](image)

**Optimising dredging: improving sediment quality and decreasing the quantity**

The southern North Sea is a marginal, shallow sea. Many of the estuaries and tidal deltas are sediment sinks. Consequently the shipping lanes towards Rotterdam need constant dredging. Every year about 20 million m³ (partially contaminated) sediments from the rivers and the sea are dredged in order to keep the navigation channels open. Optimising dredging is economic and environmentally attractive and means optimising...
• Dredging techniques,
• Monitor environmental quality,
• Classification of dredged material according to the degree of pollution,
• Confining the most polluted material into man-made basins (such as the 40 m deep Slufter basin).

Figure 8: the Slufter basin. (photo: //beeldbank.rws.nl, Rijkswaterstaat)

Since 1990 the amount of polluted material has been reduced substantially by applying these techniques and as the result of international ministerial river basin consultations (see CCC I-2-4). Minimising dredging costs was achieved by improving depth surveying through the suspended fine-grained, bottom sediment layer, resulted in more exact estimates of real water depth (CZM-Centre, 1995). This reduced the routine dredging quantities by about 25%, with an annual cost reduction of more than 10 million Euro without compromising the safety of navigation.

Figure 9: Navigation channels demand continuously dredging; optimising depth survey technologies minimises annual quantities of dredged material. (source: CZM-C 1995)

Recycling contaminated dredged sediments

Immobilising the contaminants in sediments by recycling and making vitrified bricks and gravel, which can be used in the construction industry is one initiative that could decrease the burden of polluted sediments in the coastal and marine environment (see website: Reused).

Estimates of the quantity of polluted sediments in European rivers amount to some hundreds of million m³, so there is scope for growth in recycling dredged material. Experiments with polluted sediments show that immobilisation is technically and economically feasible as building materials such as gravel, sand and clay become more and more costly. Removing contaminated dredged materials in this way, could mean a significant decrease in environmental pollution and its impact on human health.

In the absence of an integrated and comprehensive cost benefit analysis, immobilisation is not common practise and funding for large-scale application is still lacking.

Figure 10: Vitrified bricks for construction and gravel for road fillings, made from immobilised polluted dredged material. (source Reused)
Residual waste utilisation
Residual heat produced in industrial installations can be transported via pipelines to heat homes and offices rather than being released into the air. Together with cooling water and greenhouse gases their use can: i) Save energy, ii) Improve air quality by decreasing harmful emissions of carbon dioxide and nitrogen oxide, iii) Decrease the impact of warm water to the surrounding water masses, iv) Stimulate more efficient use of resources, all with economic benefits.

Some examples of utilization of residual industrial heat are:
- Producing electricity: The AVR (the Waste Recycling Rotterdam company) recycles 400,000 ton waste and produces annually about 125,000 MWh electric energy. This saves fuel and reduces CO₂ and NOₓ emissions. (Ref: Report of Executive Board of the Port of Rotterdam, 2006);
- Heating houses: In 2006, in the community Hoogvliet (GRA) about 5000 household equivalents were connected. Several plans aim at further development of heating houses, offices, glasshouse in GRA using residual heat.

From planning to implementation: 1993 – 2010 Rijnmond Covenant program
The integrated spirit during the planning phase was based on the 1993 ROM-Rijnmond Covenant and led in the beginning by the Ministry of Housing, Spatial Planning and Environment. The needed institutional arrangements were undertaken. The programme was stepwise transferred into verifiable and sustainable projects. The projects were decentralised implemented by the Covenant partners. In order to keep the ultimate aim of sustainable harbour development high during the implementation, the central government enacted Regional Development Plans (PKB) safeguarding the sustainable development.

It is good to realise that it may sound all simple, the execution is however a comprehensive and painstaking step by step process encompassing all the elements and stages of an ICZM cycle. Continuous awareness of the added economic and environmental values of this complex process strengthens the mind to sustain…… encountering the many pitfalls.

4. Future perspectives

Rotterdam Harbour Development Programme 2010 - 2020
The port’s future depends not only on its market position. The quality of life and the environment are just as important. The Port of Rotterdam Authority will continue to improve the quality of life in the area while developing the port and the industrial complex and encourage the use of renewable energy sources.

Some landmarks for the future:
- In December 2006 Rotterdam specified its future energy programme. Moreover, the city joined the Large Cities Climate Leadership Group, chaired by the City of London and signed up to the Clinton Climate Initiative.
- In 2007, Holland’s former Prime Minister, Ruud Lubbers, together with local authorities and Deltalinqs (representing the 600 harbour companies) drew up a strategy to reduce the greenhouse gas - CO₂ - emissions by 50% in 2025, compared to the 1990 level.

Figure 11: ‘Quality Map’ of the Rotterdam Harbour 2020; see: www.havenplan2020.nl/
Common mitigating measures include large-scale use of biomass, using wind and solar energy, increasing residual heat utilization reducing use of raw materials, exploring more intelligent use of coal & gas-fired power plants and looking at underground storage and reuse of CO₂.

The municipality of Rotterdam produced a Port Vision 2020 (‘Havenplan’). The Vision includes a ‘Quality Chart’ of the Rotterdam Harbour 2020 (‘Kwaliteitskaart, Figure 11’) with more than 25 categories of spatial planning units. It shows concentrations of related harbour works, planned recreation and nature areas and sites for wind energy parks.

5. Conclusions

The description of the development of the Rotterdam Harbour and the Rijnmond area clearly show the benefits of integrated planning and management directed to sustainable use of areas and resources. The main messages from the long-term development of the Rotterdam Harbour are:

- **Strong cooperation between the stakeholders pays off** both in economic and in environmental sense.
- **Integrated planning can secure sustainable development** by defining a clear goal, creating robust institutional arrangements and ensuring active participation of all partners.
- **A long-term vision helps forge cooperative work and identify opportunities for future environmentally sustainable development**.

Regional Development Plans (PKBs), provide the national, legal base and serve as a frame for the correct execution of the projects according to the long term plans made for the harbour development. The long term planning and subsequent implementation of measures to improve the functioning of the harbour area in economic and environmental sense, has all the characteristics of an Integrated Coastal Zone Management (ICZM) cycle even though it is not locally recognised as such.

*The Greater Rotterdam Area development is an example of sustainable development in practise, based on integrated planning and coastal cooperation. Successful economic development goes hand in hand with environmental improvements.*

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Marine Spatial Planning in the Netherlands Part of the North Sea

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1. The need for marine spatial planning in the Netherlands
2. Development of marine spatial planning
3. Instruments to implement marine spatial planning
4. The future of marine spatial planning in the Netherlands
5. Conclusions
6. References, PDF report & Websites

Summary
The coast and territorial waters of the Netherlands form a part of the southern North Sea. The area is intensely used and for several of these uses considerable growth is forecast. This might lead to increasing conflicts with the environment and was the main reason for developing a vision for spatial planning. Recently the introduction of a new spatial planning framework was in response to an increasing interest in new developments and a growing demand for governmental coordination of these developments. This change in policy is necessary for the Netherlands to have a sea that can provide economic and ecosystem services for next generations.

A wind farm on the Netherlands’ continental shelf of the North Sea, 20 miles west of IJmuiden.
The sustainable wind energy plans for 6,000 Megawatt of wind turbines require by 2020 at least 1,000 km$^2$ space. Integrated marine spatial planning provides clarity for the development and it prevents conflict of uses: the development of the wind farms without disturbing the busiest navigation route of Europe. (photo: //beeldbank.rws.nl, Rijkswaterstaat, Sander de Jong)
1. The need for Marine Spatial Planning in the Netherlands

The Netherlands’ territorial waters of the North Sea cover an area of more than 57,000 km², approximately 1.5 times the surface of its total land area. As in other parts of the North Sea, the waters under Dutch jurisdiction are intensely used. Table 1 gives an overview of these uses.

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<th>Activity</th>
<th>area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining and mineral exploitation</td>
<td></td>
</tr>
<tr>
<td>Subsurface oil and gas</td>
<td>Approx. 130 platforms (130 km²)</td>
</tr>
<tr>
<td>Mining commercial sand,</td>
<td>20 million m³/yr (10 km³/yr)</td>
</tr>
<tr>
<td>Land reclamation and</td>
<td>380 million m³ in 2008 – 2012 (40 km²)</td>
</tr>
<tr>
<td>Beach nourishment</td>
<td>12 million m³/yr (6 km³/yr)</td>
</tr>
<tr>
<td>Dumping sites for dredged material</td>
<td>10 km³</td>
</tr>
<tr>
<td>Designated sites for dumping of</td>
<td></td>
</tr>
<tr>
<td>unpolluted sand and mud.</td>
<td></td>
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<tr>
<td>Cables and pipelines</td>
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<tr>
<td>Oil and gas pipelines</td>
<td>3000 km length, incl. safety zone 3000 km²</td>
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<tr>
<td>Undersea telecommunications</td>
<td>4000 km length, incl. maintenance zone 2000 km²</td>
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<tr>
<td>and electricity cables</td>
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<tr>
<td>Shipping and transportation</td>
<td></td>
</tr>
<tr>
<td>Shipping routes, traffic separation</td>
<td>3600 km² shipping lanes for 260,000 ship movements per year</td>
</tr>
<tr>
<td>schemes, anchor sites</td>
<td></td>
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<tr>
<td>Military exercise area</td>
<td></td>
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<tr>
<td>Firing and practice ranges</td>
<td>4200 km²</td>
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<tr>
<td>Ammunition depots</td>
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<tr>
<td>Land reclamation</td>
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<tr>
<td>Land reclamation extension of</td>
<td>20 km³</td>
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<tr>
<td>Rotterdam Harbor II</td>
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<tr>
<td>Fishing and aquaculture</td>
<td></td>
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<tr>
<td>Beam trawlers for Herring, mackerel,</td>
<td>Whole EEZ</td>
</tr>
<tr>
<td>and demersal fish</td>
<td></td>
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<tr>
<td>Wind energy</td>
<td></td>
</tr>
<tr>
<td>Two parks are built 2007/2008</td>
<td>220 MW realized (43 km²);</td>
</tr>
<tr>
<td>Proposals energy farms in the North</td>
<td>Another 950 MW in progress (130 km²);</td>
</tr>
<tr>
<td>Sea under consideration</td>
<td>In 2020 6000 MW (600 - 1000 km²)</td>
</tr>
<tr>
<td>Recreation areas</td>
<td></td>
</tr>
<tr>
<td>Beach and shoreline recreation</td>
<td>Along 250 km shoreline</td>
</tr>
<tr>
<td>and water-based recreation, e.g.</td>
<td></td>
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<tr>
<td>yachting, wind surfing.</td>
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<tr>
<td>Nature conservation</td>
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<tr>
<td>Ecologically sensitive areas,</td>
<td>11000 km² in five areas (Voordelta, NZ Kustzone,</td>
</tr>
<tr>
<td>preservation of sea birds and</td>
<td>Doggersbank, Klaverbank, Friesc Front)</td>
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<tr>
<td>marine fauna and flora.</td>
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</tbody>
</table>

Table 1: Demands for access and use of space in the Dutch part of the North Sea

While some uses will remain at their current level, considerable growth is forecast for surface mineral extraction, water sport recreation, wind farms, nature and possibly mariculture. This expected growth and the concern that this might lead to greater conflict between users was the main reason for the development of a spatial planning vision for the North Sea.
2. Development of Marine Spatial Planning

Integration of land and sea in national planning
The Dutch Ministry of Infrastructure and the Environment – I&M (former Ministry of Housing, Spatial Planning and Environment) is responsible for the development of national policy, which provides an overarching framework for decision making. In 2005 the Ministry published the National Spatial Planning Policy Document (2006). In this document, the land and sea are no longer separate entities in spatial planning terms. It thus offers a framework for the Dutch Part of the North Sea, in which relevant international agreements and obligations and national policies are taken into account. The primary objective is to enhance the economic importance of the North Sea, to maintain, and develop the international ecological features by harmonizing sustainable spatial-economic activities, as applied for instance during large land reclamations (Figure 1).
In 2008, a revised Land Use Planning Act included an extension into the North Sea.

Implementation of the spatial policy is elaborated in the Integrated Management Plan for the North Sea 2015 (2005). The overall objectives are:

- Management to foster a healthy sea: A natural, healthy ecosystem is the central aim of this theme. The objective of a healthy sea concentrates on the sustainable functioning of the North Sea and on protecting the natural ecosystem features. The policy is concerned with water quality (reducing discharges), maintaining biodiversity including site-specific ecological features in accordance with EU and international nature conservation agreements;
- Management to foster a safe sea: A safe sea refers to a safe use of the sea and protection of human beings for the dangers of the sea. It addresses policies such as coastal defence, safe shipping traffic, military use and quality of bathing water;
- Management to foster a profitable sea: A profitable sea refers to the economic function and potential of the sea. Activities that are addressed include shipping, sand extraction, oil and gas exploitation, wind energy (see photo above, recreation and fisheries. Economic growth is primarily regulated through sectoral policies.

The Integrated Management Plan for the North Sea has the status of a regulation and obliges all relevant central government ministries to act in accordance with the plan. The plan covers the period 2005-2015 and will be revised, updated and synchronised with other legal planning structures, after the first 5 years.

Usage zones
The Dutch government has opted for a spatial policy that provides the market (economic sectors & industries) considerable flexibility in developing offshore initiatives and projects. To limit the risks involved in complete market freedom, the spatial policy provides a guiding framework in which location-based uses (usage zones) and a number of exclusion policies are defined. The usage zones include shipping routes, military exercise zones, and areas with special ecological features.

Areas where growth can take place appear in more detail on so-called 'opportunity maps' (see Windfarm Opportunity map, Figure 2). Some of the anticipated conflicts (e.g. wind farms, water sport recreation or fisheries) are addressed and given a priority rating in the Integrated Management Plan.

The opportunity maps for protected areas are based on an ecological evaluation of the Dutch part of the North Sea. These areas (the Friese Front, the Klaverbank and the Doggersbank) meet the criteria for Marine Protected Areas under the OSPAR convention and the EU Bird and Habitat Directives and their coordinates have been officially sent to the European Commission in 2008.

3. Instruments to implement Marine Spatial Planning

A central aspect of Dutch marine spatial management is a system of permits to regulate offshore activities. Additionally, there are a set of other tools that provide an insight into potential problems associated with spatial development and if necessary ways of managing the use of space (see also websites of Noordzee loket and the Noordzee Atlas):

- Opportunity maps
  These maps show areas where human activity is permitted within the current legislative and regulatory framework and where users believe it is most likely to develop. The government also aims to provide greater transparency on the individual claims for space between the sectors.
• A Spatial monitoring and permit tracking system
  This system facilitates the development of up-to-date pictures of current and anticipated uses of space, and the validation and applications of the various permits. It shows who has issued permits, for how long and for what area.

• An Integrated (spatial) assessment framework for issuing permits
  Each location-based activity that has a permit will need this assessment. The integrated assessment framework contains five elements, including (1) A definition of the spatial allocation, (2) Precautionary measures, (3) Usefulness and necessity of the activity (excluding activities explicitly permitted or encouraged by national policy), (4) Choice of location and evaluation of use of space, and (5) Mitigation and compensation for ecological impact. For activities that are potentially harmful to Special Areas of Conservation (SACs), supplementary protection provisions in addition to the integrated assessment framework are required.

• Exploratory spatial studies for a specific activity
  These studies allow adjustments in the management of one or more activities. This will be particularly relevant to avoid spatial problems in a specific area.

• A disadvantage compensation
  If a user believes that he is being harmed by another legal use, a disadvantage compensation can be claimed from the competent authority.

• Joint initiatives
  The government promotes and invites initiatives that combine functions and facilitate multipurpose use of space. The Dutch Spatial Planning Act (in effect, July 2008) contains a basis for applying the specific instruments and powers to the exclusive economic zones (EEZ), if necessary. A new interdepartmental North Sea Management Network has been established to improve the coordination between the various authorities responsible for the implementation of the spatial planning for the North Sea.

4. The future of Marine Spatial Planning in the Netherlands

Three years after publishing the first national spatial planning document and its management plan, the expectations concerning the use of the North Sea had to be refined because of new objectives with regard to coastal protection, wind farms and the protection of the marine environment.

Marine Strategy
In 2008 the European Commission adopted the Strategy on the Protection and Conservation of the Marine Environment, which aims to achieve good environmental status of the EU’s marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. The Marine Strategy will constitute the environmental pillar of the future maritime policy the European Commission is working on, designed to achieve the full economic potential of oceans and seas in harmony with the marine environment (see CCC I-1-1). The Netherlands’ factsheet on EU Maritime Policy provides an overview of relevant coastal and maritime policies, vision documents, stakeholders, spatial planning and maritime governance (website: EU Maritime Policy – the Netherlands, 2009).

National Water Plan
The Dutch government published the 2009 draft ‘National Water Plan’ and the 2010 North Sea part of the Spatial Planning Policy Document. In this plan, the Cabinet is opting for uses that are sustainable and safe and make efficient use of space. At the same time, it should be in balance with the coastal and marine eco-system (as set out in the Water Framework Directive, the Marine Strategy Framework Directive, the OSPAR convention and the Bird and Habitat Directive).
Within international frameworks, the Cabinet is giving priority to the following activities that are of national importance for the Netherlands:

• Sand extraction and replenishment provide a way of enabling the coastal profile (the foundation zone, see CCC I-1-2-1) to keep pace with the rise in sea level. Where possible, this is to take place by distributing and transferring sand along the coast. In addition, the government is exploring the feasibility of extending the coastline, to provide more space for development and use. This requires appropriate planning to find areas where sand can be mined at low costs and with minor environmental impacts.

• Sustainable (wind) energy: providing space for 6,000 Megawatt of wind turbines by 2020 (requiring at least 1,000 km²) and creating conditions for further (international) growth after 2020. Once the 1170 MW already built or in
the pipeline, the remaining 4800 MW will be allocated in so-called ‘wind development areas’. Extensive stakeholder consultation and a Strategic Environmental Assessment will form the basis for designating these areas.

- Oil and gas field development: extracting natural gas and oil from the Dutch fields in the North Sea, at a relative high rate;
- Sea shipping: building a system of traffic separation schemes, clearways and anchoring areas allowing safe and prompt handling of shipping;
- Military Defence (exercise) areas at sea.

These priorities lead to specific, delineated zones for certain developments where other functions can take place so long as they do not conflict with the priority function. Therefore, spatial planning will play a greater role in future management of the Dutch part of the North Sea in which there will be a larger number of zones with accompanying criteria for specific uses (Resume map - National Spatial Strategy, Figure 3).

The National Water plan also aims to stimulate and provide room for innovation, such as combining functions in space or time in experimental areas with fewer restrictions. In the process of drafting the Plan, stakeholders were involved and neighbouring countries consulted. Information is provided for existing and potential new users about the availability of space for new activities and the conditions attached. The new National Water plan has a time horizon up to 2020. The Integrated Management Plan 2015 will be updated in conjunction with changes in the National Water plan in 2010.

5. Conclusions

For years, industrial freedom and market forces prevailed during discussions on marine spatial planning in the Netherlands. In 2005, this contributed to the drafting of the first national spatial plan for the North Sea and its associated management plan. The 2010 National Water Plan introduces a new spatial planning framework in response to the growing interest for development in the North Sea and a demand for governmental coordination of these developments. This change in policy is necessary to provide the Netherlands with a safe ocean that can provide economic and ecosystem services to next generations.

6. References:


PDF reports:

- EU Recommendation concerning the Implementation of Integrated Coastal Zone Management in Europe;
• National Water Plan 2009-2015:
• Policy Document on the North Sea (background document to National Water plan)

Websites:
• EU Framework Directive Strategy on the Protection and Conservation of the Marine Environment:
• EU MARITIME POLICY - COUNTRY INFORMATION - THE NETHERLANDS – 2009, provides information on coastal and maritime policies, vision documents, stakeholders, spatial planning and maritime governance:
• EU-Maritime Policy actions:
  http://ec.europa.eu/maritimeaffairs/subpage_mpa_en.html
• Noordzee Atlas -
• Noordzee Loket provides overview of Activities, Themes and Information on legislation, organisations etc. (in Dutch): http://www.noordzeeloket.nl/

Figure 1: Artistic view of the extension of Rotterdam Harbour, Maasvlakte -2: 2000 ha land reclamation, 2008 - 2013. (source: Rotterdam Port Authority)
Figure 2: Opportunity map wind farms - blue favourable areas, yellow potential areas
Résumé map North Sea policy choices

Figure 3: Resume map North Sea, showing a number areas with specific uses.
One of the 130 oil/gas platforms on the Netherlands’ continental shelf of the North Sea. (photo://beeldbank.rws.nl, Rijkswaterstaat)

Regular nourishment of beaches and fore shores, here on Scheveningen, The Hague. (photo://beeldbank.rws.nl, Rijkswaterstaat)
River pollution and coastal sediment quality
Reducing river pollution increases sediment quality

Remi Laane & Jos van Gils (Deltakes, the Netherlands)
Kees Kramer (Mermayde, the Netherlands)
Robbert Misdorp

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1. Introduction
2. Sources of pollution
3. Reduction of polluting load
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5. Improved coastal sediment quality
6. Conclusions
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Summary
Pollutants affecting the coastal zone mainly come from point and diffuse land-based sources. They are largely transported to the sea by rivers and adhere to clay and silt particles in the coastal zone. In the past these have had damaging effects on the environment. In the last few decades national and international efforts to reduce the levels of riverine pollutants have been successful. Subsequently, the concentrations in coastal sediments are lowered. The chemical compounds in the sediments of the Wadden Sea followed the same trend then those off the Dutch North Sea coast. However, a time lag between the cleaning of the rivers and the decrease of pollutants in the top layers of silty sediments of Wadden Sea, is observed. This is mainly caused by storms and bioturbation.
Spectacular improvement in the quality of the sediments of the North Sea and Wadden Sea shows that meticulous cleaning of the sources of pollution, monitoring, international negotiations and cooperation benefit all the riparian countries.

The catchment areas of the rivers Rhine and Meuse - six riparian countries: Switzerland, France, Germany, Luxembourg, Belgium, the Netherlands, and the North Sea (source: “Room for the River”, Rijkswaterstaat)
1. Introduction

The coastal zones of the world are influenced by multiple pressures. Runoff of chemical compounds from land-based sources plays an important role in the degradation of coastal and marine ecosystems. This is especially true for the Netherlands where the four international rivers Rhine, Meuse, Scheldt and Ems flow into the North Sea. The circulation of the riverine water and the suspended particulate matter in the Dutch coastal zone is reflected by the salinity distribution, which is influenced by a generally anti-clockwise circulation pattern in the southern North Sea (Otto et al., 1990). The net transport of Rhine, Meuse and Scheldt waters is northwards along the continental coast causing a strong salinity gradient perpendicular to the coast (Figure 1).

Figure 1a (left): **Sampling location map of the Dutch coastal zone** with three areas: Delta (I), Dutch coast (II), central North Sea (III). o = Sampling locations of the Rijkswaterstaat North Sea monitoring program;

Figure 1b (right): **The annual average salinity distribution** in the period 1975-1983. (source: Suylen and Duin, 2001, 2002)
2. Sources of pollution

For the Dutch coastal zone, in addition to riverine inputs, various other sources of chemical compounds can be distinguished (Wulffraat et al., 1993). Dissolved and particulate chemical compounds reach the area with the Atlantic waters flowing in via the Belgian coast, and from the United Kingdom. Offshore activities such as the oil and gas industry and shipping are another source. Atmospheric chemical compounds also affect the Dutch coastal zone (Bleeke et al., 2004). Annual dredging of the waterways of the Rotterdam harbour reached a maximum in the beginning of the 1980s, due to deepening of the main navigation channel (Laane et al., 2006). The average annual amount of dredged material ranges from 15 – 20 million m³. The largest part of this material is clean and dumped offshore. Most of the dumped material moves northwards to the Wadden Sea, about a third remains on the marine dumping site and a smaller part returns to Rotterdam harbour (Sandeh, 2002, see Figure 2). The most polluted dredged material, originating from the more upstream part of the Rotterdam waterways is stored on land since 1983 (Stronkhorst, 2003), amongst others in the ‘Slufter’ (see CCC 1-2-2).

Because the rivers are the primary source of pollutants, efforts to reduce coastal contaminants focus on river basin management.

3. Reduction of the polluting load

There are a large number, more than 100,000 synthetic chemical compounds produced, many ending up in rivers and oceans (Laane, 2001). In the Netherlands, the riverine sources were significantly reduced during the 1980s (Figure 3: examples of the metal cadmium and organic contaminant polychlorinated bifenyls - PCBs). Most of this was directly from load reduction in river sediments and indirectly from dumped dredged material. The contribution from the Atlantic Ocean is more difficult to reduce and becomes relatively more important over time. However, the concentrations of these chemical compounds are relatively low and close to natural background levels.

PCBs also show a reduction, caused mainly by a large cutback in the river load. The contribution from the other three sources of contamination remains more or less the same. It is remarkable that the relatively large load reductions, factor 2 – 4, were realised in only a decade.

The results are based on regular monitoring, which began in the 1970s. Quality Controlled analysis of metals was possible from the 1980s, and some years later for persistent organic compounds like PCBs and PAHs (polycyclic aromatic hydrocarbons). It is, in principle, possible to analyze every chemical compound. However, this is very expensive and not cost-effective. Monitoring of relevant indicators, data management and exchange and reporting are essential tools and are undertaken or guided by the responsible Netherlands Ministry Infrastructure and the Environment (former Ministry of Transport, Public Works and Water Management) on a national and European level.
4. Dual track reduction policy: national and international

River basin management at national and international level has been successful in contributing to the clean-up of rivers. This has had a positive influence on the level of contamination in the lower lying deltaic states and its coastal sediments. In the 1970s, the effect of enhanced concentrations of chemical compounds in European rivers (e.g. the Rhine) and coastal zones were visible (Laane et al., 2006). The oxygen concentration in the rivers was relatively low due to untreated wastewater discharges. The increase in concentrations of persistent organic compounds and their negative effects on for instance the reproduction of seals in the international Wadden Sea was the motive for political action.

The struggle to reduce contamination involved a dual track policy:
- National: cleaning the Netherlands’ own sources of pollution (emission reduction) and confining the most polluted dredged material in man-made basins (e.g. the Slufter, see CCG1.2-2), and
- International: efforts to reduce the upstream emissions through long term, ministerial Rhine, Meuse, Scheldt-river basins negotiations.

This dual track, integrated policy approach had positive effects in two areas by reducing:
- The contaminant load by rivers, dredging and atmospheric deposition and
- The pollution in the North Sea and Wadden Sea.

The lowering riverine contaminant load was established in the Netherlands at first through stepwise gentlemen-agreements between government and industry, and later by legislative enforcements. Internationally integrated river basin management was established for the river Rhine in the 1950s by the five riparian Rhine states: Switzerland, Germany, France, Luxembourg and the Netherlands. These countries on the initiative of the Netherlands, founded the International Commission for the Protection of the Rhine (ICPR). The main ICPR objectives and tasks are to:
- Improve the chemical and ecological state of the Rhine and taking into account the state of the North Sea;
- Develop a holistic flood prevention and protection approach, which includes ecological requirements;
- Support the coordinated implementation of European regulations, such as the Water Framework Directive and the Flood Directive in the watershed of the Rhine.

Important landmarks in the history of the ICPR are the 1976 signature of the Convention on the Protection of the Rhine against Chemical Pollution, followed by the 1987 Ministers’ approval of the implementation of the Rhine Action Programme (RAP), see website ICPR.

Similar integrated river basin measures were carried out for the Meuse and Scheldt catchments.
In 2000, the EU Water Framework Directive came into force. A uniform Europe-wide policy was established, with the aim of maintaining and restoring the ecological status of the waters in Europe through integrated river basin management. This Directive covers the ecological status of all inland waters and coastal waters up to one mile offshore; for chemicals the limit is twelve miles from the coast (see website: EU Water Framework Directive).

A series of Ministerial Conferences on the Protection of the North Sea focused on reducing the loads of chemical compounds. The first conference took place in 1984 and the most recent one (Bergen, Norway, 2010) within the framework of the OSPAR Commission (see website OSPAR Com). OSPAR is the mechanism by which fifteen Governments of the western coasts and catchments of Europe, together with the European Community, cooperate to protect the marine environment of the North-East Atlantic. One of the important milestones was reached in 1987, when the countries meeting at the Second Ministerial Conference agreed to reduce the inputs of potentially dangerous substances to the North Sea by approximately 50% over the period 1985 – 1995. This Conference also agreed to eliminate the incineration of dangerous wastes and disposal of sewage sludge at sea. These were important achievements, because before then, each country had set its own objectives (Laane et al., 2005).

5. Improved coastal sediment quality

As a consequence of the lower chemical loads in the rivers, over time the concentration of pollutants adsorbed to the fine grained near-shore marine and coastal sediments is reduced. Cd, PCBs and PAHs are representative for the 150 contaminants, which are regularly monitored in air, rivers and coastal waters.

The Dutch North Sea coast

The concentration of Cd (Figures: 4a and b): the highest concentrations are found in the coastal zone, with decreasing concentrations offshore and to the north.

Time series graphs show that the concentrations have decreased over the past 25-30 years (Figures: 4b and 5b). The concentrations of cadmium in the three different parts of the Dutch coastal zone are, from 1990 onwards, close to or below the national eco-toxicological target (negligible risk concentration) of 0.8 mg/kg.

A similar picture of decreasing concentration is presented for PAHs (the six of Borneff); the monitoring started in 1986 (Figures: 5a and b). Only at a few locations in the Dutch coastal zone the PAH concentrations are above the Dutch maximum permissible risk concentration of 600 µg/kg.

Similar reductions are observed for most other analysed contaminants and the level of most contaminants is below the EU-target values and national toxicological objectives, with exception at some sites for the group of TBT (Tributyl tin compounds), PAHs, Zinc, Mercury, mineral oil and HCBs (hexachlorobenzene) (Hegeman and Laane, 2008).

This relatively rapid and large decrease in offshore contaminants appears to be related to mixing and resuspension of the fine sediment fraction during storm conditions. Over a period of about 2 years, the heavily contaminated silt particles (<63 µm) in the surface sediments are replaced by less contaminated riverine particulate matter (Sonneveldt and Laane, 2000).
Figure 4: The Dutch North Sea coastal zone: Geographical distribution (4a) and long-term trend 1981 – 2006 (4b) of the concentration of cadmium (mgCd/kg) in the surface sediments (grain size fraction <63µm) in three areas in the Dutch coastal zone. (source: Hegeman and Laane, 2008).
Figure 5: The Dutch North Sea coastal zone: Geographical distribution (a) and long-term trend: 1986 - 2006 (b) of the concentration of PAHs (the six polycyclic aromatic hydrocarbons = six of Borneff - μg/kg) in the surface sediments (grain size fraction <63μm) in three areas in the Dutch coastal zone. (source: Hegeman and Laane, 2008)
The Wadden Sea
The Wadden Sea is a tidal flat area in the northern part of the Netherlands (see Figure 6). The area is influenced by inputs from the river Rhine/IJssel, either directly though sluices in the closure dam that separates the Wadden Sea from Lake IJsselmeer, or indirectly from the rivers Rhine and Meuse, that enter the North Sea at Hoek van Holland and – mixed with the coastal seawater - travel north along the Dutch coast. The Wadden Sea is a sediment sink for silty, fine-grained sediments. As a result of riverine inputs there is a gradient in contaminant concentrations from west to east. Because of the relatively large surface area and the organic coating on particles, contaminants are mostly contained in the fine fraction of the sediment (<63 μm).

The history of contamination in the Wadden Sea comes from a series of tidal flat sediment cores extracted from the western Wadden Sea (Kramer et al., 1989; Kramer et al., 1991). The results for some trace elements of the Mokbaai sampling location (red dot Figure 6), a sheltered intertidal area, are shown in Figure 7.

Figure 6: Western part of the Dutch Wadden Sea showing the islands, tidal inlets, tidal channels and tidal flats. The red dot identifies the sampling location = Mokbaai. (photo: NASA)

Figure 7: Vertical profiles of chromium (Cr), copper (Cu), lead (Pb) and zinc (Zn) and cadmium (Cd) and mercury (Hg), in sediments of the Mokbaai core (SRS normalised). (source: Kramer et al., 1991)
All profiles showed uniform background concentrations below the 30 cm sediment depth. Then a clear increase in concentration was observed reaching a maximum at 14 cm sediment depth, the result of anthropogenic inputs. The top layers showed a more uniform distribution, with a slight downward trend for most elements. Furthermore, the results of the radiotracer studies provided congruent sedimentation rates: $^{210}$Pb $\approx$ 6.5 mm/yr, $^{137}$Cs $\approx$ 6 mm/yr, meaning that the contaminant concentrations peaked at about 1963–1965.

Interpreting these results proved difficult. Looking at pollution history of the rivers Rhine and Meuse, the maximum pollutant load occurred towards the beginning of the 1980s.

Moreover, the $^{137}$Cs distribution in the sediment (Figure 8) showed a clear presence up to 13 cm sediment depth and a nearly homogeneous distribution in the top 9 cm. $^{137}$Cs is short-lived (half-life = 2.06 yr) and all $^{137}$Cs found must be from the Chernobyl accident in April 1986, less than 2 years before the sampling took place. With the calculated average sedimentation rate the radiotracer would have been present only in the very top layers. So why did it appear lower down? It appeared that the surface sediments are very dynamic. Beside the effects of storms on the clearing of surface sediments, bioturbation will play an important role. The Wadden Sea is very rich in benthic organisms, including burrowing worms and clams. (see photo: Figure 9: Benthic activities on the tidal flats of the Wadden Sea).

Using a simple mathematical model to simulate the biological/physical mixing with three bioturbation layers (WADSEDI, Wadden Sea Sediment, Van Veen et al., 1989) it was possible to demonstrate that the distribution of chemical compounds (fixed to sediment particles) are more or less homogeneously spread in the top layers of the sediment. The depth is determined by the borrowing depth of the organisms present. Reliable sediment pollution history is attainable from sediment layers below the reach of burrowing organisms, in this case 14 cm (Kramer et al., 1991). Thus, although the results from the top layers should be evaluated with caution, a reduction in contamination of the Wadden Sea sediments is slowly taking place, due to mixing with the more contaminated sub-layers.

Sediment cores of the other Wadden locations showed similar vertical distribution of contaminants including clear signals of bioturbation and its bio-mixing effects (Kramer et al., 1989). Other, physical processes, such as the mixing of the surface sediments due to wave action as described for the North Sea coastal zone, may also have played a role in the more exposed Wadden locations.

**Figure 8: Vertical profile of $^{137}$Cs in the Mokbaai core. (source: Kramer et al., 1991)**

**Figure 9: Abundant lugworms** ( Arenicola marina) in the freshly accumulated sediments of the Wadden Sea intertidal flats, indicating large scale bioturbation activities, which also contribute to the retardation of the “cleaning-up” process. (photo: //beeldbank.rws.nl, Rijkswaterstaat)
Biological effects of pollution and bioassays

Laane et al. (2006) summarised the observed biological effects of chemical compounds in the Dutch coastal zone and estuaries. The first documented observations began 40 years ago, with lethal effects on organisms, such as the harbour seal (*Phoca vitulina*) population in the Wadden Sea. The seal population showed a sharp decline, which was correlated with increased PCB concentrations (Reijnders, 1980; 1982). In the last decade the PCB load to the western Wadden Sea has dropped to such a level, that it no longer negatively affects the seal reproduction.

![Pictures from the past: serious warnings](image)

**(photo: Harry van Reeken)  (photo: Dick Vethaak)**

*Figure 10: Serious warning during the 1980s.... Cleaning-up was needed:*

**Foam** of massive dying algae along the Dutch coast, related to high level of nitrogen and phosphate in Dutch coastal waters.

**Liver cancer** in the North Sea flounder (*Platichthys flesus* L.).

Vethaak (1985) was the first to observe that 40% of dab (*Limanda limanda*) and flounders (*Platichthys flesus*) aged over 3 years, were affected with liver carcinogen nodules, lymphocystis nodules and pseudo-tumours in skin tissue. (see Dick Vethaak 1996 – Figure 10). In large mesocosm experiments with dredged material from the Rotterdam harbours he correlated the occurrence of these nodules with the presence of PAHs in the surface sediments (Vethaak, 1993). Since 1996 the concentration of the PAHs has dropped (Figure 5b) to 400 μg·kg⁻¹ PAHs and the occurrence of liver nodules is now at a natural level. Although the concentration of PAHs in surface sediments can reach twice the target value (Hegeman and Laane, 2008) strong adsorption onto the silt/clay fraction may cause a smaller bioavailability than previously expected (Jonker, 2004).

Alternatives to monitoring the 100,000 chemical compounds have been introduced by integrated pollution monitoring techniques. Examples are: fish as water quality monitor in laboratories, mussel surveillance in the river Rhine and bioassays with benthic (bottom dwelling) organisms in contaminated dredged Rotterdam harbour material (Stronkhorst, 2003). In bioassays, various organisms are used to determine effects of chemical compounds. No significant temporal or spatial differences were observed in the surface sediments from the harbour basins and the coastal zone. Although at certain locations the concentrations in the surface sediments are above the national target, no toxicological effects could be measured (Stronkhorst, 2003).

The one exception is TBT (tributyltin), which is an anti-fouling agent for ships’ hulls. The concentrations of TBT are still above target level (Van Gils and Friocourt, 2008). TBT affects the sex organs of snails (imposex), such as the whelk. It can cause the extinction of entire populations, threatening the common whelk (*Buccinum undatum*) at various locations along the Dutch coast in the North Sea.

*The whelk* (*Buccinum undatum*), a member of the North Sea marine ecological web, threatened with extinction by anti-fouling agent from boats through imposex. (photo: © Hans Hillewaert / CC-BY-SA-3.0)
6. Conclusions

Cleaning the rivers is feasible in a relative short period of time (several decades) if riparian countries cooperate at a river basin level. The Ministerial Conferences are supported by research efforts focusing on regular monitoring, standards and target setting, data management and exchange and reporting. At the same time sources of pollution in the Netherlands were addressed, first through gentlemen agreements then by legislation and enforcement.

The large-scale reduction of contamination in rivers is reflected in the reduction of the level of contamination in the coastal zone. The relative long time lag between the cleaning of the rivers and the reduction of pollution in the accumulating Wadden Sea sediments is caused by mixing of sediments due to bioturbation and storms.

7. References


Websites
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• EU Water Framework Directive - integrated river basin management for Europe
• ICPR - International Commission for the Protection of the Rhine :
  http://www.iksr.org/
• OSPAR-Commission:
  http://www.ospar.org/ and http://www.ospar.org/content/content.asp?menu=005906000082_000000_000000
• Room for the River-Programme Directorate, Rijkswaterstaat, Ministry of Infrastructure and the Environment:
  http://www.ruimtevoorderivier.nl/meta-navigatie/english/

PDF report:
  http://edepot.wur.nl/174394
Conclusions - the Netherlands

The Netherlands, being for the greater part a densely populated and highly developed low-lying delta, is extremely vulnerable to flooding, erosion and salt water intrusion. The impacts of climate change will aggravate these problems. In order to survive, coastal zone planning and implementation is embedded in the Netherlands' history and will remain so. Historically the emphasis has been on protecting the land from flooding. With vision, ingenuity and leadership many difficult projects were undertaken. In the last few decades, the concept of coastal protection has broadened to include aspects of integrated spatial planning and sustainable development. Consequently, the Netherlands has become a fertile 'environment' for ICZM development and application, as can be illustrated by the following examples.

1. A number of very large-scale flood protection works (dams and storm surge barriers) were built in the second half of the last century. Today flood and erosion protection is based mainly on managing the sediment budget of the sandy coast. Over many decades, a thorough understanding has been developed of morphological processes and sediment movements along the coast, based on extensive monitoring programs. This facilitates the implementation of a flexible and resilient sand nourishment scheme at acceptable costs. Cooperation was established among public and private bodies, based on vertical and horizontal integration.

2. The sustainable development of the Greater Rotterdam Harbour Area provides a very specific example of the application of integrated coastal planning. This involves a wide variety of aspects related to land use-planning, economic development, environmental protection and sustainable use of resources, all based on integration of regional development plans. These plans were legally founded at national level. The path to achieve the sustainable harbour development through long term cooperation was sometimes quite cumbersome. But the time and money invested certainly pays off, both economically and environmentally.

3. From the seventies onwards, the impacts of severe chemical pollution of river and coastal waters and sediments became clear through frequent monitoring and field observations. In the decades that followed, there were extensive national and international efforts to reduce these problems. These efforts resulted in a spectacular improvement of water and sediment quality in the coastal system.

4. More recently there has been a focus on integrated spatial planning of the maritime and terrestrial parts of the wider coastal zone. This has led to an Integrated Management Plan for the Netherlands' North Sea, agreed by Parliament in 2005 and embedded in the National Land Use Planning Act (2008). It is based on zoning functional uses, such as marine wind farms. Although this plan controls and restricts certain uses, it provides more clarity on sustainable development potential and commercial use options, enhancing economic development opportunity and continuity.

5. Considering long-term future developments, the pressures of socio-economic development and the impacts of climate change pose a serious challenge to the Netherlands. The long-term consequences of possible future strategies to deal with these problems have been considered by the Delta State Committee (2008), which has proposed a comprehensive set of actions. These include flood protection, water management and spatial planning with a time horizon of a century. Moreover, the Committee has urged the Cabinet of Ministers to develop a plan for the long-term implementation and financing including the establishment of a legal and political framework. The government has adopted the proposals of the Committee and has taken active steps for their implementation.

To find solutions to meet the future challenges, vision and ingenuity is needed. The central government will demonstrate its leadership in promoting innovative adaptive response strategies, by using the experience gained in protecting life and property, during the long period of developing and living in the Dutch Delta. Finding solutions to the enormous challenges facing us can be applied to other vulnerable coastal areas in the world.
Introductory Statement - Romania

Ana Lucia Varga

- State Secretary, Romanian Ministry of Environment and Sustainable Development, (2004-2008)
- Chair of the Romanian National ICZM Committee (2005-2008)
- Member of the Romanian parliament (2009-)

Many valuable resources are concentrated in the Romanian Black Sea coastal zone. This makes the area attractive for living, working and recreation, with substantial economic and environmental value. There are two different sectors, the northern Danube Delta Biosphere Reserve and the southern economic zone.

The Romanian coastal area is under pressure from increasing population growth, urbanisation, marine transport, coastal erosion and pollution. As a result, the natural resources are adversely affected resulting in a deteriorating natural landscape, declining water quality and damage to sand dunes and dune vegetation, as well as to marine ecosystems.

Therefore, Romania began implementation of the EU Directives and Recommendations relevant to the coastal zone. The Government created a legal basis for Integrated Coastal Zone Management (ICZM) through the national ICZM Law (2003). Furthermore, the creation of a National Committee for ICZM provides a consultative group having responsibility for coordinating coastal zone management activities. Romania developed a draft ICZM Strategy, in line with the EU ICZM-Recommendations (2002) and EU Water Framework Directive (2000), as a part of a Dutch supported programme. The National ICZM Strategy will contribute to the sustainable management and development of the Romanian coastal area. At present, this Strategy is under stakeholder consultation. This includes enlarging public support for the implementation of ICZM. The settlements are also in urgent need of a comprehensive infrastructure rehabilitation programme.

In conclusion

Although Romania has only recently joined the EU and still has a long way to go to increase its economy to the EU average level, it recognises the importance of the coastal zone and the need for integrated management for its future development. We also recognise that the increasing effects of socio-economic pressure, exacerbated by the impacts of the anticipated human induced climate change, may increase conflicts between development and the environment. We are therefore looking for ways to manage these pressures, whilst using our valuable resources in a sustainable fashion. The comprehensive nature of an ICZM approach provides a management framework for addressing present and future coastal challenges. We will continue to improve the ICZM process. Integrated physical planning in the Romanian coastal zone is one of the legally binding instruments used. Cooperation between Romanian Ministries, provincial and local authorities, applied scientific institutions and local stakeholders will be improved and focused on achieving a balance between necessary economic development and ecological sustainability. The lessons learned in other countries can be useful to Romania and vice versa. It is therefore with great pleasure that we contribute to this CCC-Production, which seeks to improve coastal cooperation through the exchange of international information and experience.
Integrated Coastal Management in Romania

Claudia Coman (Black Sea Coastal Centre, Constanta, Romania)

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1. Why Integrated Coastal Zone Management in Romania?
2. Main coastal issues
3. Where ICZM is applied in Romania?
4. Romanian approach to ICZM
5. Examples of coastal projects supporting ICZM efforts
6. Some lessons from ICZM developments in Romania
7. Concluding remarks
8. References & Websites

Summary
The Romanian government has adopted the ICZM Law in 2002 and established institutional arrangements. The Ministry of Environment and Sustainable Development is responsible for water and coastal policy development and chairs the high-level national ICZM Committee.
A preliminary ICZM Strategy is in the process of stakeholder consultation. The first steps of the ICZM cycle, dealing with the planning phase have taken place. To facilitate the next steps relating to the implementation of coastal measures, the ICZM Strategy and accompanying Action Plans need to be incorporated into law. Integrated spatial planning of the coastal zone, including the marine part, may be an important legal instrument.
International cooperation within an EU context and in the frame of bilateral aid, sharing knowledge and experiences, is of great help in the development of the Romanian ICZM programme and in the preparation of adaptive coastal responses to anticipated impacts of climate change.

Constanta - Romania: the largest Black Sea harbour city. (photo: Claudia Coman)
1. Why Integrated Coastal Zone Management in Romania?

Romania, as a member state of the European Union (EU), created new perspectives for enhancing and harmonising economic development with care for the environment. Romania’s policies focus on adopting and implementing the EU Water Framework Directive (WFD - 2000/60/EC) through water resource management, within a legal and institutional framework. It is also promoting compliance with the “European Parliament and of the Council Recommendation concerning the implementation of Integrated Coastal Zone Management in Europe” (May 2002).

Although Romania has a relative low Gross Domestic Product (GDP) per capita, it has decided to begin the ICZM process, because:
- The coastal zone is a key component of the national economy, and subject to increasing pressure for natural resources and space;
- The coastal zone is rich and diverse, but pressure on the resource base leads to conflict and damage;
- The impacts of climate change require the development of adaptive responses.

![Map of Romania](image)

**Figure 1:** Romania - SE Europe, bordering the Black Sea with Constanta, the harbour city and Tulcea, the apex of the Danube Delta. (source: Google maps: ©2011 Google – Kaartgegevens ©2011 Basarsoft, Google, PPWK, TeleAtlas, Transnavicom, Geocentre Consulting)

As a consequence, a new coastal management system will provide coordination among:
(1) People who live and work in the area,
(2) Policy-, decision makers and coastal stakeholders responsible for sustainable development of coastal resources,
(3) Scientific communities providing valuable information on coastal systems, required for long term planning and implementation of coastal adaptive strategies.
2. Main coastal issues

Tourism in the coastal zone has a high priority. This together with other sectors such as harbour development, transport infrastructure and agriculture are key factors in economic development. Romania’s GDP showed a significant increase. The Purchasing Power per inhabitant doubled in the period 2001 – 2008, then fall back somewhat and is expected to reach in 2011 the level of 2008 (Eurostat website). The construction sector showed the greatest increase, while the agricultural component decreased.

These economic developments, especially on the southern Romanian Black Sea coast, put severe pressure on the coastal system, resulting in habitat loss, threatening its functional integrity and reducing opportunities for future exploitation. At the same time conflicts between users, particularly in the southern, economically developed part of the Romanian coast, portrays a wide range of conflicts.

The southern coastal zone is characterised by coastal urbanisation resulting from increasing population density, expanding summer beach tourism (e.g Navodari, Mamaia, Eforie North and South, Vama Veche) and growth of recreational activities including holiday houses. When combined with industrial activity this may have positive economic benefits. However, coastal urbanisation in particular, also has negative effects. For example, on coastal landscapes it can lead to a decrease in the natural diversity of the area and cause serious damage to the natural shoreline defence (in this case coastal sand dunes). It also impacts on traditional socio-economic structures. Other key issues affecting the coastal zone include:

- Pollution, which is one of the most critical problems. Pollution is caused by industry, urban centres and agriculture. It is derived from non point sources (agriculture fertilisers, insecticides and pesticides) and point sources (industrial and municipal wastewater);
- Coastal erosion caused by a decreasing supply of sediment from the Danube, knock-on effects of coastal structures such as harbour jetties, groynes and breakwaters and ongoing global sea level rise since the mid 19th century;
- Decrease in the coastal resources, such as fresh water, which became overexploited when satisfying the increasing demands from agriculture and tourism;
- Long-term coastal risks due to climate change and the impact of accelerated sea level rise and an increased frequency and intensity of storms on coastal erosion, changes in seawater temperature and salinity, and reduction of biodiversity.

Taken together these can result in multiple conflicts between:

- industry and tourism;
- urban development and nature conservation;
- tourism and nature conservation;
- agriculture and nature conservation;
- tourism recreation and marine environmental conservation.

Maintaining tourism as an economic driver is particularly sensitive to environmental problems. The quality of bathing waters is a significant issue for Romanian coastal areas. EU-regulations for bathing water are followed but in 2008, the Blue Flag Award was only given to one Romanian beach, Vega Beach in Mamaia resort. Local authorities such as the Public Health Authority monitor bathing water quality during the summer season. The results are made available to the public through mass media.
Tourism is not only sensitive to waste water but also to other pollutants such as chemicals, visual intrusion on the landscape and to noise disturbance. Problems arise particularly in areas with intensive uses, such as petro-chemical industry and harbours.

![Recreation opposite of the Petromidia oil refinery, Navodari beach. (photo: C. Coman)](image1)

![Sulina harbour with mixed shipping functions. (photo: C. Coman)](image2)

<table>
<thead>
<tr>
<th></th>
<th>Units</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
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<td>Tourists accommodations</td>
<td>No</td>
<td>764</td>
<td>767</td>
<td>758</td>
<td>793</td>
<td>844</td>
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<td>of which hotels</td>
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<td>258</td>
<td>259</td>
<td>270</td>
<td>275</td>
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<td>116531</td>
<td>116935</td>
<td>117218</td>
<td>118778</td>
</tr>
<tr>
<td>of which hotels</td>
<td>places</td>
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<td>73691</td>
<td>73589</td>
<td>73265</td>
<td>73665</td>
<td>74222</td>
<td>74624</td>
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<td>Capacity in function</td>
<td>places-days *1000</td>
<td>8730</td>
<td>9571</td>
<td>10390</td>
<td>10516</td>
<td>10383</td>
<td>9919</td>
<td>9423</td>
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<tr>
<td>of which hotels</td>
<td>idem</td>
<td>6459</td>
<td>7213</td>
<td>7657</td>
<td>7931</td>
<td>7788</td>
<td>7593</td>
<td>7233</td>
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<tr>
<td>Tourist arrivals</td>
<td>*1000</td>
<td>672</td>
<td>659</td>
<td>685</td>
<td>718</td>
<td>755</td>
<td>713</td>
<td>686</td>
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<tr>
<td>Foreigners</td>
<td>*1000</td>
<td>33</td>
<td>45</td>
<td>58</td>
<td>67</td>
<td>84</td>
<td>88</td>
<td>62</td>
</tr>
<tr>
<td>Romanians</td>
<td>*1000</td>
<td>639</td>
<td>614</td>
<td>627</td>
<td>651</td>
<td>671</td>
<td>625</td>
<td>624</td>
</tr>
<tr>
<td>Overnights stays</td>
<td>*1000</td>
<td>4459</td>
<td>4530</td>
<td>4290</td>
<td>4201</td>
<td>4338</td>
<td>4027</td>
<td>3746</td>
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<tr>
<td>Foreigners</td>
<td>*1000</td>
<td>266</td>
<td>373</td>
<td>435</td>
<td>468</td>
<td>593</td>
<td>634</td>
<td>445</td>
</tr>
<tr>
<td>Romanians</td>
<td>*1000</td>
<td>4193</td>
<td>4157</td>
<td>3855</td>
<td>3733</td>
<td>3845</td>
<td>3393</td>
<td>3301</td>
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<tr>
<td>Net using capacity in function</td>
<td>%</td>
<td>51.1</td>
<td>45.9</td>
<td>41.3</td>
<td>39.9</td>
<td>41.8</td>
<td>40.6</td>
<td>39.8</td>
</tr>
<tr>
<td>Average days of stays</td>
<td>days</td>
<td>6.6</td>
<td>6.9</td>
<td>6.3</td>
<td>5.8</td>
<td>5.7</td>
<td>8.2</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*Table 1: Romanian tourism capacity and activity at the Black Sea littoral during 2000-2006. (source: National Institute of Statistics yearly Book 2007)*
Tourist accommodations have expanded since the year 2000 (Table 1). The number of tourist arrivals increased recently strongly in August: with more than 20% comparing 2010 with 2011 arrivals, passing the level of a million arrivals (National Institute of Statistics). Most of the tourists are Romanians and they stay 5 – 8 days and use about half of the existing accommodation capacity. In addition to the problems associated with factors such as pollution, which impact on the number of tourist visiting a particular area, tourism is itself has environmental consequences. High-rise coastal development disturbs protected areas (e.g. 2 Mai -Vama Veche, Danube Delta) and increases pressure on the infrastructure. For example, four coastal sewage treatment plants are being refurbished through the EU- Instrument for Structural Policies for Pre-Accession (ISPA) Programme. Further from the coastline, activities such as agriculture and industries along the Danube River, are also impacting the coastal zone.

To solve all these often interrelated and complex problems, it is necessary to consider the issues in a broader socio-economic and institutional context. The Romanian government has taken several initiatives to begin an Integrated Coastal Zone Management (ICZM) programme, as a response to these coastal problems. These endeavours focus on integrated planning through implementing coastal policies directed at sustainable development of the coastal zone.

3. Where is ICZM applied in Romania?

Demarcation of the Romanian coastal zone
One of the first ICZM activities is to define the coastal zone. The following definition results from a consultative workshop held in Constanta by the Dutch assisted ICZM 2002 – 2005 (MATO) project.

How far inland?
A legal definition for the inland boundary of the coastal zone is the boundary of the watershed because of its relationship to the control of pollutants entering the marine environment. The watershed of Romanian coastal Black Sea region Dobrogea encompasses multiple administrative jurisdictions. This inland, watershed boundary is appropriate for the specific purpose of controlling land-based sources of marine pollution and fresh water inflow but not for other ICZM purposes.

The demarcation of the Romanian Coastal zone was made by applying a hybrid definition of the coastal zone, realising optimal water management and facilitating the utilisation of spatial and land use planning instruments. The existing legal provision were taken into account in defining four sub-zones and their different fields of policies and regulations (Table 2 and Figure 2).
### Demarcation of the coastal zone in Romania

<table>
<thead>
<tr>
<th>Zone:</th>
<th>Inland boundary</th>
<th>Seaward boundary:</th>
<th>Includes:</th>
<th>Pressures→Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland Impacting Zone</td>
<td>Watershed</td>
<td>50 m +MSL</td>
<td>Dobrogea hills (recharge area)</td>
<td>Human settlements, deforestation → groundwater pollution, soil erosion</td>
</tr>
<tr>
<td>Coastal Planning Zone.</td>
<td>50 m +MSL elevation</td>
<td>50 – 150 m (coastal strip)</td>
<td>Coastal plain, lakes, lagoons, DDBR</td>
<td>Agriculture, irrigation, industry, waste water, transport, tourism → soil-water-atmosphere pollution, dehydration-ecosystem damage</td>
</tr>
<tr>
<td>Coastal Management Zone</td>
<td>50 - 150 m (coastal strip)</td>
<td>1 NM seaward from baseline</td>
<td>Near shore zone (land and waters), beaches, infrastructure</td>
<td>Higher population density, waterfront development, ports and marinas construction, groundwater over-harvesting → coastal erosion-accretion, dehydration, environmental degradation</td>
</tr>
<tr>
<td>Black Sea Impact Zone</td>
<td>1 NM line seaward from baseline</td>
<td>12 NM line</td>
<td>Territorial waters</td>
<td>Water pollution, over-harvesting, ferries-shipping lanes, ecosystem damage, biodiversity loss</td>
</tr>
</tbody>
</table>

Table 2: Demarcation of the Romanian Coastal Zone. (source: Royal Haskoning – Romanian ICZM project MATO2/RM/9/1)

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![Map of the Romanian Coastal Zone](image-url)

Figure 2: The Romanian Coastal Zone: the Black Sea Coast, the Danube Delta in the north and the four zones of table 2. (Source: Royal Haskoning – Romanian ICZM project MATO2/RM/9/1)
The zones as identified in Table 2 regarding the demarcation of the coastal area will become subject to different policies and regulations. They are included in the ICZM Strategy working document. Some specific activities in the zones are included in several Romanian ICZM Laws.

The Coastal Management Zone, covering the land-water interface, starts inland at 100-150 m landward of Mean Sea Level (MSL), while the seaward boundary is defined as one Nautical Mile from the MSL. The area between MSL and 100-150 m landward of the MSL is considered as set-back area, a buffer against flooding and erosion and with strict control of construction activities.

How far offshore?
The offshore boundary of the Black Sea Impact Zone was defined as 12 NM, the marine territorial boundary similar to most other European countries. It takes into account the physical system, especially the continental shelf and the relation between national and local authorities, for controlling activities and resource exploitation offshore.

4. Romanian approach to ICZM

4.1 Introduction

Balancing coastal development with the environment in the southern part of the Romanian Black Sea coast is a real challenge. Because of the large population and intense economic activity, the Government of Romania has placed a high value on the development and implementation of Integrated Coastal Zone Management. This is not only to comply with EU requirements but also because of the economic importance of the coastal area. Furthermore, the Romanian Government realises the threats and stresses to which the coastal area is exposed now and in the future. The main challenges are:

- The unsustainable use of coastal resources,
- The increase in population in the area and
- The long-term impacts of Global Climate Change.

Creating a legal framework for ICZM was the first step to address these challenges.

4.2 Creation of the ICZM-Law – 2002/3

As an initial response to the EU ICZM Recommendations, the Romanian Government formulated the Emergency Ordinance 202 in December 2002; later modified and changed to ICZM Law 280/2003. It stipulates the tasks and responsibilities of the relevant central and local authorities and institutions, as well as clarifying ICZM aims and requirements.

In Romania, the Ministry of Environment and Sustainable Development (MESD) through its Water Resources Department is responsible for policy development and legislation related to the implementation of the EU-Water Framework Directive and the EU-ICZM Recommendations.

The Romanian legal framework of ICZM has the following main components

- Provisions relating to use of the coastal zone as public property;
- Competences of authorities responsible for environmental protection, and sustainable development;
- Public participation in decision-making and access to information;
- Evaluation of integrated management of the defined four coastal sub-zones;
- Provisions regarding infringements and offences.
Some future legal directions
At present, the Romanian ICZM Law needs more enforcement. Improvements are also required to land and sea use planning; a first combined terrestrial and marine spatial map of existing functional uses has been produced in the frame of the EU-PlanCoast project (Figure 3). Additional amendments are needed to incorporate integrated spatial planning of the coastal zone into legally binding agreements. Regulations to improve the exchange of coastal and marine data, dissemination of information to coastal stakeholders should be included. There is also a need to provide a legal arrangement for the proper functioning and financing of the activities of the high level National ICZM Committee and its technical secretariat. The inland boundary of the coastal zone must be redefined in order to correctly apply the ICZM law.

Figure 3: Romanian Marine Spatial Planning Map – existing activities. (source: EU-Plancoast Project 2008, see website)
4.3. Creation of the National ICZM Committee – 2004

Because of ICZM Law, a National ICZM Committee (NC) was established in June 2004 by Government Decree 1015/2004. As prescribed by the ICZM Law, representation on the National Committee encompasses about 50 departments, institutions and organisations from the national, county and local level. The Secretary of State for Water of the Ministry of Environment chairs this high level Committee. Under the National Committee, Working Groups consisting of key experts from relevant authorities and research institutes should provide expert advice and guidance on specific topics such as coastal spatial planning, coastal erosion, ICZM legislation and rules, action planning and strategy development, monitoring and control of the coastal environment, and information and communication. The National ICZM Committee is supported by a Technical Secretariat (TS).

![National ICZM Committee Diagram](source: Royal Haskoning – Romanian ICZM project MATO2/RM/9/1)

The proposed institutional model aims to strengthen interagency collaboration and to facilitate harmonisation in the development of integrated policies and plans (Figure 4). The final responsibility for coordinating tasks rests mainly with the MESD and the NC. This proposed institutional framework has the following main features:

- Preparation and implementation of economic sector policies and plans by existing government sector agencies, mainly at regional and local level, through existing laws and regulations.
- Implementation of proactive and adaptive measures derived from cross-sectoral integrated planning by the sectoral agencies.

In this way the guidance, steering, communication and coordination based on a thorough knowledge of the socio-economic and natural coastal system can be strengthened.


At the request of the Ministry of Environment and Sustainable Development (MESD) a preliminary ICZM Strategy was prepared by a Romanian ICZM expert with additional contributions from Dutch experts. Stakeholder consultation has helped improve the Strategy. Once agreed it will become part of the ICZM Law.

Elements within the preliminary ICZM Strategy are:

- Vision for the Romanian coastal zone;
- Policy and strategic direction for development;
- ICZM tools and technique;
• Institutional and legal ICZM settings;
• Public participation, communication and information;
• ICZM monitoring and reporting system;
• ICZM Action Plan – activities and plans to implement ICZM;
• Steps towards a comprehensive national strategy.

5. Examples of Romanian coastal projects supporting ICZM efforts


“Study on coastal protection and rehabilitation” (JICA) 2004 – 2007: resulted in comprehensive hydrodynamic analyses and recommendations on coastal defence measures.

EU PlanCoast- Spatial Planning in Coastal Zones – 2006 – 2008: developed tools and capacities for integrated spatial planning in EU coastal zones and marine areas, see Figure 3 (http://wwwplancoast.eu).

6. Some lessons from ICZM developments in Romania

1. Include ICZM Strategies and Action Plans into Law: spatial planning can act as a effective legal mechanism.
2. Create ICZM - Pilot sites such as the one for the Danube Delta (see CCC I-3-2) and Mamaia beach (see Website www.euroesion.org).
3. Increase monitoring capabilities and data management
   Natural and socio-economic processes influence the dynamic coastal zone. Effective monitoring of the way these interact is important for future policies and practice for sustainable development. Strengthen understanding through capacity building, data base management, data exchange including dissemination of information to stakeholders.
4. Create a ICZM dissemination platform
   The ICZM dissemination platform is required to inform coastal stakeholders, including the public about the coastal environment, investment projects and decisions taken in the coastal zone. The platform should be an important part of raising public awareness and increasing participation in the decision-making process.

7. Concluding remarks

Romania began the ICZM planning process in 2002 by setting the legal and institutional framework. Several demonstration projects were used to strengthen knowledge about the ICZM process. International cooperation was important to the success of these projects.

Romania, an economically under resourced EU country, which is emerging from political transformation, is nevertheless developing an integrated approach to planning and management for achieving sustainable development of its coastal and marine resources. This has been achieved partly because of shared experience, with several EU-coastal partners.

Romania will continue to improve the implementation of the ICZM process. Special attention will be given to strengthening the ICZM institutional arrangements. In the meantime, priority will be given to the National ICZM Strategy and the development and implementation of its Action Plan, as well as reviewing the Coastal Law. All the above require approval by the Romanian government, which already recognises the importance of the coastal zone to future economic and social development.
8. References

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The Danube Delta
back to nature through international cooperation

Adrian Stanica, (GeoEcoMar, Bucharest)

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1. Introduction
2. Getting back to nature
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Summary
Since the half of the XIXth Century, the Danube Delta has suffered significant changes from human interventions. Aiming first to solve navigation problems at the river mouths – and straightening the waterway, humans expanded and intensified their actions which altered the natural state of the delta. Most significant changes were made during the communist times, when the natural status of the delta itself was threatened. The change in the political regime has fortunately reversed the type of human interventions. After establishing the Biosphere Reserve status for the Danube Delta, significant international projects have been run for the restoration of the natural state and equilibrium in the delta area. The delta coast also suffered from intensified erosion phenomena due to human interventions.
New concepts of coastal dynamics, such as coastal sediment circulations cells, increase insight into coastal erosion processes and contribute to finding adaptive solutions.
Large scale international projects have brought best practice knowledge to the assessment of phenomena and ICZM plans for the Danube Delta coast.

The Danube Delta: extended, natural fresh water wetlands, northern passage to Chilia-Veche. (photo: R.Misdorp)
1. Introduction

*Geography and history of human interventions disturbing the natural equilibrium of the Danube Delta*

The Danube River is Europe's second longest river, after the Volga, with a total length of 2857 km. The source of the river lies in the Black Forest (Schwartzwald) Mountains in Germany, and the river flows into the North Western part of the Black Sea through three main channels. The Danube drainage basin covers 15 Central and Eastern European countries and has a total area of 817,000 km² (Figure 1). The Danube first divides into two deltaic tributaries: Kilia and Tulcea. The former bifurcates into a series of smaller branches, forming the Kilia Secondary Delta, situated in the Ukraine, whilst the latter splits into the Sulina (middle) and Sf. Gheorghe (southernmost) channels (Panin, 1998, Giosan et al., 1999, Stanica et al., 2007, Stanica & Panin, 2009).

The Delta (Figure 2) is flat and low-lying and therefore susceptible to external changes such as human interventions and anticipated impacts of climate change including accelerated sea level rise.

*Figure 1. The Danube catchment, fifteen riparian countries and its delta (circled in red). Base map from the Hungarian Vituki Institute.*
The Danube Delta is located in the North Western part of the Black Sea. The coastline is about 240 kilometres, of which ca. 160 kilometres lies in Romania. Under natural conditions, the Danube transported about 70 million tons/year of alluvial material to the delta, filling-up lakes and feeding the coast. The sandy bed load, which is the main source of sediment to the coastal zone is estimated at about 10% of the total alluvial discharge (Panin, 1996).

For more than 150 years, the area has been subjected to considerable human pressure along the upstream segment of the Danube River, in the Delta itself and along the Black Sea coast. There are three main categories of interventions:

**Changes in the Danube River water and sediment discharges**

The first changes to the natural flow of the Danube River dates back to the second half of the 19th Century. An engineer, Sir Charles Hartley, employed by the European Danube Commission, cut-off the natural meanders of the Sulina channel in order to shorten the distance between the Black Sea and the inland Danube harbours such in Braila and Galati (Figure 2), thereby modifying water and sediment flux between the Sulina and Sf. Gheorghe tributaries. Furthermore dam constructions, acting as sediment traps, contributed to a 40% decrease in sediment discharge (Lepsi, 1942, Panin, 1976, 1998; Giosan et al., 1997; Ungureanu & Stănică, 2000). The most serious, affecting the northern part of the Romanian coastal zone, was the construction two hydroelectric dams Portile de Fier I (in 1970, 943 km from the coast) and Portile de Fier II (in 1983, 864 km from the coast). During the 1980s, sandy sediments were dredged from the Sulina Free Zone Harbor and disposed on the Sulina Beach, immediately to the south of the jetties (Stanica & Panin, 2009).
Coastal engineering works (Stanica & Panin, 2009)
Two parallel jetties built at the end of the 19th Century at the Sulina mouth facilitated navigation at the entrance of the Sulina Canal. They are now approximately 8 km long due to incremental increases in length during the 20th Century. The jetties strongly influence the local circulation of near shore currents and related sediment transport and interrupt the dominant southward directed longshore sediment drift initiated by the Kilia tributary. This altered nearshore circulation has contributed to the increase of the coastal erosional trends. (Giosan et al., 1997).

Human interventions within the Danube Delta
These can be divided into:
a) The so called “reed period” (1960-1970): changes in the natural circulation pattern by digging canals;
c) The “agriculture period” (1980 – 1990): transforming wetlands into agricultural polders (more than 35,000 ha).
These changes improved food production, navigation and industrial output, but negatively affected the functioning of the valuable, delta ecosystem through loss of tidal land, pollution and increased coastal erosion.
These interventions together with the ongoing sea level rise of about 3 mm/year (Giosan et al., 1997, Panin, 1999, Stanica & Panin, 2009) increased the rate of coastal erosion.
Furthermore, the construction of sluices which closed the Razelm – Sinoe former coastal lagoon system (Figure 2) changed its character. It transformed the lagoon system into a series of large coastal lakes and surrounding wetlands which salinity changed from brackish to freshwater. The aim of this change was to initiate more productive freshwater fishery and to create a reserve for irrigation water for the neighboring areas from Northern Dobrudja.

Activities in the Black Sea which impacting the natural evolution of the Danube Delta ecosystem are: fishing and the introduction of alien species.

2. Getting back to nature
Beginning international cooperation for nature restoration

In 1989, at the end of the communist period, the Danube Delta as a natural environment was on the verge of destruction because of the activities described above.
A transformation began in 1991, when the Romanian part of the Danube Delta (580,000 ha) became a UNESCO Biosphere Reserve.
This was one of the first and most significant international cooperative approaches to natural resources management, with the Netherlands Ministry of Transport Public Works and Water Management (RIZA/Min.V&W, 2003) assisting in capacity building, planning and organisation, exploration of vegetation and water quality and advising on ecological restoration of the former aquaculture ponds, right from the start (comm. Hans Drost -RIZA/Min.V&W). The World Bank (GEF-grant) and WNF/Auen Institut were also providing assistance during these first years.

The Danube Delta Biosphere Reserve is managed by the Danube Delta Biosphere Reserve Administration (DDBRA), under the authority of the Romanian Ministry for the Environment and Sustainable Development. The DDBRA has built up a large international network of cooperation (see DDBRA website).
Since the beginning, the primary aim is to achieve sustainable development in the area. The first steps comprised the restoration and maintenance of the natural equilibrium of the delta. Using mainly internationally funded projects, the Reserve Administration successfully restored several former agricultural polders to wetlands.

Restoring and sustainably managing the nature conservation values of the nature reserve raised several delicate issues, which can be grouped in two main categories:
• Retaining local communities and maintaining their traditional habits.
• Dealing with changes to the delta habitats and leaving nature to take its course, by mitigating adverse human impacts.
The DDBRA developed using spatial planning as a tool (see Figure 3 – land use map of the DDBRA). The entire area has been divided into three zones: strictly protected areas (50,600 ha) and areas of traditional, economic use (306,100 ha), which are separated by buffer zones (223,300 ha).
While access in the first category is strictly controlled, the areas of economic use have been regulated in plans, which establish a series of traditional activities (such as fishing and reed harvesting) with well established maximum quotas.

Figure 3: Land use map and spatial planning of the Danube Delta Biosphere Reserve (580,000 ha), delimited by the red line. Pink/red – strictly protected areas (nature sanctuaries). Green – buffer zones. White – traditional economic use areas (for fisheries, reed harvesting, ecological tourism. Light green – areas in need of ecological reconstruction. The marine part of the Danube Delta coast is also recognised a buffer zone. (source: Danube Delta Biosphere Reserve Administration: www.ddbra.ro)
3. Back to the coast

*The Danube Delta coast – international cooperation for ICZM and spatial planning*

Why are these natural resource management activities so important to the ICZM plans for the Danube Delta coast? There are several reasons:

- The large Danube Delta contains valuable wetlands, which have a vital influence on the Black Sea.
- Human pressures affect the entire Danube Delta, but are particularly important on the coast.
- The measures developed and implemented by the DDBRA also apply most significantly to the coast.

The implementation of ICZM in a particular area requires a vision for that area.

Does a vision for the Danube Delta coast exist? The answer is Yes – even though this has not yet been officially approved by the Romanian Parliament. This vision – in the form of an outline ICZM Strategy for the entire Romanian coast is one of the deliverables of a Dutch Government (MATO) funded project, executed by the Romanian Ministry of Environment and Sustainable Development and assisted by Royal Dutch Haskoning and EUCC (see CCC I-3-1). In the mean time a draft ICZM Strategy is made and stakeholders are being consulted.

What is the vision for the Delta – or what should the Danube Delta coast look like in the year 2025?

In brief - by 2025 the Danube Delta coast should be less polluted while natural coastal dynamics restored. Maintaining natural diversity should go hand in hand with promoting traditional activities by local communities that are sustainable both for the Danube Delta ecosystems and in providing good living standards. This includes eco-tourism, which has strongly increased over the last two decades.

If this is the vision for the Danube Delta coast – how can we achieve it?

The ICZM plans for the Danube Delta coast (still in progress) include the typical spatial planning of the DDBR territory, with the strictly protected areas and areas of economic use – separated by buffer zones. Eco-tourism and some traditional activities are encouraged, by the provision of European Commission funds.

These EC structural funds are made available for the development of infrastructure for coastal settlements within the Danube Delta. Although the Danube Delta coast is sparsely populated, it must also be managed in a sustainable way. The settlements need urgent modernisation of their infrastructure (e.g. at Sulina see Coman et al, 2007). This needs to focus on combating poverty and covers a wide spectrum of restoration activities: renovation of 19th century residences and boulevards, improving sewage systems and introducing home sanitation units, generating electricity from solar energy, using solar desalination of sea water for drinking water (see also CCC III-3-3-5 & 6), repairing fishery and yachting harbours and wharfs, reintroducing controlled coastal fisheries and promoting dedicated coastal ecotourism. These activities will be evaluated by monitoring the natural coastal and socio-economic system before, during and after the rehabilitation of the Sulina coastal area. In this way, the city of Sulina could again become a gateway of Europe.

An important driving force for improving water networks is the European Water Framework Directive (60/2000) which seeks to improve water quality both in the freshwater areas and along the Black Sea coast.

4. Danube Delta coast shoreline erosion management

*International cooperation for integrated planning and sustainable coastal development*


During the last century however, coastal erosion has become a dominant, man induced and critical feature along large parts of the Danube Delta coast.
Human interventions described above, abruptly changed the natural coastal evolution trends (Figure 4). This resulted in an average rate of shoreline retreat of 3.7 m/year, a loss of about 45 ha/year from the delta. The maximum rate erosion of almost 25 m/year is recorded on Sahalin Island, see Figure 7 (Gastescu & Oltean, 1997, Panin, 1999, Vespremeanu-Stroe et al., 2007, Stanica & Panin, 2009).

The Danube Delta coast can be divided into two major sediment circulation cells (Figure 5), each with its specific characteristics.
The EC FP5 (5th Framework Programme) funded project EUROSION 2000 – 2004 (www.eurosion.eu), led by Dutch Min. V&W (RIKZ), and the EC – funded FP6 (6th Framework Programme) Project CONSCIENCE – Concepts and Science for Coastal Erosion Management, led by the Dutch Institute Deltares (2007 to 2010; www.conscience-eu.net) introduced the following key concepts:

- Dividing the coast into sediment cells;
- Recognising the value of coastal resilience;
- Identifying strategic sediment reservoirs.

The Danube Delta northern sedimentary cell, described above is one of the pilot sites for testing the CONSCIENCE key concepts concerned with controlling erosion by managing sediment movement.

The solutions from CONSCIENCE will be integrated and elaborated by the USA Government funded project COASTEROSION, into an ICZM strategy for the entire Danube Delta coast.

Figure 5: Two coastal sedimentary cells

1. In yellow: the northern cell along the Danube Delta coast between Sulina and Cape Medias.
2. In orange: the southern cell.

The concept of sedimentary cells contributes to searching for adaptive solutions - EU projects: EUROSION and CONSCIENCE. (source: Ministry of the Environment and Forest).
The Sulina – Sf. Gheorghe sediment circulation cell has a total length of the coast of about 60 kilometres. The general water circulation here, as in the entire NW part of the Black Sea, is North – South oriented. The Sulina navigation jetties induce an abrupt change reversing the near coast circulation, south of these obstacles, to a clockwise south to north direction. The erosion rates here are greater than the natural trends.

Sahalin Island, the southern boundary of the Sulina – Sf. Gheorghe coastal cell, is a lateral curved bar, situated near front of the river mouth. The island is continuously shifting to the south east direction. The entire bar system is at the same time however migrating shorewards by overwashing and is thus retreating (Figure 6) due to reduced sediment supply.

Figure 6: Sahalin spit island evolution near St Gheorghe, during the period 1911-1993. The 13 km long spit is gradually enlarging towards the south west, but the entire system moves landward and is retreating. (source: Giosan et al., 1997 and Giosan in Jugaru et al., 2006, photo © Landsat 2000)
The southern sediment circulation cell is about 100 kilometres long. The complex shoreline dynamics include sections with intense erosion, whilst others are stable or even advancing. Change in coastline orientation influences the circulation patterns. At Cape Midia, the Midia Harbour northern jetty, projecting 5 km offshore, effectively blocks all sediment transported by littoral drift.

Studies comparing annual erosion rates in both sedimentary cells show that shoreline retreat from the 1960s – 1980s was greater than in the next two decades (1990s-2000s). This change in erosion rate may be connected to the North Atlantic Oscillation (Vespremeanu-Stroesc et al. 2007), although it was during the 1970s and 1980s that the big dam constructions had strong, initial impacts on the Danube River & Delta system. These dam constructions contribute to significant reductions in sediment supply to the Delta and its coast (Panin & Jipa, 1998, Ungureanu & Stanica, 2000).

Although erosion rates have adjusted and slowed during the last decades, erosion due to human activity is still ongoing, opposite to a growing delta under natural conditions.

The large erosion in the Danube Delta southern coastal cell is also strongly influenced by the human activities in the Danube river. Local intervention however, such as blocking the outlet of the former coastal lagoons of Razelm and Sinoe (for location see Figure 2) contribute to the high erosion rates observed.

An important decision must be taken here, whether to protect the beach or re-open the lagoon. A decision will be taken only after modelling shows what the different effects will be. The US funded COASTEROSION project is currently trying to find a solution within the Romanian ICZM framework, but it will be some time before a final decision is made.

Analysing the causes of coastal erosion contribute to sustainable solutions by choosing the economic and environmentally effective coastal measures. Soft coast protection measures such as sand nourishment can help control coastal erosion in a sustainable and resilient way (see CCC I-2-1 and I-2-5, the Netherlands).

5. Conclusions

Until the end of the Romanian communist regime in 1989, the Danube Delta was subject to a damaging human activities. Two years later, the Delta became a Biosphere Reserve and restoration of the natural environment turned into a long term goal. Activities associated with this have been undertaken in cooperation with international institutes and organisation concerned with wetlands and coastal research, management and administration. The Danube Delta coast has received international funding and expert assistance (Dutch, EU and USA) for projects dealing with critical issues such as coastal erosion. New comprehensive and integrated plans include the restoration of human coastal settlements, which will help fight poverty, create employment and sustainably develop coastal resources. These ICZM efforts are being executed through national and international supported projects aiming to provide sustainable and long term solutions along the Danube Delta coast.

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Conclusions - Romania

As one of the more recent EU member states Romania is in a process of rapid economic development, increasing the pressures on its valuable resources in the Black Sea coastal zone, including the Danube Delta. Romania has recognised the importance of the coastal zone for its present and future development. It is aware of the threats imposed by uncontrolled socio-economic development and the impacts of climate change. As a result, Romania has undertaken a number of essential first steps in the ICZM process. Examples of recent achievements include:

1. Following the EU recommendation, the Romanian government has adopted the ICZM Law in 2002;
2. Based on this law, a national, high level ICZM Committee was established in 2004, chaired by the Vice Minister of Environment and Sustainable Development;
3. A draft ICZM Strategy (2007) including action plans was developed and is in the process of stakeholder consultation and should become part of the ICZM Law;
4. Within the framework of EU regional cooperation and specific bilateral arrangements, a variety of coastal projects to support ICZM efforts are being prepared: strengthening the management capabilities, the development of the data management infrastructure and the identification of coastal protection measures;
5. Integrated spatial planning of the wider coastal zone is an important legal instrument, which should be applied to ICZM in Romania. Within the framework of the EU-PlanCoast project (2008) maps for the use of the entire coastal zone (marine and terrestrial) have been produced, which are presently under consultation.

From early 1990 onwards, specific attention was paid to restoring and conserving the sensitive Danube Delta area, which at the end of the communist period had been brought to the verge of destruction through ongoing unsustainable developments. The realisation by Romanian scientists and policy makers, that the Danube Delta was one of the most valuable, surviving deltas of Europe resulted in the establishment of the Danube Delta Biosphere Reserve (DDBR) in the early 1990s, under the auspices of UNESCO. The DDBR-Administration, responsible for the management of the delta, focussed on restoring and maintaining a natural equilibrium and was internationally supported e.g. by the Netherlands. The DDBRA’s activities have focused on:

- Monitoring and developing knowledge of the natural and socio-economic deltaic system, including the establishment of the Danube Delta National Institute for Research and Development;
- The spatial planning of the DDBRA territory, with strictly protected areas and areas of economic use separated by buffer zones;
- The sediment management in the coastal zone of the delta area in order to control coastal erosion.

From the above it follows that Romania has taken a number of important steps in the ICZM process. However, quite a number of critical aspects are still to be addressed in the further development and implementation of ICZM. These include the incorporation of the strategies and action plans in the ICZM Law and the strengthening of coastal monitoring programs, mechanisms for data exchange and dissemination of information to stakeholders. Successful international cooperation should be continued to strengthen the relevant Romanian institutions addressing the impacts of climate change and improving the management and quality of the coastal zone e.g. coastal towns and beaches, attracting foreign tourists in a sustainable way.
In the last 20 years, the European Union has developed a leading role in ICZM, covering the full range of activities from problem recognition to evaluation, including both a top down and bottom up approach. The results of these efforts can be seen in a number of ways:

- By triggering ICZM in many EU countries with an increase in the general awareness of the drawbacks of unsustainable coastal development and the impacts of climate change on low lying coastal areas; the general adoption of ICZM principles; and the incorporation of ICZM in national and regional planning procedures;
- By developing ICZM knowledge and capabilities, and exchanging experiences between countries at different administrative levels and with local stakeholders.
- By applying ICZM principles, through the participation of coastal countries, at all levels (including regions and local communities) in the planning and implementation of coastal management strategies and activities.

ICZM at the EU level, and in most European countries has become very important and includes active participation of NGOs. The latter play valuable roles ranging from dissemination of knowledge on coastal systems to daily management of coastal areas.

From historic perspective, the Netherlands has been very active in the field of coastal protection. In the last few decades, the development of the concept of ICZM has led to a large number of tangible results. These relate to a variety of complex problems, common to many coastal areas in the world. The examples in the Netherlands show that it is
possible to overcome serious and complex coastal problems using an ICZM approach, although this may require considerable, long-term efforts. Major innovative achievements improving the development of the delta include the execution of resilient, sand nourishment schemes; the sustainable development of the Greater Rotterdam harbour through integrated planning; the spectacular improvement of water and sediment quality through clean-up measures in the river basins; and the establishment and implementation of a zoned North Sea Management Plan. The recent adoption of a long term strategy and its institutional arrangements is an important step addressing the serious, anticipated impacts of climate change.

In Romania, the Danube Delta was the first area to be protected, because of the increasing awareness of its critical state in the early nineties. Although Romania has only recently joined the EU and still has a long way to go to increase its economy to the EU average level, ICZM was recognised as an important mechanism, for managing socio-economic activities and addressing coastal problems such as erosion and impact of climate change in a holistic way. The process of becoming an EU member state resulted in a broadening and intensification of ICZM activities. During this period, a number of steps were taken towards establishing ICZM in Romania. International cooperation was a very important factor in the development and implementation of ICZM activities and projects. However, the ICZM process in Romania has only just begun and many potential obstacles, problems and challenges are still to be faced before it is fully implemented. In this respect, a number of other countries have already taken further steps in providing a wealth of knowledge and learning experiences. The further development of ICZM in Romania will look to the exchange of experience with other countries and cooperation through international projects and programmes.

*(photo: Simon Warner)*

*Danube Delta coast: coastal retreat and salt water intrusion affecting coastal vegetation. (photo: Stefan Constantinescu)*
Asia contains the highest mountain range in the world, the Himalayas. This is the birthplace of several large rivers: the Yellow River, Yangtze, Mekong, Irrawaddy, Ganges, Brahmaputra and the Indus. These rivers provide the lifeline for more than two billion people.

Asia, the most populous continent in the world is highly dynamic. Rapid socio-economic development, river dynamics and cyclones annually battering the coast, all contribute to a highly dynamic character of the coastal zone.

Moreover, the rate of atmospheric warming in the Himalayas over the last few decades is unprecedented. The glaciers in the Himalayas are highly susceptible to melting and accelerated shrinkage, due to the combination of high altitude and low latitude.

Almost two third of the world population lives in Asia, but the available coastline in Asia is only about a quarter of the total length of the world's coastline!
The migration of many millions of people has made the Asian coastal zone a very densely populated area, probably the most densely populated in the world. With this has come rapid coastal urbanisation. This zone is not only crowded but also economically highly productive. The Gross Domestic Product of Asia already rivals the GDP of the other two major world economies namely Europe and North America. China recently became the second biggest economy in the world. Out of the five largest harbours by cargo volume in the world, four are located in Asia and one (=Rotterdam) in Europe. Marine Asian fish yields have grown rapidly and have become the largest in the world.

This rapid economic growth - illustrated by the large industrial output, harbour development, coastal urbanisation and fish production - is a sign of increasing wealth, and this helps to combating poverty. However, it comes at a price: increasing pollution, competition for space, and declining fish stocks, to mention but a few examples.

The factors associated with economic growth put considerable pressure on the environment and particularly on the coastal system. These pressures hold especially in Asia, where the anticipated impacts of climate change will exacerbate these pressures. PEMSEA (Partnerships in Environmental Management for the Seas of East Asia, Manila) is one of the Asian based organisations which, for many years, has focused on addressing these pressures. It supports scaling up ICZM programmes - to realise an on-the-ground national framework for achieving sustainable development of coastal lands and waters - as well as twinning arrangements for River Basin and Coastal Area Management in several Asian countries. (www.pemsea.org)

In the beginning of the 1990s, within the framework of United Nations Framework Convention on Climate Change and Intergovernmental Panel on Climate Change, we produced the “Global Vulnerability Assessment” (GVA) encompassing 179 coastal countries. The GVA revealed that many Asian coastal nations and island states are highly vulnerable to an assumed 1 metre Accelerated Sea Level Rise (ASLR).

The main concerns derived from this assessment involve the ‘People living in the coastal flood Risk Zone’ and the ‘Population at Risk’ from annual flooding and the loss of food production, e.g. the rice production ‘at Loss’ (see CCC-III-2).

About two third of the world’s ‘People living in the Risk Zone’ susceptible to flooding from the sea are located in Asia (Figure 1). The estimated, worldwide ‘Population at Risk’ of annual flooding will increase due to sea level rise, but population growth and coastal migration also play an important role (Table1).

Asia generates about 85% of the world rice production. With a 1 m ASLR, this rice production could decrease by as much as 4% if no adaptive measures are taken. Vietnam is the most vulnerable country in this respect and could lose 20% of its rice production. Overall, this could mean that about 75 million Asian people would face the loss of their main daily food source.

Figure 1: Distribution of People in the coastal flood Risk Zone among the Regions of the world. (The nine other regions with ‘People in the Risk Zone’< 2% are not shown; source: R.Misdorp, based on 1993)
Table 1: People in Risk zone and Population at Risk along the world's coasts, in millions

<table>
<thead>
<tr>
<th>Scenarios:</th>
<th>People living in the flood Risk Zone</th>
<th>Population at Risk of annual flooding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base line year 1990</td>
<td>205</td>
<td>47</td>
</tr>
<tr>
<td>Assuming 1 metre Sea Level Rise (SLR)</td>
<td>260</td>
<td>60</td>
</tr>
<tr>
<td>Assuming 1 m SLR + 30 year population growth</td>
<td>395</td>
<td>100</td>
</tr>
</tbody>
</table>

(source GVA - *Global Vulnerability Assessment, 1993*)

Identifying and being concerned about these problems is one thing, helping to deal with them is another. Accordingly, the following step was to work together with Asian coastal countries, within cooperative frames such as, bilateral and multiple-lateral cooperation, the United Nations Framework Convention on Climate Change and IPCC.

In view of developments described above, it should therefore come as no surprise, that the focus of this CCC-Publication is on Asia.

The following CCC chapters on the Asian cases show how several countries are taking action to deal with the unsustainable overuse of resources. This is particularly important in light of the anticipated impacts of climate change. Addressing these impacts requires coordinated activities such as the planning and implementation of ICZM programmes, cooperative efforts and adaptive, no-regret, resilient actions in the coastal zone.

Reference:
Introductory Statement – Bangladesh

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Director General, Water Resource Planning Organization,
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It is a great pleasure for us to be associated with the Chapter on Bangladesh in the CCC Publication of Robbert Misdorp.

We all realise that climate change is becoming more and more a reality and Bangladesh will suffer heavily from its adverse impacts. The coastal area of Bangladesh is not only a vulnerable zone but also one of many opportunities. The coastal zone was badly hit by devastating cyclone “Aila” in 2009; some victims are still homeless and jobless. Increasing population, competition for limited resources, natural and man-made hazards, lack of proper economic opportunities, important ecological hot spots (Sundarbans, St. Martin Island) - are all issues that call for a continuation of the structured coastal management approach, particularly to address the negative, near-future impacts of climate change.

Considering this need, it is noted that with the support of the Governments of the Netherlands and the UK, the Ministry of Water Resources of Bangladesh through its macro-planning arm — “Water Resources Planning Organisation” — has already prepared the Coastal Zone Policy (2005), Coastal Development Strategy (2006), Integrated Coastal Resources Database (2006) and Priority Investment Programmes (2006) focusing on the vulnerabilities and opportunities in the coastal zone. We note with great satisfaction that our Government supported these efforts and activities by giving approval to all these documents in a timely way. Bangladesh is willing to carry out the next steps in implementation of the coastal policies, plans and programmes. However, these steps need strong support from the development partners to protect the people and fragile ecosystem of the coastal zone of Bangladesh.

In fact, international cooperation has played an important part in helping us to fulfil our commitment to the coastal community. We look forward to receiving further cooperation and assistance as a follow-up to the identified and initially analysed fields such as: “Vulnerability Assessment”, “First Steps ICZM”, “Estuary Water Monitoring”, “Polderisation” and “Priority Investment Programmes”. Renewed cooperation especially in the process of institutionalisation of ICZM, adaptation to climate change, strengthening of embankments, land reclamation and silt management are areas where assistance from others including the Government of the Netherlands is appreciated. Furthermore, development coordination is crucial for aid harmonisation and effectiveness. We whole-heartedly acknowledge the dedicated support of the Netherlands in the water sector in the past and wish that the bond of friendship for improving living standard of our most vulnerable people will always meet on common ground.

This Climate of Coastal Cooperation (CCC) publication will enhance the knowledge and understanding on the vulnerabilities of the coastal zone of Bangladesh to socio-economic developments, hazards and impacts of future climate change. The role played by the government agencies, development partners, NGOs, and communities is inspiring. Our efforts at implementing Integrated Coastal Zone Management (ICZM) to address coastal vulnerabilities will be helpful both for Bangladesh and for other coastal countries.
Bangladesh: assessing the Vulnerability to Climate Change

the start of the ICZM Process

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5. References, PDF Reports and websites

Summary
Bangladesh is one of the most vulnerable countries of the world to extreme weather events. The changing climate adds a new dimension to the risks that threaten the lives and livelihoods of coastal communities. Vulnerability assessments reveal that Bangladesh is critically vulnerable to impacts of climate change. The envisaged impacts are dealing with sea level rise, changing nature of cyclones and storm surges, and the occurrence of droughts. This all will affect the population through increased risks of flooding, coastal and river bank erosion, salt water intrusion and expected decrease of agriculture production in absence of adaptive measures.
Bangladesh is developing its adaptation techniques sharing its knowledge with other vulnerable countries and planning for the impacts of global changes in climate. The government and NGOs are working together, setting a good example in analysing the vulnerabilities and finding solutions. Integrated planning of sustainable coastal management and adaptive measures is identified as one of the key areas to reduce Bangladesh’s vulnerability. Important steps in integrated management were successfully taken, however much more needs to be done in the field of implementation of adaptive measures in a framework of local, national and international cooperation. The challenges are multi-sectoral, multi-dimensional and long term, the causes are global in nature.

Cyclone Sidr in the Bay of Bengal:
14th November 2007 - one of the strongest cyclones recorded in the Bay of Bengal; 3,447 death were officially declared. The Cyclone Preparedness Programme including the...
improved warning system, facilitated timely and massive evacuation to many new shelters. (photo: NASA)

1. Introduction

Bangladesh is one the most vulnerable countries in the world to climate change. It is highly sensitive due to its poor socio-economic development and limited capacity to deal with the impacts. Its geological situation and geographical location make the densely populated, flat coastal lands and islands, extremely vulnerable.

The most vulnerable part of the country is the coastal zone, housing over 35 million people, more than one fourth of the country’s total population (CEGIS). Several studies indicate that the vulnerability of the coastal zone is critical due to the combined effects of climate change: sea level rise and increased cyclone frequency and intensity, to subsidence and changes of upstream river discharge and coastal embankments (see Box and World Bank, 2000).

![Flood Affected Area](image)

**Figure 1: Flood situation map - Bangladesh**

"Open water extent" area for a number of selected districts in Bangladesh, indicating the large areas susceptible for flooding. Derived from RADARSAT ScanSAR Wide beam image of 3rd August 2007.

(source: CEGIS - [http://www.cegisbd.com/flood_situation.htm](http://www.cegisbd.com/flood_situation.htm))
Box: The Vulnerability Assessment (VA) to Climate Change - Bangladesh pilot study –

BCAS/RA/Approtech, 1994:

This study analysed the impacts of climate change in a comprehensive fashion and followed the IPCC (Intergovernmental Panel on Climate Change) -1991 Common Methodology on Vulnerability Assessment (VA) on impacts of climate change. This VA –Bangladesh, executed with the assistance of the Netherlands, demonstrated that climate change and sea level rise (SLR) will affect the whole of flat, low lying, deltaic Bangladesh not only the areas near the sea. Three of the many indicators analysed deal with the effects on the socio-economic system in Bangladesh, namely:

1. **Impact of inundation on the population**
This involves an assessment of how many people would be affected by an increase in flooding risk under changing climate conditions:
Today about 65% of the total Bangladesh population suffers annually from inundation of slight to moderate intensity. This proportion is very likely to increase under conditions of climate change and 1 m sea level rise (SLR). Assuming a “River-water-sharing-with-India” option adopted under BAU (a Business As Usual socio-economic development) scenario, 85% of the total population will be affected, of which 10% will be affected by severe floods e.g. when the water depth reaches 90-180 cm.
For the non-water-sharing option, the affected population will increase to 95%. Thus under the BAU/non-sharing option, without any adaptive measures, almost the entire country will face yearly inundations of varied intensity. About 15% of the total population will then be affected annually by severe floods in the 90 – 180 cm inundation depth range.

2. **Impacts of inundation on agriculture viz on Aman rice production:**
Effect of 1 m SLR on Aman rice production under BAU scenario with water-sharing option: a reduction of 12 % in the Aman rice production is envisaged. The effect of non-water-sharing option under BAU scenario and 1 m SLR will increase the reduction of rice production to 30%.

3. **Impacts of drought on population and agriculture**
At present about 2/3 of the population live in areas that are prone to moderate to severe drought. The proportion of the total population living in the most severe drought-prone areas would increase from the present 4% , to 9% and 18% respectively under moderate to severe climate change scenarios.
The future availability of fresh water in the dry period of the year has major consequences for the Bangladesh food grain production. More water is needed for irrigation to compensate for changes in precipitation and evaporation. On the other hand less water will become available, due to lower river flows in the dry period and increased salt water intrusion enhanced by sea level rise. Under the severe climate change scenario, the overall rice production could be reduced by about 25% for all development scenarios considered.

The regional distribution (see Figure 2) of the possible impacts of climate change and sea level rise has two axes. Changes in sea level, river discharge and cyclone intensity have a N-S direction gradient. Temperature, evaporation and precipitation changes have a W-E gradient. Combining these effects the SW and NW-zones are the most vulnerable areas, while the NE-zone is least vulnerable.

The 1994 Vulnerability Assessment- Bangladesh’ study identified several recommendations, like:
- Water availability: More balanced use of water between the two riparian countries India and Bangladesh (option water sharing), could work as important adaptive measures for Bangladesh;
- Integrated coastal zone management is considered as an effective adaptive response option and include preparing sustainable adaptive policies following the recommendations of the IPCC-1990 and the UN Framework Convention on Climate Change & UN Bio-Diversity Convention 1992, as well as those emanating from the World Coast Conference 1993;
- Effective no-regret measures to respond to the threat of climate change: improve agricultural practices and increase production, develop and apply desalination techniques, continue to plant protective mangrove belts and to create floating vegetable bed cultivation (see CCC III-3-3-8).
2. Key Hazards and Risks

This section highlights the most important key factors, which effect life, livelihood and investments on different sectors, ecosystems and communities.

Sea level rise
The South Asian Association for regional Cooperation - Meteorological Research Centre (SAARC-SMRC) carried out a study on recent relative sea level rise in the Bangladesh coast. The study used 22 years of historical tidal data from three coastal stations (Table 1). The study revealed that the rate of sea level rise during the last 22 years is several times higher than the mean rate of global sea level rise over 100 years. This is largely due to the effect of regional tectonic subsidence. Variation among the stations was found.

Table 1: Trend of relative sea level rise, observed in three tidal gauge stations (Source: SMRC-2003, Report No. 3)

<table>
<thead>
<tr>
<th>Tidal Station</th>
<th>Region</th>
<th>Latitude (N)</th>
<th>Longitude (E)</th>
<th>Datum (m)</th>
<th>Trend (mm/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hiron Point</td>
<td>Western</td>
<td>21°48’</td>
<td>89°28’</td>
<td>3.784</td>
<td>4.0</td>
</tr>
<tr>
<td>Char Changa</td>
<td>Central</td>
<td>22°08’</td>
<td>91°06’</td>
<td>4.996</td>
<td>6.0</td>
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<tr>
<td>Cox’s Bazar</td>
<td>Eastern</td>
<td>21°26’</td>
<td>91°59’</td>
<td>4.836</td>
<td>7.8</td>
</tr>
</tbody>
</table>

Salinity intrusion
The effect of saline water intrusion in the estuaries and into the groundwater will be enhanced by low river flows, sea level rise and subsidence. Pressure of the growing population and rising demand due to economic development will further reduce relative availability of fresh water in future. The adverse effects of saline water intrusion will be significant on coastal agriculture and the availability of freshwater for public and industrial sectors will fall.
Salt water from the Bay of Bengal is reported to have penetrated 100 km or more along the tributary channels in the dry season (IPCC, 2007). It is estimated that about 1.0 million ha of arable lands will be affected by varying degrees of soil salinity along the coastline of Bangladesh, adversely affecting crop production and livelihoods. Vast areas of croplands in the lower estuary of the coast remain fallow during the rabi (dry) season due to higher salinity.

Changes in the surface water salinity pattern due to 30 cm rise of sea level revealed that the present dry season saline front (= 2 deci Siemens/m conductivity) is expected to move 30 km to 50 km North, affecting most of coastal districts. With a 1 m rise of sea level, the saline water front will move further North and North-East, e.g. part of the greater Dhaka district and even the Meghna river valley may be affected by saline surface water intrusion, particularly during the dry season. The drinking water supply of major cities like Dhaka and Chittagong will then increasingly be affected by salinity intrusion.

**Increased drought**

Drought primarily affects agricultural crops reducing both vegetative growth and yield. It is caused by lack of rain and soil moisture.

The north-western part of the country normally has less vegetation and a soil moisture deficit. According to people of drought-affected areas, the intensity and longevity of drought is increasing over time. The western part of the country receives less rainfall averaging some 1400 mm as against the national average of about 2150 mm. Therefore, susceptibility and severity of drought in the western districts are much higher than elsewhere.

It is predicted that the intensity of droughts in this area will increase in the future, due to climate change. Similarly, the drought prone areas will suffer from water scarcity, temperature increase, increase in dust content in the air leading to economic deprivation and increased respiratory diseases.

**Erratic behaviour of rainfall and temperature**

Increase in temperature due to climate change is likely to result in increased demands for cooling in urban centres, housing and on transport.

In addition, Bangladesh’s major crop is rice, which is vulnerable to increased temperature as rice crop yields fall with higher temperatures. Erratic weather patterns are likely to disturb and even disrupt part of the crop calendar. The rate at which climate change may affect these shifts may be faster than the rate at which technology and the farming communities’ capacity to adapt to new and modified practices can occur.

**Changing nature of cyclones and storm surges**

The Bay of Bengal generates tropical cyclones that hit the coastal area of Bangladesh during pre-monsoon (April and May) and post-monsoon (October and November) seasons. One of the reasons why the Bangladesh coast is affected so often is the conical shape of the Bay of Bengal. Over the past 125 years more than 42 major cyclones hit the coast, of which 15 occurred during the past 25 years with wind speeds ranging from 140 to 225 km/hr. The frequency of monsoon depressions and cyclone formation in the Bay of Bengal has increased over the past decades affecting the coastal population the most. Fishing in the Bay of Bengal is one of the most important ways the poor make a living and this is currently hampered by the increased and frequent rough sea weather conditions.

It is difficult to attribute a single tropical cyclonic event to climate change directly, however, the nature and intensity of Sidr cyclone (2007) that battered the Bangladesh coast is consistent with the predictions of the Intergovernmental Panel on Climate Change (IPCC). Different models used by the IPCC revealed that future tropical cyclones (typhoons and hurricanes) are likely to become more intense, with higher peak wind speeds and heavier precipitation associated with an ongoing increase in tropical sea surface temperatures. The peak wind speed of Sidr reported to be 226 kilometres per hour, can be linked with observational evidence that intense tropical cyclone activity is related to increases in sea surface temperatures. Unfortunately, information on the extent of the area affected is limited. Pictorial representation from satellite data suggested that Sidr was the most extensive at 250,000 square kilometres, of all the cyclones to hit the Bangladesh coast in recent years. Sidr is an early message that Bangladesh is likely to face such severe cyclones more often.
Cyclone Preparedness Program contributed to reduce number of casualties and damages.

Cyclone Sidr, (Super Cyclonic Storm, category 06B) was one of the strongest cyclones recorded in the Bay of Bengal, made landfall in Bangladesh on afternoon of 15th November 2007. The storm caused large-scale evacuations and 3,447 deaths were officially blamed on the cyclone. The number of death was higher estimated by some NGOs.
Forecast heights of the storm surge, predicted by a numerical model, were communicated to the emergency response authorities in India and Bangladesh. Over 40,000 Red Crescent Bangladeshi volunteers were deployed to order residents in the 15 affected provinces into special cyclone and flood shelters. A total of 2 million people in the path of the cyclone evacuated to emergency shelters on 15th November.
The Cyclone Preparedness Program, including improved warning system, allowed to react adequately and timely reducing the number of victims and damages compared with earlier comparable strong cyclones of 1971 (500,000 deaths) and 1991 (140,000 death), while there are now more people are living in the coastal zone.

Frequency and intensity of flood
The combined effect of higher sea water levels, subsidence, siltation of estuary branches, higher riverbed levels and reduced sedimentation in flood-protected areas will impede drainage and gradually increase water logging problems. This effect will be particularly strong in the coastal zone where sea level rise will inundate coastal areas of Bangladesh. This will dislocate millions of people from their homes, occupation and livelihood.
It is predicted that around 10% of Bangladesh will be inundated with a 45 cm rise and over 21 % of the country will be inundated by a 1 metre sea level rise (IPCC, 2007). More recent estimates suggest that about 10-16% area will face additional flooding due to a 62 cm rise of sea level, which may result in over 35 million people having to migrate from coastal districts because of climate change. Sea level rise along with high winds would also allow saline water to overtop the existing coastal protection embankments and submerge coastal polders at varying degrees affecting crop yields and livelihood security (CEGIS). It is estimated that a 62 cm rise of sea level will cause severe drainage impedance in 25 polders in the southwest region and 13 polder embankments will be overtopped due to increased water levels in the peripheral rivers.
The world’s largest natural mangrove forest - the Sundarbans (World Heritage Site) of Bangladesh may be lost all together with a 1m accelerated rise in sea level. This would not only affect the coastal ecosystem, but also marginalize many thousands of poor households who subsist on the Sundarbans.

The problem will be aggravated by the continuous development of infrastructure (e.g. roads) reducing further the limited natural drainage capacity in the delta. Increased periods of inundation may hamper agricultural productivity, and will threaten human health by increasing the potential for water borne disease.

Cyclone havoc and erosion, about 85% of the total population of Bangladesh (more than 150 million inhabitants) lives in a rural environment, which is often very vulnerable to recurring hazards, particularly floods. (photo: BCAS)
Impacts of flooding: clean water supply is one of the major problems during flooding; salt water not only affecting the drinking water availability but also the agriculture production depending on the duration, flood depths and season. (photo: BCAS)

Disturbance of coastal morphological processes

This will become a significant problem with a warmer climate. Bangladesh’s coastal morphological processes are extremely dynamic, partly because of tidal and seasonal variations in river flows and run off. Simulations of expected changes in river run-off under influence of climate change (see Figure 3 and CCC III-3-2-6) revealed the extent to which loss of glaciers in the upper parts of the basins of the Ganges and Brahmaputra in the future will cause them to become mainly rain-fed. These changes will have serious impacts on salt water intrusion, agricultural production and nature development.

Climate change is expected to increase these variations, with two main (related) processes involved:

- Increased bank erosion and bed level changes of coastal rivers and estuaries. There will be a substantial increase of morphological activity with increased river flow, implying that riverbank erosion might substantially increase in the future;
- Disturbance of the balance between river sediment transport and deposition in rivers, flood plains and coastal areas. Disrupting the sedimentation balance might result in higher bed levels of rivers and coastal areas, which in turn may lead to higher water levels related to fixed landmarks.
The Sundarbans forest covers 10,000 km² of which about 6,000 are in Bangladesh (dark blue-green coastal area on the satellite image) and is the world largest single belt of tidal mangroves. It is an UNESCO world heritage site since 1997. About 150,000 ha mangrove plantation was created in Bangladesh, since the 1960s, to increase the biodiversity, protection against storms and the livelihood of its inhabitants, and preventing land degradation. Large parts of the Sundarbans may be at loss under influence of a 1 m sea level rise. (photo: NASA Jesse Allen, 28-01-08)

The mangrove ecosystem provide multiple valuable subsistence uses for its human inhabitants, protection against cyclones and flooding, and represents a large range of high (natural) values. A variety of habitats is accommodating a rich wildlife. The mangrove vegetation helps to form new land. (photo: Tjark van Heuvel)
3. Coastal policies

Balanced decision making in the coastal zone is facilitated by increasing knowledge of socio-economic and natural processes in coastal areas. One of the integrating tools applied in Bangladesh is GIS in combination with remote sensing. CEGIS (Center for Environmental and Geographic Information Services) has been developed with the assistance of the Netherlands (1996 – 2002). In 2002, the Government of Bangladesh established CEGIS as a national institution and a public trust. Since then CEGIS has been working as a self-financed not-for-profit government owned organisation (see CEGIS website).

Adapting to climate change

Integrated planning is identified as one of the key adaptations to reduce Bangladesh’s vulnerability to climate change. This holds in particular for the coastal zone and fresh water resources (World Bank, 1999).

On the other hand, communities and peoples in Bangladesh are already actively adapting to climate variability. Bangladeshis are not sitting idle, they are building dams, changing agricultural practices and irrigating their soils to accommodate the effects of droughts. But despite their dynamic approach, the climate challenge is vast. Much remains to be done. Bangladesh needs to continue developing its adaptation techniques, share their knowledge with other vulnerable countries, and plan for future weather changes. It also needs to develop the use of clean energy.

It must also continue to develop a strong team, in order to raise attention for the plight of developing countries in relation to climate change and adaptation in international negotiations. The Government and NGOs are working together and setting a good example. However, continued efforts are needed to effectively prepare and implement adaptive measures, such as identified within the Coastal Development Strategy of Bangladesh. The challenges are multi-sectoral, multi-dimensional, long term and the causes are global in nature.

Afforestation

Realising the present situation and future consequences, the Government has taken a number of initiatives in the formulation of coastal policy, including integrated coastal management projects and zoning coastal land. The National Environment Policy (1992) declared the importance of sustainable use of coastal and marine resources and the protection of the coastal ecosystem. It has indicated that newly accreted lands will be transferred to the Department of Forest on a priority basis to stabilise them through afforestation and protect them from erosion. National Forest Policy realises the need for massive plantation and for the maintenance and preservation of the coastal areas reducing the velocity and intensity of cyclones and tidal surges. The National Land Use Policy supports both environment and forest policy and states that 25% of the total land should be forested. The land use policy states that forest declared by the Ministry of Environment will remain as forestlands and create an effective buffer zone all along the coast. The Coastal Zone Policy also suggests maintenance of ecological balance and overall development through protection and improvement of the environment can be achieved as part of the protection of the country against natural disasters.

Coastal mangrove planting along the entire southern coastal frontier is an innovative measure, which began during 1960-61 through an afforestation programme along the shore land of coastal districts. This initiative gained momentum from 1980-81 with the aid of development partners and afforestation programs, which extended over foreshore islands, embankments and along the open coasts. Since 1960-61 up to 1999-2000, more than 140,000 hectare of mangrove plantation have been created under a number of coastal afforestation projects.

Land zoning

The Integrated Coastal Zone Management Plan Project – ICZMP (see CCC II-1-3) identified more than 20 projects as part of the implementing phase, laid down in the adopted Bangladesh Coastal Development Strategy (CDS - 2006). Recently the Ministry of Land has taken up one project as suggested in the ICZMP namely the “Coastal Land Zoning Project”. The objectives of this land zoning project are:

- To assign the land to its best possible uses, such as agriculture, livestock, forestry, shrimp culture, nature reserve, industrial development, etc;
- To prevent (further) land degradation and restore degraded lands;
- To preserve and protect ecosystems with high ecological and cultural value.

The project will also formulate rules and acts for different categories of use. Climate change has not been considered and therefore zoning will be static in nature. However, climate change requires that coastal land zoning should be part of a dynamic system of management to help adaptation to the changing condition of natural and physical systems.
4. Conclusions

Research and policies relevant to integrated coastal zone management in Bangladesh, are indicating that the increase of extreme events (cyclones and storm surges) may be related to climate change. The executed studies on coastal area vulnerability reveal that Bangladesh is critical vulnerable to impacts of climate change. These studies provide directions for solutions and are important for the survival of small farmer’s livelihoods throughout the coastal zone now and moreover in the future. Cyclones and tidal bores, water logging, impedance of drainage, various types of flooding, sand deposition and soil salinity are now a major hindrance to farming and production. These factors will most likely become more important as climate is changing. Strengthening of institutional capacity and mechanisms to support coastal communities in adapting to the impacts of climate change are still often missing although awareness on weather-related hazard and risk posed by extreme events has increased over time. Bangladesh has experienced several impacts of extreme weather perturbations and the costs in physical damage have been significant.

Key efforts promoting adaptive capacity to climate change, including understanding the variability in coastal processes, awareness of impacts and timing of adaptive interventions, are still limited in scope.

Gradual change such as salinity intrusion is not properly recognised. Furthermore policies, strategies and action plans are more based on historical climatic events rather than on future changes in the climatic system. Therefore related risks are not yet reflected in many policies and strategies, which contribute towards the governance of coastal development.

The hesitancy to include findings from assessments of future climate risks on relevant sectors (e.g. water, agriculture, forestry etc) in coastal development strategies and programmes is a major constraint in the context of achieving and sustaining millennium development goals. The challenges are multi-sectoral, multi-dimensional and long term.

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Websites:

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- **SAARC - South Asian Association for Regional Cooperation**: http://saarc-sec.org/main.php?id=76
Stimulating role of NGOs in Bangladesh

Mohiuddin Ahmad (Community Development Library, Dhaka)
Atiq Rahman (Bangladesh Centre for Advanced Studies, Dhaka)

Contents
1. Role of Non Governmental Organizations (NGOs)
2. Coverage
3. Activities
4. Coastal perspective
5. Institutional setting
6. Partnership at the local level
7. Incorporating NGOs in ICZM
8. Conclusions
9. References

Summary
Non Governmental Organisations (NGOs) act as windows on applied knowledge and provide links to sources of information. NGO activities are active in all nineteen coastal districts in Bangladesh. Among the NGOs that work exclusively in rural areas, the greater numbers are involved in water and sanitation, closely followed by environment and forestry, fisheries and micro-credits, providing small loans. Many NGOs address typical coastal issues, assist in solving local coastal problems and implement programmes among selected coastal communities. In recent years, the government has initiated several development projects addressing issues of coastal zone management and targeting programmes to enhance livelihoods of the coastal population.

Figure 1: Bangladesh, a low lying deltaic country product of strong and dynamic rivers and the sea. (source: Google Earth: Image @2009 TerraMetrics, @2009 Google Image, @2009 DigitalGlobe, @2009 Europa Technologies)
1. Role of Non Governmental Organizations (NGOs)

Most of the NGO activities in the coastal districts of Bangladesh aim to contribute to poverty alleviation and community development. But they tend to limit their activities to some specialised areas. For example, some mainly address women’s issues, others are involved in the financial credit programme, and yet others in social mobilisation activities. Quite a number of NGOs address issues in their immediate (coastal) environment and try to undertake activities focusing on those issues. Several hundreds of “coastal NGOs” are engaged in “coastal activities” (Sayed Iftekhar et al., 2003). Typical coastal zone activities range from: disaster preparedness, fisheries, food processing (dry fish), environment, forestry, housing. NGOs also highlight the existence of applied knowledge and provide links to sources of information on sustainable development and how for instance to mitigate and adapt to climate change or how to identify and combat the occurrence of arsenic (As).

2. Coverage

NGO activities are prevalent in all nineteen coastal districts of Bangladesh. Chittagong district has the highest number of NGOs (83), closely followed by Khulna (78), Jessore (71) and Barisal (64), while Shariatpur and Feni are covered by the lowest number of NGOs (14 each) followed by Jhalakati (15), see Figure 2.

![Figure 2: Distribution of NGOs in the 19 coastal districts. (source: PDO-ICZMP, Working Paper 22, 2003)](image)

3. Activities

Among the NGOs that work exclusively in rural areas, the highest number are involved in water and sanitation (53%) closely followed by environment and forestry, fisheries and micro-credits. Among the urban NGOs, the highest number work in the field of AIDS prevention, followed by programmes on street children, health, nutrition, and programmes concerned with adolescent children. Among the NGOs with activities both in rural and urban areas, the highest number have programmes in the field of training (42%), followed by women’s development and provision of credit. For details, see Ahmad, 2003a and ADAB, 2000.

Many NGOs operate in the coastal districts. However, not many NGOs are present in the most exposed coastal zone that are, the ‘chars’ (newly accreted alluvial land) and the islands. People in those areas have distinctive vulnerabilities as they live with recurrent disasters (cyclones and erosion) and are deprived of basic services (because of isolation). It is difficult to estimate how many households in the coastal zone are covered by the NGOs. Estimates were made (Ahmad, 2003b and Sayed Iftekhar et al., 2003). The number of households covered by 168 micro-credit NGOs in the coastal zone was about 0.7 million (December 2001). This is 10 percent of the coastal households and 31 percent of the total clientele covered by micro-credit NGOs in Bangladesh. Beneficiaries of the micro-credit programme of NGOs are mostly located in the ‘interior coast’.
Several NGOs are engaged in specific issues such as water quality and in particular, with toxic arsenic in groundwater. Understanding on the distribution of arsenic is growing. Very high arsenic concentrations of greater than 100 μgram/l occur in Bangladesh and West-Bengal groundwater. Regarding the expected arsenic distribution in wells: the shallow wells have the lowest arsenic concentration (NCC-IAH, 2008). The use of arsenic-selective adsorbents as an adaptive measure is viable in remote rural locations. (Sudipta Sarkar et al., 2008).

4. Coastal perspective

There is no well-articulated overarching NGO “coastal perspective”. However many NGOs address typical coastal issues, assist in mitigating coastal problems and implement programmes among selected coastal communities. In recent years, the government has initiated several development projects addressing issues of coastal zone management and targeting programmes to enhance livelihoods of the coastal population. Some examples of increasing NGO involvement in government projects include:
- Char Development & Settlement Project;
- Sundarbans Bio-Diversity Conservation Project;
- Coastal Embankment rehabilitation Project;
- Empowerment of Coastal Fishing Communities.

There are also many NGOs, which have a major impact on programmes concerning coastal communities, for example:
- Community Development Centre working with marine fishers;
- Association for Land Reforms & Development, addressing issues of land settlement (for the victims of erosion);
- Bangladesh Disaster Preparedness Centre, which is engaged in disaster preparedness;
- COAST Trust, which is involved in the enhancement of livelihoods of the poor;
- Coastal Development Partnership, which is active in networking and information dissemination.

Since the inception of the Programme Development Office (PDO) for the Integrated Coastal Zone Management - ICZM Plan (see CCC II-1-3) in February 2002, the ICZM concept is being introduced to the NGO community. Many NGOs have responded positively, and extended extensive support and cooperation in accomplishing certain activities of this programme.

5. Institutional setting

NGOs have their own clientele. They generally work with the poor. They organise their clients into community or village based groups who use NGO services. Local NGOs sometimes have their own reasons not to make use of existing institutions and traditions, in order to implement their programmes and to deliver their services.

Different NGOs acting at different levels and a growing number of NGOs play an important role in improving the living conditions of the poor coastal people.

National NGOs with a good overview of pressing coastal issues, can assist both in monitoring coastal processes and helping coastal inhabitants both before and after hazard events. An example of such an NGO is ”Bangladesh Centre of Advanced Studies” (BCAS website), bridging international and national coastal efforts for local people. BCAS co-produced for instance the valuable Bangladesh Vulnerability Assessment (CCCII-1-1).

![Bangladesh during severe 2007 flooding.](photo: www.tear.org.au)
Example of the role of NGOs: Water for life

There is no well in this village of Shyamnagar Upazila in Satkhira district, as the groundwater is too saline. The pond is the only source of water and the water is filthy. Diarrhoea, dysentery skin diseases were common in almost every household. Sripati Kumar Mondal is an affluent farmer. He has donated a 0.37-acre pond for community use. The pond was re-excavated and cleaned with project support from Caritas Bangladesh in August 2000. Water is reserved for use for drinking and cooking purpose. A water-storage area has been made with brick and cement at one corner of the pond with a sand-filtering system and a hand pump to take water from the storage area. Sushilon, a local NGO, introduced the pond-sand-filtering technology. Women from about five hundred neighbouring households come with buckets and pots to take water from here. Many fisher-boatmen also take water for their boat before they sail for hours on the river. The incidence of water-borne diseases has dropped considerably. The pond is cleaned once in every three months. A five-member committee headed by Sripati oversees it. People call it the grammo shebok committee (rural volunteers’ committee). The committee looks after the maintenance fund. (photo: Mohiuddin Ahmad)

6. Partnership at the local level

NGOs have consultative status in different forums (committees) at the district and the upazila (sub-district) level where they participate in, and contribute to the implementation of selected programmes together with local government officials, representatives of local government institutions and members of the civil society. Table 1 provides a list of these committees/meetings.

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Name of the governmental committee &amp; meeting</th>
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<tbody>
<tr>
<td></td>
<td>District level</td>
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<tr>
<td>1</td>
<td>Agriculture Rehabilitation Committee</td>
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<tr>
<td>2</td>
<td>Disaster Management Committee</td>
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<tr>
<td>3</td>
<td>House Allotment Committee</td>
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<td>4</td>
<td>Tree plantation Implementation, monitoring and evaluation committee</td>
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<td>5</td>
<td>NGO Activity Monitoring Review Meeting</td>
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<td>6</td>
<td>VGD (Vulnerable Group Development) Co-ordination Meeting</td>
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<td></td>
<td>Upazila level</td>
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<td>1</td>
<td>Agriculture Rehabilitation Committee</td>
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<td>2</td>
<td>Fertilizer and seeds monitoring Committee</td>
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<td>3</td>
<td>NGO coordination meeting</td>
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<td>4</td>
<td>Agriculture Development Committee</td>
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<td>5</td>
<td>Disaster management committee meeting</td>
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<td>6</td>
<td>Forest Retention Committee</td>
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<td>7</td>
<td>VGD Committee</td>
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<tr>
<td>8</td>
<td>VGF (Vulnerable Group Feeding) Committee</td>
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</tbody>
</table>

Table 1: List of governmental committees with NGO participation

While Government - NGO cooperation is promoted as an ideal instrument of programme implementation, government agencies and NGOs face the difficulties of working under project conditions. In many respects, they have to go beyond their conventional domains to work out arrangements with their counterparts in the programme.
NGOs feel encouraged when they are treated as ‘trustful partners’. However, they are often treated as paid ‘contractors’ in government projects, and complying with all contractual obligations may consume energy meant to help relieve the poor.

**Example of the role of NGOs: Lighting nights and minds**
Has anybody ever contemplated that the shanties in a remote Munda village in Satkhira district would sparkle with fluorescent bulbs? This is no longer a fairytale. Small solar panels stand out on bamboo tops at Mundapara. All the 48 households are connected. Centuries-old night gloom is gone and replaced by children’s reading schoolbooks.

A poribesh (environment) school was set up by Caritas Bangladesh at the edge of the neighbourhood where the children gather in the morning. The school was set up in 2000 and currently has 80 students. Sabita and Prasanta, a blissful young Munda couple from the village, work as teachers. They enlighten the minds of the children of their own community. Students enrol from Grade Shishu (nursery) to Grade-III. The National curriculum is used along with a separate course containing environmental messages. The entire neighbourhood has changed its outlook. All the houses have water-sealed latrines. Earthen houses are clean and regularly mopped. Backyards are full of green vegetables. Men and women have accumulated savings of over taka 57,000. Income has increased by 30 per cent since June 2000. They do not feel vulnerable anymore.

**Example of the role of NGOs: Adaptation to climate change (see also CCC III-3-3-8)**
Flood and water logging is a common problem in Bangladesh. A vast area of Bangladesh is situated below mean sea level, affected by high tides. Climate change will aggravate the problem in the future. Evidences of adverse impacts are already visual. The main impacts are on the livelihood of people in terms of crop loss and food insecurity. Many communities have developed baira cultivation as an adaptation strategy to reduce their vulnerability. BCAS with local NGOs are providing training and material to local communities to improve the floating bed cultivation and to reduce seasonal food insecurity in the coastal villages.

**7. Incorporating NGOs in ICZM**
An effective way of incorporating NGOs in a structured ICZM fashion is to make use of a civil society forum. Such a forum, representing stakeholder interests, could review and monitor the functioning of the ICZM programmes. Several coastal NGOs participate in a fragmented manner, which requires better integration and coordination. A Coastwatch frame is proposed, that could function as a broad civil society platform and could develop into an umbrella organisation: a network of NGOs that have interest in coastal sustainable development. The main activities of an umbrella organisation which will strengthen coastal coordination of NGO activities, could be dealing among other things with:

- Review ongoing developments in the coastal zone of Bangladesh, annually reporting;
- Liaise and interact with different stakeholders in the coastal zone and with institutions at the policy level that have involvement in the coastal zone and periodically disseminate information on coastal issues through newsletters;
- Help government agencies to adhere to the principles laid down in the coastal zone policy and strategy work as a civil society pressure group to realise the ICZM goals.
8. Conclusions

NGOs do have special capabilities that are essential for alleviating poverty and vulnerability that are amongst the objectives of ICZM. An important advantage is their efficiency and effectiveness in reaching out to the poor especially by channelling donor support towards them.

NGOs are also very valuable in providing a link between authorities and organisations linking local, national and international sources of information and funding. Some examples of “International to local and vice versa” linkages are the identification of impacts and directions of solution dealing with climate change and perils of arsenic.

The introduction of an umbrella organisation, could increasingly help civil society to integrate within the national and local development processes. This may lead to greater awareness about coastal issues, better planning through stakeholder participation in media debate and promoting the voice and participation of the civil society.

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Bangladesh’s ICZM efforts in practice

M. Rafiquil Islam (Manly Council, Australia)

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1. Introduction
2. Coastal Management – success stories
3. ICZM as a process – historical milestones
4. Building coastal cooperation
5. Institutional mechanisms
6. Four years after adoption of coastal policy
7. Concluding remarks
8. References, PDF reports and Websites

Summary
Bangladesh, over the last two decades, has successfully embarked on adopting Integrated Coastal Zone Management (ICZM) approaches and projects, supported by e.g. the World Bank and the Netherlands. A number of ‘success stories’ formed the basis for this integrated and comprehensive approach to coastal management.

Between 2002-2006 a new stage in the ICZM cycle was reached with greater importance and emphasis placed on building co-operation between and among many institutions, stakeholders, and communities. The Coastal Zone Policy and Strategies were adopted and many ICZM planning tasks were accomplished see WARPO - website.

However, after 2006, the transition to full implementation did not take place due to reduced funding, complicated proposals for project organisation and changes of governmental priorities. Pro-active institutional leadership is important for pursuing cooperation when implementing ICZM.

Recently, international support efforts by the World Bank and the Netherlands are being undertaken to provide assistance building on the positive results obtained during the 2002 – 2006 period.

*The three rivers and the coastal zone of Bangladesh.* (photos: NASA, PDO-ICZP)
1. Introduction

The coast of Bangladesh is characterised by a long indented coastline and many emerging shoals. The deltaic coast is formed by the interactions of the highly sediment loaded rivers: Ganges, Brahmaputra and Meghna, and the Bay of Bengal. The delta is one of the most densely populated areas of the world.

The coastal zone covers 19 of 64 districts facing or having proximity to the Bay of Bengal (MoWR 2005): 62% of the land of the coastal zone has an elevation of up to 3 meters and 86% up to 5 meters (Islam, 2006).

Figure 1: The coastal zone of Bangladesh with the Sundarbans in the west. (source: PDO-ICZM-P)

The population of the coastal zone of Bangladesh was 36.8 million (= a quarter of the total Bangladesh population) in 2001 and is projected to grow to about 43.9 million in 2015 and 60.8 million in 2050 (Ahmad, 2005). Official poverty indicators show a slightly higher percentage of the population living below the absolute poverty line in the coastal zone compared to the country as a whole (52% v/s 49%).

The fertile coastal zone has distinctive economic opportunities and development potential (Islam, 2008). It contributes 29% to the Gross Domestic Product (GDP).

On the other hand, the coastal zone of Bangladesh is also highly vulnerable, topping the list of most vulnerable developing countries in the world (Singh et al, 2005, see also CCC II-1-1). The Government has identified the zone as an ‘agro-ecologically disadvantaged region’. It is prone to natural disasters, such as cyclones, storm surges, and floods. In combination with other hazards, such as scarcity of drinking water, land erosion, the high arsenic content in ground water, water logging, water and soil salinity and various forms of pollution, these disasters have slowed down social and economic developments (Islam & Ahmad 2004). On top of this, the zone is vulnerable to risks from earthquake, tsunami and above all climate change.
2. Coastal management – success stories

Efforts to exploit economic opportunities, to make coastal lands more productive and safer began many decades ago. This has resulted in the following success stories:

Polderisation of Bangladesh coasts
In 1960s, construction of coastal embankments to form a large number of polders was initiated. Polders are now an embedded feature in the coastal landscape. There are 123 polders formed by 5,107 km of embankments, of which 957 km are sea-dykes. These polders provide flood protection to a total of 1.5 million ha of land. Sea-dykes also provide protection against, hazardous events and the effects of present rate of sea-level rise. New settlements have been established within the polders. The objective to increase agricultural productivity, was achieved with great success for the first ten to fifteen years until clogging of drainage water became serious in some parts. Polders also opened new opportunities for shrimp farming.

Figure 2: Map of the coastal polderisation – in dark green the completed polders, (source: CERP)
Mangrove forests – a natural barrier
Over 10,000 km² of the forest area of Bangladesh are in coastal regions. This includes the Sunderbans, the largest productive natural mangrove forest in the world. From 1964, the Forest Department started massive plantation of mangroves in the coastal areas forming a coastal green belt. About 120,000 ha mangrove was planted in the period 1965 – 1990 (Saenger & Siddiqi, 1993).
The mangrove belt save lives and properties from cyclones, tidal surges, and wave actions. and delivers many other services like: fishes, medicines, fuel wood. Threats are the loss of valuable habitats and species, and the impacts of climate change. It became a UNESCO world heritage site in 1997 and is an important habitat for e.g. the endangered Bengal tiger and Chital deer in the south. (photo: R. Islam)

Cyclone shelters – multi-purpose infrastructure for coastal communities
Purpose-built cyclone shelters are visible all along remote coastal areas and coastal islands. The number of cyclone shelters was 449 in 1990; increased to 1,921 in 1997, 2,133 in 2004 and are still being constructed. These shelters, can accommodate about 30% of coastal population, never the less they have successfully reduced loss of life in recent cyclones. Bangladesh is set to construct another 2,000 cyclone shelters in the years, after cyclone SIDR (2007). Most of the cyclone shelters are also used as vital social infrastructures such as schools, clinics, community centres, and storehouse during normal periods of the year. (photo: R. Islam)

Low-cost cyclone warning system – a model for developing countries
The Cyclone Preparedness Programme (CPP) operates an extensive network of 143 HF and VHF radio communications facilities covering 11 districts in the coastal area. A total of 34,000 trained volunteers help train communities to respond to early warning signals in order to save lives. This programme reaches at least 11 million people residing in the low-lying coastal area and offshore islands in the Bay of Bengal. Almost all these radio stations are equipped with solar panels with storage batteries. Mobile phone networks are currently being installed. This total system is considered a model for other regional countries.

These success stories, developed over decades, and originated from different sectors of the Government to form the basis for integrated and comprehensive coastal management in Bangladesh.
Co-operation and support from development partners, notably World Bank, Asian Development Bank and bilateral donors like the Governments of the Netherlands and Denmark had been crucial in building these success stories. Government of the Netherlands has shared its experiences and skills in coastal management and supported Bangladesh in coastal land reclamation, delta development, polder management and estuary studies.

3. ICZM as a process – historical milestones
Supplementing these success stories, steps were also taken to develop area specific management in the coastal zone of Bangladesh through a number of initiatives (Islam 2004):
- Creation of the Off-Shore Islands Development Board (1977-82);
- Formulation of the Bangladesh National Conservation Strategy (1987);
- The UN/ESCAP-GoB Coastal Environment Management Plan for Bangladesh (1987);
- The Coastal Area Resources Development Plan (1988);
- The formation and activities of the Special Parliamentary Committee on Coastal Area Development (1988-90);
• The Assessment of Vulnerability of Bangladesh to Sea Level Rise (1992-1994), supported by the Netherlands Government;
• The start of the Bangladesh ICZM process, supported by CZM-Centre (Netherlands Ministry of Transport, Public Works & Water Management) 1995;
• The national capacity building on ICZM initiative (1997).

These initiatives gradually prepared the ground for the government’s initiative in 1999 to embark on a process of Integrated Coastal Zone Management (ICZM). In that year, the government expressed its commitment through a policy note entitled ‘Integrated Coastal Zone Management: concept and issues’ (MoWR 1999). The conceptual approach was further elaborated through a Joint Mission of the Bangladesh Government, the Netherlands Government and the World Bank. Eventually, the preparatory phase for formally introducing ICZM in Bangladesh continued from February 2002 to June 2006, with support from the Governments of the Netherlands and U.K.

4. Building coastal cooperation

Building coastal co-operation is not easy and cannot be developed overnight. It should be seen as a process built upon past successes. During the preparatory phase (2002-2006), great importance and emphasis was placed on building co-operation between and among many institutions, stakeholders, and communities by undertaking the following initiatives and practices:

Establish a coordinating office, is important & vital
A Programme Development Office (PDO) for ICZM was established as a multi-ministerial and multi-sectoral arrangement. Hence, the PDO housed experts from four different Ministries (Water Resources, Agriculture, Fisheries & Livestock and Environment & Forestry), experts from the Water Resources Planning Organisation (WARPO) and a team of national and international consultants. This office gradually assumed roles and responsibilities of a national focal centre. This multi-ministerial office is important for meaningful engagement by all Government and non-Governmental agencies.

Bring relevant institutions together
Integrated Coastal Zone Management (ICZM) helps to bring relevant Government and non-governmental institutions together. The Bangladesh ICZM programme consisted of 34 different government agencies involving 13 different Ministries. These agencies were structured into an Inter-Ministerial Steering Committee, chaired by the Minister of Water Resources, providing policy guidelines and an Inter-Ministerial Technical Committee contributing technical knowledge and helping resolve inter-organisational conflicts. The Technical Committee also had representatives from universities, NGOs, private sector and the civil society. These arrangements and representations gave feelings of wider ‘ownership’ and ‘participation’.

<table>
<thead>
<tr>
<th>Box: Multi-Level Consultations during the formulation of the Coastal Development Strategy</th>
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<tr>
<td>• An annotated and extended outline was presented at a national and four regional consultation workshops in October 2004.</td>
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<td>• Based on workshop recommendations, the first draft was prepared in February 2005 and sent to relevant agencies and members of the task forces.</td>
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<td>• ‘Coastal Development Strategy highlights’ was disseminated through Coast News and posted on the website.</td>
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<td>• Comments and suggestions were solicited from general people through a public announcement in four national dailies (February 2005).</td>
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<td>• The draft was presented during March -April 2005 at 28 local level consultation meetings. These consultations contributed in further revision of the draft CDS, including strategic priorities and prioritization of concept notes.</td>
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<tr>
<td>• A peer review of the draft by selected experts was organized in June 2005.</td>
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<tr>
<td>• The draft was presented to Members of Parliament in July 2005</td>
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<td>• The draft was presented and discussed at two consecutive inter-Ministerial Technical Committee meetings.</td>
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<tr>
<td>• The draft was approved at the 2nd inter-Ministerial Steering Committee meeting held on February 13, 2006.</td>
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Extensive Consultation created ownership of coastal planning
Extensive consultations at different levels offered an opportunity for participation. Structured consultations were organised in all key decisions, such as delineation of the coastal zone or land zoning exercise and in formulation of key documents such as the Coastal Zone Policy and the Coastal Development Strategy (see Box).

Build knowledge base
A book titled 'Where Land Meets the Sea: A Profile of the Coastal Zone of Bangladesh' was published as a base reference book on coastal zone. An abridged version in Bangla, 'Upokulo Anchal – Ekti Tathyta Alekhya' was also prepared and 3,000 copies were printed & distributed. In addition, 19,000 copies of district information booklets, 1000 each of the 19 coastal districts, were printed and distributed through district administration. This exercise helped build a comprehensive knowledge base and create an informed community.
More than 40 technical working papers on different topics were published. These reports were made available on the ICZMP Project WARPO (see WARPO website) and also as print documents. Full sets of all documents were handed over to universities and selected libraries & institutions.

Build networks – formal and informal
In order to establish a network, the PDO published a directory of 'Who is doing what' in the coastal zone. This resulted in dialogue and cooperation between managers and professionals of active projects. 'Focal Points' were established at operational level in each of 34 agencies. They acted as operational contact points in day-to-day activities. Field visits in groups were organised routinely. Opportunities for social interactions strengthened team building.

Know your coastal communities
Extensive surveys, analysis of data and case studies were conducted to obtain a better understanding of the strengths, weaknesses and vulnerabilities of coastal communities. This resulted in several reports on coastal livelihood conditions, resource use by indigenous communities, inventory of social safety nets and micro-credit, urban poor and employment status & potentials. A status paper on 'Women of the Coast' was also prepared. This pro-active engagement with coastal communities led communities to place trust and confidence in this ICZM process. Many coastal NGOs supported the initiative and helped in building bridges with coastal communities (see also CCC II-1-2). This building of trust and confidence is important and helps strengthen co-operation.

Undertake information dissemination & social communication
Sixteen issues of a communication bulletin, Tata Rekha (Bangla version) and Coast News (English electronic version) were published and distributed. 7,000 copies of each issue of Tata Rekha were mailed to a range of stakeholders including the Local Government administrative tier. Brochures and leaflets were printed and distributed. CDs containing project reports were widely disseminated. The project website was created. The site contained relevant information on the coastal zone of Bangladesh and provided a comprehensive overview of the extensive PDO-ICZM activities and in-depth information on projects, coastal districts, project publications in the form of downloadable PDF reports and a Knowledge Portal on Meghna Estuary Developments.

All these activities evolved through cooperation involving many thousands of stakeholders and the active dissemination of the principles of sustainable development in the coastal zone. These achievements were made possible by major efforts by the coordinating PDO-ICZM office, related NGOs, applied scientists, and policymakers of the various Bangladeshi Ministries and the support of international organisations.

5. Institutional mechanisms to promote further cooperation

The institutional structure is based on the assumption that governmental (line) agencies are the best performers regarding implementation within an agreed national planning framework, while coordination is to be undertaken at local level (Huda 2004). Such institutional arrangements for integrated management at a local project level work more effectively if parties realise that working together in this manner is beneficial both for those involved and for achieving common goals.
This approach is more effective when actively pursued at local level, close to the coastal problems and solutions. The national level should provide general coastal knowledge, financial and physical planning instruments. The goals and institutional framework promoting coastal co-operation are outlined in the Coastal Zone Policy and detailed in the Coastal Development Strategy (see PDF report).

The key national institution is the Program Co-ordination Unit (PCU) for ICZM, its main function is the institutionalisation of ICZM in Bangladesh. It is a multi-disciplinary and multi-agency organisation. The objectives of the PCU is to co-ordinate, monitor and harmonise the ICZM planning and the implementation and to serve as a service centre supporting the relevant government and non-government agencies, local government institutions, private sectors active in the coastal zone. The PCU support structures are:

- Inter-Ministerial Steering Committee,
- Inter-Ministerial Technical Committees,
- Focal Points and
- Several Task Forces

These PCU support structures were operational during 2002-2006 and contributed in preparatory implementation of ICZM in Bangladesh (Islam 2008), but became too complex to function at a national level after 2006.

A similar institutional structure at local level has operated for over a decade at Noakhali, a coastal district within the Char Development & Settlement Project, supported by the Netherlands Government. The structure involves local communities, local NGOs and four government agencies (Wilde & Islam 2002).

6. Four years after adoption of coastal zone policy (2006 - 2009)

Although adoption of the Coastal Zone Policy (2005) and Coastal Development Strategy (CDS, 2006) by the Government of Bangladesh were hailed as milestone achievements, policy and strategy directives have remained largely unimplemented. The major setback occurred when no funds could be made available to continue and nurture already operational institutional structures. The status of activities, during the last four years, is not encouraging and now stands at:

a) Program Co-ordination Unit (PCU) exists on paper at the Water Resources Planning Organisation (WARPO). However, there is no effort to embark on a system with effective co-ordination and guidance.

b) The Government, basically the lead Ministry (Ministry of Water Resources) has unfortunately not been able to utilise the opportunity for formalising an integrated management of the coastal zone, based on its own approved and adopted policy and strategy documents. During this period, however, Bangladesh has seen change in Government, political instability and faced major natural calamities;

c) Coastal Zone Policy and Coastal Development Strategy have not been included in key national programmes and policies;

d) Only one of the identified ICZM investment programmes has entered the Government’s Annual Development Programmes: The Ministry of Land is implementing the important programme of coastal land zoning.

In the absence of pro-active institutional leadership and lack of national focus and funding development partners have also changed their priorities. Cyclones SIDR (2007) and Aila (2008), which devastated coastal Bangladesh in recent years, have again brought the coastal zone into focus. Global attention of the impacts of climate change puts further international emphasis on coastal zone.

Recently, international support efforts are being undertaken to provide assistance building on the positive results obtained during the 2002 – 2006 period;

The World Bank, after the catastrophic cyclone SIDR, has indicated interest in supporting some of the projects from the coastal zone priority investment programme in consultation with Asian Development Bank and United Nations Development Program (UNDP) and other donors. The World Bank is now implementing the ‘Cyclone Recovery and Restoration Project’ in coastal districts. The project will support: (i) Recovery of the agriculture sector and improvement programme; (ii) Reconstruction and improvement of multipurpose shelters; (iii) Rehabilitation of coastal embankments; and iv) Developing long-term disaster risk management programme. These and other development partners prefer the Government of the Netherlands to take a lead role.
The Government of the Netherlands has officially indicated its continued support for ICZM and led a multi-donor initiative. In 2009, this included a mission to support Government of Bangladesh in pursuing meaningful investments in the coastal zone. The mission suggested three phases over the next ten years. Initial works have begun. Meanwhile, the Government of the Netherlands is continuing the implementation of coastal projects such as, the Char Development & Settlement Project and the Estuary Development Programme (CDSP) both good examples of participatory approach.

7. Concluding remarks

Cyclones SIDR and Aila have again exposed the vulnerabilities of the Bangladesh coastal zone. Sectoral planned measures in the past have protected the coast but not anymore. With increasing population, declining natural resources and on-going and increasing impacts of climate change, coastal zone cannot be managed from a sectoral perspective. Sectoral management has resulted in unintended negative impacts in many cases (impeded drainage as a result of polderisation, salinisation through shrimp farming). Co-operation among many and diverse agencies and stakeholders is becoming increasingly crucial and beneficial (Huda 2004, Thomalla et. al. 2005). Bangladesh, for the last two decades, has very successfully embarked on adopting the approach of ICZM but had to discontinue its implementation for many reasons. The 2002-2006 attempts brought Bangladesh to the position where it was ready to start the implementation of the next stage in the ICZM cycle. The ICZM approach not only helps mitigate the effects of disasters, but also provides opportunities to exploit resources in an economically beneficial and sustainable way. ICZM in Bangladesh is not for environmental or ecological gain but a survival strategy for millions living at the mercy of nature. Bangladesh has no other alternatives.

The responsibility, hence, still stands on the Ministry of Water Resources (MoWR) and the Water Resources Planning Organisation (WARPO) to lead and to nurture gains made during the formulation and preparatory years of ICZM. Pro-active institutional leadership is important to pursue cooperation within an ICZM framework.

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Conclusions - Bangladesh

Bangladesh is extremely vulnerable to the impacts of climate change due to a combination of factors. It is a low-lying and flat coastal plain, exposed to cyclones and flooding from major rivers. It is densely populated; and has very limited financial resources. International cooperation dealing with water management and coastal development is an important issue for Bangladesh. Particularly the cooperation with the Netherlands, in these fields was mostly successful and appreciated.

Most pressing problems are flooding, intrusion of saline water and seasonal drought. Bangladesh is actively adapting to present problems by building protection works and changing agricultural practices. However, much more needs to be done to cope with future challenges. Key issues in future coastal policy are: afforestation and forest preservation in coastal areas; planting protective mangrove belts; protecting ecosystems by zoning land use; restoring degraded lands; water-sharing arrangements between riparian countries. Most critical for implementation are awareness of climate impacts, understanding the measures required and limitations of available resources. Implementation of integrated coastal policy is limited. Actions are mostly driven by events such as cyclones and storm surges and based on historical knowledge rather than assessments of future risks.

In the last two decades, considerable efforts were made to adopt and implement the ICZM approach initially from the top down. There is a record of accomplishment of historic milestones in ICZM institutional development. Success stories include the polderisation of a substantial part of the coastal area, a massive plantation of forest and mangroves in coastal regions (including Sundarbans), building cyclone shelters (elevated structures of which more than 2500 were realised up to 2004) and the implementation of a low cost cyclone warning system, and producing a comprehensive ICZM knowledge base. In the mean time emphasis was successfully placed on building cooperation between and among the many national and local institutions, stakeholders, and communities to prepare coastal measures.

On the downside, a large number of policy and strategy directives have remained unimplemented, due to organisational and institutional difficulties. National focus and coordination could be strengthened. Further implementation of the identified, priority investment programme for the coastal zone can be considered as an efficient adaptive response option.

The central government, as one of the main partners, has a special duty ensuring the continuation of the ICZM process, raising funds and harmonising the international donor activities related to integrated water and coastal management.

NGOs are widespread in the coastal districts of Bangladesh, operating in a broad field (health, water and sanitation, credits, training and livelihood). The potential for NGOs to involve local communities in developing and implementing solutions at the grass root level is great and a key factor in coastal management. The ICZM concept has been introduced to the NGO community and was well received. Some NGOs combine their hazard relief activities with the creation of adaptive measures. With the support of the coastal villagers they help to create mangrove plantations, to develop floating vegetable beds, to construct clean water ponds or to introduce small solar energy units. Other NGOs are active in dissemination of knowledge to manage coastal resources in a sustainable way.

Although many successes were scored, the organisation and continuity of a number of valuable NGO activities faces challenges.
Shanghai: from ‘Black and Stink’ to clean Suzhou Creek

Peter J.M. Kerssens (Deltares, the Netherlands)
Chen MeiFa (Shanghai Water Authority, China)

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2. Suzhou Creek Rehabilitation project
3. Project Activities of the Suzhou Creek Rehabilitation project
4. The results of the Suzhou Creek Rehabilitation Project
5. Institutional Issues
6. Conclusions
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Summary
Suzhou Creek flows through Shanghai, one of the world’s largest mega-cities. During the 20th century, the creek fell victim to rapid urbanisation, swallowing most of the city’s waste. In 1996 the ‘Economic and Social Development Plan for Shanghai’ was adopted, in which the rehabilitation of the creek formed an important component. Due to this 12-year plan to clean up the waterway, Suzhou Creek is no longer an embarrassing, stinky black river. With a number of selected ‘no regret’ type of projects and measures the Shanghai Municipal Government has been very successful in quickly cleaning up Suzhou Creek.

One of the major factors contributing to the success of the Suzhou Creek rehabilitation project has been the institutional arrangements of the project and particularly the willingness of the various relevant parties to cooperate.
The Shanghai Municipal Government has set a good example of cooperation in the field of water resources and coastal management, and effective decision making in order to enable implementation of such major projects in a relatively short time frame.

Shanghai, view across Huang Pu river to PuDong.
(photo: Peter Kerssens)
1. Introduction

Shanghai, on the Central-East coast of the PR of China, is a good example of the rapid development of many Chinese cities and the challenges this presents to the municipal government. In the last two decades, urban construction activities have skyrocketed, under the pressure of industrial development and large scale urban migration. The latter mainly caused by the need for labour, in industries and business, for the construction of new urban sub districts, office buildings, etc. A new international airport was constructed at PuDong, harbour and activities were relocated from Yangtze river mouth to a new deep sea harbour on YangShan island connected to the mainland by a 32.5 km long bridge. The infrastructure in and around the town was wholly upgraded to international standards. For instance, a sky train was built between PuDong airport and the city, while Nanjing and Hangzhou were connected with high speed railways. An extensive road system was constructed through and around Shanghai and its suburbs, new tunnels and bridges were made to connect the city with PuDong as well as Chongmin island, and a whole new metro system was developed within a relative short period.

In PuDong, on the other side of the HuangPu river, a complete new Commercial and Business district was built and has been in operation for 10 to 15 years. Now Shanghai is not only a centre of industry and commerce, but also the gateway to the Chinese hinterland for goods moving up and down the Yangtze river. Moreover, it has become a major player in the banking and financial sector in East-Asia.

Apart from the rapid urban developments described above, Shanghai has not neglected the socio-economic and cultural aspects that go parallel with such activities. In their desire to become a world-class city, they have paid considerable attention to cleaning up their environment, and to upgrade the service in the water supply and sanitation sector. New sewerage systems, as well as a number of wastewater treatment plants were built, while several new drinking water intake, storage and conveyance systems were constructed in and along Yangtze river and Tai lake.

With regard to culture, a new Shanghai Museum was built meeting the highest international standards, opera and musical facilities were provided and/or expanded, and the arts sector is flourishing, with regard to both architecture, film, music and other visual arts. In the field of sports, new stadiums and an international Formula 1 racetrack have been constructed and are intensively used.

2. Suzhou Creek Rehabilitation project

In the middle of the nineties, the Shanghai Municipal Government (SMG) realised that the condition of Suzhou Creek (SC), running from Tai lake right through the heart of the city to Huangpu river, did not meet environmental standards and was unacceptable for healthy living. A valuable database was created and contained the point sources of pollution, about 3,300 sources from factories, hospitals, restaurants, hotels are located in the Suzhou Creek area (Figure 3).

In February 1996 SMG’s People’s Congress adopted the ‘Economic and Social Development Plan for Shanghai’ for the period 1995-2000 and up to 2010. In this plan, the rehabilitation of SC was one of the city’s most important projects to meet its environmental development goals. With full backing of the central government, the rehabilitation of Suzhou Creek was considered essential for the further development of Shanghai into a global city.

*Suzhou Cree, before the era of pollution.*
*(photo: Peter Kerssens)*
The original Plan stated, amongst other things, that before the year 2000:

"The present sewage system SSP-I should be improved and modified as perfectly as possible; interception and collection of all industrial waste (water) along Suzhou Creek (SC) should be completed; direct pollution of SC from domestic waste loads should be stopped; and all engineering measures should be taken to change the presently 'black and stink' areas into domestic living conditions meeting the accepted standards of the People’s Republic of China."

The Shanghai Municipal policy allowed for a rehabilitation period of the SC area of 15 years, after which the area should become a financial/business cum residential area, providing medium/high class living conditions, meeting the national PRC water quality standards, and providing the proper environment for tourism purposes. This called for a concerted action to improve the water quality conditions in SC in two stages, to meet water quality Class V standard in the city between 1997 and 2000, and Class IV between 2000 and 2010.

Black and Stink in Suzhou Creek in the early 1990s. (photo: Simon Groot)

Figure 1: Project area with main infrastructure. (source: Delft Hydraulics and AEA Consultants, 1998)
3. Project Activities of the Suzhou Creek Rehabilitation project

Early in 1997, the Asian Development Bank (ADB) granted an advisory technical assistance to the Government of China to help the Suzhou Creek Rehabilitation Project in Shanghai to prepare a comprehensive plan for water quality management (WQM) for the Suzhou Creek. The assistance was provided by a combination of international and local consultants, being Delft Hydraulics (now Deltasys) from the Netherlands as leading partner, in association with AEA Technology from the UK, and a variety of Chinese institutes, bureaus and universities providing the local consultancy. The major task was to compose an improvement plan for the immediate clean up of Suzhou Creek, at that time being a dirty, black and stinking river.

The studies mainly concentrated on three different types of measures to fulfil this goal. Firstly, the water resources components: through flow diversion and augmentation measures, and dredging polluted sediments from the bed, the water quality of Suzhou Creek and its tributaries should be improved in the short term. Secondly, the water management components: the interception of sewage in the city districts draining into Suzhou Creek and its tributaries should be created by the construction of sewerage projects, e.g. the Shanghai Sewerage Project, combined with wastewater treatment plants.
Finally, a number of urban renewal measures should be carried out, covering the removal of garbage and night soil landing sites along the Creek, rehabilitation of the floodwalls, construction of parks and boulevards, etc. In Table 1 an overview is given of the various components of the plan and its detailed projects and measures within the individual components/packages.

Table 1: Project components (first stage, 1998 – 2000)

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>PROJECT TYPE</th>
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<tbody>
<tr>
<td>I. WASTEWATER MANAGEMENT COMPONENTS</td>
<td>• Flow interception</td>
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<td></td>
<td>• Elimination of WW disposal</td>
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<td></td>
<td>• WW treatment</td>
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<tr>
<td>II. WATER RESOURCES MANAGEMENT COMPONENTS</td>
<td>• Hydraulic structures</td>
</tr>
<tr>
<td>• FLOW DIVERSION AND AUGMENTATION</td>
<td>• Flow augmentation</td>
</tr>
<tr>
<td>• WATERWAY REHABILITATION</td>
<td>• Clean-up</td>
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<tr>
<td>• SEDIMENT AND AERATION MEASURES</td>
<td>• Sediment dredging</td>
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<td></td>
<td>• Re-aeration measures</td>
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<tr>
<td>III. URBAN RENEWAL COMPONENTS</td>
<td>• Embankment reconstruction</td>
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<tr>
<td></td>
<td>• Relocation of wharves</td>
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</table>

4. The results of the Suzhou Creek Rehabilitation Project

In various phases of the Technical Assistance project from Asian Development Bank, a variety of technical and non-technical studies and analyses have been carried out by the consultants, in cooperation with the Shanghai Suzhou Creek Rehabilitation Project Office, assisted by various local bureaus and institutes:

- Waste load management and wastewater treatment;
- Wastewater modelling and water quality analysis, including waste water reduction/ interception and low flow augmentation;
- Environmental impact assessment;
- Social impact studies;
- Institutional analysis;
- Financial/economic analyses;
- Overall project management, final conclusions and recommendations.

One important element was the development of the water quality modelling and Decision Support System (DSS), including databases and computer models, to simulate the flow and the water quality in the system, including the waste load from domestic, industrial and agricultural sources in the districts. This DSS was used to test the effects/efficiency of a number of so called 'no-regret' measures defined to improve the water quality and environmental conditions of Suzhou Creek as quickly as possible. This was based on the requirements of the Shanghai Municipal Government to ‘remove the black and stink’ before the year 2000.

The measures included the low-flow augmentation and water diversion project, dredging of polluted sediments, flow aeration, and the closure/gate construction in six main tributaries discharging heavily polluted water into the Creek. The DSS was at a later stage also used to assess the efficiency of the sewage interception and wastewater treatment, etc. on the quality of the surface water system. Apart from the technical feasibility, all (10) different project components were also evaluated on their economic/financial feasibility. Finally, the DSS was also used to check the effect of the construction of a new gate at the mouth of Suzhou Creek, resisting high water levels from two directions. However, this was executed as a separate project and not one of the 10 projects in the Suzhou Creek package.
Figure 4: Output of the Decision Support System - DSS. Combined tidal and upland flow flushing scenarios of the Suzhou Creek in relation to the water infrastructure of greater Shanghai area. This DSS combined with the results of the wastewater modelling and water quality analysis provided on overview and the base for a smart flushing scheme and series of rehabilitation measures executed in short period of time.

The measures designed during the first study phase and tested with the DSS system turned out to be quite effective. Using the DSS the most promising scenarios were developed and during the second study phase some of the measures were implemented.

The scenarios analysed with the DSS (see also Figure 4) were as follows:
- **Base case (present situation);**
- **East-North flushing (previously called scenario 1), from Huangpu river through Suzhou Creek to YunZaoBang, making use of the tidal movement;**
- **West-East flushing (previously called scenario 2), low-flow augmentation from Tai lake/upper Suzhou Creek, making use of upland discharge;**
- **Combined: East-North during spring tide, West-East during neap tide periods;**
- **Combined reverse: East-North during neap tide, West-East during spring tide periods;**
- **ADTA (Advisory Technical Assistance) : East-North operation on Suzhou Creek, West-East operation/diversion on YunZaoBang, and operate (existing) gates and pumping stations;**
- **ADTA+: same, with new infrastructure (gates and pumping stations).**

Particularly the low-flow augmentation and water diversion project combined with a specific operation of the Suzhou Creek gate at Wusong bridge (ADTA+) turned out to be so successful that the water quality of the Creek substantially improved and the ‘black and stink’ was gone within about two years. By 1999/2000 many foreign delegations, including the Dutch Prince of Orange in his position of ‘water manager’, visited the Suzhou Creek Project Bureau and the project organisation proudly took them to Suzhou Creek itself as an example of the very efficient cleanup and the water quality and environmental improvement that had been achieved.
5. Institutional Issues

During the various stages of the Suzhou Creek studies, as well as in other projects/studies related to the Shanghai Water system, an extensive analysis of the institutional conditions regarding water resources in Shanghai was made. An assessment was made of the various parties and stakeholders involved in water resources management, flood management, wastewater collection, transport and treatment, and water quality and environmental control and management (see Figure 5). Multiple discussions were held between the project partners and the various bureaus and institutions with an interest in some part of the water sector and a Tasks, Responsibilities, Activities and Mandate (TRAM) matrix was made up for all relevant parties (see Table 2).

From this assessment, it was concluded that the existing institutional conditions were not ideal for an efficient quantitative and qualitative management of the water resources and the water related environment. There was little or no horizontal coordination among the many institutions dealing with water issues. This also put a constraint on the implementation of the Suzhou Creek project and the expected results, since the responsibilities for the specific (sub)projects would be split between the bureaus of Water Resources, Transportation, the Bureau of Urban Construction, and the Environmental Protection Bureau (EPB).

The Municipal Government of Shanghai reacted very quickly and founded the Shanghai Water Authority (SWA). This new organisation integrated the Bureau of Water Resources and parts of the bureau of Urban Construction (as related to sewerage and water treatment) and the Environmental Protection Bureau. Both latter bureaus still exist since their scope is much broader than just water, but the water-related tasks and activities have mainly been concentrated in the SWA. The founding and operations of SWA was considered by all relevant authorities at both municipal and national level as a good and very successful example of institutional change. It has been declared a pilot case for governmental reform in the water sector, combining integrated planning and implementation, water quality and quantity, innovations and infrastructure leading to improving public health increased tourism and recreation.

Beijing municipality has followed this example and other municipalities and provinces are likely to do the same. The experience so far is that SWA is operating efficiently with respect to integrated planning and management of the Shanghai water system and the reform is certainly a success. This also reflects in the implementation of the Suzhou Creek rehabilitation project, the construction of the new Suzhou Creek barrage, and other water related initiatives and investments.

**Renewal of Suzhou Creek embankment and flood wall** (photo: Peter Kerssens)
6. Conclusions

The success of the Suzhou Creek Rehabilitation project is illustrated by:

- A number of selected ‘no regret’ type of projects and measures, such as flushing, environmental dredging, re-aeration, and interception of wastewater, the Shanghai Municipal Government has been very successful in cleaning up Suzhou Creek and remove the so-called ‘black and stink’ in a relative short time.
- The middle- and long term, projects and measures contribute to an even greater reduction of pollutants into the Creek and to a substantial improvement of the water quality. This refers to elimination of wastewater disposal, wastewater treatment, the relocation of solid waste processing wharves, embankment reconstruction, etc.
- One major factor contributing to the success of the Suzhou Creek rehabilitation project has been the institutional arrangements of the project, and the willingness of the various relevant parties to cooperate. In a later stage the governmental reform, i.e. the formation of the Shanghai Water Authority from the bureaus of Water Resources, and parts of the Environmental Protection Bureau and the bureau of Urban Construction, has strengthened the institutional conditions and has contributed to the rapid improvement of Suzhou Creek.

The Shanghai Municipal Government should be complimented for setting such a good example of cooperation in the field of water resources and coastal management, and effective decision making in order to enable implementation of such major projects.

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* No or little horizontal coordination between columns
* Universities at Central and Provincial level, sometimes connected to Technical Ministries
* Multiple Institutes at Central, Provincial and Regional level
* Bureaus at Provincial and Regional level

* Legislation by NPC, NPCC and State Council
* Policy guidelines for development by NDRC
* National budget by MoF
* Policies by the various ministries set at Central Govt. level and implemented by provincial/local government
* Universities at Central and Provincial level, sometimes connected to Technical Ministries
* Multiple Institutes at Central, Provincial and Regional level
* Bureaus at Provincial and Regional level

Figure 5: Institutional setting Water Sector China 2007. (NPC = National People’s Committee, NPCC = National People’s Consultative Committee)
<table>
<thead>
<tr>
<th>Administrative level</th>
<th>Water resources issues</th>
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<td>Ministry of Health/Sanitation Bureaus</td>
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++ large involvement/responsibility + small involvement/responsibility
Support for the Sustainable Development of the Yellow River Delta

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Wang Zheng Bing (Deltares & Delft University of Technology)
Marcel Marchand (Deltares, Delft, the Netherlands)

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4. Conclusions
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Summary
The environment in the Yellow River Delta (YRD) is under stress. A Sino-Dutch project contributed to the sustainable, long-term development of the Yellow River Delta. One of the challenges is to analyse how to best use the limited fresh water resources in a sustainable way. The Sustainable Development YRD project made use of valuable integrated framework with analytical tools in which future developments and strategies can be analysed in a systematic way.
Such an approach provides a strong incentive to start communication and mutual understanding between the different responsible authorities and stakeholders.
Various follow-up projects were proposed upon the finalisation of the YRD project and some of them were executed. The results of these international cooperative activities confirmed that an integrated water management policy is the key element in the future development of the Yellow River Delta.


Yellow River Delta: a fast rate of development 1997 - 2010
1. Introduction

A Sino-Dutch deltaic project focusing on the sustainable development of the Yellow River Delta (YRD, China) was undertaken between 1995 – 1997. The study area in the YRD encompasses almost 7900 km². The principle goal of this project was to contribute to the sustainable, long-term development of the Yellow River Delta through providing an integrated planning framework including environmental and technological planning tools. The project was co-sponsored and undertaken by the following organisations:

- Chinese authorities (China International Centre for Economic and Technical Exchange, YRD Conservancy and Development Research Centre and with experts for the State Planning Commission, China Institute for Water Resources, Institute of Geography of the Chinese Academy of Science and Beijing University);
- The CZM-Centre /Rijkswaterstaat/Netherlands /Ministry of Transport, Public Works and Water Management and the Netherlands Economic Institute/Ecorys;

Three main objectives were defined by the project partners and contributed to:

- Stabilisation of the Yellow River channel in the Yellow River Delta (YRD) and control of sedimentation;
- Enhancement of the capacities for comprehensive and technical analysis, research and planning of local organisations;
- Production of inputs to an overall comprehensive plan for the sustainable development of the YRD including industrial and land use planning.

The results of this Sustainable Development YRD project aimed to provide the Chinese national and local policy and decision makers with an improved overview of the status, and the consequence of future strategies regarding the natural and socio-economic developments of the YRD. After completion of this Sustainable Development YRD project, several follow-up projects were carried out between 1998 and 2007, such as the Yellow River Delta Environmental Flow project. The project makes use of a valuable integrated and analytical approach. This systematic approach provides a number of proven tools to manage a complex deltaic/coastal area in an integrated way, now and in the future. These concepts on integrated management and sustainable development have been used in the follow-up projects in the YRD and along other parts of the Chinese coast (see CCC II-2-3 and II-2-4).

2. Some major aspects of the Yellow River Delta at the end of the 20th Century

The Yellow River Delta (YRD) contains rich and vast land resources. An example of the vast land availability: the averaged land occupancy per capita (0.48 hectare/ capita) is 5 times higher than the average in the Yangtze delta. There are also rich aquatic resources including abundant salt-water habitats. Major petroleum and natural gas reserves are the most important economic resources. They are located around Dongying and north of the river mouth. The oil installations are located on special, grid subdivided and embanked areas (visible on Integrated Development map - Figure 1), which are protected against flooding from the sea and the river. The fresh water resources mainly come from the Yellow River. Although overall on average fresh water is abundant, there are increasingly serious problems during dry seasons. In part, this is caused by increased extraction of water upstream. Infrastructure in Dongying municipality, a city of almost 2 million inhabitants is well developed. Roads, highway, ports, railway, airport, power plant and distribution lines are all in place. The Shengli Petroleum Administrative Bureau has a dominant role in the socio-economic prosperity of this part of the YRD and has a big influence on the future development of this area.

Environment under stress

The environment in the Yellow River Delta is under stress and is being monitored by the government, especially in relation to:

- The level of industrial air pollutants, especially SO₂;
- The rivers flowing to the Yellow Sea, which were seriously polluted during the nineties of last century;
- Urban sewage water treatment. The level of microbial pollutants, which exceeded the national standards by a long way in the nineties, is now steadily improving.
- Ground water quality, which during the nineties was unsuitable for human use and irrigation (Yang Yuzhen et al., 2004).
The Chinese Government established two Nature Reserves. The one in the eastern part of the delta of 153,000 hectares, was created in 1992 (see Figure 5). It consists of both freshwater and saltwater wetlands. Those wetlands are visited each year by millions of migratory birds.

The area is however also renowned for a number of rare and endangered resident bird and plant species such as Saucer’s Gull (Larus saundersii), Great Bustard (Otis otis) and Red-crowned Crane (Grus japonensis). Parts of the Nature Reserve area are under stress due to oil exploration and potential pollution from oil spills.

One of the challenges as a precondition for the sustainable development of the delta will be to analyse how best to use the limited supply of fresh water, and furthermore to understand the consequences of the limits to non-renewable energy resources.

Objectives and criteria for the sustainable development of Yellow River Delta

The project proposed four specific objectives for sustainable development:

1. Economic development: including increases in local income, to realise sustainable development through diversification of economic activity and optimising investment costs by economic cost-benefit analysis;
2. Environmental duality: this includes a guarantee of sufficient fresh water supply, maintaining a healthy environment for the local population, protecting the wetland nature reserve area and promoting development of environmentally sound industrial and agricultural activities;
3. Social development: including eradication of poverty, improvement of the education and health care system;
4. Safety: protection from dangerous flooding by rivers and the sea for the population and the infrastructure.

3. Results and products

3.1. Overview of products

The Sino-Dutch cooperation resulted in a number of different products. An integrated framework for analysis was provided, taking into account the various land and water-uses, natural processes as well as commonly defined strategies and scenarios. Alternative development scenarios were analysed and their consequences compared and assessed. Tools were developed for this purpose: such as the modelling of the river harnessing, the flooding module, the economic input & output tables, the description of the environmental situation and the Geographical Information System (GIS), all containing a wealth of information needed in order to make balanced choices for the future.

A comprehensive and multifunctional GIS Atlas was produced, which supported an integrated approach and provided a framework for analysis. By giving a spatial overview of the functional uses and natural processes in the Yellow River Delta, it demonstrated the potential interactions between them. Figure 1 gives an example of an Integrated Development map from the Atlas (Liu Gaohuan and Drost, 1997). Frequent monitoring and time series of airborne/satellite images inserted into the GIS facilitated temporal analysis of the highly dynamic Yellow River delta. The GIS tool also allowed a spatial, cartographic demonstration of the outputs of the analysis and consequences of the different strategies and scenarios.

Furthermore, capacity-building efforts were undertaken: several training workshops in China and dedicated training courses abroad were organised, covering the use of GIS and environmental and hydraulic monitoring. The scope and objectives of the project as well as strategies and scenarios were commonly identified during several workshops. During (inter)national conferences, the interim and final results were presented and discussed. All these project activities were organised with and for Chinese authorities and experts at the national, provincial and local level.

3.2. Sustainable economic and social development

In order to change the traditional approach of national planning and focus more on the local available assets, several tools were provided. These included Input-output analysis of different development strategies, a Social Accounting Matrix for determining the distribution of income and Scenario analysis of the influence of future growth rates.

Four different strategies were adopted:

1. Profit priority (enterprise becomes the major actor);
2. Target sector priority (Government targeting especially industrial policy);
3. Environmental priority (Government as major actor to correct the market failure in dealing with environment);
4. Social priority (Government plays a major role in achieving the social objective).
The project also introduced the notion of water pricing to the Water Authority of the province Shandong. Water pricing is a method for stimulating sustainable use of water for both industry and agriculture. Proposals were generated for optimising the use of water, popularisation of water saving techniques, utilising fully the water saving potential of the agricultural sector and using good quality water.

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Figure 1: Integrated development of the Yellow River Delta, with cities, nature reserves and large oil industrial parks: one around Dongying and the Godong Oil Field 20 km south east of Dongying Harbour. (source: 'Atlas of the Yellow River Delta' - Liu Gaohuan and H.J. Drost, 1997)
3.3. Safety: Channel of the Yellow River Delta and the coastline

River course
A precondition for the development of the delta is the stabilisation of the channels of the Yellow River to prevent breaching of dikes. The lower part of the river in the past changed its course frequently and unexpectedly (Figure 2). Investments and developments near the mouth of the Yellow River cannot be sustained without taking into consideration the dynamics of the river course and the nature reserve.
During the planning of measures to control the position of the river courses, several aspects need to be considered. In the short-term a fixed river course seems most beneficial for the local socio-economic development of the delta. However, in the long-term, the river course management will influence the development of the whole delta. In fact, the whole delta is determined by the pattern of deposition of the sediment in the Yellow River. The shape of the present delta and its coastal contour is the result of the interplay between the changes of the river and the actions of the sea.

Figure 2: River course changes in the modern Yellow River Delta (after Liu and Drost, 1997) showing:
- The last apex is located around Yuwa, and the previous apex was found more up-stream at Ninghai;
- The large dynamics of the delta shoreline encompassing several tens of kilometers of coastal accretion of the central deltaic part during the last century.
- The coastline of the central delta has been moving seawards by 30-40 km since 1855. With the bed slope of about $10^{-4}$ in the downstream part of the Lower Yellow River this means a vertical bed level increase along the whole river by about 3-4 m.
This fast growing delta is a direct manifestation of the most heavily sediment loaded river of the world. Its dynamics strongly effects the socio-economic development of the delta.
At the mouth of the river, the delta grows into the sea and new land is created. At other locations where the sediment supply from the river is limited coastal erosion takes place due to tidal flow and wave action. The river always tends to find the shortest way to the sea. Regular, lateral movements of the river course form a fan-shaped (sub) delta, commencing at the apex (= head of the fan-shaped delta).

The management of the river course since 1976 is characterised by keeping the existing course of the channel at the same alignment for as long as possible. After extensive studies and modelling, three alternative schemes were analysed and compared. In the end, it was decided to form a Northern Branch with an most seaward apex in the Qingshuigou Channel, which was implemented in 1996. This scheme was also the most advantage for oil exploration because north of the river mouth, oil reserves are present near the shore and with such branch more easily accessed. Consequently, it is expected coastal erosion in the northern part of the delta, around the old river mouth (before 1976, indicated with nr 9 in Figure 2) will continue into the future.

It should also be realised that there is an interaction between the river course management and the development of the river basin upstream. For example, the construction of the large reservoirs upstream and the water diversions along the river have decreased the water and sediment input to the delta substantially in recent years (Wang et al, 2008 - see Figure 3 and CCC II-2-3). Therefore, the creation of new land at the river mouth after 1996 has not been as fast as was anticipated.

![Graph showing variation of annual runoff and sediment load](image)

**Figure 3: Variation of annual runoff and sediment load in the period from 1960 to 1997 at Lijin Station, in the Yellow River Delta. (after Wang et al, 2008)**

**Risk analysis and follow-up**

Finally, risk analysis for flooding hazards was made. As a result, it was proposed to apply norms for flood prevention of once in 100 years event as the most appropriate frequency, taking into consideration the costs and benefits. Various follow-up studies were upon the finalisation of the YRD project, some being executed such as a continuing study on the future of the present channel, the so-called Qingshuigou Channel of the Yellow River Estuary in relation to long term management (see e.g. Li et al, 2001).

### 3.4 Integrated water management in the Yellow River Delta

Fresh water is of key importance for many economic activities in the Yellow River Delta. It is used as drinking water, for growing crops, for industrial activities and for maintaining healthy ecosystems throughout the Delta. Of all the consumers, agricultural irrigation has the highest demand, which is not surprising because of the high evaporation rate during most of the year. This evaporation causes capillary rise of the saline groundwater into the top soil, which has to be flushed with fresh water. The sea also has a major influence on the surface and ground water and the soils of the Delta. The low topographical level of the delta, not more than a few meters above sea level, results in much of the ground water being in contact with the sea and has the same, or higher, salinity than the seawater. Currently around two thirds of the Delta has moderate to serious salinity problems.
Figure 4: The Yellow River Basin: the second largest river basin of China - 800,000 km², accommodating 9% of the Chinese population and with the Three Gorges Dam near Lanzhou and the main Hydro Stations. (map: © Shannon, Creative Commons Attribution-Share Alike)

Conflict between supply and demand
Because evaporation is much higher than the annual rainfall in the delta, the most important source of freshwater is the Yellow River. Unfortunately, the Yellow River basin (Figure 4) is very deficient in water resources. The conflict between supply and demand is prominent. Since 1992 the annual discharge of the lower Yellow River reached dangerously low levels, leading to frequent periods of zero discharges of more than 100 days per year. From 1995 to 1998, the river was dry during more than 120 days every year, up to as much as 226 days at the town of Lijin, in the delta (Figure 1), in 1997. This regular drying up of the lower Yellow River had a serious impact on the downstream socio-economic functions and caused considerable ecological damage in the delta. Therefore, the Yellow River Conservation Commission (the basin wide administrative agency) implemented a regulated discharge regime of the river from 1999, in order to restore the river downstream of Lijin (Liu Xiaoyan et al., 2006). This alleviated to some extent the risk of drying up and water deficiency in the lower delta. However, there is still a long way to go to provide optimal allocation of water resources required by all economic sectors and the ecosystems of the delta (Liu Gaohuan & Drost, 1997; Liu Gaohuan, 2006).

Optimising freshwater use from the lower Yellow River requires a balance between the demands from the domestic and economic sectors and the nature reserve while leaving sufficient water discharge at the mouth of the river to minimise seawater intrusion. Because of the highly variable water demands and supplies over the months of the year, this requires sound water management from month to month or even day to day.

Involvement of stakeholders
The planned development of the Delta uses the opportunities that are offered by the natural conditions such as new land, mineral resources and water, while ensuring a favourable environment for man and nature. Because water remains a critical issue for many of the economic sectors, much attention is paid to water saving techniques and other innovations (such as desalination). Besides technical solutions, there is a continual need for close cooperation between the many stakeholders in the delta who are dependent on fresh water. Their water demands need to be quantified and allocated in time and space; for this the Yellow River Conservation Commission has the main responsibility. In order to fulfil this responsibility, knowledge and information has to be available both from the physical (supply) side as well as from the water demand side. In addition, in order to plan, forecasts and predictions need to be made with respect to both of these. Decisions on water allocation should be transparent, based on scientific evidence and commonly agreed assumptions. This requires the involvement of all relevant stakeholders who need to provide adequate information on their requirements.
Box: The Yellow River Delta Environmental Flow project

The Yellow River Delta Environmental Flow project (Lian Yu et al., 2007) was designed to provide essential information and scientific knowledge with respect to the environmental water demands of the lower (new) delta and its nature reserves. It was carried out during 2005-2007 as a bilateral cooperation between Dutch and Chinese research organisations. The integrated approach included hydraulic modelling of the water flow and water depths in the delta (Zeng Bin Wang et al., 2007) combined with groundwater dynamics and evapo-transpiration (Figures 6 and 7), and subsequent modelling of the vegetation and habitats for specific red-list bird species, like Saundér’s Gull (Larus saundersii), Great Bustard (Otis otis) and Red-crowned Crane (Grus japonensis).

Examples were given for the habitat suitability of these species and the succession in their habitats. The analysis was based on an integrated assessment of various management strategies, defining the amount of water and the distribution of water flows over the year, as required for sustainable development of the internationally valuable wetland ecosystems in the Yellow River Delta.

The Nature Reserves in the delta are a real test case, not only with respect to protecting recently formed wetlands and rare and threatened bird species, but also in finding a balance between environmental values and economic development. The project showed that a landscape-ecological study with a proper representation of surface and groundwater dynamics enables the assessment of alternative water management strategies to safeguard essential nature values, without imposing unrealistic water requirements from the Yellow River.

Figure 6: Simulated development of vegetation types after 5 years of improved freshwater supply - output from LEDESS model, see Figure 7.
(source: Lian Yu et al. 2007)

Figure 5: The two Nature Reserves in the Yellow River Delta, with Core areas in dark green and Experimental areas in light green and the embanked, gridded oil industrial park. (source: Yellow River Conservation Bureau)
4. Conclusions

Natural and socio-economic developments in a dynamic deltaic area are intertwined. This calls for an integrated approach whereby economic, environmental and social developments are balanced. The management of the river course in the delta should not only include short-term local considerations, but also geared to a long-term overall vision. This vision includes the development of the entire river basin and the whole delta including the coastal zone.

The challenges for the future are manifold. They contain ongoing high economic development in China and Shandong Province, the increasing demand for energy and fresh water, the challenge to comply with the latest environmental standards and the changing water and sediment flows of the Yellow River due to upstream developments. In addition the possible effects of climate change such as changes in rain-fall patterns, increasing relative sea level rise and associated salt intrusion and the expected change in flooding risk, both from river floods and from storm surges are important. These challenges require an integrated water management policy, which is the key element in the future development of the delta.

To combine spatial and temporal aspects in an integrated approach, greater insight into the complex processes associated with the development of the river and its delta including the marine and coastal processes are required. This calls for a series of programmes and research projects whereby systematically the sustainable development objectives of the delta are defined and realised. Such a comprehensive effort is a continuous process in which feedback loops, including evaluation of sustainable measures have an important place. Such an approach requires continuation and reinforcement of the recently begun cooperation between the many agencies and departments involved in the delta. It will also require a robust system to monitor change, continuously upgrading the design framework for integrated analysis, which aims to provide information on the status, overview and consequences of policy options.

It is also clear that this approach provides a strong incentive for communication and mutual understanding between the different sectors and strong support for the sustainable development of the Yellow River Delta.
5. References

ICZM & the Application of Geosciences in the Chinese Coastal Zone

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Summary
In recent decades, the China's coastal zone is being faced with large-scale urbanisation, industrial and harbour development. The increasing coastal development, land use and marine pollution, conflicts between coastal and offshore activities led to the introduction of Integrated Coastal Zone Management (ICZM) in China at the beginning of 1990s. Geoscientific research plays an important role in the present planning of large-scale buildings, infrastructures and reclamation, the creation of coastal Eco-Cities, and in future adaptation to the impacts of climate change. ICZM is important and has been practiced. Examples of integrated development in three deltaic areas demonstrate the importance of geosciences contributing to the ICZM process in China.
1 Introduction

China’s coastline has a length of 18,400 km. If the coastal zone is defined between 10 kilometre inland and the ~10 m contour line offshore, it occupies 13% of the total territory of the country, and accommodate around 40% of its population. Of the gross domestic product (GDP) of China, 60% is produced in the coastal zone, which makes it the most important economic zone of China. In addition, China’s coastal zone also acts as the door to the outside world.

China’s government and the public value China’s coast greatly and for that reason it has launched several projects involving multidisciplinary investigation of coastal processes and coastal management. In addition, there have been a number of thematic investigations in some key areas and two nationwide integrated surveys. However, due to the geological complexity, impacts of climate change and the sometimes competing activities in and around the coastal zone, major challenges for geoscientists within an ICZM framework lie ahead.

A preliminary vulnerability assessment to sea level rise, revealed that the low lying coastal areas, particularly the deltas of the Old Yellow River, Yangtze Delta and the Pearl River (encompassing about 35,000 km²), are most vulnerable areas. Considerable costs, dealing with additional reinforcement of dikes to avoid impacts of a 1 m sea level rise, were also preliminary estimated (Du Bilan, 1993). Later studies on sea level rise and its impacts on the Chinese coastal zone confirmed the potential critical effects.

2 Geological background

China’s coast extends from Hainan Island in the far south to Liaodong Bay in the north. China’s coastal zone crosses 22 degrees of latitude ranging from the tropics in the very south around Hainan Island, sub-tropics in the area near the Yangtze River and temperate regions to the north. Precipitation decreases from south to north - from over 2000 mm per year in the southern provinces to 500 to 800 mm per year in the provinces around Bohai Bay.

The stability of a low-lying sedimentary coast depends upon the balance of the sediment input supplied by the rivers and the coastal processes exerting pressure on the shoreline. The majority of the largest rivers of China discharge along the eastern coastline. The total drainage area of these rivers comprises 45% of the total territory of China and water discharge is up to 70% of the total of all rivers of China. Among these rivers, from north to south the major rivers are Liaohe River, Haihe River, Yellow River, Huaihe River, Yangtze River, Qiantang River, Minjiang River and Pearl River. Water discharge [10^8 m^3/yr] and sediment load data [10^6 ton/yr] of these major rivers are presented in Table 1. The total long-term water discharge approximates to 1270 x 10^8 m^3/yr and in total, these rivers supply sediments on a long-term average of 1270 x 10^6 ton/yr (Liu Cheng et al., 2007). This total sediment discharge decreased considerably to 477 x 10^6 ton/y during the decade 1997 – 2006, while the total water discharge remained more or less the same. The Yellow River however lost two thirds of it water discharge and sediment load during the last decade. This large river nevertheless transports a considerable but reduced amount of sediments to the sea with a relative low water discharge.

<table>
<thead>
<tr>
<th>River (control station)</th>
<th>Drainage basin (10^3 km²)</th>
<th>Data time ranges</th>
<th>Water discharge (10^8 m³)</th>
<th>Sediment (10⁶ t)</th>
<th>discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liaohe R. (Tieling)</td>
<td>120</td>
<td>1954-2006</td>
<td>3.0</td>
<td>1.6</td>
<td>12.2</td>
</tr>
<tr>
<td>Yellow R. (Lijin)</td>
<td>752</td>
<td>1952-2006</td>
<td>31.1</td>
<td>11.2</td>
<td>766.5</td>
</tr>
<tr>
<td>Huahe R. (Bengbu)</td>
<td>121</td>
<td>1950-2006</td>
<td>26.9</td>
<td>24.0</td>
<td>9.3</td>
</tr>
<tr>
<td>Yangtze R. (Datong)</td>
<td>1705</td>
<td>1950-2006</td>
<td>899.6</td>
<td>917.8</td>
<td>407.9</td>
</tr>
<tr>
<td>Qiantang R. (Lanxi)</td>
<td>18</td>
<td>1977-2006</td>
<td>16.5</td>
<td>16.6</td>
<td>1.9</td>
</tr>
<tr>
<td>Minjiang (Zhuqi)</td>
<td>54</td>
<td>1950-2006</td>
<td>53.8</td>
<td>58.1</td>
<td>6.0</td>
</tr>
<tr>
<td>PearlR.(Bolu, Gaoyao)</td>
<td>377</td>
<td>1964-2006</td>
<td>242.1</td>
<td>244.8</td>
<td>69.7</td>
</tr>
</tbody>
</table>
Since the Yellow River shifted its channel from the south to its current location in 1855 (CCC II-2-2), the delta has grown by 20 km² per year.

The Yangtze River delta has expanded since the Late Qing Dynasty at a rate of 9 km² per year. Since 1970 there has been a reduction in water discharge and sediment load due to the decrease in precipitation and increase in human activities in the upper reaches of the rivers. Because of the reduced sediment load carried by the rivers, the sandy and muddy coasts of Bohai and Yellow Seas are increasingly eroding.

3. Coastal zone management

With the increasing development and land used along the coastal zone in China, conflicts between coastal and offshore sea-related activities and increasing marine pollution led to the introduction of ICZM into China at the beginning of 1990s. The need to strengthen (marine) legislation and formulation of regulations to effectively coordinate and manage the ocean resources and the coastal zone of China was presented by Zhang Guochen (SOA) in 1993.

The State Oceanic Administration (SOA) of China is the Central Government authority for coastal and offshore management. Provincial and municipal marine management authorities are in charge of the local coastal management based on national and local laws and regulations. ICZM concepts and methods are taught in the universities and studied in many research institutions in China.

Chinese “Regulation of Sea Uses” for regulating the coastal and offshore uses came into force in 1993. At the same time the National Coastal and Offshore Planning Framework was initiated, with concepts and theories of integrated coastal zone management fully introduced and practiced in the planning process. After 1998, local government started province-based or municipal-based coastal planning according to the national general planning framework and local development demands. In 2000 and 2001, the “Law of Marine Environment” and “Law of Sea Uses and Management” came into being with the enforcement of coastal and offshore management.

In the meantime, Chinese central government and local authorities cooperated with international organisations on ICZM issues, for instance, International Oceanographic Commission (IOC) have provided ICZM training for Chinese coastal and marine researchers and managers. Partnerships in Environmental Management for the Seas of East Asia (PESMA) sponsored an ICZM demonstration project in Xiamen city at the southeast coast of China in the past decade, to introduce the new concept of ICZM and transfer the technology associated with its implementation. An ICZM framework for Shanghai was introduced (Shi et al.2001). ICZM is also well practiced in other major coastal cities, such as Qingdao, Dongying, Dalian and major economic zones, such as Bohai Bay area, where coastal developments are ongoing, and marine and high quality coastal habitats are at risk (Liu Xuehai, 2010).

Role of geoscientists

The role of geoscientists is very important within China’s ICZM. During 1980s and early 1990s, a series of coastal zone and islands survey projects were conducted along the Chinese coast. Important geological information including topography, geomorphology, offshore bathymetry, sedimentology, stratigraphy, groundwater, mineral resources, coastal stability and potential geo-hazards, was collected. This information has been taken into account at the stage of coastal planning, especially for large scale, geological related coastal activities, such as the planning of harbours, across-bay bridges, (nuclear) power plants and other major coastal engineering projects.

With the high intensive coastal development, environmental challenges occur. These include serious pollution, coastal erosion, coastal wetland loss, groundwater shortage, subsidence due to groundwater over-extraction and increased risk of flooding due to sea-level rise. Environmental geology survey projects carried out along the Chinese coast aim to satisfy the information demand of ICZM.

Bringing all the different types of valuable information together in a coherent way, uses the application of Geographic Information Systems (GIS, see also CCC II-2-2 and III-3-2-1). The China Geological Survey (CGS) started the Coastal Environmental Geological Survey Programme in order to provide more detailed and updated geological information for coastal planning, management and protection. According to the Chinese “Law of Sea Uses and Management”, for each single coastal project an Environmental Impact Assessment (EIA) has to be carried out. One of the key factors within the EIA is to undertake a geological environment assessment.
4. Three examples of the role of geosciences in development
In the text below the developments in the economic areas of Bohai Bay, Shanghai including the Yangtze River delta and the Pearl River delta and the south eastern provinces will be discussed.

Figure 1: Map of Chinese Coastal Zone, the red rectangles show the location of three coastal development areas:
- Caofeidian Bohai Bay,
- Shanghai and Yangtze River Delta and
- Pearl River Delta.

4.1 Caofeidian Bohai Bay

The Caofeidian Island is located along the Bohai Bay, and is suitable for large-scale deepwater ports and industries. According to a bathymetrical survey undertaken by Qingdao Institute of Marine Geology (Research Report of Digital Coastal and Offshore of Nanpu-Jidong Oil Field, 2005), the water depth at 500 meters offshore reaches 25 meters, while the trough in front of the island, the lowest point of the Bohai Sea, is 36 meters deep. These water depths allow the construction of terminals for 300,000 ton ships without the need to dredge a new shipping channel. In order to create space for a deep water port, large-scale land reclamation has to be carried out: an area of 310 km$^2$ will be converted into land, with an average infill depth of about 5 m, which means that more than 1.5 billion m$^3$ sand will be dredged.
To accelerate the overall development of Caofeidian, by 2003 the construction of infrastructure facilities began. The 18.74 km long Tongdao Sea Bridge Highway was opened in September 2004. The Qinlin Road, electricity supply, and communication projects became operational by the end of 2005. Other projects, such as a water supply project, the port railway, and a project for an iron and steel plant, were completed by the end of 2008.

Tectonic stability
Meanwhile geo-biological and geo-environmental problems were taken in consideration during such a large-scale land reclamation project.
One of the major concerns is the tectonic stability related to settling pressures in this reclamation area. The deep water – the so-called trough - and the nearby relative steep slopes, poses a real challenge. Caofeidian is also close to the Tanlu Earthquake zone. The Tangshan Earthquake (7.8 degrees at Richter’s Scale) happened on the 28th of July, 1976 killing more than 250,000 persons. The earthquake centre was only 60 km from Caofeidian. The concerns of the Caofeidian reclamation project are the earthquake risks for the newly built infrastructure and for the land reclamation, especially the area close to the deep-water channel, which might be susceptible to submarine slope slides. A series of survey and monitoring projects had been set up for earthquake risk assessment.
The subsidence rate and the stability of the deep water channel slope are monitored frequently.

Eco-City Caofeidian
According to the national plan, the overall development and construction of Caofeidian will be carried out in two phases, the industrial harbour phase to receive up to 300,000 ton vessels and the construction of the Caofeidian Eco-city (see CCC II-2-4), which will require large amounts of drinking and industrial water. Large-scale water abstraction will affect the wetland ecosystem in Tanghai County, where biodiversity will also suffer from industry and shipping activities.
By the use of hydrodynamic numerical models of Bohai Sea researchers studied the change of hydrodynamic conditions at the different stages of the land reclamation activities. The comparison shows that the impact of the construction will cause the current velocity to increase near the shoreline causing seabed erosion.
Other geo-environmental problems in the near future include the seawater intrusion drastically affecting rice cultures, land subsidence, and shoreline instability exacerbated by the anticipated impacts of future climate change.
To compensate for the loss of wetlands, artificial wetlands will be constructed, which will also be designed to store two million m³ fresh water.

In order to build a safe modern Eco-City of Caofeidian in the near future, a comprehensive analysis of the coastal environment and geological processes along with the socio-economic processes in the Caofeidian area is necessary. Such an integrated approach will also increase the ability for adaptation to future climate change and in the long term to be better prepared for geological disasters such as earthquakes and tsunamis.

For more information on the rapid Caofeidian development, see the CIZAC website.

Figure 3: Large scale land reclamation (310 km²) offshore Caofeidian in progress, indicated by blue lines in the inset maps. (source: Lu Y.J. et al., 2008/7)
4.2 Shanghai coastal zone development

Yangtze River Delta area is one of the most intensely developing coastal regions in China. It has the highest population density, a rapid urbanisation, and large-scale coastal infrastructure developments (see Figure 4). However, present day impacts and future changes will affect coastal resources, living conditions and the environment.

![Diagram of Shanghai coastal region]

Figure 4: The location of the large scale coastal projects in the framework of the Shanghai coastal zone development (photo: Jun FU & Ping YIN): including the 32.5 km long Donghai Cross-sea Bridge (photo: Zhang 2008)

Threats

The Yangtze River Delta suffers from serious subsidence as a combined result of sediment compaction and over-extraction of groundwater. Between 1921 and 1965, in the Shanghai central area subsidence reached 1.75 m = 4 m/century. The situation in Shanghai is currently under control by regulating the use of ground water. The subsidence rate of Yangtze River Delta urban area, however, is on average more than 5 mm/year, and in some new, developing urban zones even higher. These rates of subsidence are of serious concern, realising that the average elevation of the vast Yangtze River Delta area is between 3-5 m above the present mean sea level.

Also global warming and sea-level rise may threaten the coastal zone and can cause enormous damage due to increasing frequency and strength of storm surges and floods. The coastal storm-surge protection dike along the river bank had to be raised from 4.7 m to 5.85 m in the last three decades. Increased sea level rise will also affect the salt water intrusion into the fresh water aquifers in the coastal zone and in the rivers.

Seawater intrusion into the Yangtze River Delta is also influenced by the decreasing river water discharge due to upstream damming and the increasing demand for water in the lower delta. Seawater intrudes along the Yangtze River, which resulted in a serious event in 2006, when it reached up to 170 km upstream from the coast.

Effects of damming

Large scale damming of the upstream Yangtze River and siltation behind those dams led to vast coastal erosion as a result of decreased sediment discharge. New approaches such as sediment agitation and special low-dam sediment discharge devices are part of the Three Gorges Dam construction. Sediment discharge (in 10^6 ton/y, Figure 5) from the Yangtze River to the Yangtze River Delta decreased by 40% since 1950s, resulting in increased coastal erosion. Whilst under natural condition most deltas are growing about 40% of the coastline in Yellow River Delta area is directly threatened by erosion. The construction of the Three Gorges Dam began in 1994, and the dam was closed for storing water at the beginning of 2003.

After 1998, there was a tendency for lower sediment discharge and by 2005 only about 200 million ton/y, was released due to retained sediments during the filling of the reservoir. The beneficial effects of special dam adaptations, which focused on the continuation of the sediment transport through the dam, may become clearer in the future.
Need for geological information in urban development
Shanghai with more than 18 million inhabitants is the largest coastal city of China. The rapid urbanisation of Yangtze River Delta demands land and fresh water. A sustainable development of Shanghai needs space and resources from both the coast and the offshore zone. As well as the clear need for geological information with regard to its tectonic setting and a detailed assessment of the stability and dynamics of the coast and its subsurface, additional information on water resources and quality is required.

Shanghai is looking for safer fresh water supplies and in 2007 the construction of the Qingcaosha fresh water reservoir, began on the Changanx Island in the Yangtze River mouth with an area of 70 km², and an effective volume of 435 million m³ (Figure 6). The daily water demand of Shanghai County is about 7 million m³. The fresh water reservoirs will be mainly fed with rainwater and with river water only during periods when there is a large river flow.

Figure 6: Qingcaosha Fresh water Reservoir (red oval): the project began in the November, 2007 and the dike closed in February, 2009. Total ring dike length is 48.4 km and the height up to 8.5 m. (source:................permission............
(web page http://citynews.eastday.com/csdb/res/1/281/2011-01/06/27/res01_attpic_brief.jpg) (this photo is renewed)
Information and data on water quality, coastal stability, and underground stability (for construction) are very important for the development of the coast. Construction of a cross-sea bridge (Donghai Bridge, Figure 4) required detailed geoscientific information of the tectonic stability, sedimentary processes acting on the seabed and the composition of the subsurface.

Given the on-going reclamation projects in and around the coastal zone for harbours and airports there will be a continuous need for geo-scientific support on long- and cross-shore sediment transport processes, subsidence and storm surge risk assessments.

![Donghai Cross-sea Bridge and Yangshan Harbour](http://www.hypcw.cn/backdoor/uploadfiles/20091281042.jpg)

*Figure 7: Donghai Cross-sea Bridge and Yangshan Harbour* - The project started in June of 2002 with the construction of the 32.5 km long Donghai Cross-sea Bridge connecting Shanghai and Yangshan Harbour; the opening of Yangshan Harbour: December, 2005; the Phase-3 of Yangshan Harbour finished in December 2008. The Yangshan Harbour key reached a length of 5600m. The whole project will be finished in 2020. (photo: web page http://www.hypcw.cn/backdoor/uploadfiles/20091281042.jpg)

The successful constructions of the Donghai cross-bridge, Yangshan (Figure 7) and Shanghai harbours and the Pu Doing Airport showed that a fundamental understanding of the geology and dynamic coastal processes are essential and can take into account the natural environment.

### 4.3. Developments of Pearl River Delta

The Pearl River Delta zone covers nine prefectures in the province of Guangdong (Figure 8) and had a population of approximately 60 million people in 2008. Since the late 1970s, the Pearl River Delta has become one of the leading economic regions and a major manufacturing centre of China. It is one of the world's workshop producing products such as electronic goods (watches and clocks), toys, garments and textiles, plastic products, and a range of other goods.

New transport links between Hong Kong, Macau and Zhuhai in the Pearl River Delta are expected to open up new areas for development and facilitate trade within the region. The proposed 29-kilometre Hong Kong-Zhuhai-Macau Bridge will be among the longest in the world.

#### Environmental problems

The industrial activities caused the delta to become severely polluted. The sewage and industrial waste treatment facilities is unable to keep pace with the growth in population and industry. Much of the area is frequently covered with brown smog, increasing the pollution levels in the delta.
At the same time, practically no natural coastal landscape remains, due to human interventions. Most of the delta plain is poorly protected, being situated below local high tide and storm-surge levels. The delta region is thus exposed to natural disasters such as typhoon-driven storm surges and ground subsidence caused by local sediment compaction and regional tectonics. These effects are compounded by the threat of accelerated relative sea-level rise estimated to reach 0.5 m within the next 50 years. Without massive protection works this would lead to the inundation of 95% of the delta region, and could include the destruction of entire cities such as Guangzhou.

The effects of human interventions in the Pearl River Delta region have the same significance as those associated with geological processes. This important aspect has to be taken into account when studying the recent evolution of the delta, especially when seeking sustainable solutions for the economic development of the region.

![Location map of the mouth of the Pearl River and its surroundings with Hong Kong, Macau and Zhuhai.](source)

5. The role of geo-science in the coastal projects

Qingdao Institute of Marine Geology (QIMG) is one of the major coastal geological survey and research institutions in China. From the 1980s, QIMG participated in the coastal and offshore geological survey near Caofeidian area, with the priority of providing geological information for the oil exploration industries in this area. QIMG finished 1:50,000 and 1:100,000 bathymetry mapping, sub-bottom profiling and seismic survey, surface sediment sampling and drilling. Subsidence monitoring was carried out for a stability assessment of artificial islands for oil exploration. A GIS database provides multi-disciplinary geo-information. Today, QIMG continue working in this area with geological and geophysical technologies, such as sampling, drilling, seismic survey to provide shallow geological structure information in the reclamation area and in the near shore. This is especially concerned with the coastal sediment properties and transport, stability of the harbour and channels, neo-tectonic movement and engineering risk assessment, and environmental impact assessments.

In the Yangtze River Delta close to Shanghai, QIMG completed a 1:1,000,000 and 1:250,000 regional survey and mapping project, with integrated geological and geophysical methods, including surface sampling and coring, drilling, magnetic and gravity survey, bathymetry, side-scan sonar, shallow seismic profiling, seismic and hydrological survey and monitoring. This geo-information was used for planning the Donghai over-sea bridge and Yangshan Harbour.
Coastal and offshore monitoring of the impact of the Three Gorges Damming project on the Yangtze River Delta area has been carried out since 2002. Series data are collected and modelling studies have been carried out to forecast the long-term impact and provide solutions to coastal management problems including coastal protection. QIMG also carried out marine aggregates survey in neighbouring areas to identify sources of sand and aggregate for the construction and development of harbours and bridges. QIMG is also working on a submarine ground water survey project near the Yangshan Harbour and island area to provide fresh water supply to the islands lying some distance from the mainland.

The successful operations regarding the construction of large infrastructures in the coastal zone such as the Donghai cross-sea bridge, Yangshan Harbour, PuDong Airport, and Shanghai Harbour learned that a fundamental understanding of the geology and coastal dynamics can help to “Build with Nature (see CCC III-3-3-1). But the water pollution, rapid subsidence and sea water intrusion continuously tells us that the carrying capacity of the coast needs to be well considered during the planning and development of industrial and harbour infrastructure, and for addressing the impacts of climate change.

6. Conclusions

Over the last decades, China’s coastal area has faced large-scale urbanisation and industrial and harbour development. These developments will increase in future and may cause serious environmental problems. These problems, including those associated with the potential impact of global climate change, must be addressed in a holistic way. China recognised this growing pressure in the 1990s and made institutional arrangements for developing ICZM. ICZM, integrated spatial planning and Environmental Impact Assessments are very important mechanisms supporting the integrated planning and sustainable implementation of large-scale coastal projects. Geoscientific research plays an important role in planning large-scale infrastructure projects, land reclamation and creating coastal eco-cities, as well as future adaptation to climate change impacts.

Applied geo-science has delivered knowledge and understanding efficiently to the Chinese policy/decision making community and the construction companies.

The Netherlands has shared its coastal hydraulic engineering and ICZM experiences with China specifically regarding coastal geo-science applications during the planning, design and execution phase of a number of large-scale infrastructure projects.

*Figure 9: A formal cooperation between China Geological Survey and the Dutch Deltares has been signed on September 11th, 2008 establishing the Dutch-Sino Centre for coastal Geology. (photos: Deltares)*
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Conclusions - China

In order to facilitate its enormous growth in the vulnerable coastal area under increasing pressures of climate change, China is very rapidly developing and applying principles of Integrated Coastal Zone Management (ICZM). Over the last decade, such ICZM developments have become clearly visible in a number of ways:

1) Development and application of ICZM knowledge and capacity
China has developed its ICZM capacity through international cooperation and nationwide initiation of ICZM programs, together with the development of institutions, regulations and laws from the nineties onwards. An early example of cooperative projects between China and the Netherlands is the Yellow River Delta project (1995-1997) focused on providing an integrated planning framework and GIS knowledge base for the development of the Delta. This project included environmental quality, social conditions and protection from flooding and formed the base for further coastal cooperation. Specific attention was furthermore paid to the application of geosciences related to sediment supply, subsoil stability and land-sea interactions in the Chinese coastal development areas. Examples of these applications include:
  - The deep-sea port and industrial development of Caofeidian island in Bohai Bay, involving a large land reclamation project and related infrastructure development;
  - Shanghai and Yangtze delta including large projects and infrastructure developments such as the Donghai cross-sea bridge, water reservoirs in the coastal area, harbour development (Shanghai and Yangshan harbour) and Pudong Airport;
  - The coastal protection of Pearl River Delta.
Recently a formal cooperation between China – the Netherlands has been created by establishing a Dutch-Sino Centre for coastal Geology, linking the China Geological Survey and the Dutch institution Deltares.

2) Large scale rehabilitation of degraded areas
Rapid urban development in densely populated coastal areas in the second half of the 20th century has created severe problems related to the management of land and water resources, in particular water quality. In the last decade, China has taken action to rehabilitate the most degraded areas. An example is the restoration of Suzhou Creek and Lake Tai, the major water supply sources in the greater Shanghai coastal area. An extensive rehabilitation program was developed, using a phased approach, including: hydraulic measures and clean up actions; wastewater flow interception and treatment; removal of polluted sites and embankment reconstruction. An integrated water quality model and a Decision Support System facilitated the identification and selection of measures to be taken. A major restructuring of the institutional arrangements of the water sector contributed considerably to the successful implementation of this rehabilitation project.

3) Large scale coastal developments in anticipation of climate change
In China, in the last twenty years some 100 million people moved from inland areas to the coast. This process of massive coastal urbanisation will continue and accelerate in the next decades, involving another estimated 200 million people. In preparing for the enormous coastal pressures, China is developing and applying the concept of eco-cities, as a holistic approach to sustainable urban living. New land is developed according to the principle of ‘Building with Nature’ (see also CCC III-3-3-1), while ensuring control and protection of land and water resources. Supply of water, energy and transport and waste (water) management based on the use of renewable sources and clean technology principles are fully integrated in the urban design concept. Examples of present developments include the cities of Caofeidian and Tianjin Binhai in Bohai Bay and Dongtan near Shanghai. These planned developments are regarded as large scale ‘pilot projects’. The results of these projects will help determine whether new eco-cities will be built along the entire Chinese coast. There is considerable enthusiasm in Chinese society for eco-cities. The ambition may set a standard for the rest of the world.
Interdisciplinary approach to water management
From the uplands to the coast – the Ganges-Brahmaputra-Meghna basin

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1. Need for a holistic approach
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Summary
Many people have stressed the need for a fundamentally new approach to the management of rivers and coastal areas. Water resource engineering and management need a broadened framework, which includes ecology, social and economic development and integrated institutional arrangements. This changing perspective provides a very different functional format for developing policies for rivers and coastal areas. These policies should be based on interdisciplinary knowledge of the river from the upland catchment to the coast. Economic analysis and ecosystem valuation can play a facilitating role in trans-boundary cooperation, so important to survive in the Ganges-Brahmaputra-Meghna (GBM) river basin now and in the future.

Initial estimates of the likely impacts of climate change at a river basin level are diverse and the STREAM model suggests that the water availability in the Ganges-Brahmaputra-Meghna catchment may decrease. This will effect the growing number of inhabitants and the valuable ecosystems, if no adaptive measures are undertaken. Trans-boundary discussions leading to a common and integrated water management policy for the entire river basin is an important adaptive option. Such international cooperation will help conserve water and increase the resilience of the Ganges-Brahmaputra-Meghna basin and its resident population.

The Himalaya – the uplands, home of the glaciers where the rivers start their journey to the coast. (photo of Annapurna-South, Nepal: © Evert Wesker)
1. Need for a holistic approach to water management

South Asia is characterised by a very high degree of engineering intervention in the terrestrial part of the hydrological cycle. Led by India and Pakistan, the region is the home of the largest irrigation system in the world. In the second half of the last century, many water engineering projects were undertaken using traditional engineering approaches that originated in Europe. These were introduced to Southern Asia by the colonial rulers who were primarily interested in higher return from agriculture. There was little understanding of and concern for the effects on the aquatic ecosystems and their services. Large dams and barrages were built to harness hydrological flows, mostly for the promotion of irrigation. Many projects guided by traditional engineering have drawn serious criticism when looked at from the perspective of sustainability, social equity and the economy. No consideration was given to the value of the freshwater ecosystem services in supporting the livelihood of millions of poor either in policy or in practice.

The Ganges-Brahmaputra-Meghna (GBM) basin is an example where trans-boundary issues play an important role in water management. The GBM basin forms a part Hindu-Kush-Himalaya region (Figure 1) and covers more than 1.7 million km², 85% of the rainfall occurs during the June – October monsoon. The population density of the basin varies from over 700 in Bangladesh to 120 inhabitants/km² in Nepal. The population of the GBM basin will pass 1 billion by the year 2020. The increasing need for water represents a great challenge for the governments and the water professionals of the river basin countries, especially if one considers the anticipated impacts of climate change.

Figure 1: The Ganges – Brahmaputra catchment area: 1.75 million km², five riparian countries, about 1 billion inhabitants in 2020 forms an important part of the Hindu-Kush-Himalaya region. (source: ICIMOD, Kathmandu)

Over the past decades, and in the aftermath of the Rio Earth Summit in 1992, it became clearer that a professional approach to water management was required. Surface and groundwater needed to be considered as a resource, forming part of the global hydrological cycle rather than a reserve to be controlled by structural interventions.
Accordingly, diplomatic negotiations and agreements on the management of trans-boundary rivers, should be based on the emerging interdisciplinary water sciences and ecological water engineering.

Fortunately in the past few years water science and engineering have recognised the importance of the aquatic ecosystems and their needs. These needs are not merely quantitative, but include for instance the knowledge on periodic patterns of flow in order to maintain the ecosystem services. Examples include the water needs of the fishing economies, which require flows of a sufficient quality and quantity that can support the movement of fish communities and their life cycles. Sufficient quantities of good water is needed for humanity and ecosystems to maintain the productivity of their valuable resources.

From the uplands to the coast

Emerton and Bos (2004) provided the impetus for the transformation of the traditional view of rivers, simply as a source of water to one of a diverse ecosystem functioning, all the way from the upland catchments to the estuary and the deltaic and coastal systems. From this perspective, ecosystem processes are closely linked to the naturally available water resources. The integrated approach of an entire river basin, as a collection of productive ecosystems, is important for the sustainable development of the water resources. The holistic understanding of rivers strengthens the need for ecological engineering and facilitating its applications. Such a development in thinking will have a positive influence on the approach to negotiations for basin level collaboration, joint management and hydro- diplomacy, directed towards equitable and sustainable use of water in the river basin. International river basin negotiations are particularly relevant against the background of present water use and water quality, and for identifying resilient, adaptive responses to the impacts of climate change.

Low lying coastal area of the GBM basin: Where the waters and sediments of the Ganges, Brahmaputra and Meghna reach the coast; fertile, densely populated deltaic plains, intertidal areas and a large mangrove belt dissected by rivers and tidal channels. (photo: NASA)

A number of positive experiences in river basin cooperation and negotiations are at hand. See CCC I-2-4 and the integrated river basin and marine management plans and its implementation by the EU countries (websites: European Commission - EU Water Framework Directive and International Commission for the Protection of the Rhine - ICPR). The coastal part of the Ganges-Brahmaputra-Meghna basin is heavily dependent on the freshwater flows from the upstream areas and socio-economic processes therein. Flooding of the low-lying deltaic plain depends largely on the upstream river
regime. The agriculture, fishery and natural environment of the Indian and Bangladesh coastal zone is for instance affected by the extent of the salt water intrusion during dry season. The survival of the valuable and highly productive Indian and Bangladesh Sundarbans, a unique unbroken mangrove belt, is affected by subtle changes in the boundary between fresh and salt water. Today the encroachment of salt water depends very much on the river discharges. In addition, it is envisaged that accelerated sea level rise may also play an increasingly important role.

2. The importance of economics

The narrow perceived economics of the use of trans-boundary waters have created local upstream-downstream conflicts. Wider economic considerations are often neglected, however they can make a positive contribution in the policy context when addressing trans-boundary water issues, such as is the case of the Ganges-Brahmaputra-Meghna (GBM) river basin in south Asia (Bandyopadhyay and Ghosh, 2009).

Traditionally, engineering interventions into water systems are purely designed to satisfy narrow economic demands. In order to arrive at an optimum policy for river basin management, a wider economic assessment of water engineering projects is essential. This new paradigm for water management, while emphasising the need for demand led management, stresses the need for a more comprehensive means of allocating resources. This mechanism will create a valuable trade-off among the various water, social, cultural, economic and ecological sectors, and compromise socio-economic and ecological services.

Ever since traditional engineering was applied in the GBM basin, national economic priorities guided the interventions. The Farakka barrage on the Ganga, for example, was constructed without any bilateral or multilateral discussions, other than data sharing on floods in the Himalayan Rivers.

The basin remains a unique developmental puzzle with the co-existence in the basin of relatively good per capita water availability and the largest number of people of the world living in poverty.

The wider considerations including economy and ecology, should pave the way for the countries sharing the basin to seek and create a more comprehensive agenda for cooperation in water system management at various spatial levels. Considerations of ecological characteristics in the adoption of a modern engineering approach in the basin and the promotion of a diversity of inputs in the design, can make the transition to a new era of holistic and inclusive hydro-diplomacy more feasible.

In addition to the emerging ecological point of view, a fundamental rethink on the economics of water is taking place. Important economic values are being identified within ecosystem processes. Ghosh and Bandyopadhyay (2009) deal with valuation of water in the economy and the ecosystem sectors. Valuation of natural processes can raise awareness of the market and the policymakers on the importance of the ecosystem and natural resources. The relevance of biodiversity conservation or carbon sequestration by wetlands is better understood if expressed in monetary values. Valuation can also help legal proceedings determining damage, such as pollution from upstream areas negatively influencing downstream inhabitants and ecosystems. To deal with compensation policies properly, the economic value of the damage needs to be assessed in order to obtain the cost of the negative effects (Bann, 2002; OECD, 2002).

Valuation of natural processes and resources helps the revision of investment decisions, such as infrastructure development, that might otherwise ignore the possible harm to the natural environment. The assessment of ecological costs and benefits of water projects is more and more recognised to be integrated in large scale hydrological projects. Notably, the absence of estimates of the ecological costs of large hydrological projects provides an inbuilt subsidy (Flessa 2004).

Pricing of water

It is critically important to choose the most comprehensive and inclusive mechanism for the valuation of water related ecosystem services. Here, an inclusive valuation framework that would encompass the various issues of ecology, economy, and society is needed. In such an inclusive valuation framework, the valuation not only of the socio-ecological systems (SES) as defined by Ostrom (2005), but also a broader ecological system that is contingent upon the intricate dynamics of the SES is discussed. In the inclusive valuation framework, the ecosystem and its services are included in the account statistics of a
nation’s economy. While such a development in procedures will be necessary and welcome, most of the policy makers of the countries involved in the Ganges-Brahmaputra-Meghna basin are not yet equipped for such a transition.

Water market
Once a baseline valuation of the various services provided by water systems is obtained, a basin wide market for the various services (provisioning, regulating and cultural) can emerge. While a customised forward contract can exist between nations on water sharing, in a more mature framework, one can think of a future market where standardised contracts can be traded. This may have considerable significance for conflict resolution and mitigation of the use of scarce resources. An efficient futures market for water can help in determining the price of water. Of course, this will require multi-level participation from all the nations in the region. With proper information dissemination, this price will reflect upon the scarcity of the resource.

3. Need for Regional cooperation

The South Asian Association for Regional Cooperation (SAARC) was established for the promotion of regional cooperation. The rivers connect several countries in the region, and thus, their cooperative management is very important for the best use of water resources and the economic development of the basin. However, hydro-diplomacy on the international rivers has not been on the agenda of SAARC in any serious way. In fact, the most recent water-related cooperation date back to 1996 when both the India-Bangladesh Treaty on the sharing of the restricted flow of the Ganges and the Treaty between India and Nepal on projects on the Mahakali came into effect. One of the oldest bilateral negotiations between India and Nepal on the river Kosi has been in place for several decades without a breakthrough.

On the positive side, the delay will allow all the projects to be reconsidered from an ecological perspective with a more comprehensive economic framework, than was possible for those conceptualised in the earlier traditional engineering paradigm. In addition, such an agenda should include China in hydro-diplomatic discussions for several reasons. Firstly, China plans to undertake many water related projects on Tsangpo (Brahmaputra) upstream of the river’s point of entry into India. Secondly, a part of the Ganges sub-basin also falls in China. Here global climate change may have a significant impact on the permafrost areas, affecting the pattern of river discharges.

In recent years, the SAARC has achieved some progress in cooperation on developmental issues such as trade and industry. Economics may be a preferable entry point for water related negotiations and diplomacy on the Ganges-Brahmaputra-Meghna basin. Economic and ecologic valuation of the water resources in the basin has been proposed as an instrument for mediating trans-boundary water conflicts. If properly applied, in the trans-boundary context, it offers a more objective and achievable basis for resolving disputes. The need for trans-boundary cooperation within the basin will increase with the pursuit of common, no-regret adaptive solutions to fight the impacts of global climate change.

The SW Bangladesh – NE India coastal zone the Sundarbans (blue green), the largest uninterrupted mangrove belt of the world, an UNESCO World Heritage site and Biosphere Reserve, is dependent on the equilibrium of between fresh and salt water in its estuaries and groundwater. Large parts of the mangroves could be lost under influence of climate change. (photo: NASA, Jesse Allen, 28-01-08)
The story of water in the Ganges-Brahmaputra-Meghna basin

The Ganges-Brahmaputra-Meghna (GBM) river basin in south Asia poses several complex challenges to the existing notions of development and hydro-diplomacy. Spread over the south Asian nations of Bangladesh, Bhutan, India, Nepal, and vast areas in the Tibet region of China, the GBM basin (1,745,400 sq km) is the second largest hydrological system in the world after the Amazon. The two major rivers of the hydrological system are the Ganges and the Brahmaputra. These two rivers and their tributaries flow beyond national boundaries and are prone to disputes that are a common feature of international trans-boundary watercourses around the world.

The story of humanity and water in the GBM basin is the story of numerous anthropogenic interventions. In the process, human societies in the basin have substantially transformed the natural flows and environment of the basin, from the Himalayan uplands to the deltas, where the highly productive mangrove forest, the Sundarbans, is located. This is the largest mangrove forest in the world.

For a sustainable future, the following steps are suggested:

- Cooperation between and among countries sharing the GBM basin, based on a perspective of the Himalayan rivers as functioning ecosystems, from the uplands to the delta, informed by scientific knowledge on all the ecosystem services they provide;
- The most critical concern arises from the absence of publicly available data on detailed hydrological flows, and other associated important variables in the basin. In the interest of the residents of the basin and for scientific knowledge on its waters, the need to share information among the various nations has been stressed by many professionals. Without this, no framework for hydro-diplomacy, can provide for sustainable use of the water resource;
- Understanding and assessing the impacts of global warming and climate change on water availability and ecosystem services of the Himalayan rivers is urgently needed (Bandyopadhyay, 2009). Such studies will be facilitated by an international collaborative approach. Serious consideration in developing such an future perspective is a priority of the region;
- The annual inundation of flood plains during the monsoon needs to be viewed as a known natural process, which needs better understanding and not routinely described or ignored as a ‘natural disaster’;
- The scope and objectives of structural interventions in these rivers needs to be expanded beyond the present preoccupation with large structures for water supply and hydropower generation;
- More comprehensive methods for the assessment and approval of water projects should be employed from the very beginning e.g. in the pre-feasibility studies;
- Economics can play an important facilitating role through institution building (creation of water markets), as well as providing an objective tool for conflict resolution (by the inclusion of valuation tools).

India because of its position in south Asia politically, economically, and technically and with its high level of diplomatic competence, can take the initiative forward and help develop a new perspective for closer cooperation in the Ganges-Brahmaputra-Meghna basin. Never before has the challenge of poverty alleviation depended on the art of hydro-diplomacy and the science of ecological engineering and climate so critically, as it does in the basin today. The role of economics in providing a comprehensive evaluation framework needs to be re-emphasised, as it is also needed for sustainable management in the basin today.
4. Estimates of impacts of climate change in the Ganges-Brahmaputra-Meghna basin

The climate change impacts may exacerbate the water resource availability in the GBM basin. Changes in rainfall and increasing temperature will affect the extent of the glaciers, rain and snowfall, evaporation, and river discharges all influencing the water balance and the water availability in the entire river basin including the coastal zone. The likely impacts of climate change on the coast will be an accelerated sea level rise, an increase in frequency and intensity of typhoons. These impacts will increase the frequency of flooding by the sea and the encroachment of salt water (see CCC II-1-1). Initial estimates of the likely impacts of climate change at a river basin level are diverse and the STREAM model suggests that the water availability in the Ganges-Brahmaputra-Meghna catchment may decrease.

Spatial distributed water balance models simulating water balance in large river basin are important for integrated management of an entire basin. STREAM is such a Geographical Information System based model allowing analysis of water availability patterns and changes in these patterns, both temporally and spatially. These changes can be caused by socio-economic interventions as well as by external influences such as climate change. The factors used in the STREAM–GBM application range from land-use changes such as deforestation, increased irrigation to dam construction and dredging of river channels. These influence flooding, salt water intrusion and the health of the mangrove forest.

The Intergovernmental Panel on Climate Change regional climate scenarios for precipitation and temperature and sea level rise are also used as input parameters, together with land-use and soil type maps and Digital Elevation Maps. All these input data are freely available (see also CCC III-3-2-6).

The output parameters are maps with changes in monthly aridity, water discharges and snow cover, and water demand versus water availability for the entire GBM basin. Salt-water intrusion and mangrove habitat suitability were the output modules for the delta. The STREAM model, with a grid size of 50 km², is calibrated and validated using several decades of monthly hydrological observations.

Four sets of hydrographs of the Ganges station Faraka (on the Indian side of the Indian Bangladesh border) and the Brahmaputra station Bahadurabad in Bangladesh (near the Indian border) show the current situation and the estimated reduction in the peak flows of the three IPCC based climate scenarios. The 2050 Medium Climate change scenario is based on a “carbon dioxide doubling temperature” of 3.0 degree Celsius.

The hydrographs suggest a substantial reduction of the peak flows of both rivers (see Figure 2). The reduction of Brahmaputra peak flow may be somewhat smaller.

The spatial distribution of the aridity indices shows serious shortage in the Western part (Rajasthan) of the Ganges sub-basin. This estimated reduction in river discharges is, in large part due to increased evaporation.

![Figure 2: Monthly discharges (m³/sec) in the lower Brahmaputra and Ganges - current situation and three IPCC climate scenarios: 2050 Low & Medium and 2100 Low scenario; these hydrographs are output of STREAM-GBM GIS model – see also CCC III-3-2-6.](image)

Climate of Coastal Cooperation II-3-1
February: Lean season

August: Monsoon season

Current situation

2050 Medium climate scenario - IPCC

Discharge (m³/sec)

- 0 - 99
- 100 - 999
- 1000 - 4999
- 5000 - 9999
- > 10000

Figure 3: STREAM-GBM output: River spatial drainage pattern and discharges in m³/sec for the months February and August, current situation and in 2050.
The STREAM-GBM spatial discharge outputs suggest a reduction of Ganges river discharges notably in the SW and W and in the ‘foothills’ of Himalayas, and a smaller reduction of the Brahmaputra peak flow in the NE part of the basin. Similar changes in spatial distribution can be observed during the low-flow season.

This GIS based river basin model can provide preliminary estimates of the effect of remedial measures as well as the impacts of climate change on the water cycle. The STREAM GBM model outputs are regarded as first estimates only and illustrate the possible order of magnitude of the impacts of climate change for a basin.
STREAM encompassing an entire river basin, is used in trans-boundary river basin management and discussions. The GBM- STREAM demo is available in this CCC-Internet publication (see CCCIII-3-2-6).

5. Conclusions

River and coastal management is in need of a new approach. For a holistic view, water resource engineering and management need to be considered in a broadened framework, which includes factors, such as ecology, institutional arrangements, and social and economic development. This changing perspective in water resource engineering will provide a very different functional format for developing river and coastal policies. These policies should be based on interdisciplinary knowledge.

Feasibility studies for large scale river intervention projects should take into account the ecological costs of stream-flow diversion, depletion, and their impact on ecosystem services. Economics can play a new and important facilitating role in trans-boundary cooperation, through introducing water saving concepts such as water markets and providing objective tools for conflict resolution.

First estimates of climate change impacts at the entire Ganges-Brahmaputra-Meghna river basin suggest that the area of decreased water availability might increase notably in the W – SW of Ganges sub-basin. The Brahmaputra basin seems somewhat less affected. A reduction in future peak flow will increase the salt water intrusion in the coastal zone of the basin, further exacerbated by the anticipated acceleration of sea level rise, affecting the quality of drinking water, agriculture and natural environment, such as the mangrove ecosystems in the Sundarbans.

The possible, serious impacts of anticipated climate change provide another strong reason for basin-wide, trans-boundary planning and implementation of adaptive measures. Such a basin – wide approach can be considered as a solution that will help conserve water, increase the resilience of the Ganges-Brahmaputra-Meghna basin and thus work towards the reduction of the widespread poverty in the basin.

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  http://www.sawasjournal.org/
Decision Support System for ICMAM

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2. Method & Theory
3. Results
4. Application of the ICMAM-DSS in India
5. Conclusions
6. References, PDF report and Websites

Summary
A Decision Support System (DSS) was introduced in India to support Integrated Coastal & Marine Management (ICMAM). It consists of a computational framework with a user interface, which assists the analysis of alternative management strategies. The DSS enables the user to quickly compare alternative solutions (strategies) for different development options (scenarios).
The Decision Support System (DSS) was primarily built for the Chennai coastal zone (Tamil Nadu) to support Integrated Coastal & Marine Management (ICMAM). The elements making up the framework were completed by stakeholders of the Chennai coastal areas at a series of workshops.
The DSS module based on ‘cross-impact analyses’ quantified and illustrated the various relationships between the stakeholders, the uses and their impacts on the environment and resources. The co-design of the ICMAM-DSS by the Indian project partners, regional stakeholders and the Dutch experts determined the contents of the DSS and identified the key issues and actions. This required flexibility in the design of the DSS.
The successful use of this ICMAM-DSS is illustrated by its application in the coastal zones of Chennai, Goa and Gujarat, and has supported the ICMAM plans for these areas.

Figure 1: The three ICMAM States: Tamil Nadu, Goa and Gujarat.
1. Introduction

This chapter discusses Integrated Coastal and Marine Area Management (ICMAM) in India. In particular it focuses on the design and development of a Decision Support System (DSS). It describes the background, aims and results related to the design and evaluation of different coastal area management strategies.

The main objective of the ICMAM project was to advance and execute a framework for the preparation of an Integrated Coastal and Marine Area Management (ICMAM) plan for the Chennai (Tamil Nadu), Goa and Gujarat coastal zones. The long-term objective of the project was to strengthen the institutional capacity for Integrated Coastal and Marine Area Management based on the concepts of participation, vulnerability and sustainable development. The ICMAM project was led by the Project Director (PD) of the Indian Ministry of Earth Sciences, with the support of the World Bank. It was carried out by Tamil Nadu Research Institutes between 1999 and 2001, assisted by the Dutch consortium: Resource Analysis and the CZM-Centre of the Netherlands Ministry of Transport, Public Works and Water Management.

The ICMAM project evolved into the ICMAM-Project Directorate becoming part of the Indian Ministry of Earth Science (see websites of ICMAM and MoE).

An important input to the development of the ICMAM plan was the assessment of the key issues, actors and policies in the Chennai coastal and marine area, with the involvement of different stakeholder groups. Attention was paid to the physical, the socio-economical as well as the institutional system. The management needs were identified and possible solutions analysed for their contribution to sustainable development of the Chennai area. The preparation of an ICMAM plan for the Chennai area was supported by an electronic Decision Support System (DSS), developed as part of the project. The DSS demonstrated:

- The framework for preparation of the ICMAM plan and the support needs;
- The formulation, assessment and comparison of coastal strategies.

The Chennai area in the State of Tamil Nadu, India has a coastline of 140 km from Pulicat Lake to Mahabalipuram, bounded by the Bay of Bengal. The city Chennai is the capital of Tamil Nadu and the most important harbour in the area. The urban agglomeration of Chennai accommodates more than 8 million people.

Figure 2: Chennai the capital of the State Tamil Nadu. (source: ©2011 Google – Kaartgegevens ©2011 Google)

During the last few decades it has faced explosive urban and industrial development. The new port of Ennore has greatly enlarged the Chennai harbour capacity. Along the coast many fishing villages, nature areas and cultural-historic places can be found. The coast of the Chennai area is increasingly at risk from erosion (see CCC II-3-5), water quality problems and land-use planning conflicts. Sustainable development of the Chennai coastal and marine area requires integrated planning to ensure that economic growth is based on the controlled use of natural resources. The preparation of an Integrated Coastal and Marine Management (ICMAM) plan is an important step in this direction.

Figure 3: The Chennai ICMAM coastal area between Pulicat Lake in the north and Mahabalipuram in the south. (source: ©2011 Google – Kaartgegevens ©2011 Google)
2. Method & Theory

Framework policy analysis
The problems that need to be tackled in ICMAM are increasingly becoming too complicated for traditional, sectoral problem solving. A formal 'Framework for Analysis', developed by Resource Analysis, was used to structure the ICMAM process. (Bower et al., 1994; Resource Analysis and Delft Hydraulics, 1993; Rijsberman and Koudstaal, 1989). It consists of five main steps:
1. Identify the key problems and issues in the coastal area;
2. Set objectives and criteria (targets to be realised by the decision maker);
3. Specify scenarios (influences on the coastal area that are outside the influence of the coastal area manager);
4. Identify policy strategies (sets of interventions that will influence the coastal zone);
5. Analysis and evaluation of integral effects of strategies and scenarios on the coastal area.

Design of the Decision Support System
Computer models can facilitate the complex decision making process. Many sectoral expert computer models are available. Examples are numerical hydrological models and water quality models. However, the integration of computer models that are used by experts for the simulation of e.g. socio-economic, physical and biological processes is difficult. In addition the information they produce may not be directly relevant or understood by the decision maker.
A different approach was taken in ICMAM. The computer model that was designed focussed on supporting the process of ICMAM. It aimed at an integrated analysis of effects on the coastal area and communication between different actors. The communication and information requirements of the stakeholders are determined. By presenting the available information and giving insight in the complexity of the coastal system, the model explicitly supports the decision maker and his objectives.
This type of model is called Decision Support System (DSS) and is used to support the ICMAM plan. Its objectives are:
• To increase the understanding of the coastal system;
• To identify knowledge gaps hampering decision making;
• To create a communication platform for developing objectives, actions and their effects through cross-impact analyses;
• To offer training in Integrated Coastal and Marine Area Management by focussing on the process of policy planning within a structured framework.

The ICMAM-DSS cannot incorporate all issues in a coastal area. Comprehensiveness must be weighed up against detail and accuracy. Selection of issues should be made in contact with as many stakeholders as possible. Only then can the DSS offer the multi-sectoral integrated approach that is necessary for Integrated Coastal and Marine Area Management.

The development of the ICMAM-DSS focused on environmental and economic impacts of developments, graphical user interfaces, and visualisation. Decision support systems use simple, but transparent and consistent analytical modelling in line with the “first order” requirements of decision makers. Often great detail is not needed and can deflect from the main policy options.

3. Results

The ICMAM project used the Framework for Analysis in the development of the DSS to structure and support the ICMAM plan.

Identification of the major problems and issues
The key issues for the ICMAM plan were identified and discussed during a May 2000 Workshop I, in Chennai. Preceding the workshop, an assessment was put together based on background studies and a fieldtrip. It included data on erosion, beach profiles, the carrying capacity for tourism, the legal framework, an actor interaction matrix, and a socio-economic survey carried out by the project partners such as IIT – OEC (Indian Institute of Technology - Ocean Engineering Centre, Chennai) in association with ICMAM- Project Directorate. The survey resulted in data on the main threats and livelihoods for the coastal population. The DSS provides the interface to access these data, allowing workshop participants and other interested parties to explore the problem areas from different perspectives.
The project area for the ICMAM Plan for Chennai was extended from Pulicat Lake in the North to Mahabalipuram in the South. To focus on the typical characteristics of the coastal region, the 140 km long stretch of coast was divided into four zones (Figure 4). The characteristic features and issues, interactively identified, are detailed for each of the four zones in Box I and are imported into the DSS interface (Figure 5).

The Workshop participants emphasised that in addition to the observable problems in the coastal area, such as man-induced coastal erosion and accretion, pollution and habitat degradation, indirect factors such as inadequate coordination and harmonisation between the coastal stakeholders are nearly as important and need to be addressed from the beginning. In fact, out of the 39 coastal problems identified by the participants of the Workshop, 15 were grouped into the category: "Management Arrangements and Institutional aspects". During the discussion it became clear that a number of participating NGOs associated the word "Institutional" with bureaucracy. It was decided to add an additional issue: "Community Participation". Box II shows the six key issues that were identified together with influence diagrams for each issue and more detailed descriptions of the coastal problems, as perceived by the workshop participants.

Objectives and criteria commonly defined
The formulation of the common objectives of the project and the translation into clear criteria are the most important steps in this phase and determine the success or failure of the project. For the development of the DSS it is crucial to identify criteria that decision-making will be based on. Which parameters in the system are crucial and should be improved in order to call a policy successful?
In the DSS the users defined the objectives and selected the relevant criteria from a list, defined by the Workshop I. Criteria are reflections of the selected objective. They translate the objectives into measurable parameters such as "Contribution from industry to GDP" and "Water quality". Three categories of criteria are supported: Economic, Social and Environmental.

Selection of scenarios and policy strategies
The third and fourth steps in the DSS process help to specify the conditions upon which the analyses will take place. These conditions are separated into two groups: scenarios (developments outside the influence of the decision maker that impact on the system) and strategies (sets of human interventions) that make up an ICMAM plan.
A scenario includes factors that influence the outcome of a policy decision (e.g. population growth, international transport, tourism growth, industrial growth, impacts of climate change). In the DSS the user was asked to choose between three predefined scenarios:
1. The optimistic scenario, which assumes low population growth, and high growth of industry, tourism and international transport;
2. The pessimistic scenario, which assumes high population growth, and low economic growth;
3. The no growth scenario.

The identification of solutions began during Workshop II on the ICMAM plan for Chennai. After this workshop a series of management actions was selected to be represented in the ICMAM-DSS. The user of the DSS formulated his strategy by selecting a number of defined activities including:
1. Whether to develop certain zones or not;
2. The size of the development;
3. Whether to make interventions in order to mitigate: erosion & accretion, industrial pollution, and / or human waste.

Figure 6 illustrates the definition of some strategies in the DSS.

Evaluation strategies and scenarios
The DSS offers an impact analysis of the identified strategies under the selected scenario. Impacts are assessed for each criterion selected in the second step. The results of the analysis are presented in a scorecard and graphs. These analyses are based on the outputs of a cross-impact model and an interface. Figure 7 illustrates the scorecard comparing a Predefined Strategy: Reduction industrial waste' and a 'New Strategy' defined by the participants, both under the influence of the same 'Optimistic Scenario'.
The results of the simulations from the DSS were discussed in Workshop III on the ICMAM Plan for Chennai and checked with other sources of information. The DSS at this stage facilitates comparisons between different strategies under a same scenario, or between different scenarios under a same strategy.

In order to make such comparisons a first order quantification of the natural and socio-economic coastal processes is performed by means of a simple to use, spreadsheet model, the so-called interface. The many lines of relationships between the different actors and their impacts are laid down in a cross-impact analyses model. These two interacting models form the core of the DSS, which after fine tuning, allows to analysing the effects of different interventions on the coastal system.

4. Application of the DSS in India

The structured, analytical approach and the results of the DSS were used for the ICMAM – Chennai Plan. Moreover the ICMAM-Project Directorate has implemented the DSS cross-impact analyses for the other ICMAM pilots in Goa and Gulf of Kachchh during 2002 and 2003. The reporting of the ICMAM- DSS Chennai was performed in an ICMAM Publication Technical Report #9 (ICMAM website).

The positive influence of the ICMAM – DSS cross-impact approach is also reflected in the Mandate of the ICZM-Project-Directorate of the Ministry of Earth Science: “The mandate of the Project Directorate is to demonstrate application of GIS, Remote Sensing, Environmental Impact Assessment and Mathematical Modelling in the evaluation of sectoral impacts caused by each sector (like Ports and Harbours, Waste disposal) on other sectors and using these tools for development of integrated management solutions to minimisation of cross impacts for sustainable development of economic activities in the coastal marine areas and sustain the resources.” (http://www.icmam.gov.in/mandate.htm)

Furthermore, model ICMAM Plans have been prepared by ICMAM-PD for Chennai, Goa and Gulf of Kachchh and reported (Ministry of Earth Science: Annual Report 2003 – 04).

5. Conclusions

The DSS demonstrated how data and knowledge about the Chennai coastal area can be integrated into a computational framework and how a user interface can assist in the analysis of alternative management strategies. The DSS enables the user to quickly analyse and compare alternative courses of actions (strategies) for different development options (scenarios). One of the core activities within the DSS, the cross-impact analyses, illustrated the interactions between the functional uses and their effects. The DSS was successfully used as a structured input for making the ICMAM Plans for the coastal zone of Chennai, as well as for coastal areas of Goa and the Gulf of Kachchh.

The co-design with Indian project partners and regional stakeholders determined the contents of the DSS and identified the key issues and actions. This required flexibility in the design of the DSS.

Project members and ICMAM-DSS workshop participants recommended the following activities for the ICMAM in Chennai:

i) Strengthen the community participation in identifying interventions related to various problems is essential;

ii) Increase the economic valuation of resources for cross-impact analyses;

iii) Make legal arrangements to improve enforcement capabilities in the coastal zone.

6. References


PDF Reports:

Websites:
• ICMAM – PD: *Integrated Coastal and Marine Area Management Project Directorate*, an attached office of Ministry of Earth Sciences (MoES),
  [www.icmam.gov.in/](http://www.icmam.gov.in/)
• MoES: Ministry of Earth Sciences:
  [www.moes.gov.in](http://www.moes.gov.in)
• IIT – OEC: Indian Institute of Technology - Ocean Engineering Center- Chennai
  [http://eoc.iitm.ac.in/ ioe/ioi.htm](http://eoc.iitm.ac.in/ioe/ioi.htm)
Figure 4: *Interface DSS: the four zones* identified for development of ICMAM plan. The menu on the right follows the Framework for Analysis.

Figure 5: *Interface DSS: key issues* interactively identified and structured along the four coastal zones.
Selection of development interventions

Setting the size of the selected development

Selection of interventions addressing erosion & accretion problems

Selection of interventions addressing human waste problems

Figure 6: Interface DSS: The selection and definition of some strategies and measures = interventions
Figure 7: Interface DSS for the evaluation of strategies comparing a predefined strategy: 'Reduction of industrial waste' with a 'New' strategy defined by the participants of the ICMAM-DSS Workshop III; both strategies are analysed under the same 'Optimistic' Scenario.
Box I: Key issues and Zones for ICMAM Chennai plan

The project area for the ICMAM Plan for Chennai extends from Pulicat Lake in the North to Mahabalipuram in the South. It has been divided into four zones, each with typical characteristics.

**ZONE 1  PULICAT LAKE - ECOLOGICALLY SENSITIVE COAST**

**Characteristics**
Pulicat lake, ecologically sensitive large shoals, Sand spits and their migration, shrinking lake water body, groundwater as freshwater supply and fishing by local population.

**Issues**
Influence of Satellite port on Pulicat lake entrance, sediment transport, erosion of sand spits and water quality

**ZONE 2  ENNORE - INDUSTRIAL GROWTH AND BACKWATER**

**Characteristics**
Development of Satellite Port, Power stations, narrow tidal inlet to Ennore creek, Brackish water fishing, sediment transport

**Issues**
Development of satellite port on inlet, sediment transport, accretion of coast, dredging for allowing tidal exchange, withdrawal of coolant water, effect of diversion of saline water into Buckingham canal from north side and its influence on fishermen along Buckingham canal

**ZONE 3  ROYAPURAM - CHENNAI**

**Characteristics**
Royapuram - EROSION ZONE: Eroding coast, Industrial belt
Chennai - PORT AND SEDIMENT ACCRETION: Chennai port, sediment accumulation sand bar formation at Cooum

**Issues**
Royapuram: Sediment depletion, loss of coastal properties, compulsory relocation of local fishermen, sewage disposal, heavy vehicular traffic due to port activities and sea water intrusion
City of Chennai: Congestion, sedimentation and blocking of domestic sewage by river mouth sand bars, pollution of urban wetlands and lagoons

**ZONE 4  KOVALAM - MAHABALIPURAM**

**Characteristics**
Kovalam: TOURISM & AQUIFER SAND DUNES: Mushrooming tourism industry, availability of good ground water, sand dunes & wide beach fronts, patches of casorina trees, backwater, partly unspoilt coast
Mahabalipuram: NATURAL COAST AND TOURISM: cultural heritage, Natural coast with marginal human interference

**Issues**
Growth of Tourism & influence of natural disasters (e.g. cyclones on coastal population). Protection cultural heritage.

<table>
<thead>
<tr>
<th>ICMAM-ISSUE &amp; PRIORITY</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erosion/accretion</td>
<td>1*)</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Pollution</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Habitat degradation</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Institutional arrangement</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Socio-economic development</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Community participation</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Box II: Key issues and system diagrams in the DSS

Six categories of key issues, identified during workshops and addressed in the ICMAM plan. These are introduced below together with more detailed problem descriptions.

<table>
<thead>
<tr>
<th>Erosion/accretion</th>
<th>Conflicting Land &amp; Water uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Diagram of erosion/accretion]</td>
<td>![Diagram of conflicting land &amp; water uses]</td>
</tr>
</tbody>
</table>

1. Erosion at Royapuram (Lakshmipuram, Periakuppam, Chinakuppam) and north of Ennore port.
2. Threat to the protective shoals at Ennore and the sand spits at Pulicat Lake.
3. Accretion at Adyar mouth, Ennore Creek and Cooum, decreasing outflow of water, e.g. decreases the cooling capacity for the power plant.
4. Dredging hinders fishing operation. Dredged sand dumped in nearby villages reduces potential for expansion of the kuppams. Dumping in the water itself affects the bottom biota including commercial fishes like prawns and increases the siltation of canals.

<table>
<thead>
<tr>
<th>Industrial Pollution</th>
<th>Human waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Diagram of industrial pollution]</td>
<td>![Diagram of human waste]</td>
</tr>
</tbody>
</table>

1. Marine oil spills (operational, chronic discharges by ships)
2. Pollution from industries on coast affects traditional fisheries.
3. Pollution of ground water at Ettukuppam village due to the percolation of effluents from industries
4. Fly ash disposal affects in-and nearshore fisheries
5. Ennore thermal power plant utilise seawater for cooling purpose. Warm effluents are discharged increasing water temperature in the estuary / coastal areas, decreasing cooling capacity.
6. Untreated effluents from prawn hatcheries (e.g. at Injambakkam and Kovalam) increases mortality of fish and prawn seeds in near shore areas and reduces fish catch.

1. Forced migration of local communities from coastal areas due to increasing development and coastal erosion.
2. Tourism development conflicts with traditional fisheries. Hinterland denied for the utility of the coastal people.
3. Industrial development requires land acquisition near Ennore port and threatens Pulicat Lake.
4. Saltwater intrusion into ground- and drinking water wells.
5. Resorts and amusement parks over-utilise ground water.
6. Lack of proper sanitation, water and shelter in slum areas.
7. Pollution from industries adjoining coastal areas affects the traditional fisheries and health of fishermen.
8. Dredging and port activities conflict with fishing.

1. Inadequate flushing of waste (domestic sewage and industry) and degradation of wetlands due to pollution, population pressure and reduced fresh water inflow at Cooum River, Adyar River, Buckingham Channel & Ennore
2. Water pollution transported through the rivers (BOD, heavy metals) due to human waste and very small businesses
3. Pollution of Fisheries harbour (side-catch, oil and garbage disposal)
4. Air pollution in Chennai due to traffic.
<table>
<thead>
<tr>
<th>Institutional arrangement</th>
<th>Community participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Classification of Coastal CRZ(^1) – categories is ambiguous. Strict implementation of CRZ will cause non-availability of hinterland for fishermen handling crafts and drying gears.</td>
<td>1. Lack of community participation in resettlement and rehabilitation of slums of Chennai.</td>
</tr>
<tr>
<td>2. State Coastal Zone Management Authority under the Central Government does not delegate subordinate bodies.</td>
<td>2. Lack of public awareness on water conservation.</td>
</tr>
<tr>
<td>3. Lack of integrated approach to address erosion &amp; accretion.</td>
<td>3. Lack of awareness among the beach users disposing solid wastes contributing to anaesthetic appearance of beaches.</td>
</tr>
<tr>
<td>4. No plans for restoration of degrading ecosystems.</td>
<td>4. Imbalance of power of stakeholders &amp; difficulties to make communities participate in decision-making process.</td>
</tr>
<tr>
<td>5. Unsustainable coastal tourism due to non-assessment of the carrying capacity of the area.</td>
<td>5. Difficulties in enforcement of CRZ regulations in suburban areas.</td>
</tr>
<tr>
<td>6. Inadequate co-ordination among water management, research and monitoring agencies.</td>
<td>6. Limited involvement of local fishing people in official meetings and discussions.</td>
</tr>
<tr>
<td>7. Inadequate enforcement of water policy and existing legislation for sewage disposal into the sea.</td>
<td></td>
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<tr>
<td>8. Inadequate funding for implementation of coastal protection measures.</td>
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</tbody>
</table>

\(^1\) Four Coastal Regulation Zones (CRZ) were notified in 1991, under the provision of the EPA at central level (Ministry of Environment and Forest). The CRZ’s are related to High Tide Level.
Artificial reefs
Increasing biodiversity and long term coastal fisheries in the Tuticorin region, Tamil Nadu, India

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Rob J. Leewis (Netherlands Centre for Biodiversity Naturalis, Leiden, the Netherlands)

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2. Material and methods
3. Results
4. Conclusions
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Summary
In 2002, the community-based artificial reef programme began, aiming to restore a lost fishery and to increase marine biodiversity within the frame of a Netherlands-Indian coastal cooperation. The artificial reefs were locally constructed and placed in the Gulf of Mannar (Tamil Nadu). The effects were intensively monitored. The results are clear and undeniable, revealing that artificial reefs enhance coastal fishery stocks, coral recruitment and help form new food chains. It became clear, that although artificial habitats are mostly designed for a variety of biological functions, they primarily serve social functions by providing services and resources to different user groups. This ultimately enhances the socio-economic status of the poor, traditional fishermen, who gradually became more enthusiastic about the positive effects of the artificial reefs. The higher yield of fish catches and the monitoring of the artificial reefs, essential for evaluating the results of the programme continued also after the Dutch assistance ended in 2006, are signals of success of this reef project.
1. Introduction

The Gulf of Mannar is one of the four major natural reef areas in India and is located at the southeastern part of Tamil Nadu. The 140 km Gulf of Mannar stretch extending from Rameswaram to Tuticorin, located between Lat. 8°47’ N and 9°15’ N and Long. 78°12’ E and 79°14’ E includes 21 uninhabited islands, which are surrounded by coral reefs (Figure 1). In 1986, the Government of Tamil Nadu declared the Gulf of Mannar a Marine National Park, including all 21 islands and surrounding shallow coastal waters covering an area of 560 km². In addition to this, in 1989 the Gulf was also declared as “Marine Biosphere Reserve” covering an area of 10,500 km² from Rameswaram to Kanyakumari (= the southern most tip of India).

The Gulf of Mannar is influenced by seasonal monsoons - southwest monsoon and northeast monsoon. The islands are located at an average distance of 8-10 km from the mainland. Narrow fringing reefs are mostly located at a distance of 100 to 350 m from the islands, patch reefs rise from depths of 2 m to 9 m and extend up to 1 - 2 km in length with a width as much as 50 m. Large areas of reefs along the Gulf of Mannar are generally in poor condition due to a number of destructive activities – such as coral mining and destructive fishing practices carried out by several hundred people who live along the coast and depend on reef resources for their livelihood.

In 2002 the Suganthi Devadason Marine Research Institute (SDMRI, based in Tuticorin = Thoothukudi) in collaboration with the Coastal Zone Management Centre in The Netherlands, began a community-based artificial reef programme, to study efficiency of artificial reefs in enhancing the lost fishery. This programme was part of a cooperation between India and the Netherlands to strengthen integrated coastal zone management. The aim was to increase the resilience of the coastal habitats and its people through coastal measures involving no net environmental loss. The programme aimed to increase the biodiversity and fishery catches helping to combat the poverty of local fishermen.

2. Material and methods

Study Locations
Three stations were located around Vaan and Koswari Islands in Tuticorin coast. 37 artificial reef modules were deployed in site 1 (5.6 m depth), 37 modules in site 2 (3.6 m depth) and 31 modules (3.2 m depth) in site 3.
There were two main target fishery villages for the project: Vellapati (close to Vembar) and Tharuvaikulam near Tuticorin.

Deployment of artificial reefs modules
In the present study, the artificial reef modules were made of Ferro-cement. This material was cheap, locally available, and easy to handle. The modules were constructed as three slabs for easy transportation and deployment. Each slab was 137 x 90 cm in size with 12 holes of two different diameters: 18 and 11 cm (see Figure 1).

Parameters measured
Physico-chemical parameters (temperature, salinity, dissolved oxygen, pH, transparency) and nutrients (calcium, magnesium, phosphate, nitrate and nitrite) in the water were assessed continuously. Sediment samples were collected using cylindrical cores for the study of (macro) benthos and particle size composition. Plankton samples were collected using plankton nets for the analyses of phytoplankton and zooplankton species and plankton biomass.
SCUBA divers surveyed the species composition and cover of the epifauna on the artificial reef modules. The epifauna species are benthic (bottom) animals that live on the surface of a substrate, such as rocks, pilings, marine vegetation or on the (sea) bottom. They were identified and samples collected by scraping the animals off the surface with the help of a special “Epifauna sampling scraper”. Epibenthic invertebrates were surveyed by counting quadrants of 15 by 15 cm.
In addition, plates such as cement slabs, tiles and pieces of wood were placed horizontally on the artificial reef modules and secured with plastic wires. After 10 days, the plates were retrieved and brought to the laboratory for the identification of newly established epifauna.
Catch Per Unit Effort (CPUE) was assessed by fishing once a month around the artificial reef sites using nets constructed like Mayavalai and Nandu valai (both are modified gill nets with different mesh sizes, used in the target villages). The species caught were numbered and recorded.

Gut content of all finfishes caught in the nets and traps was analysed to find out whether their diet came primarily from the reef or from elsewhere.

The diversity and quantity of fin fish and shellfish landed by different types of gear was recorded. Collected data was statistically analysed by (ANOVA) Analysis of Variance to establish any significant difference in the mean of various parameters observed at the control and artificial reef stations. In addition, the statistical Duncan’s multiple range test was also applied.

3. Results

The variations in the physico-chemical water quality parameters for the period up to 2008 were not significant. Also, statistical analysis showed no significant difference between the means of physical parameters in the control and the artificial reef sites, but most of the chemical parameters were found to be higher in comparison to the baseline data. Data provided in this report cover the period 2002 – 2008. Monitoring the artificial reefs continued in order to improve the evaluation of the results, after the cooperation with the Dutch ended in 2006.

Plankton

Plankton biomass was observed to be very low in the 2002 baseline surveys. Plankton increased gradually from 2003 to 2008. Statistical analysis shows a significant difference in the plankton biomass by wet weight between stations. The reason for the higher dry and wet weight at station 2 was probably the proximity of a natural reef area. The presence of many plankton-feeding fish species such as *Siganus* sp. in the area, may be the main reason for the lower dry weight of plankton in the artificial reef sites.
Sediment Analysis
During the baseline study in 2002 the percentage of sand was very high (above 60%) in all stations and the percentage of clay was low (below 9%). The recent data reveal a reduction in the percentage of sand and an increase in the silt and clay in all the sites from 2003 to 2008.

Benthos and associated fauna
The monitoring of the artificial reef stations from 2002 to 2008 showed that the artificial reef is efficient in attracting and aggregating biological resources (Figure 2). Among the macrobenthic community, bivalves were the dominant category in the baseline survey. The monitoring reveals an increase in the percentage of gastropods and bivalves, confirming the increase in the benthic population. Gastropods were the dominant contributor followed by bivalves. For the echinoderms, scaphopods, polychaetes and crustaceans, the percentage was below 5% at all stations, but showed an increase over time when compared to the baseline data. This again suggests that due to the presence of the artificial reef sites, more encrusting forms and their associate dwellers became established.

Figure 2: Development of numbers (percentages of total number benthos) for two groups of benthic fauna (Gastropod shells are mostly spirally coiled snails and Crustaceans includes animals as crabs, lobsters, shrimps, krill and barnacles) in the three artificial reef stations from 2003-2008, compared with baseline (BL) surveys

Epifauna
The epifauna began developing on the modules from the 5th day. After two weeks, the cover was around 15%. The total cover further increased to 40 - 50% after 8 weeks and 65 - 70% after 20 weeks. Barnacles (main macrofoulers) in all three stations dominated the cover and gorgonians (sea fans) were observed in small numbers in the 3rd station after six months of the deployment of the modules. Since there is not much predation by carnivorous gastropods or other predators, they thrive well along with hydroids and ascidians.

Coral recruitment
The coral recruitment pattern on the modules was studied from 2003 (Figure 3a). There was high coral recruitment density on the artificial reef modules from 2003 to 2008 as the modules acted as perfect substrate. The observed coral genera were, Goniatrea, Favites, Favia, Turbinaria and Pocillopora. Most of the recruits on the modules were massive coral species (Figure 3b).
Figure 3a: Development of coral recruitment on the modules in the three artificial reef stations from 2003-2008

Figure 3b: Massive (left) and table (right) coral recruitment on the artificial reef modules, in 2008. (photo: SDMRI)

Fin fishes
The visual survey in the artificial reef area confirmed the aggregation of large number of fishes and invertebrates on and near the reef over time. Shortly after the deployment of the modules, *Lutjanus* species were observed aggregating around the structures. Initially there were only 2 or 3 individuals, but this gradually increased confirming the attraction of the fishes towards the artificial reef.
**Lethrinus sp.** in one of the Artificial Reef sites, Tuticorin coast. (source – SDMRI)

During the entire program, 42 species of fishes involving 27 families of 7 orders were observed from 2002 to 2008. Among these 42 species, 10 appeared during most of the months. Due to the habitat preference, food availability and the depth, some species of fish prefer certain areas. Shoaling fishes like snapper and bream seem to swim around the artificial reef site, while solitary fishes like sea perch, grouper and puffer seem to dwell in the crevices of the artificial reef modules.

**CatchPer Unit effort (CPUE)**

There was no baseline data for catch per unit effort. Data were recorded only after the deployment of the artificial reef modules. A gradual and significant increase in the catch per unit effort data in fin fishes, crustaceans, echinoderms and molluscs was observed in all the three stations from 2003-2008 (Figure 4).

*Figure 4: Development of CPUE for fish and crustaceans, the two most important groups for the fishermen, from the artificial reef area (2003-2008)*

The most common fin fish species caught were *Psammoperca waigensis*, *Lethrinus nebulosus*, *Lutjanus russelli*, *Lutjanus lunulatus*, *Scarus ghobban*, *Triacanthus sp.*, *Terapon jaruba*, and *Siganus canaliculatus*; Crustaceans such as *Portunus pelagicus*, *Portunus sangoventris* and *Thalamita cernata*; echinoderms such as *Pentasteraster affinis* and *Diadema savingnyi*; and molluscs such as *Lambis lambis*, *Harpulina lapponica* and *Dolebella auricularia*. The cuttlefish Sepia
pharaonis was found to be spawning on the modules, evident by the presence of egg capsules on the ropes connecting the modules.
In a study of artificial reefs at the west coast of India (Kerala), the catches near artificial reef sites, included trigger fishes, snappers, thread fin breams and lizard fishes all classified as resident fishes at the artificial reef site (Collins et al., 1995).
Many studies have referred to high fish density, rapid colonisation and high catch rates in areas where artificial reefs have been deployed (Bohsnack and Sutherland, 1985).

**Gut content analysis**
Gut content analysis of the fish caught in the nets showed that Lutjanus sp., groupers, Psammoperca waigensis and Plotosus sp. mainly eat crabs. Thalamita sp. occurs in all the artificial reef stations. Among the fishes, snappers Lutjanus russelli, L. lunulatus, sea bass Psammoperca waigensis, groupers Epinephelus coioides and Cephalopholis formosa were observed throughout the study period. Their gut content analysis (Lutjanus russelli, L. lunulatus and Psammoperca waigensis) also supports the fact that they are the residential fishes of the artificial reef area. The fishes along with their gut content analysis are classified according to their residential status based on their association with the reef (D’cruz and Vivekanandan, 1995).

**Daily Landing Data**
The statistical analysis of the catches recorded in the daily landings shows significant differences between fishing gear types. The two target fishing villages operate different types of gear for fishing. The landings of the two villages also vary because of the mode of fishing. There is increase in the landing of fin fishes, shellfishes and cephalopods, particularly in Tharuvaikulam, near Tuticorin (Figure 5). The influence of varying way of fishing especially near the Vellapatti landing affected its fish landings.

The artificial reef modules are one of the reasons for the increase of landings in the two villages. In addition, the decrease in nearshore destructive fishing activities, such as shore seine and push net operation in and around the artificial reef, helped.
The modules also increased the awareness among the local fisher community of the importance of artificial reefs and the long term negative effects of destructive fishing.

![Fish landing data in Tharuvaikulam](image1)

![Fish landing data in Vellapatti](image2)

*Figure 5: Landings of fish in the two target villages* (in 2005 and 2006 landings were not monitored).

The amount of data on the landings is considerable, covering landings per species for fin fishes and shellfishes independently for the 2 target villages. The data are available as tables at request to the authors of this paper.
4. Conclusions

Literature shows that artificial habitats are designed for a variety of biological functions, but they primarily serve social functions by providing services or resources to different user groups. The success of the artificial reef programme is reflected by the enhancement of coastal fishery stocks, coral recruitment and the formation of new food chains. This ultimately helps enhance the socio-economic status of the poor traditional fishermen - who mainly depend on the fishery resources near the reef areas - through increased fishery production.

The fishermen and their families in the target villages were informed about species diversity and density in the artificial reefs stations through the awareness programmes. They were impressed with the fishery production in the artificial reefs area. The target villagers of Tharuvaikulam and Vellapatti have requested the deployment of additional artificial reefs around the Islands of Tuticorin region in order to increase the fishery production. This would enable them to obtain catches more easily and help avoid inshore trawling.

Eco-tourism opportunities are clearly present in the Tuticorin coastal area, however not experimented with, so far. There are indications that eco-tourism will play a greater role in this area in the near future. In that case, artificial reefs could play a major role in attracting diving tourists, which in turn would help to support the livelihood of the local fisher folk and strengthen conservation initiatives.

5. References

- **Lazarus, S., 1995**: Artificial fish habitats in traditional fisheries of southwest coast of India; in: ECOSET 95’ International Conference on Ecological System enhancement Technology for Aquatic Environments, The Sixth International Conference on Aquatic Habitat Enhancement, Tokyo, Japan: 732 – 737.

Website:
- **SDMRI: Suganthi Devadason Marine Research Institute – Tuticorin:**
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Tropical cyclones and the added value of ICZM – Andhra Pradesh, India

an integrated approach reducing vulnerability

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Summary
Strengthening early warning systems and planning Integrated Coastal Zone management (ICZM) were simultaneously and successfully applied on the coast of India. The number of casualties and damage by cyclones can be reduced by proper implementation of these approaches. Applying an ICZM programme together with the development of a decision support model, provided for the integration of disciplines, structure and synthesis of complex data sets and is forward looking. The benefit of such an approach is demonstrated in improved decision-making related to spatial planning and efforts to reduce poverty, which is one of the dominant factors in post-cyclone recovery.

Cyclone 07B – over the Godavari Delta, State of Andhra Pradesh, east coast India, during 6-7 November 1996, with wind speed to 230 km/hour. (photo: National Geophysical Data Center / National Oceanic and Atmospheric Administration)
1. Coastal hazards, damage and human suffering

Tragic events such as Hurricane Katrina (2005), the Asian Tsunami (2004) and tropical cyclone Nargis that struck Burma (Myanmar) in May 2008 have highlighted the fact that coastal areas are hazardous places to live. Many low-lying coasts suffer ‘natural’ disasters owing to the highly dynamic environment. At the same time they have attracted human occupation because of their natural resources (such as fertile soils, fish stocks and navigation facilities). This paradoxical situation is likely to increase in the light of future climate change in combination with population growth.

Worldwide up to 120 million people on average every year experience tropical cyclones. Countries with substantial populations located on coastal plains and deltas with a relatively high vulnerability to cyclones include India, Bangladesh, Honduras, Nicaragua, the Philippines and Vietnam (Pelling et al. 2004).

Whereas the damage from cyclones shows an increasing trend in time, the loss of life seems to reduce somewhat over the years, although there are large differences between countries. For instance, in Andhra Pradesh there has been a marked reduction in casualties between two cyclones of similar intensity and landfall (1970 and 1990), mainly attributable to improvements in early warning systems and contingency planning for mass evacuation (Raghavan & Rajesh 2003). A similar improvement in warning and preparedness (e.g. cyclone shelters) is observable in Bangladesh. However, cyclone Nargis in 2008 with over 100,000 lives lost showed that not all countries have yet embarked on effective contingency planning with regard to cyclones.

What can be done? Hazards will continue to threaten societies, especially on the coast. Traditional engineering options, such as strong embankments and dikes, are not always effective or economically feasible. Other measures include better spatial planning, improved early warning systems and evacuation procedures, improved housing and community preparedness. Within the domain of disaster management there is increasing awareness that there are solutions using a combination of measures.

![Figure 1: The location of the Godavari Delta in the State of Andhra Pradesh: Twenty cyclonic depressions and tropical storms have crossed the Andhra Pradesh coastline between 1977 and 1996; the Expert Decision Support System (EDSS) was set up and calibrated in the Godavari delta.](image)

This CCC chapter focuses on the use of ICZM as a planning and management approach to reduce the vulnerability of coastal societies for tropical cyclones. It is largely based on many years of research in coastal Andhra Pradesh, India, but is also relevant for other countries that face similar tropical cyclone hazards.

2. Cyclone hazard and economic development in the State of Andhra Pradesh (AP), south India

Twenty cyclonic depressions and tropical storms impacted on the Andhra Pradesh (AP) coastline between 1977 and 1996, affecting the lives of millions of people. Thousands of people died and hundreds of thousands hectares of crops...
were lost (O’Hare, 2001). The November 1977 cyclone and its accompanying storm surge in the Krishna Delta (AP) was the most devastating recent event in India, killing 10,000 people in one night and destroying an area of more than one million hectares (Reddy et al., 2000). More recently, the November 1996 cyclone struck the Godavari Delta leaving 1,076 persons confirmed dead, while 1638 people were missing (Marchand, 2009). Figure 2 shows the mandals (municipalities) in the delta closest to the landfall counted the most casualties; however, also in more distant mandals considerable number of victims were confirmed. The distribution of the vulnerabilities also displays a dispersed pattern, as can be seen in the Vulnerability Map (Figure 5).

The extent of damage and losses caused by a cyclone depends on a number of factors, amongst which the most important are the:

- Severity of the cyclone itself;
- Local geomorphology of the coastal area at the landfall point (e.g. the land level, the existence of mangroves, a sand spit, a lagoon etc.);
- Evacuation: infrastructure and preparedness of the local population;
- Effectiveness of the early warning systems.

![Godavari Delta](image)

**Figure 2: Mandal wise distribution of deaths in the Godavari Delta from the November 1996 Cyclone.** (source: Offices of the District Collectors in Kakinada and Eluru; Marchand, 2009)

Because of the combination of these factors, not every part of the Andhra Pradesh coast is equally vulnerable to cyclones and associated flooding. Deltas, pre-eminently low-lying areas are particularly susceptible to damage and loss of life because the combination of a cyclonic storm surge with high river discharges can lead to severe flooding.

Cyclones are one of several hazards in this coastal area. The other hazardous threats include drought, water pollution and salt water aquifer intrusion. These adverse environmental conditions significantly affect the ability, especially of the poorer sections of the communities to cope with the impact of a cyclone. Vulnerability to cyclones is not equally distributed among the society. It is highest in the communities and households that have the lowest incomes (Winchester 1992; Winchester 2000). This warrants specific responsibility with respect to a sustainable and equitable development of the coastal resources as a part of a disaster management strategy.
When the Andhra Pradesh Government commissioned the Cyclone Hazard Mitigation Project in 1999, it correctly put the emphasis for the reduction of vulnerability in the coastal areas on both early warning systems for immediate actions and ICZM for long term planning action.

The early warning part of the project produced e.g. a calibrated, dynamic model of cyclone movement and point of landfall. This model increased the accuracy of the predictions of location and timing of landfall to such an extent that 72 hours in advance its location and strength can be reasonably accurately predicted. This contributes to reducing the vulnerability of cyclone prone areas.

The main objective for the ICZM part of the Cyclone Hazard Mitigation Project was formulated as: “To envisage optimum utilisation of coastal resources, minimisation of impacts due to cyclone disasters and improvements in equitable quality of life levels while ensuring environmental protection and biodiversity conservation”.

3. A framework for ICZM in Andhra Pradesh

Over the past decades, population growth in the coastal zone of the State of Andhra Pradesh has greatly increased the pressure on the limited natural resources, such as land, fresh water, forests, fish and prawn stocks. There are clear signs of water quality deterioration, overfishing, fuel wood shortages and groundwater salinisation. Reduction of mangrove forests, tidal marshes and lagoons has made large parts of the coast more vulnerable to the destructive forces of a cyclonic storm surge. Combined with the increased number of people living close to the sea as well as their increased economic activity, this has led to an increase of the total number of people and value of assets at risk.

Improved early warning is essential in reducing the number of casualties due to cyclonic disasters. However, this alone cannot prevent serious damage to properties and infrastructure. Therefore long-term measures are also required in order to reduce the vulnerability of coastal Andhra Pradesh. Such measures need to be based on a sound understanding of the socio-economic structures and natural coastal processes.

The key to reducing the cyclone vulnerability of the coastal population is to understand implications for different economic groups. For example the same event in the same place affects poorer households more than it does the economic better-off. Poverty alleviation is therefore a major factor in reducing the vulnerability to cyclones. This is best achieved by developing the coastal areas and its resources in such a way that they become more accessible and attractive for public and private investments. At the same time, the coastal areas should be made healthier and safer.

ICZM is a framework that helps with long-term sustainable development, taking into account the environmental carrying capacity and equity in terms of resource use and economic profit. It provides decision makers in both the public and private sectors with information that enables them to optimise resource use.

An ICZM Framework provided a supporting model for planning decisions at local and regional level. This identified a number of strategic options. The key recommendation was that reducing vulnerability should involve a policy of poverty alleviation and protecting the most vulnerable land uses in the coastal zone. Sustaining private agricultural sectors that are already growing actively and contributing significantly to enhanced levels of employment, as well as increasing public investments for the improvement of drinking water conditions are the most important development issues for the next five years. Other priority policy elements include investment in primary health care, education, roads and communication, water management, flood control and drainage improvement and coastal forestry.

The ICZM Framework also addresses the institutional settings. The Framework is mainly operating within the existing planning and priority system, already set by government (e.g. “The Vision 2020 framework” - CGG, 2003, and the Janmabhoomi programmes), and is broadly within current institutional structures. The Framework also acknowledges that village-based organisations are key institutions from which to build long-term sustainable cyclone vulnerability reduction programmes.

The ICZM Framework furthermore, provided the necessary facilitating tools. One of these tools is an Expert Decision Support System (EDSS), a model of coastal development and vulnerability, exploring scenarios and strategies at different levels.
4. A model for coastal development and vulnerability

Delft Hydraulics/Deltares in cooperation with AP Government developed a model (Baarse & Marchand, 2003; Marchand et al., 2006) that predicts physical and socio-economic vulnerabilities. These predictions are calibrated and validated with information based on fieldwork analysis. The model calculates the interactions between the impact of natural events, environmental and socio-economic processes at different spatial and temporal scales. The model links the socio-economic character of the coastal zone to land use and all related activities that generate income. It is sensitive to both planned (crop selection) and unplanned (cyclone disaster) land-use changes and estimates annual agriculture production, income, resource use and waste generation.

The Godavari Delta
The model has been calibrated for the Godavari Delta (Figure 1), a coastal area that is relatively more prosperous than other parts of the Andhra Pradesh coast, but also more prone to cyclones. For instance, the cyclone 07B that landed in November 1996 near Kakinada (Figure 3) resulted in a tragic loss of over 1000 lives, 44 billion Rs (around 880 million US$) of crop losses and 6 billion Rs (120 million US$) of damage in the housing sector.

![Figure 3: Cyclone 07B – November 1996 – track.](source: background image NASA; tracking data from the Joint Typhoon Warning Center; http://en.wikipedia.org/wiki/File:Cyclone_07B_1996_track.png)

Color scheme from the Saffir–Simpson Hurricane Scale:

| TD | TS | 1 | 2 | 3 | 4 | 5 |

This damage equals around one third of the Gross Domestic Product of the Delta. As the recurrence period of this severe cyclone is about 50 years, this represents an annual economic risk of around 1 billion Rs, i.e. 0.6% of the GDP for the Delta.

Rate of economic recovery
The model calculates the recovery of the asset values and income of households one year after the cyclone. The model shows that for a severe cyclone such as 07B in one year the average recovery of assets value could be more than 95% of their pre cyclone levels for the better-off households. However, the average recovery for the lowest income groups in the rural areas could be as low as 50% of their pre cyclone levels demonstrating the differential nature of vulnerability. This finding from running models supports our key definition of vulnerability – the degree of inability to cope with or recover from a disaster (cyclone), such as defined in IPCC, 1991.

Changes explored in land & water use
The model explored a number of development scenarios affecting different land and water uses, and population growth for the next 20 years in the Godavari Delta (Marchand & Mulder 2007). The relationships between agricultural practice and employment potential and between development and environmental destruction were defined. The model runs suggest that land development and diversification is more likely to support sustainable development than the continuation of the traditional rice agriculture and related investments for irrigation. Investments in the power sector, better roads to markets, and more credit facilities and education, however will diversify and increase the resilience of farming.
Two crucial issues need further attention: (i) the reversal of environmental degradation, and, (ii) the opportunities for more equitable growth with the introduction of new land uses.

The diversification programmes, dealing with changes in the use of resources and labour require careful planning and management, accompanied by environmental protection policies controlling water pollution and replanting of mangrove forest

**Flooding and storm, casualties and damages**

The model also analysed several measures directly aimed at vulnerability reduction. Model runs showed that ‘maximum flood protection’ against storm surges increases safety, but would hardly reduce the damage to assets, mainly caused by high winds. Maximum flood protection and evacuation improvements reduce the number of casualties considerably. Improvements in the road and warning systems, and the provision of more cyclone shelters will decrease the expected casualties by half.

The majority of the assets (crops and houses) are static and vulnerable to flooding and storms. Therefore, relief funds given as grants to households that have suffered losses remain of utmost importance to reduce vulnerability to assets and income. In the model, there are several levels of grants available. A ‘medium grant’, defined as the provision of relief funds that compensate for 70% of losses incurred by poor households and 50% compensation for medium income households would cost on average of 2 billion Rs and would reduce the number of people vulnerable to financial loss by 60%.

**5. Added values of EDSS - ICZM project**

We started the coastal program in Andhra Pradesh under the assumption that the principles of ICZM would have a benefit to disaster management. Now, after having studied the problems in the coast, developed an EDSS model and formulated recommendations it is possible to look back and identify the these benefits.

**Interdisciplinary approach**

This basic integrated interdisciplinary approach has been very important. The team consisted of Indian and Dutch experts from both the natural and social sciences. They undertook field visits, contributed to workshops and collaborated on desk studies. This greatly improved our understanding of the complex problems and feasibility of potential solutions.

Lively and serious discussions led to a balanced and scientifically sound assessment of current practices and recommendations for enhancing a sustainable and socially justified development. This fruitful cooperation resulted in an extensive knowledge base on coastal issues, documented in 14 Technical Reports and 11 Supporting Documents.

**Integrating model**

However useful this wealth of information may have been, it did not directly provide guidance for the future sustainable development of the coastal zone vis-à-vis vulnerability. For this, the model proved to be a valuable additional instrument as it synthesized data and acquired knowledge on the relationship between the coastal environment, its inhabitants and hazards. The model provided a structure. Large amounts of data from the various sectors and disciplines became visible and operational. It proved to be a vehicle through which a better understanding of the current vulnerability was gained. An example of this is the explanation of spatial differences in vulnerability (see Box). Hence, by combining and presenting data in a way that could not have been done through a mono disciplinary approach, the model was able to contribute to a truly integrated synthesis.
Box:
In the middle of the Godavari Delta lie two mandals (communities) next to each other: Atreyapuram and Kadiam. Neither administrative unit has a high risk of flooding or wind hazard. Nevertheless, Atreyapuram ranks considerably higher in terms of vulnerability than Kadiam. How can this be explained? Closer examination of the socio-economic structure of the mandals revealed a high dependence of the local economy on banana’s in Atreyapuram: the 1250 ha of banana plantations contributed to 38% of the total income. Kadiam on the other hand has only 300 ha of banana that contributes only 5 % to the local economy, which is largely dominated by three large factories. Since banana is highly vulnerable to damage by high winds, the impact of a cyclone is much higher for Atreyapuram than for Kadiam.


Figure 4: Banana plantations of Atreyapuram, near the Godavari River, vulnerable for hazardous winds.

Figure 5 : A vulnerability Map for the Godavari Delta - Base-case 2001: the fraction of population vulnerable for cyclones. The population is multiple vulnerable : in the inland district Atreyapuram the inhabitants are vulnerable for large storm damages and in the coastal district Thallarevu for severe flooding associated with the landfall of cyclones.
Long term future explorations
The analytical capabilities of the model were used to explore different and plausible future (‘scenarios’) and measures that can be taken. Such a scenario analysis does not aim to predict the future, but rather to identify the range of measures the government can take. This approach tests the usefulness and robustness of these measures (Groves & Lempert 2007). The value of the model lies in the increased understanding of the long term functioning of the coastal system. The model does not provide readymade choices, but facilitates informed decision-making.

The ICZM Framework and model results is not a blueprint or Master Plan prescribing in detail what the coastal zone should look like in future. The sheer number and complexity of issues and the huge extent of the coastal zone require initiatives at many different levels and by many different stakeholders. These initiatives would follow concerted decision making by stakeholders, each having their own specific responsibilities. The bedrock of ICZM is that it requires the collaboration of all coastal zone stakeholders in the conception and implementation of a development model that reflects the many and varied mutual interests of the coastal populations.

6. Conclusions
The dual approach to reduce the vulnerability for cyclones by strengthening early warning systems and implementing ICZM was successful. The number of casualties and damage by cyclones can be reduced by proper implementation of these approaches. The implementation of an ICZM programme centred around the development of a decision support model, providing integration of disciplines, structure and synthesis of complex data and predictions for the future. It brought together a large variety of information on natural processes, hazards and socio-economic issues. This Expert Decision Support System (EDSS)-ICZM combination allowed an exploration of future long-term scenarios and strategies, as well as estimates of short-term loss of life and damage from hazards such as cyclones. The benefit of such combined integrated approach is also demonstrated in improved decision-making related to spatial planning and efforts to reduce poverty. Poverty is one of the dominant factors in post-cyclone recovery.

7. References

- Winchester, P., 2000: Cyclone mitigation, resource allocation and post disaster reconstruction in South India: lessons from two decades of research; Disasters, 24, 18-37.
Websites:

PDF Reports:
Coastal defence guide
to cope with erosion in the broader perspective of ICZM

Kees Dorst (Rijkswaterstaat, Ministry of Infrastructure and the Environment, the Netherlands)

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2. Coastal guide
3. Vulnerability assessment
4. Strategies for coping with erosion
5. Selection of alternative measures
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Summary
As with many countries in the world, India suffers from coastal erosion. This can have a considerable influence on both the natural and the socioeconomic systems of a country.
A coastal guide has been produced to help coastal managers identify what type of coastal measures they can take to reduce or arrest coastal erosion. It discusses the entire spectrum of (hard and soft) coastal defence measures and the relationship to integrated coastal management. Three main types of response strategies to coastal erosion are distinguished. During the selection process determining the most appropriate measures, several assisting tools are available: Environmental Impact Assessment, Cost-Benefit Analysis and Multi-criteria analysis.
The guide is general in character and based on long term experiences.
The entire 'Coastal Protection Guideline' is made available as PDF report in this CCC Internet publication.
1. Introduction

During missions of Dutch delegations to Tamil Nadu in India in the late nineties, the Dutch members were asked by representatives of several State institutions and the Central Water Commission of the Indian Ministry of Water Resources to assist and co-operate with research and management of the Indian coastal zone. Coastal erosion is one of the severe problems along many stretches of the Indian coastline, both on sandy as well as on rocky cliff coasts. Considering the high population density and property values, efforts to stabilise the coast and protect its features are very important.

Within this framework of cooperation, a number of Indian-Dutch collaborative activities in the field of integrated coastal zone management were undertaken. One of these was a survey of Indian coastal protection strategies, which resulted in a “Coastal Protection Guideline”. The Secretary to the Government of India, the Ministry of Water Resources, receiving the first copy (2001), considered this appreciated ‘Coastal Protection Guideline’, a step towards an Indian Policy Document on Coastal Strategies.

The guide is general in character and can be used in other States and countries with sandy coasts where erosion is prevalent.

Severe Coastal erosion affecting the coastal road, north of Chennai, Tamil Nadu, India. (photo: R. Misdorp)
2. The coastal guide

The coastal guide discusses the entire spectrum of (hard and soft) coastal defence measures and highlights the relationship between integrated management and the various coastal protection options. The guide also contains some technical information and documentation on construction and maintenance of hard coastal protection solutions. This should be helpful to coastline managers who want to know what measures they can take to reduce or arrest coastal erosion.

The coastal zone is not only important to protect the hinterland; it also accommodates various human uses, such as fisheries, recreation, housing and transportation. Integrated Coastal Zone Management is extremely valuable in helping to deal with these different uses and to find the best solution based on a general coastal vision and on a solid consideration of effects and costs.

This is why the guide begins by discussing coastal vulnerability assessment as a first step towards Integrated Coastal Zone Management.

3. Vulnerability assessment

The method of vulnerability assessment can be used to establish whether there is a serious threat to an area or region from erosion. This method, firstly described in IPCC-1991, is also helpful in finding solutions to erosion problems. Coastal erosion influences both the natural and the socio-economic system. Identifying a number of response strategies enables the impact of erosion to be determined and using a standard policy analysis a choice is made between the various strategy options.

The first step is to delineate the area under study. The second step is to collect all relevant data, such as physical characteristics, habitats and species, socio-economic information and land use and values. The third step is to identify relevant development factors, both human-induced and natural. These may include the number of people present (or population density), land use and level of production activities, capital investment levels, natural values, morphological changes and human-induced subsidence. The fourth step is the most important phase of the vulnerability assessment and involves the identification of the physical changes and natural system responses. In step five a response strategy is chosen. An explicit assessment of the costs and benefits of each option should also be included. The final assessment of the vulnerability of a coastal region (steps 6 and 7) takes place in two stages. The first is a consideration of the susceptibility of the area to the physical changes imposed by erosion and the related, potentially adverse socio-economic and/or ecological impacts. The second stage is an assessment of the practical feasibility of response options.

It is wise to put measures for coping with erosion into the broader perspective of Integrated Coastal Zone Management by producing a National Coastal Zone Plan. However, even if no ICZM plan is yet available, it is still possible in the short term to weight up measures for coping with erosion against other interests in the coastal zone. This can be achieved by following steps 5 to 7 of the process described above, which provide an insight into the likely impact of each policy or management response. The benefit of an ICZM plan is that it allows a balanced consideration of anti-erosion measures in the context of other interests and ensures attention to the coherence of the different activities in the coastal zone.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Answers, following questions and actions</th>
</tr>
</thead>
</table>
| Delineation and collecting data  | Definition of coastal features  
Special focus on coral coasts  
Special focus on mangroves and muddy coasts |
| Relevant development factors     | Coastal processes responsible for erosion  
Human use of the coastal zone; human-induced erosion |
<table>
<thead>
<tr>
<th>What do I know about my coast?</th>
<th>Are long-term coastal measurements available?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NO: Start measuring today</td>
</tr>
<tr>
<td></td>
<td>How can I measure beach profiles and waves at low cost?</td>
</tr>
<tr>
<td></td>
<td>YES: Analyse data and determine problem</td>
</tr>
<tr>
<td></td>
<td>Do I understand the processes causing the erosion on my coast?</td>
</tr>
<tr>
<td></td>
<td>NO: Study data and literature</td>
</tr>
<tr>
<td></td>
<td>YES: Do I have acute erosion or chronic erosion?</td>
</tr>
<tr>
<td>How can I preserve my coast and what solution to choose?</td>
<td>Study several alternative strategies and the different measures that can be taken</td>
</tr>
<tr>
<td></td>
<td>Weigh alternatives in light of social-economic-environmental issues; choose most promising</td>
</tr>
<tr>
<td>Needs and actions</td>
<td>Carry out maintenance and monitoring and evaluation on effectiveness</td>
</tr>
</tbody>
</table>

Table 1: How to proceed from an erosion problem to a solution

4. Strategies for coping with erosion

The following text describes how to proceed from problem to solution. The coastal guide provides more detailed information about each step.

Definition of coastal features
This step consists of describing the parts of the coastal zone, which contribute to the protection of the hinterland and of the natural forces that cause coastal change. In the case of the coastline of India, the existence of a monsoon system and the occurrence of cyclones are important factors. Wave action changes twice a year, which causes a seasonal fluctuation of the beaches. Cyclones cause large waves, but also raise the water level in the sea and in combination these usually causes acute coastal erosion. The mechanism involves sand transportation from the dry shore to a point just below the waterline. This sand may or may not be transported back to the beach. If not, it is carried away from the coast leaving it exposed to further erosion. There are many factors involved in determining whether this occurs or not.

Relevant development factors
Before undertaking any action to control coastal erosion, it is important to understand the processes that produce the problem. Most erosion is caused by changes in alongshore transport of sand by a combination of current and waves. Breaking waves generally create a current parallel to the coastline, and this transports sediment along the coast. Because of a movement in alongshore sediment transport, the area just inside the line where waves break will become shallower (in case of accretion) or deeper (in case of erosion). Where such a movement is absent, cross-shore transport is often part of the normal dynamics of the coast and usually nothing to worry about. During a storm, there will be some erosion of the upper beach and in the following calm season, the eroded sand will be transported from deeper water back onto the upper beach. However, where there is an interruption in alongshore transport causing loss of sand, the area just inside the breaker line will become deeper. The consequence is that sand eroded from the upper beach during storms will be deposited in the hole created by the scours caused by the alongshore currents and is therefore not transported back during the following calm season. This means that the erosion of the upper beach will not be replaced by nature.
In practical engineering terms, this means that coastal erosion problems have to be solved by restoring the equilibrium profile in the breaker zone. Almost all the interruption in sediment supply and alongshore transport are human-caused for instance: river damming, sediment extraction in rivers, construction of harbours, dredging access channels, construction of breakwaters and groynes. Apart from erosion due to sediment loss and interruption in alongshore transport, rising of sea levels also cause coastal erosion.

**Solutions to choose**

When the processes that can cause coastal erosion are known, information must be gathered about the amount of erosion and the (socio-economic) costs of all alternative solutions. There are three main types of response to coastal erosion:

<table>
<thead>
<tr>
<th>Buildings</th>
<th>Wetlands</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETREAT</td>
<td>ACCOMMODATE</td>
<td>PROTECT</td>
</tr>
<tr>
<td>Establish building setback codes</td>
<td>Regulate building development</td>
<td>Protect coastal development</td>
</tr>
<tr>
<td>Allow wetland migration</td>
<td>Strike balance between preservation and development</td>
<td>Create wetland/mangrove habitat by landfiling and planting</td>
</tr>
<tr>
<td>Relocate agriculture production</td>
<td>Switch to aquaculture</td>
<td>Protect agriculture land</td>
</tr>
</tbody>
</table>

*Figure 1: Summary of three main strategies addressing coastal erosion (in this example forced by sea level rise; IPCC, 1992).*

1. **Retreat**

This strategy is in fact not to combat the erosion as such, but only to set back and to undo its negative effects. It means that no important developments are allowed in the endangered area. In most cases this is the cheapest solution in the long run. However, it requires anticipation of the erosion, efficient coastal planning and compliance with government decisions and legislation by all those concerned.
Restrictions on land-use are often applied involving a system of setback lines (see Sri Lanka chapter CCC II-6-1) indicating where people are (or are not) allowed to undertake economic or house-building activities because of the danger of erosion. There is a difference between coasts suffering from acute erosion and those suffering from chronic erosion, they need different set-back regimes.

2. Accommodate
This strategy is similar in that it does not try to stop the erosion, but aims to accommodate change. This allows the area to be flooded during cyclones, whilst precautions are taken to evacuate people and minimise damage, for example, by using cyclone shelters, introducing aquaculture and salt resistance strains of rice.

3. Protect
Under this scenario attempts will be made to prevent erosion. This will be achieved either by “hard” or “soft” protection. Examples of soft solutions to chronic erosion are:
- Artificial beach nourishment. This involves man-made deposition of sand on the beach, which is reshaped to a natural profile by the forces of nature.
- Sand bypassing. This is a very efficient use of resources solving the erosion problem by dredging sand bar in a river mouth or lagoon outlet, serving navigation and recycling the dredged sand to the erosion zone.
- Gravel beaches. Instead of feeding the beach, it is possible to reduce the sediment transport capacity by replacing the sand by gravel. This will have the effect of changing the rate of transport capacity and - with the right design - will stop local erosion. However, it is important to remember that this can cause erosion on the downstream side of the protection.

The soft solution to acute erosion is to increase the amount of sand on the beach or in dunes protecting the hinterland.

Hard solutions to chronic erosion may be considered if the coast downstream from the structure is of limited value and therefore expendable. Examples are a single long groyne, or multiple groynes and offshore breakwaters. The differences between these structures are mainly a matter of cost. From a morphological point of view, all these structures act in the same way and it is important to realise that also hard structures require maintenance and often shift erosion problems to another stretch of the coast.

Hard solutions to acute erosion require the construction of a rip-rap revetment, a (vertical) seawall, a sandbag protection, gabions or a dike-type protection. Often hard solutions (e.g. jetties) are used for protecting harbour areas and facilitating shipping.

5. Selection of alternative measures
Erosion is not only a technical problem, but a land-use problem as well. The best strategy to combat the adverse effects of erosion is to select from a range of options, weighing up human and ecological considerations as well as financial and technical ones.

An explicit and well-structured planning exercise based on participation of stakeholders and concise data collection and analysis is crucial to produce rational decisions in the complicated context of land-use planning and coastal zone management.

Environmental Impact Assessment
Once alternative actions or strategies have been specified, environmental impact assessments should be conducted to ensure that the relevant environmental consequences of the various alternatives are recognised early in the project cycle and taken into account in selection, planning and design. The process known as environmental impact assessment (EIA) is an important environmental tool for developers, decision makers and the public (see DR-EIA, chapter CCC III-3-2-5).
Flow chart for solving coastal problems

Figure 2: *Every type of erosion requires a different type of measure.* Some of them are not very relevant to the situation in India, but they are included in order to make the overview more complete.

Cost-benefit analysis
Extended analysis of the costs and benefits of different development alternatives may be used in decision-making. Although many environmental factors are difficult to express in monetary values, this approach has the advantage of representing results in the economic language familiar to decision makers. Cost-Benefit Analysis (CBA) is a tool to
facilitate decision making by comparing the costs and benefits expressed in monetary terms, which can provide a greater insight into the relative value of the identified alternative solutions. The different costs and benefits relate not only to the construction and maintenance of the coastal protection structure itself, but also to associated effects on its surroundings and to society.

Multi-criteria analysis
There are limits, philosophical and/or practical, to the extent to which ecological and socio-cultural costs and benefits can be expressed in monetary terms. Economic cost-benefit analysis is therefore merely one input into balanced decision-making.

Impact assessment produces an overview of the expected impacts of the different alternative strategies. This includes quantitative and qualitative information on indicators or criteria related to the objectives of local, regional and/or national planning rules. In relation to the feasibility of implementation, reference should include social acceptability and institutional change. Scores for such indicators can be qualified in terms of ‘high/low’ or ‘good/bad’.

A Multi-Criteria Analysis (MCA) helps in the evaluation of such multi-objective scores. In addition to scoring, the use of MCA requires weighting, e.g. putting different weights to different indicators.

6. Conclusions
Erosion can have considerable influence on both the natural and the socio-economic systems of a country. Vulnerability assessment helps establish whether an area has a serious erosion problems and to devise response strategies to combat them. The Coastal Guide, downloadable via the CCC-website (see CCC-V-1), may be helpful for this process. It is advisable to put the anti erosion strategies into the broader perspective of Integrated Coastal Zone Management, by drawing an ICZM plan. In this way, their implementation can take account of other interests and ensuring coordination between different activities in the coastal zone, both in the short and long term.

7. References:
- IPCC-IPCC-Intergovernmental Panel on Climate Change, Response Strategies Working Group, 1992: Global Climate Change and the Rising Challenge of the Sea; Ministry of Public Works and Water Management, Directorate General Rijkswaterstaat, Tidal Water Division, the Netherlands

PDF Reports
- Coastal Protection Guidelines: A guide to cope with erosion in the broader perspective of Integrated Coastal Zone Management; RIKZ/CZM-Centre 2001; to download see training manuals: CCC-V-1.
Conclusions - India

Important examples of ICZM development and initiatives in India relate to the following topics:

1) Integrated approaches to river and coastal management to reduce vulnerabilities
Integrated, interdisciplinary water management of the Ganges Brahmaputra Meghna (GBM) river basin including its coastal zone is proposed to start with trans-boundary discussions. Such trans-boundary cooperation, based on economics, would have beneficial effects for all the riparian countries, faced with increased future droughts and flooding. Economical valuation of water for use for people and ecosystems is regarded as a common base for discussion focused on measures to reduce vulnerabilities and increase resilience of the river system. Examples of successful riparian cooperation and negotiations can be found in Europe e.g. the International Commission of the Rhine Basin. In the last decade, several developments in ICZM planning have taken place in India supported by international cooperation. The Indian Department of Ocean Development with support of World Bank and the Netherlands, started the Integrated Coastal and Marine Area Management (ICMAM) project, in 1999. The project focused on producing a development plan and strengthening institutional capacity, in the Chennai area (State of Tamil Nadu). The first results included the development and application of a framework for analysis and an integrated modelling system based on intensive participation of stakeholders, to identify solutions. In about the same period and also with the support of the World Bank and the Netherlands, a project commissioned by the Andhra Pradesh Government involved the development and application of the ICZM approach in the Andhra Pradesh (AP) State, focusing on using ICZM to reduce vulnerability to cyclones. This project included a model of coastal development and an assessment of vulnerability for the Godavari Delta, describing the impacts of cyclones and flooding on the coastal community and their possible recovery over time. The results led to the identification of promising measures to reducing vulnerability and provided a basis for integrated spatial planning of the AP coastal area exposed to cyclone and flood hazards. Although these developments have enhanced the capacities at the planning level it also became clear that the ‘real’ problems in protecting the coast are those that are less visible. The coordination and harmonisation among and between stakeholders can strongly be improved through strengthening the community participation, while effective management needs improved legislation, clear mandates and financial resources.

2) Coastal protection Guideline available on the CCC website
ICZM applications have focused on measures to cope with coastal erosion. This has led to the development of a coastal Guide for the protection of sandy coasts considered from a broad ICZM perspective. The coastal Guide was developed in a number of logical steps, which involved analysing the erosion problems (by the collection and interpretation of data), the identification of developments and evaluation of possible solutions. The Guide stresses the need to consider the trade-offs between hard engineering structures and other solutions taking a long term, land use planning and ICZM perspective in order to achieve sustainable solutions.

3) Local initiatives for improving environmental and livelihood conditions
The variety of specific coastal problems and local circumstances requires tailor made approaches at the grass root level. An excellent example of such an approach is the programme to install artificial reef (AR) modules in the Gulf of Mannar (the South-Eastern tip of the State of Tamil Nadu), which took place in the period between 2002 and 2008. The modules consisted of triangular slabs of ferro-cement with holes of different diameters, which were produced from locally available materials. A monitoring programme revealed clear beneficial effects on fishery production, coral recruitment and creation of new food chains. Hence, it was concluded that such small-scale applications have significant potential for improving the livelihoods of local people. The strong involvement of the local fishery communities, greatly increase awareness of the AR benefits. It contributed to the reduction of the destructive fishing and coral mining. The cooperation between the local Marine Biological Research Station (SDMRI) and Netherlands (expertise and funding) was a healthy one, illustrated by the fact that after the Dutch left, the monitoring and the high sustainable yield of fish continued.
Sustainable, post-tsunami restoration of Aceh - Indonesia

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Summary
The Indian Ocean Tsunami of 26th of December 2004 hit the Province of Aceh in Indonesia hard, causing massive casualties and destruction of houses and infrastructure. An Indonesian - Netherlands consortium developed a strategy for coastal restoration focusing on sea defence, flood protection, multifunction refuge construction and a regional early warning system. A comprehensive strategy was developed based on integration of results of vulnerability assessments, public participation, base-line surveys, modelling and flood mapping, disaster management and public awareness and leading to adaptive and preventive measures. The consortium worked intensively with local government, NGOs and local research centres. The strategy forms the basis of investment packages for restoration of the coastal area of about US$ 120 million. The Detailed Engineering Design and Tender Documents are prepared and the works are being constructed. These works support the people of Aceh and Nias in the establishment of a safe habitable environment enabling economic recovery and sustainable development.

Tsunami destruction Banda Aceh, satellite pictures: before (left) and after the 2004 Tsunami (right) struck the coast.
(photos: © United Nations Environment Programme © Digital Globe)
1. Introduction

In the morning of the 26th of December 2004, a very strong earthquake of 9.1 on the Richter scale (USGS website) occurred below the Indian Ocean, just northwest of Sumatra Island. The earthquake caused a tsunami wave, which hit the west coast of Aceh within 30 minutes. The tsunami caused major loss of life, loss of goods, houses and infrastructure, and a major disruption to social and economic activities. In Aceh and North Sumatra it is estimated that about 130,000 people lost their life and about 37,000 are missing (BRR, 2005).

The impact of the tsunami was well documented:

- Damage to life (160,000 victims) and goods (approx. US$ 5.6 billion)
- About 500,000 Internally Displaced Persons
- Major damage on the West Coast of Aceh over a length of 1,200 km
- Infrastructure destroyed, Banda Aceh to Meulaboh road plus 120 bridges
- Houses (120,000 units), schools (2,000 units), health facilities (127 units) destroyed
- Nias struck by Earthquake in March 2006, damaging houses & roads.

The Indonesian Agency for Reconstruction and Rehabilitation (BRR) and the provincial government (supported by NGOs and international donor community) guide and supervise the reconstruction of the Province of Aceh. Because of the impact of the tsunami, this is an enormous challenge. Since 2005, there has been a massive operation in which houses, schools are being built, damaged roads, drainage, and water supply systems repaired, electricity networks re-established, businesses re-opened, health clinics operating and people resettled.

In order to speed up and structure the reconstruction the BRR has formulated the Aceh Nias Tsunami and Earthquake Response Programme (ANTERP). This programme consists of a number of initiatives, each designed to address the needs of discrete infrastructure packages. One of the initiatives in this programme is the Sea Defence, Flood Protection, Refuge and Early Warnings System (EWS) initiative, an integrated plan by the Sea Defence Consultancy. The challenge faced by the project is to create a safe habitable environment that enables economic recovery and sustainable development in Aceh and the island Nias.

Early in 2006, SDC - Sea Defence Consultancy Project, financed by the Royal Netherlands Embassy, was awarded to a Netherlands - Indonesia consortium. SDC consortium, lead by DHV together with Witteveen + Bos, Deltares and several Indonesian consultants, is to support the Aceh Provincial Government and BRR - Agency for Reconstruction and Rehabilitation of Aceh – Nias.

2. Coastal restoration strategy

Sea Defence Consultancy Project (SDC) started with the formulation of a strategy for coastal restoration and the definition of “wet” infrastructure reconstruction projects. The strategy was formulated based on the following main steps:
1. **Execution of a vulnerability assessment:**
   A vulnerability assessment was carried out based on existing data about physical coastal properties, population data and economic values in the coastal zone (including tsunami damage reports).

2. **Identification of six representative pilot areas**
   Vulnerabilities were studied in depth in selected pilot areas each representing different types of vulnerability conditions such as:
   - **Urban areas in high risk situation,** large flood hazard (low-lying areas in high impact zone) and large impact of such an event (large population rates and economic values);
   - **Rural areas in high risk situation,** large flood hazard (low-lying areas in high impact zone) with smaller impact (low population rate and economic values);
   - **Urban area in low risk situation,** adopted because of reconstruction in post-conflict situation.

3. **Damage inventory of the pilot areas**

4. **Public consultation**
   The main driver for a successful formulation and execution of a sustainable restoration strategy is the organisation of several on-site public consultation meetings in selected pilot areas. Meetings include representatives of local communities, local government (municipality and districts) and representatives of NGOs working in the field of housing and infrastructure reconstruction. By doing so, SDC formulated a demand-based project strategy whereby project ideas and concepts are embedded in the local environment and community. The approach is shown in Figure 3.

![Figure 3: Public consultation: Local Government & Community, leading to demand-based integrated strategy for restoration of Aceh and Nias](source: SDC)

Several rounds of consultation were necessary to formulate the integrated coastal restoration strategy:

- Public consultation 1 of the pilot areas: problem definition and priority setting (engineers view and public opinion);
- Public consultation 2 of the pilot areas: project ideas and first concepts for solutions.

After drafting the strategy, the following consultations were organised for the pilot studies:

- Public consultation 3: preliminary designs and start feasibility studies (EIA, finances, land acquisition, resettlements etc);
- Public consultation 4: draft designs and presentation of results feasibility study;
- Public consultation 5: finalisation and handing over to BRR for implementation (tendering and construction).
3. Results

3.1 Integrated coastal strategy
An integrated strategy was drafted for the coastal restoration of Aceh and Nias in the aftermath of the tsunami based on the approach and lessons learned of the pilot studies.

The coastal strategy results in a combination of adaptive measures (warning system, evacuation and refuge facilities, -zoning risk zones and implementation of setback zones) and preventive measures (coastal protection measures- with a preference for soft flexible measures). The combination of adaptive and preventive measures formed the basis for an integrated approach, delivering far more in reducing the risk of future hazards than just the sum of the elements proposed. Furthermore, the coastal restoration strategy was also implemented for other problem areas identified.

Preliminary designs, detailed designs and tender documents were drafted. These include structures such as flood dikes, drainage channels, outfall structures, seawalls, breakwaters etc. as well as designs for soft measures such as nourishments and re-greening of coastal areas.

3.2 Early Warning System (EWS) and Risk Zoning
SDC has focused on building a complete chain of early warning centres, including generation of a warning signal and warning communication as well as identification of areas at risk and providing escape and refuge infrastructure. This task was supported by zoning of areas at risk.

Zoning helps identify areas that need to be evacuated and areas that are suitable for providing a refuge. Four zones are distinguished: the safe zone, the wet feet zone, the evacuation zone and the direct impact zone. Based on the tsunami inundation map (produced through extensive and state-of-art tsunami inundation modelling) it is possible to produce a zoning map (see Figure 4). A basic principle applied is that for water heights above 1 m evacuation is required.

![Figure 4: Computed inundation map Banda Aceh (left), and zoning map Banda Aceh (right). (source: SDC)](image)

For evacuation planning, horizontal and vertical evacuation is considered. Tsunami inundation maps provide critical information about the required height of escape buildings. Areas are identified in which (existing or new) 1, 2 or 3 storey buildings can serve as escape buildings (see Figure 5). Furthermore, supported by tsunami inundation maps, the location of critical infrastructure can be evaluated such as hospitals, warehouses for emergency goods, police head quarters, communication centres and local government offices. These critical facilities should preferably be located in the safe zone. Facilities in the wet feet zone can be used, but adjustments should be made for flooding and access.
For example, critical hospital facilities (emergency rooms and operation theatres) should be located at the first floor, while the ground floor should be easily evacuated.

![Image](image_url)

**Figure 5:** *Sea Defence Consultancy design for escape building (left), and constructed escape building in Banda Aceh (right).* *(source: SDC)*

### 3.3 State-of-the-art baseline studies

A problem encountered in Aceh (and encountered in many disaster areas) was the lack of reliable data and information as well as consistent approach and guidelines. SDC prepared several state-of-the-art baseline studies to provide a solid base of knowledge and information, necessary for SDC project design but also for any future coastal developments. Results of the studies are available to use for all interested parties, and have been shared through training, workshops etc. (see SDC - PDF Reports)

The baseline studies drafted are:

1. Coastal morphology during and after the tsunami (impact and expected future development)
2. Hydraulic conditions (tides, waves, currents, water levels)
3. Tsunami inundation modelling + damage modelling (tsunami risk assessment, see a modelling output Fig. 4)

A wide range of numerical models was used as basis for the studies, including drainage models, wave models, tidal models, tsunami propagation models, tsunami inundation models, damage models, morphological models etc. Furthermore, SDC tendered out and managed bathymetric and topographic surveys. The surveys were required for design purposes but also forming the basis for a solid monitoring programme.

### 3.4 Awareness building and capacity building

Public awareness and community preparedness are key-elements for Aceh society to be prepared for a potential tsunami. SDC focused on development and implementation of public awareness campaigns, community preparedness and the planning and implementation of regular evacuation drills. In a first pilot phase, a number of small community-awareness events were executed in cooperation with the local University Syiah Kuala, Provincial Red Cross and local disaster management authorities. Events focused on a joint inventory of refuge areas / buildings, escape routes, evening meetings with desa (village) community and finally evacuation drills. SDC's public awareness methodology was further developed based on these exercises. Public awareness programmes were extended and handed over to the consortium of Provincial Disaster Management Agency, University, PMI - Red Cross Indonesia.

Based on the pilot experiences, SDC and partners concluded to focus on the future generation as the special target group. With local experts, help of teachers and trials at schools, course material was developed for primary schools and incorporated through the Department of Education in the curriculum of all primary schools in Aceh.
SDC from its start in 2006 until the end of 2009 has cooperated extensively with local government departments, local institutions, universities and NGOs. By various ways and means (workshops, training, joint exercises, joint policy formulation, joint research programmes) different organisations were supported. Some highlights are:

- Preparation of regional guidelines Aceh & Nias for coastal protection and restoration post-tsunami;
- Preparation of national guidelines for coastal protection (see Box below);
- Joint development of RiskMap (a tsunami warning tool) with local universities;
- Training, hand-over of RiskMap to Provincial Disaster Management Agency and national authorities
- Guidelines on escape routes, designs of refuge buildings and escape areas (including sets of designs of escape infrastructure for the towns of Banda Aceh en Meulaboh)
- Quick scan for escape infrastructure, which was jointly implemented with local government departments along the west coast of Aceh.
- Joint public awareness campaigns with various institutions.
- Institutional strengthening of the provincial disaster management agency.

The Guidelines for Coastal Protection for Indonesia consist of the following subjects:

- Coastal characterisation (based on coastal type, physical properties, coastal land use and functions) and integrated coastal zone management
- Strategy for coastal protection Indonesia (for flooding and erosion)
- Site-specific selection of solutions
- Functional design of solutions

The Guidelines book was accompanied by the Design Manual for Coastal Protection Works, in which a more detailed elaboration of design rules and calculations is given for different types of coastal protection measures, based on site specific data.

For more information on the results of the SCD project, see the extensive list of downloadable SCD – PDF reports.

4. Conclusions

Formulation of a restoration strategy in a post – disaster area faces many challenges. By using an integrated approach, using the knowledge and experience of different disciplines, a coastal restoration strategy can be developed in which prevention and adaptation measures are combined. The strategy is worked out in different Guidelines and tools, which are adopted by the national government departments. Sustainability is achieved by working intensively with local governments and community in the formulation of the restoration strategy. The strategy formed the sound basis for the formulation and design of infrastructure investment packages with a value of about US$ 120 million. The infrastructure packages are currently being implemented and are supporting the people of Aceh and Nias in the establishment of a safe habitable environment that enables economic recovery and sustainable development.
5. References, PDF reports & Websites

References:

**SCD – Sea Defence Consortium PDF reports:**
- *Main report: coastal strategy and design guidelines Aceh and Nias*
- *Volume I: Morphology and Coastal System*
- *Volume II: Hydraulic Conditions*
- *Volume III: Tsunami Modelling and Risk Assessment*
- *Volume IV: Guidelines Coastal Defence Measures*
- *Guidelines for Coastal Protection Aceh and Nias*
- *Manual for the Design of Coastal Protection Works Aceh and Nias*
- *Guidelines for Coastal Protection Indonesia*
- *Manual for the Design of Coastal Protection Works Indonesia*
*can be downloaded through:  http://seadefenceconsultants.com/en-download/

Websites:
- DHV BV: www.dhv.com
- Sea Defence Project: www.seadefenceconsultants.com
Introductory Statement – Seychelles

Rolph Payet
Special Advisor to the President of the Republic of the Seychelles, President & Vice-Chancellor of the University of Seychelles

The Republic of Seychelles practices coastal conservation, preserving coastal vegetation and valuable habitats to help safeguard the livelihood of our population. We take care of our environment through programmes that range from the mountains to the coral reefs.

The public at large actively supports these programmes, which provide a balanced use of natural resources, protection against hazards and attracting tourists in an environmentally friendly way. The experience of the 2006 tsunami shows that an uninterrupted coastal vegetation belt is very effective, helping to save lives and minimise damages to houses and other capital investments.

There is an urgent need for better understanding of coastal processes and the impacts of global climate change, in order effectively prepare adaptive responses. This need is particularly true for all small island nations and the least developed low-lying coastal nations.

The President of the Republic of the Seychelles took the initiative of creating an international Foundation: “Sea Level Rise”, to promote international exchange of knowledge, experience and technology for effectively designing adaptive responses suitable to apply in our islands and coastal countries, and introducing forms of renewable energy to help to mitigate climate change.

International cooperation is essential for the future of our nations, therefore I hope that through the “Climate of Coastal Cooperation” publication the transfer of tools, instruments and technology for adaptation will be stimulated.

Seychelles: white beaches and green vegetation belt help to decrease coastal erosion and flooding (photo: R. Misdorp)
Tsunami Mitigation
Nature Conservation pays off

Rolph Payet (University of Seychelles)
Alain de Comarmond (Ministry of Environment & Natural Resources, Seychelles)

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2. Forests
3. Characteristics of coastal vegetation
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Summary
The Republic of the Seychelles pays particular attention to maintaining its vegetation on the mountains slopes, the terrestrial coastal plain and in the coastal areas offshore. Protecting the vegetation helps protect the population against hazards and reduces the impacts of tsunamis and climate change. The coastal vegetation belt absorbed the waves associated with the major 2004 Tsunami, provided shelter for the people living close to the shore and prevented large scale flooding and erosion.
At the same time, the valuable natural resources provide the basis for attracting tourists who make a considerable contribution to the national income.
An holistic vision for sustainable exploitation of the coastal resources is in place, based on legislation and cooperation. Preparing for future global changes is a challenge for the island community as a whole and international cooperation is actively pursued. The recent creation of the international Sea Level Rise Foundation by the President of the Republic of the Seychelles is an example of the high-level awareness and commitment to preparing adaptive strategies in the face of future global change.
1. Country introduction

The Republic of Seychelles is an island country, consisting of 115 oceanic islands in the western part of the Indian Ocean, some hundreds of miles north east of Madagascar. The Seychelles has a total land area of 455 km² and a total sea area of 1.37 million km². Forty-one of the islands are granitic and they are located within a radius of 50 km from the main granitic island, Mahé. The granitic mountains are densely forested and range up to 900 m elevation. The remaining 74 islands are very low-lying coral islands.

The country has a rich and varied series of habitats, which include a number of endemic species, which deserve conservation and protection.

The Seychelles islands form part of the Indian Ocean Biodiversity Hot Spot and Centre of Plant Diversity (CEPF, 2001). Maintaining the biodiversity of the islands is therefore of utmost importance, particularly in terms of plants, invertebrates, amphibians, reptiles and fresh water fish. The Seychelles has a coral reef area of 1,690 km² with 310 coral species, including eight sea grass species, and 29 km² of mangrove forests with seven mangrove species. The islands form a critical stepping-stone in the bio-geographic distribution and recruitment of shallow marine species across the Indian Ocean.

Figure 1: *The Seychelles, the archipelago* in the western part of the Indian Ocean on its submarine plateau and the main Island Mahé (total length of 30 km) with the capital Victoria, mountains up to 900 m elevation and large scale land reclamation in the sea. The international airport is constructed on the south eastern part of the land reclamation area.
In 2009, 87,500 people inhabited the Republic of the Seychelles, of which 88% live on the granitic main island of Mahé and 10% live on the granite islands of Praslin and La Digue. The 74 low-lying coralline islands support a population of only a few hundred people (FOSA 2001).

The economic development is concentrated on the narrow coastal plain of the three granitic islands. The main economic sectors operating in the coastal areas are agriculture, fisheries and tourism. The tourist sector employs about 30% of the labour force and provides more than 70% of hard currency earnings. The total GDP in 2006 was $593 million and GDP per capita about $7,000 (constant 2000 US$, WRI).

2. Forests

The forest area cover (including coastal vegetation) is estimated at 90% of the land area of Seychelles. About 90% of the forests are natural, while plantation forests cover the other 10%. These forests protect biodiversity, act as water catchments and are under great pressure from various development sectors. The vegetation on many granitic islands consists of lowland forests (0 - 300 m above sea level), intermediate forests (300 - 550 m above sea level), and mountain moss (above 550 m). The slopes of the mountains are covered with forest, which functions as protection against severe soil erosion during torrential rains.

The pressure is highest on the coastal plain consisting of valuable coastal ecosystems such as lowland woodland, dunes, beaches and lowland wetlands including mangroves and in the sea: sea grass and coral ecosystems (see Figure 2). The coastal plains of the three main populated islands of Mahé, Praslin and La Digue are covered by coconut plantations, trees of agro-forestry value and native coastal vegetation.

3. Characteristics of coastal vegetation

The Seychelles has characteristic and distinct vegetation zones typically associated with small island states. The zones are in a natural equilibrium. For example forest operations in the mountains, affecting the lower lying areas, is strictly limited by regulations effectively enforced by the Ministry of Environment and Transport. The population at large supports this enforcement, which is well aware of the high value of the vegetation in the mountains and coastal plains.

![Sketch of vegetation zones from Mountain to Coral Reef, Seychelles](source: R.Misdorp)
Littoral zones
The coastline of the Seychelles includes a combination of sandy shores (beaches and sandy flats) and muddy shores derived from fluvial deposits from the islands’ rivers. The coastal vegetation of the Seychelles is varied. The most typical beach-fringed vegetation consists of takamaka, coconut trees, casuarinas, patatran, and vouloutier. These vary in their characteristics. Usually there is a clear distinct zonation: creepers on the upper crest of the beach followed by scrubby vegetation and hard wood species on the back beaches. The rocky shores are characterised by granitic headlands and embayments, dropping directly into the sea.
This zonation is not always present. Where shrubby vegetation is absent, the back-beaches and the buffer of coconut trees, takamaka trees and casuarinas, are more exposed to wave action.

Figure 3: Cousine Island, just West of Praslin Island, with creepers and scrubby vegetation on the beaches. (photo: Alain de Comarmond)

Mangrove forests
Mangrove forests also form a major component of the Seychelles coastline; there are 7 different species of mangroves present in the Seychelles. Mangroves act as a barrier between the sea and the land. Soil washed down by the rivers is trapped in the mangroves and helps protect the coral reefs from siltation. Mangroves also protect the edges of the land from erosion by reducing wave action. They are a habitat for many species of fauna and form important spawning areas for many of the popular reef fishes of the Seychelles. Mangroves are also habitats for many invertebrates in the Seychelles.

Figure 4: Mangrove forest on Silhouette Island, 15 miles NW of Mahe Island, Seychelles. (photo: Courtesy of Department of Environment)
Unlike many other countries mangroves in the Seychelles are not exploited for firewood and timber or used in other direct ways. At some locations mangrove forests are used as express or access-ways by fishermen. One of the major problems of the mangroves is littering. Traditionally wetlands are viewed as ‘smelly wastelands’. Small illegal reclamation by private landowners and developers still occur occasionally and are dealt with under the Environment Protection Act 1994. All mangroves in the Seychelles are protected under this Act 1994. There is a National Wetlands Policy, which highlights the importance of the ecosystem and grades the different wetland areas into categories depending on their biodiversity. Seychelles is a party to the Ramsar Convention and has already declared one of the largest mangrove areas in the Seychelles at Port Launay and Base Ternay, in the western part of Mahe Island (see Figure 1) a designated Ramsar site.

4. Role of coastal vegetation against hazards: tsunamis and cyclones

The 26 December 2004 tsunami hit the east coast of Mahe and Praslin at midday, an extreme low tide was immediately followed by 2.5 – 3 - 3.5 metres high waves. Refracted waves also hit the west coasts, half to one hour later. A second, somewhat smaller wave hit the coasts four hours later. The sea water surges caused local flooding. Two people were killed and the infrastructure damage estimated at 30 million US $ (UNEP, 2005b). The damage to the natural resources (UNEP, 2005c) needing short and long term interventions which were estimated at 4 respectively 35 million US $.

The tsunami was followed by extreme rainfall (250 mm) in the northern and central areas of Mahe, causing severe landslides, tree and rock falls. This caused associated damage to houses, infrastructure and vegetation on the steep slopes. The coastal vegetation in the Seychelles plays a vital role in protecting the coastline and infrastructures against coastal hazards such as storm surges, tsunamis and sea level rise.

Such vegetation acts as a natural barrier against all those forces. The typical Seychelles coastal vegetation holds the beach system together providing natural resilience, absorbing and dissipating the energy exerted on the coastline or beach. The tsunami highlighted the importance of this protective function. The sheer force of the Tsunami waves, however, destroyed in several locations the most seaward vegetation (see Figures 5 and 6), causing beach erosion and associated uprooting of palm trees. The more landward vegetation was able to withstand the enormous waves more easily.

Figure 5 Crushed coastal vouloutier (Scaveola cereceoa), hours after tsunami struck Anse Royale beach with waves of about 3 meters height, (photo: A. De Comarmond, 26 December 2004)

It became clear that the impacts of the waves were more obvious and the extent of the damage inland was greater in the few areas, which lacked coastal vegetation.

Thus protecting mangrove systems and coastal vegetation in turn helps protects the inhabitants from severe storm surges and tsunamis. This vegetation with its natural beauty and high biodiversity also supports for a large part the Gross National Product by attracting tourists.

Environmental conservation from the mountains to the reef remains the basis for the present and future economic sustainability of the Seychelles.
5. Management of coastal vegetation

For all developments and at all scales, the protection of coastal vegetation is of high priority. The management of the vegetation is covered by several managerial instruments, policies, regulatory measures, legislatures and management programmes.

The Department of Environment is the responsible agency in the Seychelles for the management of coastal vegetation through its day-to-day activities. The Department has a very strict policy against any activity, which adversely affects all coastal vegetation. It is prohibited to uproot, cut, trip or lop any tree or brushwood without permission from the Department. Strong enforcement is at place when needed.

The Department of Environment’s National Parks and Forestry Section and the Coastal Zone Management Unit has an annual coastal planting programme. Annually about 50,000 coastal plants are prepared in nurseries and then planted at relevant beaches and shoreline on a regular basis. The planting activities are carried out by the Departmental staff themselves and by the private sector, NGOs, school children and local communities in general. It must be noted that coastal planting is one of the most popular environmental activities undertaken.

The management of coastal vegetation is scrutinised in the Environmental Impact Assessment (EIA) process for all projects and developments. Setback distances are recommended so as to minimise the impact of construction on existing coastal vegetation. The maximum 25-30 m setback line is not regulated under any legislation or by any written policy, however it is one of the most important, if informal instruments used by the Planning Authority and Department of Environment to control the location of coastal development along the coastline of Seychelles.

In order to complement the values of the existing vegetation developers are always encouraged to plant more to increase the protective beachfront in front of their property.

Special measures are also taken, in order to minimise human impacts on the coastal vegetation. The newly planted seedlings for example, are protected from trampling or being crushed by vehicles at beaches, by the installation of bollards. These restrict the parking areas on the beaches.

6. Challenges

The Government of Seychelles is facing the challenge of finding a balance between economic development and the pressure associated with tourism. Other coastal issues are marine pollution, sewage, coastal degradation and erosion and impacts of climate changes.
The Seychelles are particular vulnerable to storm surges and typhoons. Three impacts of climate change will affect the coastal plains of Seychelles:

- Sea level will rise and increase flooding risk and coastal erosion;
- The cyclone belt is widening and is getting closer to the Seychelles (5 – 10 ° S);
- Sea surface temperature will increase and coral bleaching may be enlarged (UNEP, 2005b).

These impacts will affect the economic sectors the country depends on. The island’s sensitivity is further enhanced by the fact that the main granitic islands, which rise up to almost three thousand feet, have steep hill slopes prone to landslides, and a narrow coastal plain.

The Mahe’s Port, Airport and new land for settlement are built large scale land reclamation areas, protected by revetments. These newly reclaimed areas with a height of about 4 m above mean sea level although well protected, together with other low-lying shores will become more and more vulnerable to flooding and coastal erosion.

A rise in sea level will affect Seychelles if no adaptive measures are or can be taken (FOSA 2001):

- Inundate the low lying part of the coastal plains, effecting the agricultural areas and displacing wetlands;
- Cause the low-lying coral islands, especially the sand cays to disappear;
- Coral reefs will become more stressed by increasing sea water temperature;
- Threaten the fresh water aquifers;
- Increase salinity of mangrove swamps and raise groundwater level affecting plant growth.

The natural protection provided by the healthy island ecosystems, is very important in combating coastal erosion and flooding now and in the future, given climate change scenarios.

In its efforts to build its capacity in understanding the shoreline changes, the Seychelles Government embarked on its National Beach Monitoring Programme in 2003. With this programme, the Department is in a better position to assess and analyse the changes in shoreline and beaches in the long-term.

![Map of Mahe Coastal Resources](image)

**Figure 7:** Coastal Resources of Mahe island. (sources: UNEP 2005a)
7. Conclusions

The Seychelles provide a good example of integrated coastal cooperation in an effective economic and ecologically beneficial way. The cooperation between the Ministries and stakeholders result in effective spatial planning and enforcement to preserve and help the sustainable development of the natural resources. There is a broad public understanding of the natural values that need to be preserved. This includes the awareness on the ability of coastal vegetation to reduce the impacts of hazards, such as were demonstrated during the 2004 tsunami and adapt to future impacts of climate change.

Within this framework, integrated nature conservations is a positive force, which increases coastal resilience. The natural coastal defence provided by coastal vegetation proved to be successful against the 2004 tsunami: saving lives, houses and natural resources. Valuable ongoing integrated coastal management endeavours will be strengthened. This will involve increasing the training of young professionals, improving the capability to monitor the anticipated impacts of climate change, developing adaptive responses and creating a legal framework as an umbrella for these long term and complex activities. The recent creation of the international Sea Level Rise Foundation by the President of the Republic of the Seychelles is a token of the high-level awareness and commitment to preparing adaptive strategies in the face of future global change.

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Sri Lanka
Decades of ICZM experience

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Summary
Integrated management of the coastal zone was needed...that was the notion in the 1970s.
Ongoing coastal erosion triggered the holistic integrated approach. Step by step the coastal zone management programme was broadened to include management of other issues such as water quality, coastal fisheries and aquaculture. In addition, the traditional approach to combat coastal erosion through structural solutions (hard and soft measures) was broadened to non-structural approaches such as to prevent devastating sand and coral mining.
The success of the ICZM approach in Sri Lanka was based on adopting the Coastal Conversation Act, creating the Coastal Conservation Department, producing and updating CZM Plans and creating Set back Areas. The Sri Lanka ICZM programme has also been the testing ground for emerging planning approaches such as Special Area Management Planning, that provide for greater involvement of the stakeholders and the local level administration.

The low-lying parts of the Sri Lankan coastal zone are vulnerable to the impacts of climate change and coastal hazards. The tsunami of the December 2004 inundated large areas along the east, south and southwest coast. Climate change will pose a series of extra challenges due to increasing storm surges and sea level rise. Intensified coastal monitoring and a long-term vision are prerequisites for timely adaptive responses.

Continued cooperation between international, national and local levels is one the key factor for the success of the Sri Lankan ICZM programme, now and in the future.

The topography of Sri Lanka with the narrow coastal zone. (image: NASA/JPL/NGA)
1. Introduction

Sri Lanka has a population of about 21 million inhabitants and more than of the population lives in the coastal districts. The relatively narrow coastal zone (Figure 1) is densely populated (480 inhabitants/km^2) and has many functional uses. It contains very productive ecosystems that sustain a large part of the country’s people, flora and fauna.

Demographic and economic developments have increased the pressure on the resources of Sri Lanka’s coastal zone. These stresses cause serious environmental problems, including degradation of protective coral reefs and mangroves. For many years, coastal erosion has continued to be a critical problem. Furthermore, the anticipated impacts of climate change may exacerbate the vulnerability of the Sri Lankan coastal zone.

2. ICZM programme and outcomes

Realising that a more planned and integrated approach for managing coastal problems was needed, an Integrated Coastal Zone Management (ICZM) programme was developed based on the Coast Conservation Act of 1981. The adoption of CZM Plan (1990) and “A Resource Management Strategy for Sri Lanka’s Coastal Region – 2000” (1992) provided the policy framework. In the early phase, the programme focused its attention mainly on mitigating coastal erosion and reducing the impact of coastal development by regulating the location of new developments and to a lesser extent, managing coastal habitats. In the later years, the programme was broadened to include other aspects of coastal management: water quality, fisheries and aquaculture. Realising that local level implementation and community involvement are key to effective management, the programme has over the years sought decentralisation. It must be noted however, that prior to 2009, due to the civil strife that prevailed in the North and the East, the ICZM programme did not at first cover these coastal areas. An overview of the key elements of the ICZM programme is provided below:

The Coast Conservation Act -1981

The Coast Conservation Act is recognised worldwide as a pioneering piece of legislation. It provided a solid legislative framework for integrated coastal zone management in Sri Lanka, at a time no more than a handful of countries had initiated similar programmes. The Act laid the foundation for the establishment of the Coast Conservation Department (CCD) and an Advisory Council comprised of government and non-governmental officials. The Act also established a ‘Coastal Zone’ extending 300m landward and 2 km seaward (Figure: 1) within which all development activities, which altered the physical state of the coast, such as construction, dredging and laying pipelines are regulated and managed through a permit system.

Figure 1 : ‘Coastal Zone ’ as defined in the Coast Conservation Act – 1981. (source: Coastal Zone Management Plan, 2004)

Permits for smaller constructions are issued at the provincial/district level. Permits for larger houses, commercial and industrial buildings and other structures are issued by the Coast Conservation Department (CCD). For larger developments, the developer needs to prepare an Environmental Impact Assessment (EIA), for which the criteria and procedures are contained in the Coastal Zone Management Plan. The Act also sets out punitive measures for activities that contravene its provisions.
Coastal Zone Management Plan (CZMP)
The Act mandates the Coastal Conservation Department to develop a Coastal Zone Management Plan (CZMP) and update it regularly. The first plan was produced in 1990 and revised plans were developed in 1997 and 2004. The broad objectives of the ICZM Plan are to:

- Identify the nature and magnitude of the problems and issues to be addressed
- Give an outline of the existing plans, policies, programmes, laws institutional mechanisms and enforcement regimes that influence the management of coastal resources;
- Present objectives, policies, strategies and proposed actions for managing the coastal zone and its resources.

Considering the limitations imposed by an inadequate information base, restricted financial resources and technical capacity, an incremental approach has been adopted for the Plan development process. The 1990 Plan addressed coastal erosion, coastal habitat management and management of areas of archaeological, cultural and historical significance. The scope of the 1997 Plan was broadened and included coastal pollution control and Special Area Management. The 2004 Plan addressed, in addition, the issue of integrating coastal fisheries, aquaculture and public access.

Coastal erosion management
Since the publication of the Coastal Erosion Management Plan in 1984, coast protection has been undertaken in a more integrated and a planned manner. The measures employed to manage erosion, consist of a mix of engineering and non-engineering measures. Engineering measures include hard structures such as revetments, groynes and offshore breakwaters (Figure 2).

Over the years, the design and construction methodology have improved, and monitoring, consultation with stakeholders, as well as implementation of emergency protection measures have also become more effective. Non-engineering measures include the control of sand and coral mining, and the imposition of setback areas for coastal development. The Coastal Conservation Department (CCD) uses the permit procedures to direct new development activities away from erosion prone areas and to prevent new coastal construction exacerbating erosion.

![Offshore breakwater, Revetment, Groyne](image)

**Figure 2: Structures to combat coastal erosion**: ‘hard’ in places combined with ‘soft’ measures. (photos: Coastal Conservation Department, Sri Lanka)

The selection of erosion management methods have been a compromise between protection requirements dictated by land use, maintenance capability, environmental requirements and the availability of immediate and long-term funding. Since 1985, several large-scale erosion management schemes have been implemented. Since 2002, in certain stretches of the west and southwest coast, sand nourishment in combination with holding structures has been carried out. Overall, the erosion management measures undertaken to date, provide protection for about 80% of the erosion prone area along the west and southwest coast. Regular monitoring, periodic maintenance of hard structures and sand replenishment are required to ensure continued stability of these areas.
The Coastal Zone Management Plan of 2004 recommended addressing the problem of coastal erosion more holistically. It calls for a broader scope involving the investigation of erosion trends, land and beach use, and socio-economic and environmental conditions in the area under consideration.

Coral mining prohibition
In view of the alarming levels of coral mining, especially along the south and southwest coasts and its impact on beach stability, the Coast Conservation (Amendment) Act No 64 of 1988 prohibits mining, collecting, possessing, processing, storing, burning and transporting in any form whatsoever of coral within the coastal zone. Collection of corals for research purposes is permitted. A CCD study in 1984 revealed that many thousands of tons of coral were extracted annually in south and southwest Sri Lanka. This caused severe coastal erosion, decreasing the natural and touristic values of the coastal areas. Since coral mining provided a lucrative means of livelihood and employment to a large proportion of the population in certain areas the implications for the local economy was considerable. As of 1991, enforcement of this measure and its effects on the livelihood of coral miners was the most difficult challenge faced by the CZM programme. Due to the prohibition imposed by the CCD coral mining was reduced to 50% in 1994. (Seneviratne, 2005).

Regulating sand mining
The primary source of sand to the littoral budget in Sri Lanka is the sand brought into the coastal waters by rivers. Deficiency in this supply would therefore affect the nourishment of the beaches. In the early eighties, the levels of sand mined from both rivers and beaches increased rapidly. A CCD study carried out in 1984 revealed that in the western and south-western coastal areas alone, about 1.5 million m$^3$ of sand was extracted annually from beaches and the lower reaches of the river. Since 1984, the removal of sand from the coastal zone is regulated through the permit procedure and guidelines for sand removal have been developed. A National Sand Study (NSS, 1992) and the follow-up interim sand study undertaken by Lanka Hydraulic Institute, investigated how to prevent and mitigate environmental hazards and degradation caused by practices of sand mining. It also investigated practical alternatives for to the use of river sand, such as using washed sea sand pumped from deep offshore waters. (Hettiarachchi & Samarawickrama, 2005).

Setback Areas and response to the 2004 Tsunami
In the 1980s, so-called setback lines were defined as a geographical strip within which certain development activities are prohibited or significantly restricted. They comprise a reservation area in which only absolutely essential uses/activities are allowed and a restricted area, which can be used for a few low impact activities such as small dwelling units (Figure 3).

Variable setback lines, determined for different coastal sectors, were based on a variety of parameters including coastal erosion rates, coastal geomorphology, extent of coast protection measures already in place and vulnerability of coastal habitats (see: http://www.coastal.gov.lk/Coastal_Setback.pdf). The setback guidelines have been revised on the basis of new criteria and new information and are published in the Coastal Zone Management Plans.

In the wake of the Tsunami in 2004, that ravaged the coastal areas, there was much discussion about setbacks lines. The immediate response of the Government was to declare a 1000 m setback line without due considerations of the implications of establishing and maintaining an area free of development.

Figure 3 Setback Area applied in Sri Lanka. (source CZMP 2004)

Subsequently, a buffer zone of 100 m along the west and southwest coast and 200 m along the east coast was declared. However, these declarations failed to recognise the implications of existing laws and regulations, the absence of adequate land outside the buffer zone and the socio-economic implications of large scale resettlement of people (Karunaratne 2008). Further study of the Tsunami impacts and considering the implications of a wide buffer zone, the Government has reverted
to the original setback guidelines contained in the 1997 Plan. Broader buffer zones were only put in place in the most vulnerable areas.
During post Tsunami reconstruction activities included: altering the design parameters for coast protection structures and some harbour breakwaters were altered by increasing the heights in order to provide additional safety, and attempts were made to re-establish greenbelts in some areas. Observations during the aftermath of the Tsunami, made clear that intact coral reefs, vegetated dunes, deep stands of mangrove forests gave significant protection to the coast behind them (UNEP, 2005).

**Decentralised approach and Special Area Management (SAM) Planning**
The Sri Lanka ICZM programme has also been the testing ground for Special Area Management Planning providing greater involvement of the stakeholders and the local level administration. Sri Lanka’s initial coastal management efforts were centrally planned and administered. Small-scale fish farming, mangrove clearing, lagoon fishing, waste dumping and other activities may be relatively insignificant, but the cumulative impacts degrade and deplete coastal habitats. Effective management of these local activities require the support and empowerment of the local administration and the local communities.
Special Area Management (SAM) Planning was seen as an opportunity to organise local communities, identify local problems and design strategies for collective management on the level of community residents and local agencies. SAM plans are a bottom-up strategy for managing coastal resources that complements the existing top-down regulatory approach in Sri Lanka. Participation by community residents or stakeholders in planning and management is central to the SAM concept. The SAM projects include several types of management interventions including education and awareness programs, collaborative self-management, capital development projects, micro-enterprise development. In the mid-1990s, three pilot projects were developed at Rekawa Lagoon, Hikkaduwa and Negombo lagoon/Muthurajawela wetland area.

1. **Pilot Rewaka Lagoon – south coast - 75 km E of Galle**
Rekawa Lagoon (area 250 ha) is a shallow and brackish coastal lake, situated along the south coast 75 km east of Galle. It receives freshwater from the river Kirama Oya and is connected to the sea via two outlets. The presence of mangroves, along with coral reefs and five species of globally threatened marine turtles in nearby coastal waters, give a high biological value to the lagoon and surrounding environment. Fisheries are the most important livelihood of the rural village community.

One of the main components of the SAM plan was to stop destructive activities, such as coral mining and mangrove removal. The plan addresses problems such as: poverty in the community, coral mining, sea turtle egg poaching, restricted water exchange between sea and lagoon, and overfishing in the lagoon. The Fishery Cooperative Society adopted rules governing lagoon access and gear requirements. The initial implementation of the plan received external support from the ADB (Coastal Resources Management Project).

![Figure 4: Rekawa, the lagoon system along the south coast of Sri Lanka. (photo: Google Earth: Image ©2009Geo Eye Image 2009 TerraMetrics 2009 Google)](image)

The basic objective of the plan was resource management, combined with community and livelihoods issues. For example:

- A causeway structure was replaced by a bridge, allowing exchange of water and shrimp larvae and, increasing the shrimp production and water quality of the lagoon and
- Promoting eco-tourism to provide alternate livelihood opportunities
2. Pilot Hikkaduwa – 15 km NW of Galle

Hikkaduwa is a tourist resort about 100 km south of Colombo. The 4 km coastal strip bordering Hikkaduwa town was known for its coastal reefs, sandy beaches, waves and relatively clean marine waters. The rapid growth of tourism has contributed to a number of problems, including degradation of the coral reef ecosystem (mainly due to coral mining), deteriorating coastal water quality, increasing traffic congestion and noise, and conflicts between tourist and fishing interests. The main SAM activities planned were the construction of a central sewerage and a waste management system, construction of a fishery harbour and the establishment of a marine reserve. The marine area near Hikkaduwa was declared a nature reserve in 1988 and upgraded in 2002 to be one of the two marine nature parks of Sri Lanka.


The Muthurajawela Marsh and Negombo lagoon wetland ecosystem (7,000 ha) is situated near Colombo. The marsh and lagoon system provides numerous services, both to people and nature, and the total economic importance of the estuarine system exceeds 8 million US$ annually (IUCN, 2003). However, there is little management of the wetland resources and the system is under severe stress due to destructive fishing gear, encroachment into the lagoon, expanding housing areas and water pollution, and social disparity. The communities were initially not organised at a level that allowed them access to technical or policy discussions. In 1991, the Greater Colombo Economic Commission (GCEC) and Euroconsult Netherlands, began an Environmental Profile and a Master Plan for the Lagoon ecosystem with funding and technical
assistance provided by the Dutch government. The Wetlands Conservation Project of the Central Environmental Authority (CEA 1994, 2003) piloted the process of Special Area Management. Some of the results included:

- The declaration of the Muthurajawela Marsh Conservation Zone as a sanctuary under the Fauna and Flora protection Ordinance;
- The preparation of a fishery management plan by the Department of Fisheries;
- The boundary demarcation along the Negombo lagoon by a fisheries community organisation;
- The establishment of a Muthurajawela Visitor Centre and related infrastructure such as a board walk through the wetlands for nature education, bird-observation and eco-tourism.

Although the visitor centre is not functional at present, eco-tourism in Muthurajawela Sanctuary is gradually developing (see: Muthurajawela Sanctuary website). Maintaining the infrastructure and assisting the community in effectuating the management plans are the concerns for all involved in this SAM pilot.

![Image of Muthurajawela wetlands and Negombo lagoon](photo: ©2009 Google Data SIO, NOAA, U.S.Navy, NGA, GEBCO Image ©2009 DigitalGlobe)

![Image of Google Map showing Muthurajawela wetlands and Negombo lagoon](photo: ©2009Google Image ©DigitalGlobe Image ©2009 TerraMetrics Data SIO, NOAA, U.S.Navy, NGA, GEBCO)

*Figure 7: SAM pilot - Negombo lagoon and the Muthurajawela wetlands, just north of the capital Colombo.*

3. Experiences in coastal management and cooperation

**Assessment of the Coast Conservation Act**

Recently, the Coast Conservation Act was assessed (Karunaratne, 2008). This assessment revealed that although a comprehensive policy framework is available for the management of the coastal zone in Sri Lanka, the legislative framework in its present form is insufficient to achieve the stated policy objectives. The main shortcomings identified are:

1. More effective control on sand mining by the CCD is hampered by the Mines and Minerals Act of 1992;
2. The definition of the coastal zone is too narrow allowing detrimental activities outside the defined coastal zone, which adversely affect the coastal zone;
3. The absence of a legal basis for Special Area Management.

**Experience with implementation of Special Area Management plans**

The initial implementation of pilot scale SAM plans received financial and technical support from external project funds. In addition to the above three, CCD initiated SAM projects at five other sites.
Although the implementation of SAM plans has had reasonable success at the project level, sustaining their management has encountered problems. Once a project in a SAM site ended, it was difficult for the local authorities and the community organisations to sustain the momentum or continue all the activities set out in the SAM plans. For example, in Hikkaduwa, the local residents and commercial establishments have been slow to construct sewerage connections from their properties to the central sewerage system. In the Negombo lagoon, the Fisheries and Aquatic Resources regulations do not have sufficient legal force to control activities that are detrimental to the marsh/lagoon system. Sustainability of these local level management measures require several improvements at the level of local administration. These include allocation of budget, provision of institutional and legal support necessary for local level implementation through amendments to the Coast Conservation Act and local ordinances, establishment of local level ICZM units with dedicated staff and strengthening of ICZM capacity at local levels. Formal arrangements with local level NGOs are often imperative for effective implementation and sustaining community participation. Where appropriate, planning and management of SAM sites should be incorporated within development plans of regional/national development projects.

**Benefits of ICZM**

The benefits of ICZM deal with improved economic and environmental values for coastal population. Intact and robust ecosystems, such as mangrove, coral reefs and vegetated dunes, are able to absorb strong wave actions. These valuable systems lessen the impacts of natural disasters (tsunamis, cyclones, storm surges) as was experienced in Sri Lanka during the onslaught of the Tsunami in 2004 (UNEP 2005).

As well as offering protection, conservation of the mangrove and coral systems also increases biodiversity, enhancing fish productivity, improves livelihoods and offering high quality tourism.

*Figure 8: Conservation of coastal vegetation is a good investment for coastal protection, EUCC 2006*

**International cooperation**

Planning and implementation of an ICZM programme and associated activities is a comprehensive, long term and complex task. The Sri Lanka programme has been successful in accessing international cooperation and external funding from several sources. Technical assistance and funding to manage coastal erosion, planning and execution of hard and soft protective measures, has come from DANIDA (Denmark), GTZ (Germany), the Netherlands (Ministry of Foreign Affairs, Delft Hydraulics, Arcadis & Euroconsult) and the Asian Development Bank (ADB). The development and implementation of some of the Coastal Zone Management plans and SAM plans was supported by the USAID and the Coastal Resource Centre - Rhode Island, United States.

Because of this foreign assistance and the contributions made by the Sri Lankan government, its Coastal Zone Management Program became a successful model among developing countries.
Knowledge exchange with other Asian coastal states concerning issues such as ecological restoration in coastal zones (e.g. Casuarina shelter belts in Hainan – China and in Tamil Nadu, India) and mangrove planting in Indonesia, Bangladesh and Vietnam (see also CCC II-1, 4 and 8) can be beneficial for strengthening the coastal resilience of Sri Lanka. Thailand’s efforts to restore a degraded aquaculture landscape also provide a valuable experience (CCC II-7-1).

Sri Lanka participates in the South Asia Marine and Coastal Protected Area – network (see SA-MCPA –website). This network of coastal cooperation has recently published a MCPA-Toolkit for South Asia. This Toolkit is built on the Toolkit developed for the West Indian Ocean Region to support the Marine Protected Area - Training Manual (Francis et al. 2003), which was developed with assistance of the CZM-Centre/Netherland’s Ministry of Transport, Public Works and Water Management (see CCC III-3-2-7).

4. Conclusions responding to new priorities

Several recent reviews of the Sri Lanka’s ICZM programme have highlighted the need for review and change in direction of the ICZM programme in Sri Lanka (Coastal Zone Management Plan 2004, Karunaratne, 2008, Lowry et al. 2007 and Wickremaratne, 2007). Some priorities identified include:

- The Coastal Conservation Act needs review in order to strengthen the legislative framework to meet the current management imperatives. The Act should provide for the regulation of activities that are located outside the defined Coastal Zone but having impacts within the Coastal Zone;
- The successful decentralisation through adequately funded SAM efforts should gain more legal and institutional support. They also require financial commitment from local authorities, after the external financial and technical support has come to an end;
- The maintenance of the coastal stabilisation schemes already in place will require the continued commitment of significant funds by the government. Intense efforts to control sand-mining in the lower reaches of rivers needs to continue as well as making available viable alternatives to the supply of river sands to lessen the pressure of coastal erosion;
- Responding to natural hazards, effects of sea level rise, and to changes in storm and rainfall regimes affecting the increasing coastal population will be a growing concern of the coastal managers. Planning adaptive response measures, such as buffer land acquisition proposed in the CZMP 2004, is seen as being even more critical after the Tsunami;
- Although Sri Lankan coastal management agencies are staffed by a number of well-educated and committed professionals, further capacity building is important in the fields of inter-agency collaboration, community based management, monitoring, coastal information systems for the assessment of the impacts of pollution and climate change and identification of adaptive response options.

Sri Lanka is one of the few coastal countries with a long history of ICZM. This long-lasting experience clearly shows that ICZM is a continuous cyclical and interactive process providing the enabling conditions for sustainable development of coastal zones. Continued international cooperation and efforts of the Sri Lankan government are needed to begin a new generation of ICZM activities, which can effectively address the complex coastal challenges ahead.

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Conclusions - Indonesia, Seychelles and Sri Lanka

Although all quite different in nature, Indonesia, Seychelles and Sri Lanka represent typical examples of island states, all three being vulnerable to the effects of storm surges and tsunamis. The latter is certainly true for Indonesia being situated in a particularly active earthquake zone. However, recent events have also shown the vulnerability of more remote areas such as the Seychelles. The three island states, each in their own way, have taken steps to reduce their vulnerability to these damaging events.

**Sustainable, post tsunami restoration in Indonesia**

Triggered by the big tsunami at the end of 2004, Indonesia has taken steps to improve their system for sea defence, involving the development of flood protection measures; construction of multifunctional refuges; and regional early warning (linked to a national early warning system). The improvements for flood protection include design guidelines for sea defence and urban drainage measures, including dikes, drainage channels, outfall structures, seawalls, breakwaters, sand nourishment and the ‘regreening’ of coastal areas. Other improvements relate to the use of integrated spatial planning and zoning principles (based on flood hazard maps from tsunami flood modelling), evacuation routes, training and awareness building.

**Seychelles: tsunami mitigation by nature conservation**

The Republic of Seychelles is a vast archipelago in the western Indian Ocean, including 115 small islands with less than 500 km² within a sea area of more than a 1 million km². Some 40 islands are granitic. The others are low-lying coral islands. The number of inhabitants is less than 90,000. Most people live on the 3 largest granitic islands (Mahé, Praslin and La Digue). The main islands are protected by distinctive vegetation zones from the mountain ranges to the beaches. Coastal vegetation is important for coastal protection. Mangrove belts in particular are also multifunctional and valuable ecosystems.

The Seychelles have been able to protect and maintain their valuable vegetation belts because of effective and enforced legislation, capable institutions and public awareness. The 2004 Tsunami hit the island with 4 metre waves causing only very limited damage. The Seychelles will be vulnerable to storm surges aggravated by the effects of sea level rise and particular the southern islands, may become more effected by tropical cyclones, as temperature increases.

The continuation of the present spatial planning and vegetation protection policies provide a solid basis to help cope with the problems that lie ahead. The Seychelles provide an excellent example of the great benefits derived from their integrated spatial planning approach and nature conservation, its successful implementation and enforcement. Efficient nature conservation management results in effective protection against erosion and flooding, and appreciation by tourists contributing for about half to the GDP of the Seychelles.

**Sri Lanka: the ICZM cradle in Asia**

Sri Lanka has a high population density particularly in its coastal zone. There is also a large variation in coastal areas, which suffer from a variety of coastal problems. The country has a long history of coastal zone management, with ICZM programme development beginning in the 1970s. The first focus was on solving coastal erosion problems. Later on, attention was broadened to include degradation of habitats such as valuable coral reefs and mangroves, water quality issues and sustainable development of fisheries and aquaculture. Developments of the ICZM approach went hand in hand with institutional developments. In addition to these top down planning and institutional developments, special area management (SAM) planning provided a greater involvement of stakeholders and local administration. The range of activities has produced successful examples of improvements for example promotion of ecotourism, the establishment of marine reserves and enhancement of shrimp production by improving water quality and restoring larvae exchanges between the coastal and lagoon waters. However, the experiences in ICZM implementation have also shown severe limitations, for instance in the knowledge base, and weaknesses in the power and mandates of coastal authorities and in the underlying legislation. The experiences in Sri Lanka show that the establishment and implementation of ICZM can be seen as a series of battles, which are not always victorious.
Thai aquaculture: lessons for shrimp farming
Gains and losses, rehabilitation, coastal cooperation and capacity building

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Summary
Thailand is one of the world’s leading shrimp farming nations. Shrimps provide protein-rich food. With the depletion of the ocean fishery resources, shrimp and fish farming become an increasingly important activity. The rapid development of shrimp farming in the vulnerable coastal zone is accompanied by degradation of the coastal environment and the abandonment of shrimp ponds. Rehabilitation is not always possible and if undertaken, can be very expensive. In order to minimise the negative impacts, it is necessary to protect the natural environment. This is not only important for people and the environment, but also for the continuity of shrimp farming itself. Sustainable shrimp farming should be based on integrated approaches of the coastal resource exploitation. Extensive shrimp culture may be combined with other kinds of land use, such as rice production and mangrove plantations. This demands increasing knowledge of coastal processes and strengthening integration between institutions and stakeholders. Capacity building at national and local level is important, some tools are provided and can be downloaded (see CCC V-1).

Black tiger shrimp - Penaeus monodon. (photo: CORIN)
1. Introduction

Coastal regions provide a rich and diverse natural resource. Fisheries are important providers of protein rich food for coastal inhabitants. However, intensive fishing has led to a situation where more than 30% of the world fish species are overfished. Commercial fisheries can no longer guarantee a sufficient food supply, certainly not in the future with a growing human world population.

Aquaculture such as shrimp farming is therefore an increasingly important coastal activity.

In 2002, the world shrimp farming production was about 1.6 million metric tons (Chamberlain, 2003). The majority taking place in South-East Asia: China, Thailand, Vietnam and India together produce more than one million metric tons of shrimps annually. The shrimp culture has developed exponentially.

Species

The dominant species is the giant black tiger shrimp (Penaeus monodon) with a relatively short growing period, great adaptability to salinity changes and a high market price. It is followed by the white penaeid shrimps, often less valued, (P. merguiensis - banana shrimp, P. indicus, P. chinensis) and the dominant species in the Western hemisphere P. vannamei, P. penicillatus (like the white shrimp) and P. semisulcatus (green tiger prawn) are also farmed. The giant black tiger shrimp production worldwide peaked at almost 600,000 metric tons in 1995 and has since declined due to several diseases, as well as the decreasing quantity and quality of wild breeding stock.

The production per ha of the white shrimp (P. vannamei) is getting higher than that of the black tiger shrimp, as demonstrated in the 2000s by Wyban (2007).

Inefficient resource use

The rapid development of coastal aquaculture in the vulnerable coastal zone causes conflicts and inefficient resource use. Consequently the degradation of coastal environment increases, leading ultimately to abandonment of shrimp ponds. Rehabilitation is not always possible and if undertaken can be very expensive. The effects of rapidly developing shrimp culture are well documented in Thailand, and several lessons can be learned. This chapter shows how the boom-bust cycles in Thai shrimp culture developed, as well as some of the effects and integrated solutions for their sustainable shrimp farming in the future.

2. Shrimp farming in Thailand

Thai history

Shrimp culture has a long history in Thailand. About 60 years ago a sudden fall in salt prices, encouraged the coastal salt farmers to diversify their activities. They converted the salt pans into shrimp ponds and mixed several species of shrimp and fishes. Controlling production and larvae growth in the 70s put shrimp culture on a development path based on intensive and specialised production. In the 1990’s, this intensification made Thailand the world’s largest producer, with more than 25,000 farms, covering 80,000 ha and 250,000 metric tons of annual shrimp production. From 1972 to 1999, the area of Thai fish farms increased by a factor of 8 and the production increased by a factor of 200 (Figure 1). A maximum production value of 3.7 metric tons of shrimp per hectare was reached in 1994, followed by a stabilising or decreasing trend.

Figure 1 : Strong intensification of production of the cultured Black tiger shrimps, during the 1990s; 1000 rai = 1.6 km²; 1 US$= 34 Thai Baht. (source: R. Leewis & S. Boromthanarat)
This very high level of intensified shrimp production is unprecedented in the world and made Thailand the leading shrimp farming nation in the world exporting the most shrimp in terms of volume and value.

After 2000, the production of the black tiger shrimp decreased considerably, while the production of the pacific white shrimp (P. vannamei) increased. This reached such a level that Thailand became one the world’s leading suppliers of the white shrimp. A key factor of Thailand’s success with P. vannamei was their controlled brood stock imports to ensure sufficient supplies of true specific-pathogen-free white shrimp (SPF P. vannamei). (Wyban, 2007a). In the years following the introduction of the SPF P. vannamei, the production of shrimps exceeded the 1990’s level. In 2006, P. vannamei represented over 98% of Thailand’s total production and the production is nearly 400,000mt. (Wyban 2007b).

**Intensive farming**

About 95% of the shrimp farms in Thailand are now under intensive production. The majority of the intensive farms use the semi-closed system. Only a few extensive farms are still in existence and there are almost no semi-intensive farms (Huitric et al. 2000). The value of the Thai cultured shrimp production has increased considerably from 20 to 90,000 million Thai Baht during the period 1972 – 1999. The contribution of the shrimp farming to the Thai GDP is about 2% (2002) and constitutes about 3% of the Thai export volume.

**The Boom-Bust cycles in Thai shrimp farming during 1972 - 2000**

Boromthanarat & Nissapa (2002) summarised the development of the shrimp farming industry in Thailand from the early 1970s, and distinguished three series of “Boom - Bust” cycles. The Bust (= abandonment) is followed by moving to the south and west migration of the shrimp farm waves (see Figure 2).

**Thai Shrimp farming:**

**Southward migrating Boom-Bust waves**

![Figure 2: Shrimp farming development in Thailand with southward migrating Boom-Bust waves, reaching the southern province of Nakhon Si Thammarat along the Gulf of Thailand and the coastal areas of the Andaman Sea. (source: S. Boromthanarat)](image-url)
The following Boom-Bust observations were made:

1) The Thai national shrimp farm statistics show only small changes in the periods of 'local' cycles of Boom and Bust. This is due to the quick response of the shrimp farm industry: boom, bust and move to the south of Thailand. This short cycle provides large economic return but is accompanied by severe resource depletion. Three periods can be distinguished in the mid 1970s, the 1980s and mid 1990s;

2) The astonishing rate of intensification during the end of the 1980s and first half of the 1990s, and the first part of the 2000s, resulted in a high production level per hectare (reaching almost 4 ton/ha by the end of the 1990s and is rapidly increasing again). Severe negative consequences have been observed: long lasting, detrimental environmental impacts, and social disruption in the abandoned pond areas;

3) The Thai awareness of the consequences of this very high level of intensification of shrimp farming, led to experiments with modern, more extensive farming at beginning of this millennium;

4) The abandoned, barren and contaminated shrimp farms are difficult to restore. It is easier to initiate a new, short cycle by 'simply' moving to new, southern coastal areas.

![Figure 3: Several boom and bust cycles: shrimp farming development in the province of Nakhon Si Thammarat](image)

**Figure 3: Several boom and bust cycles: shrimp farming development in the province of Nakhon Si Thammarat** (qty = quantity). The smooth increasing value curve (mthb = million Thai Baht) is also influenced by external world market prices. Major causes of the bust are often environmental degradation and subsequent diseases threatening the exploitation of the shrimp ponds. (source: S. Boromthanarat)

3. Impacts of Shrimp Farming on Coastal Resources

**Land conversion & habitat degradation**

In 1995, about 40% of coastal land area in southern Thailand was covered by shrimp farms. The preferred areas are the low-cost lands (Funge-Smith & Stewart, 1996). Shrimp farms have to be located near the sea to facilitate the exchange of water with the sea.

The previous land uses before shrimp farming in southern Thailand are rice paddies (50%), fruit and vegetables, mangrove and wetlands (15%), waste land and extensive shrimp farms (Lindberg & Nylander, 2001). Shrimp farms are responsible for an estimated 30% destruction of the Thai mangroves (Tookwinas, 2001, pers. comm.).

**Pollutants**

Pollution from the shrimp farms largely involves water pollution due to excess use of food, fertilisers, antibiotics, pesticides, and the dumping of sludge from the shrimp ponds. Although the pollution from shrimp farm water is considerably less than from domestic or industrial water, the effects are important. Another problem with shrimp ponds
in mangrove areas is the potential acidity of the soil. The clayey soils often contain sulphuric compounds like pyrite, which become highly acidic when exposed to air. This happens every time ponds are allowed to dry out (in the belief that undesirable substances will be baked out by the sun). It is even more significant when ponds dry out after abandonment.

**Large scale abandonment**

The explosive development of the highly intensified and profitable venture (shrimp farming) has left a large number of abandoned ponds in Thailand. In 1994, there were 20,800 ha of abandoned shrimp ponds (Anon, 1995). A later report (Kaosa-ard and Wijukprasert, 2000) stated that around 40,000 ha of shrimp farming areas in the Upper Gulf of Thailand alone became abandoned during the second bust period, which forced 90% of the local farmers out of business. In the Upper Gulf of Thailand (Hossain, 2001; Hossain & Lin, 2001) some abandoned areas were restored to extensive shrimp farms, salt farms and rehabilitated mangrove, at great cost and effort, and with varying success. Large-scale abandonments leave behind barren land without livelihoods for the coastal people left behind and have severe environmental and social consequences.

**Social impacts**

The conversion of mangroves and rice paddies to shrimp farms is often accompanied by a sequence of social degradations: breakdown of traditional livelihood support systems, leading to the marginalisation of the rural poor; increase of landlessness and poverty; and transfer of land and wealth to local and national elites, strongly benefitting from shrimp culture. Small-scale shrimp farmers, however, are often afraid to invest in shrimp culture due to diseases, debts and other social constraints. Conversion without sufficient knowledge or access to capital is often a source of failure in shrimp culture.

Saltwater intrusion from shrimp ponds and brackish water aquaculture to agriculture land such as paddy fields is also an important source of conflict: Rice yields decrease too such an extent that farmers have either to abandon their land (and often leave the area) or to convert it into shrimp ponds. The salinisation of ground water is another consequence of uncontrolled discharge of saline pond water (Primavera, 1998), reducing domestic and agricultural fresh water supply.

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**4. Sustainable Development and ICZM**

Sustainability for shrimp farming mainly requires two things:

1. Obtaining a reasonable economic return from the activity, enabling farmers and supporting industries to attain a reasonable standard of living and incentives for making long term investments;
2. Minimising the negative social and environmental impacts of shrimp farming is not only necessary to protect the natural values and their “services” for humanity, but is also of vital importance for the continuity of shrimp farming itself. The basis for this lies in the quality of water and soil, and in the continuing prospect of being able to catch larvae or adult specimens in the wild. This means that the quality of the habitats in the sea is important too.

**ICZM**

During the last decade, it has been realised that not only having adequate resources, but also institutions, management and stakeholders are integral to successful shrimp farming activities. Sustainable shrimp farming development using integrated planning tools has become the main concern in the new millennium. These efforts are directed at integrating public participation, policy dialogue and international networking within the context of Integrated Coastal Zone Management (ICZM).

ICZM now faces two important issues related to shrimp farming:

- In areas that already have shrimp farms: restore the abandoned shrimp ponds, the surrounding landscape and the natural values into the ‘natural’ situation; restore basic conditions and original ‘environmental services’.
- For new shrimp farms: avoid the degradation of farming practices; maintain the equilibrium between the various land uses, including the natural biodiversity.
5. Some examples of integrated approaches

Pak Phanang Royal Project
In 1997, the King of Thailand ordered the restoration of the devastated aquaculture area of the second phase of decline, in the Pak Phanang basin in the province of Nakhon Si Thammarat. The King’s order made it possible to give thoughts, manpower and money to achieving this. The Pak Phanang River Basin Development Project is initiated not only to solve the problem of seawater intrusion into the Pak Phanang River and its tributaries during the dry season but also to supply fresh water for the people by functioning as a fresh water storage reservoir to support agriculture uses and daily consumption as well as to prevent the flooding. Moreover, the Project offers solutions for solving the conflicts between shrimp farmers and rice farmers, and in turn, promotes the harmonious co-existence among the people and nature so as to bring about sustainability.

The project is located in the Nakhon Si Thammarat province (see Figure 2) covering about 2,000 ha., which is only 5% of the 40,000 hectares of abandoned ponds in the Upper Gulf of Thailand, as estimated in 2000. The project uses the surplus fresh water from the river Pak Phanang. This surplus water is collected by the construction of a large barrier in the mouth of the river. The actual execution of project started in 1999 and cost about 100 million $, excluding the construction of additional waterways. The water is subsequently diverted to the devastated areas of former aquaculture, and washes out the polluting substances, which are fixed to the clayey sediments of the bottom aquaculture ponds. The outflow then enters the sea. In some areas, proper drainage presents a technical problem, which will take several years to resolve.

Lastly, in the consolidation phase, social structures will be repaired, marginalised families helped and mangrove systems replanted. The rehabilitation costs are high in comparison to the extent of the rehabilitated area.

Figure 4: A part of the Pak Phanang area, before the very intensive shrimp farming started (photo: Processed Landsat TM Image, 1994 – GLCF)
Figure 5: **Image of partly abandoned shrimp farms.** Pak Phanang area (district Rawa, 60 km north of Songkla), Nakhon Si Thammarat Province. (photo Google Earth: Image ©2008 DigitalGlobe Image ©2008 TerraMetrics ©2008 Tele Atlas ©2008 Europa Technologies)

Figure 6: **The river Pak Phanang and the coastal zone.** Areas after abandonment of the no longer productive shrimp farms in the coastal zone. the barren coastal plain is not providing any livelihood for the original coastal inhabitants. (photo: Processed Landsat TM Image, 2002 – GLCF)

**Seawater Irrigation Projects**
These projects support the key policy for sustainable shrimp farming put forward by the Thai Department of Fisheries (DOF). Its primary purpose is to manage seawater supply and farm effluent discharges. The tiger shrimp farms under
the responsibility of this project are given good quality seawater and the system collects effluents from each farm for further physical and biological treatment.

Four operating seawater irrigation projects provide models for improved farm management (see a.o. Tookwinas and Yingcharoen, 1999). The Kungkrabane Royal Project in the east of Thailand is the best example. The success of such projects is based on (i) original acquisition of land, (ii) sense of ownership of the farmers in the project, and (iii) communal leadership. The DOF supports project implementation in terms of both investment and operating costs.

**Shrimp-mangrove experiments**

Attempts have been made to integrate shrimp farming and mangroves into an ecologically robust system, such as incorporating the mangrove buffer zone in Kanchanadit district, Surat Thani province. This coastal province is the largest of the southern provinces of Thailand and located on the Gulf of Thailand north west of the Nakhon Si Thammarat province (see Figure 2). The contribution of mangrove to shrimp farming lies in its capacity to act as a bio-filter for shrimp farm effluents, which improves water quality. The filtering capacity of mangroves can only be successful if the density of shrimp ponds is low and the ratio of mangrove area to shrimp ponds is high. Only in this way it is possible to filter the nitrogen and phosphorous loading adequately from an intensive shrimp farming system (Robertson and Phillips, 1995). The positive findings regarding the bio-filtering capacity of mangroves are confirmed by Gautier (2002) along the Caribbean coast of Colombia.

**Shrimp Central Markets**

Before the 1990s there was only one privately-owned shrimp central market in the Mahachai district of the province of Samut Sakhon in central Thailand. In late 1990s two new shrimp markets in the south of Thailand were approved by the Thai Cabinet: one in the Pak Phanang district of the Nakhon Si Thammarat province (government-shared), and one in the Phun Phin district of the Surat Thani province (privately-owned). The establishment of these new markets reduced transportation time and costs, facilitating preservation of the freshness of the shrimps.

Bringing the markets nearer to the production and processing sites may also serve to guarantee that financial benefits will eventually be equally distributed among all stakeholders in the shrimp industry (Nissapa and Boromthananarat, 2002).

**Residues Inspection & Shrimp Product Certification**

The Department of Fisheries has coastal aquaculture centers and stations in all 22 coastal provinces. These have as one of their responsibilities the monitoring of the coastal environment in marine shrimp farming areas. The data obtained are utilised for designing technical advice to farmers. Shrimp, water and sediment in culture ponds are checked regularly for antibiotic residues. In addition, the harvested shrimp are also inspected for antibiotic residues and hygienic checks in order to be able to issue a product safety certificate before export.

6. **Integrated Planning Tool: SAMPAK**

Special Area Management Pak Phanang (SampaK) is an integrated simulation tool, GIS based, that can be used to evaluate the consequences of coastal management measures, prepared and determined by policy- and decision makers. The objective in the application of the tool is to enhance economic growth through sustainable use of natural resources of the Pak Phanang area. SAMPAK is a member of the COSMO-family of GIS simulation models, (see CCC III-3-2-2) a co-production of the Netherlands (RA & CZM-Centre, the Netherlands) and Thailand (Coastal Resources Institute, Prince of Songkla University, Hat Yai, Thailand).

The user of SAMPAK has to go through 7 steps from identifying issues and problems to ranking results using MCA (Multiple Criteria Analysis, see Figure 7) and is thus forced:

* To think of different ways of looking at planning opportunities, and
* To make clear strategic choices on the basis of criteria and scenarios.

The tool allows the construction of a map showing the results of the model in the area under consideration. This very visual aspect makes it a strong tool (see Figure 7).
Figure 7: Screendump from SAMPak

Using this, a policy maker can have a rough idea of the consequences of a decision during the planning phase before the decision is taken! The outcome of the model is not a prediction; it shows however, the direction the development of a region is likely to go.
A Demo-SAMPak application (see CCC III-3-2-2) can be downloaded as member of the COSMO family see CCC V-1-2.


The experience of more than 70 years of shrimp farming in Thailand constitutes a very valuable learning school for other Asian shrimp farming nations.
This awareness formed the basis for developing an ICZM-aquaculture training module, based on the design and testing of a provincial level coastal aquaculture programme. This module was developed by Leewis and Boromthanarat (2003) for the CCP programme in Vietnam (see CCC II-8) and is now available as CCG-PDF (see CCC V-1).
It shows the position and development of Thai and other Asian countries shrimp culture against the background of world production figures. It then illustrates the detrimental effects on ecology and (local) economy of mismanaged shrimp culture ponds. Some rehabilitation projects are shown, but the most important part of the module is the identification of the measures that have negative effects and hence should be avoided, if a sustainable shrimp farming industry is to be achieved.

8. Conclusions

Shrimp farming provides protein-rich food. With the depletion of the ocean fishery resources, aquaculture becomes increasingly important. Thailand has more than 70 years of experience with shrimp farming and thus has much to offer in developing an environmentally sustainable industry.
In summary the main developments of Thai shrimp farming are:
• It adds to economic development and constitutes 2% of GDP, 3% of the Thai export;
• Most of the farms are of the intensive type with an average annual production of more than 4 metric tons of shrimps per hectare;
• A cycle of intensive shrimp farming in a particular coastal area can only be carried on for a short time after only a few years it moves from: boom→bust→abandonment of barren ponds→move to exploit new coastal areas;
• Abandonment encompasses large coastal areas: more than 40,000 ha of coastal zone in the southern Gulf of Thailand alone and includes long lasting, detrimental environmental impacts and social disruption in the abandoned areas;
• Rehabilitation undertaken by the state is complex and costly, and not always successful;
• The production level of more than 4 tons of shrimps/ha/year can be considered as a non-sustainable resource exploitation, because of the large scale damage. Rehabilitation is costly, while the gains of short term, intensive shrimp farming production are modest expressed as contribution to the Thai Gross Domestic Product;
• Experiments are being explored by the Thai government in new ways of cultivation, which stress integrated approaches to management (applying ICZM principles);
• These ‘new ways’ demand an improving knowledge base of natural coastal processes and socio-economic conditions as well as strengthening integration between relevant national and provincial institutions and local stakeholders;
• Capacity building at national and local level is important, some tools are provided: SAMPACK and Training Manual with lessons from Thailand.

The shrimp farming industry has brought wealth to a few people (mainly the investors), but the negative effects cost the local communities and national government large sums of money.

The main lesson to be learned is, that it would be wiser to invest beforehand in spatial planning, improved farm management and environmental protection.

By extensive shrimp farming, in combination with other land uses such as rice production or mangrove forests, the destruction of coastal ecosystems can be avoided. The experiments in Thailand help increase our knowledge of sustainable shrimp farming based on integrated approaches to coastal resource exploitation.

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Website:

• **GLCF – Global Land Cover Facility:** [http://glcg.umiacs.umd.edu/index.shtml](http://glcg.umiacs.umd.edu/index.shtml)

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Fisheries and co-management in coastal zone

Yves Henocque (IFREMER, France; Co-Director of CHARM project, Thailand)
Sanchai Tandavanitj (Co-Director of CHARM, Department of Fisheries, Bangkok)

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Summary
One of the main reasons for the creation of the Coastal Habitats and Resources Management CHARM project was the recognition that overfishing of the marine waters of Thailand caused negative effects on the marine fish stocks, ecosystems and the coastal fishermen. The total marine annual catch is double the estimated maximum sustainable yield. The Thai government responded, in partnership with the European Commission, by carrying out the CHARM project. This large scale project has developed its approach around five attributes of co-management: participation, partnership, capacity building, development of integrated approaches and methods, and learning and adaptation. An example of results of this co-management approach is provided in the improvement of fishery status in the Phang-Nga Bay during 1997-2005. The approach has shown that the future of coastal resources co-management for better coastal governance in Thailand lies on the one hand with skilled, self-organised community-based organisations and on the other with strong, committed and enlightened local governance, supported by the national government agencies. Changes in the behaviour all the partners becoming more responsible for local marine resources is as important as establishing proper users rights in a participatory fashion. The future fields of engagement should also be broadened to enhance community based tourism and small enterprises, using the unique richness of the Thai coastal and marine environment in a sustainable way.

Many faces of the sea – a tropical slug.
(photo: CHARM)
1. Introduction

Thailand's marine and coastal resources are abundant and unique. Its two distinct coastal areas—the Gulf of Thailand in the South and the Andaman Sea in the Southwest—have impressive natural resources, including mangrove forests, coral reefs, beaches, and wetlands. These resources play an important role in Thailand's tourism industry, trade, local livelihoods, and fisheries. The Thai marine fish resources have traditionally been rich and abundant and marine fisheries contribute substantially to the country's GDP. Of the total marine fisheries, 70 percent comes from the Gulf of Thailand and the remainder from the Andaman Sea. However, the fish stocks are under increased pressure and the marine resources in Thai waters more generally are declining.

Figure 1: The different coastal regions of Thailand
(source: Poonnachit Korsieporn, 2000)

Thailand Fishery Capture Production Marine waters
1950 - 2005 (WRI)

Figure 2: Thai capture fishery in marine waters in metric tons 1950 - 2005, with several interruptions, but with a gradual decline after the 1995 maximum production of 2.8 million m ton. This recognition of gradually decreasing fish production accompanied by an increased fishing fleet, was one of the reasons why the CHARM project was created. (source: WRI, adapted by R. Misdorp)
2. Degradation of coastal and marine resources

Fifty years after the rapid increase in fishing, the success story of Southeast Asian has been revisited. The uncontrolled development of industrial fisheries has resulted in overcapacity and overfishing for decades. Fortunes were made, but now the Gulf of Thailand fisheries are depleted with it an increase in social conflicts among fishermen and their families. This has resulted from an overall failure in managing what was once plentiful – a seemingly limitless resource – just a few decades ago.

With the relative abundance of resources in inshore area (in sharp contrast to the depleted deep sea areas), trawlers and other industrial fishing operations will often and illegally encroach on areas reserved for smaller-scale fishers. This trespassing, facilitated by a lack of cost-effective MCS (Monitoring Control and Surveillance) and insignificant punishment for those arrested for violations has adverse consequences. Illegal fishing not only causes unfair and intense competition for the resources, but also destroys fragile and productive coastal habitats that play an essential role in the biological productivity of tropical waters. They also regularly damage passive fishing gear used by small-scale fishermen.

<table>
<thead>
<tr>
<th>Area</th>
<th>Fish Category</th>
<th>Maximum Yields</th>
<th>Sustainable Yields</th>
<th>Actual Catch (2005) (Unit: tons)</th>
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<tbody>
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<td>Gulf of Thailand</td>
<td>Pelagic</td>
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<td>Demersal</td>
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</table>

Table 1 - Maximum sustainable yields and actual catches in Thai waters. The table shows that the fishing operations in both sides of the Thai waters, the Andaman sea and Gulf of Thailand, are catching more than the carrying capacity of the sea. The total number of the actual catch is nearly double the maximum sustainable yields.

3. Co-management as strategy to improve resources

The tools to address fisheries issues and improve marine resources are fishery plans, policies, laws, taxation and enforcement as well as management. Each can offer a different way of controlling fishing activity and therefore offer different avenues of reform, which are explored more fully in the main project document (CHARM, 2007a).

ICM: IMPROVED COASTAL GOVERNANCE

Figure 3: Co-management arrangement scheme: improved coastal governance towards Integrated Coastal Management (ICM) depends on government, market and civil society mechanisms. At local level, it is conditioned by both skilled self-organised communities and strong committed local governments with Natural Resources

Management Committee, Learning centre and financial (Saving group) facilitating platforms. The awareness and contribution of the education sector (Schools) is considered as crucial for today and tomorrow. (source: CHARM, 2008)
Within this framework, community-based management, and later co-management of fisheries resources, became key strategies for addressing some of the imbalances. Co-management, in particular, introduced a dynamic partnership between resource users and government.

The underlying rationale of co-management is as follows: sound and equitable coastal resources management is not achievable without partnership arrangements in which community and government share the responsibility and authority for the management of natural resources. It is focused on the process: how is the work carried out. It has clear connections to participation and sustainability.

The up-scaling process operates through the provincial governance level and volunteer organisations (VO) supported by coordinated Department, provincial offices and NGO networks (Figure 3; CHARM, 2008). As a driving force, the market mechanism calls for Public-Private partnership agreements. Knowledge centres (universities, research centres) got committed in the governance process through practicing useful knowledge transfers to users and decision-makers. Co-management works at the interface between the ecosystem and the human system, seeking changes in the state of the first by bringing about changes in the behaviour of the second.

4. Coastal Habitats and Resources Management project (CHARM)

In parallel with some measures for the decentralisation of management authorities, innovative approaches such as community-based and rights-based fisheries gained momentum as in Southeast Asia in general. Pilot projects initiated by government agencies or NGOs were an effective way to begin. For this reason the Thai government, in partnership with the European Commission, carried out a large-scale project focusing on Coastal Habitats and Resources Management (CHARM) between 2002 and 2007. CHARM specific objectives were: to design and establish the coastal habitats co-management framework and procedures in two Southern Thailand areas that can serve as models to be replicated elsewhere in the country.

Operating under the Department of Fisheries, supervised by a Project Steering Committee composed of sixteen public Departments and two national private associations, and covering five provinces, the CHARM project was a national project designed to produce positive and sustainable local and national coastal-related policies.
5. Outcomes

For the benefit of the project first beneficiaries, i.e. the coastal communities, CHARM developed its approach around the five attributes of co-management, which are participation, partnership, capacity building, development of integrated approaches and methods, and learning and adaptation (see CHARM, 2008). The outcomes of the CHARM project under these five co-management attributes have the following outcomes:

Participation
At the end of 2006, a total of 479 projects in 50 of the existing 99 coastal Tambons (subdistricts) were carried out, of which 226 were CHARM led projects (funded by EU and Royal Thai Government - RTG). The other projects were “Cooperatives Promotion Department-led” projects and “Tsunami Funds” projects. Totally, the projects had the participation of 14,022 people. These efforts represented a combination of various community initiatives and innovations, including those built on the traditional – but effective – developments.
Participation

Partnership
CHARM has enjoyed the participation of governmental departments, local government agencies, local community organisations and local stakeholders, as partners of the CHARM project. It maintained a special tie up with several Non-Governmental Organisations (NGOs) and have benefited from the roles they have played. In our analysis, the roles in bridging various development gaps that several local NGOs played, were essential in the fast evolving situation and in relation to unexpected events, such as the 2004 Tsunami disaster.

Integrated approaches and methods

Various tools are necessary for groups of stakeholders with mutual interests to work efficiently together. In the early stages CHARM contributed an effective tool for scoping a coastal area plan by producing Vulnerability Maps of the project areas. With the help of an EU expert, we documented an environmental profile and improved the vulnerability mapping of Chalong Bay in Phuket.

In addition, a number of mutually interested groups signed partnership agreements. The “Trang Sea Coastal Management Group” has signed an agreement on Monitoring, Control and Surveillance (MCS) of Trans Sea in an effort to control persistent illegal fishing. The MCS network in the entire Phang Nga Bay will also help the Trang Sea group to provide a stronger deterrent to inter-provincial fishing fleets.

Learning and adaptation

Learning and adaptation are central to any co-management modules. The various stakeholders gather new, sometimes unexpected experiences and knowledge from the joint implementation of agreed activities. Among the field projects supported by CHARM, communities have learnt the value of working in a group. Their combined experience can help secure the desired outcome in relation to a specific issue.

The NGOs working for the CHARM-supported projects have also learnt from the field experience. They now understand development on a wider scale, favouring the ‘ecological unit’ approach rather than their traditional ‘community based’ frame of development.
Learning, discussing and adapting to a changing fishery culture. (photo: CHARM Annual Booklet, 2005)

Building capacity
Different methods are needed for in order to strengthen the development capacity of each stakeholder as they each have different characteristics and needs. The weakest communities and local governments need urgent help. Income generation pursued by community organisations is one way to strengthen this stakeholder group and bail them out of the tenacious grip of poverty. CHARM has not only encouraged them to work as “an occupational group”, but also insisted that they derive lessons to inform future development from self-assessment.

6. Example of a result: improvement of fishery status

The CIARM project does not operate as a separate entity in the overall system. It aims to help the Department of Fisheries and its immediate topic-related agencies. It is therefore realistic to expect that CIARM will make a difference that is incremental and cumulative in relation to other initiatives that have considered by the project for collaborative development.

One of the most obvious results is the improvement of the fisheries status in Phang Nga Bay (ASFRDC, 2007). Figure 4a shows that after the expansion of the prohibited area for trawlers and push netters in 1998, the production of marine produce in Phang-Nga Bay has slowly increased over the 1997-2005 period, although not always smoothly. This was the assumption behind the progressive removal of destructive fishing gear from the area. While push netters and pair trawlers were effectively removed in 1998, beam trawlers catching shrimps and operating inshore were given an extra five years to operate in the bay. The production from beam trawlers (Figure 4: light yellow colour) shows an upward trend until 2003. The decline occurred by 2004, as they were effectively banned from the main part of the bay. The value of marine products rose within the same period (Figure 4b) also due to an increase in shrimp catches and higher quality products.
7. Recommendations

These recommendations are made within the development framework based on the two principles of co-operative management and coastal governance. They provide valuable insights in their own right and in the context of their contribution to the integrated vision described above.

- **Develop a vision encompassing all elements of coastal governance**
  The vision should encompass all the elements that affect the management of sea fisheries. These range from the nation as a whole and include all levels of governance. It should also recognise the dynamic interplay and the flow of information and resources between the different layers of government, the economy and the social fabric of the regions.

- **Strengthen and expand co-management arrangements at local and provincial level**
  The governmental levels and units involved are the village (through occupational group strengthening and networking), the Sub-district (through the setting up of Natural Resources Management Committees, Information and Learning Centres, Saving groups and school network), the Province (through issue-related agreements and planning support) and the seascape management units such as Chalong Bay, Phang Nga Bay or Ban Don Bay.
• **Find a way to relate to each other’s stories**  
Project leaders need to be able to find a way to learn from each other’s experiences. Although each local or regional project has a different starting context, and a different focus, they all involve the same system of actors, institutions, processes and interactions.

• **Strengthen occupational group networks**  
A strong focus on the development of sustainable livelihoods facilitates marine conservation initiatives. Initial field projects focused on single village occupational group development. This has evolved over the years to multiple village occupational groups and more recently to occupational group networks recognised as legally based *community enterprises* and *community network enterprises* under the support of the Agriculture Extension Department.

• **Support the further development of coastal Community-based tourism in Thailand** as an income-generating and conservation awareness activity.

• **Seek and encourage the engagement of the private sector**  
CHARM worked with the diving industry in Phang Nga Bay and some tourist operators. However, the project did not (or could not) include the important private sector stakeholders such as shrimp farmers and commercial fisheries in its co-management activities. They were engaged to a small extent in the last fisheries conflict resolution study.

• **Support coastal resources and marine spatial planning at provincial level**

• **Create the enabling conditions for a more coordinated approach between government agencies**

• **Seek and encourage the networking of NGOs at provincial level**  
CHARM has established working partnerships with various NGOs to implement key elements of the project. This strategy came into its own after the Tsunami, with many Bangkok and Chiang Mai based NGOs moving south to assist local communities. These larger NGOs have been very effective in networking primarily as Save Andaman Network immediately after the disaster.

• **Enhance and integrate Thailand’s coastal-management research**  
There are many universities, institutes, and other organisations involved in coastal resources management related research in Thailand but the focus is more on the condition of coastal resources than on management itself. On the model of the Thailand Research Fund, a Sea Grant Programme could facilitate formulating a national vision, mission, and priorities for integrated coastal management research.

The Marine and Coastal Resources Policy Green Paper (Henocque & Tandavanitj, 2008) provides more information on recommendations towards Sustainable Coastal Development in Thailand, dealing with formulating a National Vision collectively helping conserve the natural resources and enhance environmental quality for the society, six Principles for Coastal Management and collating feedbacks for further development of the Thai coastal policy.

8. **Conclusions**

The achievements of fishers' institutions studied in Southern Thailand highlight the validity of *co-management* in addressing conflicts and gaps in fishery management. Although this approach is typically geographically isolated and cut off from the mainstream management system, *co-management* and *rights-based fisheries* offers much more in terms of establishing a working decentralised system, which can be sustained and implemented on a national scale.  
Progressive decentralisation of management functions to the provincial level should be supported. This should include provision for provincial management bodies to support local fishery institutions. Thereafter, the province could decentralise some management rights to local fishery institutions, with an appropriate legal status. This would establish them as partners of the government in management, together with the granting of group user rights.
The establishment of such rights would ensure a proper understanding of the current fishing capacity in Thai waters, especially including small-scale and non-registered boats/gear. It also allows for the establishment of mechanisms for the control of fishing effort. By ensuring regulations are properly enforced, and with collective action taking place in coastal communities, the behaviour of fishermen will change toward more responsibility for marine resources.

Self-organisation and collective action do not always come easily to fishermen, which often depend on local tradition. Therefore capacity building by government agencies will be a prerequisite to ensure the involvement of most communities in local fisheries management, including solving fishery conflict. Institutional capacity building, begins at the national level, must include provincial management bodies and eventually fishing communities. This is a long term process that will take years and require lasting political will and endeavour.

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Conclusions - Thailand

Aquaculture and fisheries have been very important drivers of economic development in the coastal areas of Thailand during the last few decades. However, due to a number of unsustainable practices, these developments have not brought continued prosperity and led to severe problems especially, for the local and poor communities, and for the coastal environment. Experiences from the past have provided valuable lessons, which could provide a better basis for future development in Thailand and in other coastal areas in the world.

Lessons from shrimp farming

From the 1990s onwards aquaculture and especially shrimp farming has been booming in South East Asia. Thailand has become one of the major producers. These developments were based on a transition from extensive to highly intensified forms of shrimp production, triggered by high prices and good domestic and export market potential (Japan, USA). Unfortunately, the intensive methods proved to be detrimental to the production systems themselves and their environment and led to several ‘boom and bust’ cycles. The boom was achieved by rapid exploitation of vast coastal areas, the following bust resulted from degradation of shrimp ponds and the occurrence of diseases. There were also wider effects on the environment such as salinisation of surface water and groundwater, water and soil pollution (from fish food, fertiliser, antibiotics, pesticides and sludge), acidification of soils and destruction of natural vegetation (mangroves) and agricultural lands. As a result, large contaminated and barren coastal areas were abandoned as they could not provide a livelihood for local people. This disrupted local societies and especially affecting the poor. Investors would take short-term profits and move on to the next coastal area. The main conclusion is that the shrimp farming practices in the past have brought wealth to a few rich investors at an extremely high cost to the local community as well as to the national government bearing the rehabilitation. There are a number of lessons. Firstly, there is an obvious need for sustainable, less intensive aquaculture practices, which can provide a lasting income. This requires investment in spatial planning, improved farm management and environmental protection (including pond refreshment by sea water irrigation and treatment of shrimp pond effluents). Secondly, future aquaculture developments should be under the jurisdiction of local communities, allowing them to protect and exploit their own resources. Because of the harm done in the past, there is a strong requirement to rehabilitate abandoned areas (in Thailand an estimated area of 40,000 ha was abandoned in the Upper Thai Gulf area alone). Rehabilitation is very costly, but necessary to retrieve valuable, indispensable coastal areas. Capacity building is an important element of coastal management. The Training Manual: “Aquaculture experiences in Thailand” is made available, through the CCC website, to promote the application of the Thai lessons in other coastal areas.

Co-management in fisheries

The coastal waters of Thailand (Gulf of Thailand and Andaman Sea) suffer from severe overfishing. The total annual catch in these waters is estimated to be double the maximum sustainable yield. Community-based management (co-management) is considered a powerful way of improving the situation. Co-management is a dynamic partnership between resource users and the government, leading to a community-based and rights-based system of fisheries. The CHARM project (Coastal Habitats and Resource Management) helped with the development and establishment of a framework, which could serve as a model for replication elsewhere in the country. The project identified a number of major co-management issues and developed a scheme to strengthen and liaise with committed local governments and skilled self-organised communities. CHARM supported over 200 projects involving a variety of community initiatives, innovations and developments creating partnerships between government agencies, local community organisations, local resource users and NGOs. This resulted amongst other things in an increase of fishery catches in an area where decrease due to overfishing is common. Furthermore the most devastating manner of fishing was abandoned. Major recommendations include the continued strengthening of community enterprises, the enhancement of community based tourism, the engagement of the private sector and further cooperation and integration of the various parties.
Our country has a long and beautiful coast, rich in coastal and marine resources. We exploit these resources at an increasing pace, contributing to our growing national income. The coastal zone of Vietnam is, however, not only an economically important zone but also vulnerable to the environmental consequences of rapid exploitation and impacts of global change.

Vietnam has taken important steps in the last few decades towards managing and developing the use of these resources in a sustainable way. Legal frameworks for balancing coastal economic development with environmental protection are provided. These include the enacted national Strategy for Environmental Protection 2001 – 2010, and the Regulation on the Survey and Management of Marine Resources and Environment 2010, both accompanied by a long-term vision.

As well as providing the legislative base, we have taken important steps in the process of managing our coast in an integrated manner. We realise that the present and the future coastal challenges are complex and need to be addressed in a holistic way. The knowledge of coastal processes is being improved through increased efforts in monitoring and dissemination.

ICZM programs take place at the national level and in pilot provinces, through international and bilateral cooperation. These ICZM programmes delivered a wealth of products and experiences, which have been extended to other coastal provinces in Vietnam.

We also strengthened the institutional ICZM arrangements through creating a dedicated coastal management centre within the newly established Vietnam Administration of Sea and Islands of my Ministry. This focuses on the application of ICZM, on integrated coastal zone planning including sea use and coastal fisheries.

Much effort is needed to keep pace with the rapid modernisation of our country, balancing the economy and environment, and at the same time preparing adaptive, resilient coastal measures to combat the impacts of climate change.

We are looking forward to continuing the important cooperation with the Netherlands in order to identify, plan and implement adaptive responses for our valuable and vulnerable coastal areas. We welcome this “Climate of Coastal Cooperation” publication reflecting a number of important results obtained in the last two decades of international coastal cooperation.
Vietnam: a decade of Coastal Cooperation
from Vulnerability Assessment to Integrated Coastal Zone Management, from planning to implementation

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Summary
Vietnam has a highly dynamic coast. Its exponential economic growth, has left it critically vulnerable to the typhoons that regularly reach the coast. The projected impact of climate change makes the coast even more vulnerable. A decision-making process based on holistic ICZM provides a flexible approach to achieving more sustainable management in the interests of the population, economic development and the environment. Vietnam has made great strides in developing institutional mechanisms to developing such policies, simultaneously executing an ICZM programme at national and local level. Long-term international cooperation provides valuable experience to help cope with the present and prepare for adaptation to the potential future impacts of global changes.

This chapter describes the approaches adopted by the Vietnamese and the collaborative efforts with the Netherlands in preparing the framework and executing coastal projects during the last two decades. The success of these endeavours can be measured by the self-reliant and ongoing efforts of the Vietnam government to start the ICZM process in an increasing number of provinces, with the support of the Vietnamese Ministry of Natural Resources and Environment.
1. Introduction

Vietnam is a densely populated country with a long coastline. Half of the coastal zone is low lying, and 75% of the population live in provinces near the sea. Half of the major towns are situated in the coastal zone. The Red River Delta in the north and the Mekong Delta in the south are fertile and important economic areas. The coastal plain of the central provinces is relatively narrow and bordered by high mountains.

Figure 1: Vietnam, its 3500 km long coastline and the three coastal VA and ICZM pilot provinces:
1. Nam Dinh, Red River Delta,
2. Thua Thien Hue, central part and
(source VNICZM-Atlas, 2006)

Population and economics
The population density is unevenly distributed throughout the country: the highest concentrations of population (>3000 inh/km²) are found in the two major delta areas. The population is growing steadily, at a rate of 1.2% annually. Vietnam is a dynamic country characterised by strong economic growth. Since the enactment of Vietnam’s “doi moi” (‘renovation’) policy in 1986, Vietnamese authorities have committed themselves to increased economic liberalisation and structural reforms to modernise the economy and produce more export-driven industrial products, such as increasing oil-output.
The agriculture production increased in the same time to such an extent that Vietnam is now the second largest rice exporting country of the world, while in the early days Vietnam needed to import rice.
The economy grew since the middle of the 1990s annually with 6.8% and in 2007 even with 8.5%.
The shift away from a centrally planned economy to a more market-oriented economic model has improved the quality of life for many Vietnamese, the per capita income has been strongly rising since the beginning of the 1990s.

The contribution of the coastal regions to the GDP is more than 80% of the national GDP (VVA, 1996). The largest part of the capital investment occurs also in Vietnam’s coastal region and was estimated to be 2.3 times GDP in 1995. The total (State+ Non-State+ Foreign) investment in Vietnam is growing each year and increased with a factor 6 in the period 1994 – 2010, to a level of 400,000 Billion Dong (at a constant 1994 Dong value) in 2010 (GSO). The 2010 GDP of Vietnam is at 2010 current value 2,030,000 Billion Dongequivalent with 104 Billion $US.
Accordingly, the capital investment in the coastal zone increased also very considerably. Hence the risk of flooding is strongly enlarged through strongly increased economic impacts of a flooding event in the low lying coastal and deltaic zones, as compared with the level of risk in the mid 1990s.

**Political development and coastal legislation**
The management of the coast of Vietnam combines both sectoral and territorial approaches. Ministries are charged with implementing nationwide policies and interests in the relevant sectors (fisheries, agriculture, forestry, industry, tourism). The Provincial People’s Committees are responsible for the development of their Province. The responsibility for decision-making in the coastal provinces lies with three main bodies: the National Assembly, the Central Government (Ministries) and the People’s Committees. The most relevant Ministries for coastal affairs are the Ministry of Resources and Environment, which has a coordinating role for environmental monitoring, Environmental Impact Assessment and maintaining and improving the quality of the water resources. The Ministry of Agriculture, Rural Development and Planning is responsible for water quantity management, flood protection and coastal defence and disaster management, and the Ministry of Planning and Investment for spatial planning and financing coastal infrastructure.

Several Laws, Ordinances and Decrees are important for coastal zone developments, such as the Law on Environmental Protection (1994 and 2005) and, the Decree on State Management of Investment and Construction (1994). The Decree on Comprehensive Management of the Sea and Islands (2009) developed by the government of Vietnam will be submitted to the parliament for approval in 2011.

**Natural coastal habitats and biodiversity**
An overview of coastal characteristics shows the large variety of coastal habitats. Coral reefs on rocky coasts alternate with the Red River and Mekong Deltas, dynamic sandy shores, dunes and tidal mudflats and mangroves. At some locations sea-dikes are protecting the land. The coastal terrain is mainly low and flat in the two deltas and along the large Tam Giang lagoon in the central part of Vietnam. Coastal lagoons occupy about 5% of the coastline and vary in size from several hundred to more than 20,000 ha. The lagoons are separated from the sea by sandy beaches and dunes (up to 25 m high), they are connected to the sea by narrow inlets. These seasonally shifting inlets play an important role in the exchange of salt sea and brackish lagoon water. The residence time of the lagoon water, the water quality (salinity, pesticides, nutrients etc), the water and sediment balance influence nature conservation, fisheries, shrimp (cultures) and rice cultivation.

Tidal marshes in the north (75,000 ha) and in the south (205,000 ha) support 230,000 ha of mangrove forest (VVA 1996). These tidal marshes support more than 60 species of fish, 140 molluscs, and 110 crustaceans, many water birds and mammals. Two thousand marine fish species have been recorded, 70% of which are demersal. The offshore coral reefs house many hundreds of species of marine algae and thousands of marine invertebrate species.

**Land-use**
The distribution of different land-uses in the Vietnamese coastal zone is one of the socio-economic indicators, required for a Vulnerability Assessment (VA) – study. Land-use maps have been made for the entire coastal zone of Vietnam, including the two deltas and are based on Landsat TM-5 images and produced with GIS.

From the 13 identified land-use classes: rice culture and forests, grassland and rural settlements in the north and south, are the most important, see the land-use map of the Mekong Delta region (Figure 4).

**The threats**
The coastal zone of Vietnam is vulnerable to flooding by rivers and sea due to typhoons and associated extreme rainfall events. Flooding has most serious consequences in the economically active areas such as the Red River and Mekong Deltas, as well as in the low-lying central coastal area. An average of six typhoons annually cross the coast of Vietnam, accompanied by heavy rainfall and extreme wind speeds, high waves and storm surges. The Northern provinces suffer the majority of these typhoon events (see Figure 2).
Figure 2: Marine, hydraulic characteristics of the coast of Vietnam:

- Averaged number of typhoons ranging from 2-3 per year in the north to less than 1 in the south,
- High tidal amplitudes in the north and south (up to 4 m, in Hon Dau and Vung Tau),
- Large wave heights, between 9 - 12 m, during 1 in 10 year storm surge events.

(source: Vietnam Vulnerability Assessment, 1996)
The combined effect of typhoons, the steady increase in population and strongly growing economic values has increased the pressure on the coastal resources, leading to unsustainable forms of resource exploitation, increase in environmental pollution and decrease in productivity of the resources. The main environmental threats to the sustainability of the coast and its resources are (Ministry of Natural Resources and Environment, MONRE 2006):

- Unsustainable use of natural resources (manifested by a decline of fish reserves, water resources and mineral resources);
- Degradation of ecosystems such as offshore coral reefs and sea grass meadows, and coastal mangrove forests. The natural value of these coastal wetlands, to protect the coast against storm damage and flooding, has strongly diminished during the last half century.
- Environmental pollution (water and soil) & natural and environmental disasters;
- Population pressure and conflict of interest between coastal stakeholders.

Besides these natural socio-economic pressures, the envisaged impacts of climate change are an ongoing concern.


Introduction
A first exploration of the potential impacts of climate change, such as sea level rise, on the coastal zone of Vietnam, was presented at the World Coast Conference by Nguyen Ngoc Huan (1993). The vulnerability of the coast of Vietnam to Accelerated Sea Level Rise (ASLR) due to human induced climate change was assessed using the UN-IPCC – Common Methodology on Vulnerability Assessments (1991).

The Vietnam Vulnerability Assessment (VVA, 1996) thoroughly analysed the institutional setting, socio-economic developments and changes in hydraulic conditions of the coastal zone. Three scenarios were assessed for the base year 1995, the year 2025 (with 30 years of socio-economic development) and effects of a 1 m sea level rise. Central in the assessment were:

- The GIS analyses: digitised land-use and topographic data were used to determine the areas flooded in two cases (no SLR and with 1 m ASLR);
- The Flooding and Flood Risk analysis: using the GIS input, risk and loss calculations for categories: ‘areas’, ‘people’ and ‘capital value invested’ were performed;
- The Geo-Management System: to store, view and manage the large amount of diverse data of all the coastal units.

A full Vulnerability Assessment (VA) was conducted in 18 months (1994-1996). During this period, the technical capacity of the Vietnamese partners was strengthened through workshops and GIS training courses. These included the application of the tools facilitating decision-making, which were demonstrated through on-the-job training not only in the capital Hanoi, but also in local pilot study areas with different coastal problems. Seven technical reports were produced by a dedicated and large group of Vietnamese, Dutch and Polish experts funded and supported by the Vietnamese and Dutch Government (Ministries of Foreign Affairs, and V&W/CZMC-C). The Vietnamese hosting institution: HydroMeteorological Service / Marine Hydro-meteorological Centre was responsible for the execution of the VVA, with support of W | Delt Hydraulics/Deltares, Frederic R.Harris and the CZM-Centre (The Hague) and the Institute of Hydroengineering of the Polish Academy of Science (Gdansk).

The VVA socio-economic scenarios cover the period 1995 – 2025. Socio-economic predictions over a 30-year period are difficult to make. However, with hind-sight, the scenarios used in 1995 are very good, when compared with the 2008 values of the General Statistics Office (GSO-Vietnam, 2008): Population, Gross Domestic Product (GDP) and Capital Value invested. This provides confidence in the results of the VVA.
Results of the Vulnerability Assessment:

Sea level rise is certainly not the only impact of human induced climate change effecting coastal zones. However, other important impacts such as changes in storm/typhoon regimes and rain intensities were not sufficiently quantified at the beginning of the 1990s to enable analysis to take place. Some of the main findings on the impacts of 1 m Accelerated Sea Level Rise (ASLR) and 30 years of socio-economic development (2025) scenario, in the event that no adaptive measures are taken, were:

- **The Population at risk** of annual flooding would rise by about 60% due to the effect of 30-year (scenario 2025) population growth. The effect of a 1 m ASLR on the population would result in annual flooding affecting up to 17 million people who might need to be moved. Over 14 million of those coastal inhabitants potentially affected will be located in the Mekong Delta provinces.

  ![Vietnam: coastal Population & Capital Value, annually affected by Development (2025) and 1 m ASLR](image)

- **Capital Value (C.V.) at risk** of annual flooding would increase by about a factor 10, due to the effect of 30 year of socio-economic development. The impact of 1 m ASLR on the **Capital Value to be lost** due to annual flooding will increase to 17 US$ billion, a significant proportion of the GDP (Figure 3).

The expected impacts of a 1 m ASLR on the increase of Population at risk is severe; the 30 years socio-economic development is particularly enlarging the value of Capital Investment at risk

- **Coastal wetlands lost** due to a 1 m ASLR could be as much as 60% of those present in the reference year 1995. The most threatened areas will be Minh Hai and the Vung Tau – mangroves near Ho Chi Minh City in the Mekong Delta and the Xuan Thuy Ramsar site at the Red River mouth. These coastal wetland losses will be difficult to prevent because there is no room for them to migrate landward.

- **About 40,000 km2 of the Vietnamese coastal zone** will be subjected to annual flooding in the case of 1 m ASLR. Over 90% of this area is located in the very flat and low-lying Mekong Delta, which will be almost completely inundated annually (Figure 4).

![Mekong Delta – Land-use and Flooding](image)

**Figure 4: Mekong Delta – Land-use and Flooding:**  
*Land-use:* dominant rice cultivation (yellow), rural-urban settlements (red/orange) and mangrove belts (blue green);  
*Flooding:* the Mekong Delta will be annually flooded under a 1 m ASLR scenario (in blue) in case no adaptive coastal protection measures are taken. (source: Vietnam Vulnerability Assessment, 1994 – 1996)
- **Rice production loss**: the Global Vulnerability Assessment (GVA, 1992) revealed that the coastal rice production of Vietnam is very vulnerable. About 15% could be lost as consequence of 1 m ASL. This potential loss of rice production is the highest of all Asian rice producing nations investigated.

- **Protection against flooding**: is one of the three adaptive types of coastal responses identified, the other two are: Retreat and Accommodate (IPCC, 1992). Raising all river dikes and low-lying houses in the Mekong Delta, strengthening coastal defences, installing additional pumping capacity and beach nourishment are all measures to help protect and considerably reduce the level of risk to the population and capital value. According to VVA estimates in 1996, the construction and maintenance costs of protection against the effects of a 1 m ASL are very high: several percentages of GDP.

**In summary (VVA 1996)**: the overall vulnerability of Vietnam to a 1 m ASL, is critically high when considering the values that could be lost and those at risk, and the cost of adaptive measures. Vietnam is in many ways comparable, in terms of vulnerability, to the small island states of the world.

**Integrated Coastal Zone Management** is one of the effective adaptive responses to the potential impacts of climate change.

**A more recent workshop on impacts of climate change in Vietnam**

The importance of analysing the impacts of Climate Change, assessing the vulnerability of Vietnam and identification of adaptive response options has been confirmed during an MONRE workshop in Hanoi (MONRE/ICEM/IIEED, 2007). This workshop discussed the major risks caused by climate change in the coastal region of Vietnam and the need to integrate adaptation measures in the development planning process. One of the outcomes was to focus on an analysis of the vulnerability to sea level rise, storm surges and flooding on the most affected districts and communes. The above VVA 1996 results could serve as a well-established methodological base for further detailed vulnerability assessments, integrated management, and identification of adaptive, no regret responses.

**3 The Vietnam Netherlands ICZM project (VNICZM, 2000-2006)**

The Vietnam-Netherlands Integrated Coastal Zone Management project (VNICZM project) was conducted under the leadership of the Vietnamese Ministry of Environment and Natural Resources (MONRE). The project aimed at strengthening long-term ICZM capability in Vietnam, focusing on advising the Vietnamese Government in the planning and development of a Vietnamese sustainable coastal zone strategy.

From the Netherlands: Royal Haskoning - leading partner of the Dutch NEDECO-consortium (website: Royal Haskoning Vietnam), which consisted of WL | Delt Hydraulics/Deltares (website: Deltares) DHV consultants (website DHV-Group), UNESCO-IHE (see website) participated, as well as experts from the Dutch Ministry of Transport, Public Works and Water Management (CZM-Centre/Min.V&W, see website Netherlands Ministry of Infrastructure and the Environment). The Netherlands Embassy in Hanoi provided much appreciated financial support and guidance.

The VNICZM project was implemented in the context of the Vietnamese vision of an effective integrated coastal programme: “An ICZM programme should simultaneously be executed in the capital Hanoi and in coastal provinces according to the Vietnamese conviction of positive, holistic approaches and gradual decentralisation”. Therefore, it was put in operation in Hanoi, Nam Dinh, Thau Thien Hue and Ba Ria Vung Tau provinces.

The Vietnam-Netherlands Integrated Coastal Zone Management (VNICZM) project contained different components. These included strengthening vertical integration (from river to coast and from national, provincial to community level); horizontal integration between research institutes and policy makers; strategies and action plans for ICZM at national and provincial level; institutional structures, legislation for ICZM; capacity building, stakeholder participation and dissemination of knowledge on coastal processes. These are all the first steps of any ICZM cycle. An overview of legal frames and institutional developments related to ICZM is provided in MONRE&MA, 2007.
3.1 Some of the results at the national level:

A National framework CZM Strategy and Action Plan (SAP) was produced and adopted by the Ministry of Natural Resources and Environment (MONRE) and formed the basis for the Vietnamese ICZM Strategy. The framework strengthened institutional cooperative arrangements and helped screen Socio-Economic Development Plans dealing with coastal investment projects.

The need for a CZM Centre for Vietnam has been identified through a Definition Study. The Ministry of Natural Resources and Environment (MONRE) is establishing incrementally a unit for ICZM. An ICZM Division, within the Vietnam Environmental Protection Agency of MONRE was formed in 2003. This paved the way for the establishment of an ICZM and Planning Centre within a newly established Vietnam Administration of Sea and Islands (part of the MONRE), and provides support for all ICZM Projects in Vietnam.

Improved accessibility of databases & GIS
A GIS framework for ICZM has been established for national use and in the three pilot provinces, based on implementation of the MONRE GIS Standards. A GIS meta-database has also been established (> 450 layers) and linked to the VNICZM project website. Training courses in GIS have been conducted in Hanoi, in the three provinces and in the Netherlands. Vietnam Coastal Zone Atlases (2006), have assisted the national level and provinces in producing the zoning plans as a part of the ICZM Strategy and Action Plan.

Dissemination, capacity building and awareness raising.
Capacity building was undertaken in different ways. A series of workshops and training courses were held in Hanoi and the three pilot provinces during the lifespan of the project. Missions to the Netherlands for high level Vietnamese (Vice Minister, DG and Vietnam project Director and Coordinator) of the hosting MONRE and other relevant Ministries were held annually to discuss the progress and coordination, with the Netherlands Ministries of V&W and Foreign Affairs. The development and practice of the Netherlands coastal management was demonstrated to many Vietnamese project colleagues. Their coastal knowledge was also increased by intensive training courses, and MSc education in the Netherlands training and water education centres (IHE-UNESCO, ITC, WL | Delft Hydraulics/Deltares, TUD, see alsoCCC II-8-5 and 8-6).

Awareness raising efforts on integrated water and coastal zone management and sustainable development were also undertaken at Vietnamese national and provincial levels, involving coastal experts, stakeholders, NGO’s and school teachers. VNICZM newsletters were distributed regularly as a hard copy among the coastal provinces and institutions, and also published on the VNICZM Project website, an essential instrument for the dissemination of the ICZM concepts and the products of the VNICZM project.

Evaluation of VNICZM project

Several evaluations of the projects were undertaken by independent experts. The last evaluation was performed during a public meeting, where the results of the VNICZM project were presented and discussed with scientists and NGOs under the guidance of the Deputy Minister of MONRE. During this final workshop, the provincial authorities expressed their eagerness to continue with the ICZM processes and have made allocations from state budgets. They also requested the Royal Netherlands Embassy consider a new project, which would not only further strengthen the introduction but also support the provinces with implementation of ICZM and harmonisation of coastal resource issues between neighbouring provinces (Vietnamnews, April 2006).
3.2 A number of VNICZM results at provincial level:

The VNICZM project operated in three coastal provinces, cooperating and involving Provincial People's Committee's, provincial departments, coastal districts and communes, NGOs, Universities and stakeholders. Many ICZM activities were carried out, such as:

Nam Dinh Province - Red River Delta:
- ICZM Strategy and Action Plan was produced and approved by the People’s Committee of Nam Dinh Province;
- Nam Dinh Pilot Study - Sea Dike: coastal erosion threatening coastal villages. The sea defence study for the Hai Hau District addressed immediate solutions for this pressing problem in the province;

![Image](PEOPLE'S COMMITTEE OF NAM DINH PROVINCE)

![Image](ICZM STRATEGY FOR NAM DINH PROVINCE)

Figure 5: Cover page of ICZM Strategy, Nam Dinh 2003. (source: VNICZM, 2003)

Figure 6: Nam Dinh Province: salt panning behind the sea-dike in a polder; ongoing coastal erosion and flooding; eroded and flooded & ruined village with remnants of church towers; sea-dike toe erosion. (photos: Hans Pos, VNICZM project)
• **A review framework** was provided for wetland management issues of the RAMSAR site at the Xuan Thuy reserve and the land reclamation issues near the Nan Co River mouth;
• **Master planning** was undertaken for accreted new land in the Nghia Hung district, Nam Dinh;
• **Ecotourism** potential at Xuan Thuy National Park was explored.

**Thua Thien Hue province: central Vietnam**

• The Provincial People’s Committee of Thua Thien Hue province adopted the ICZM Strategy and Action Plan produced by the stakeholders. A strong ICZM base was established by intense participation of stakeholders focused on producing an ICZM Strategy Document. In the preparation of the Strategy, the Peoples Committee of TT Hue province chaired the process of dialogue, which uniquely brought together Departments, local consultants and stakeholders in detailed discussions of problem issues, strategies for the future and potential action plans for solutions.

![Coastal erosion Thuan An, TTHue Province, due to the November 1999 typhoon. (photo: R.Misdorp)](image)

The concept of carrying capacity for the TTHue Lagoon was introduced and defined as the 'load' that an ecosystem can 'carry' before 'breaking'. 'Load' is the 'impact' of functional uses on an ecosystem. The ecosystem can ‘carry’ these 'loads' because of the intrinsic natural potential for neutralising impacts. A lagoon monitoring system, measuring some of the carrying capacity indicators, was set up by Coastal Cooperative Programme (see hereunder and CCC II-8-4) as a first step to quantify the carrying capacity of the Lagoon.

**Ba Ria Vung Tau province: northern part of the Mekong Delta**

• **Key ICZM issues were inventoried**: conflicting pressures of tourism, nature (mangroves), industrial developments and coastal erosion. Dialogues were held across a wide group including the People’s Committee, Departments and coastal Districts.
• **A Guideline for ICZM Strategy and Action Planning** was well received.

![Severe erosion at Loc An shore with damaged coastal vegetation, after sever storm surge, Ba Ria Vung Tau (photo: Hans Pos)](image)

![Beach tourism in Thuy Van, Ba Ria Vung Tau Province (photo: Hans Pos)](image)
• **Commune level evaluation** and participatory studies at Loc An and Phuoc Tinh have been conducted where estuarine water quality and dike erosion problems cause degradation of living standards and safety.

• **Subsistence fisheries** continue to play an important role in coastal communities: examples from the Vung Tau pilot area were investigated in relation to the mangrove’s vitality and industrial developments.

• **Need for oil spill contingency planning** in the HCMC–Vung Tau corridor, was identified as a critical issue, a project outline was produced, which will be submitted for donor funding.

The three VNICZM pilots have completed the three steps of the first ICM cycle including preparing, initiating and developing adaptive response options and sustainable resource management in the Vietnam coastal zone (MONRE & MA 2007).


The Vietnam Netherlands Coastal Cooperative Programme (CCP) was an extra-support to the VNICZM project. The VNICZM project provided the long term “over-arching” strategic framework, while CCP focused on more “practical” coastal issues to be implemented at provincial level (Global Studio, 2002).

The Coastal Cooperative Programme was an inter-ministerial programme between the Vietnamese Ministry of Natural Resources and Environment (MONRE) and the Netherlands Ministry of Transport, Public Works and Water Management (CZM-Centre/Min.V&W/Min.I&E), and Ministry of Foreign Affairs (Royal Netherland Embassy – Hanoi). It was formalised during the visit of the Netherlands Vice Minister of V&W to Vietnam, October 2001.

CCP’s main aim was to contribute to a better understanding of the natural and socio-economic processes in the coastal zone of TTHue province and to strengthen the decision making process. A detailed work plan with thematic activities was agreed and carried out.

An overview of results of the seven thematic Coastal Cooperative Program activities:

**Strengthening the ICZM - Government to Government relation** at a national level by regular exchanges between high level governmental officials of MONRE and Min.V&W, and Netherlands Embassy, and supportive preparations for a CZM centre in Hanoi.

**Platform discussions at local level:** involving authorities and stakeholders at provincial, district and commune level for identifying present and future coastal problems and solutions. Three consultative Platform discussions with heads of districts, farmers, fishermen, aqua-culturists, representatives of women leagues, were held in Thuan An, one of the main fishery towns on the shores of the Tam Giang lagoon, TTHue Province:

*Coastal problems* were prioritised and the number one problem was the quality of drinking water, followed by sanitation, typhoons causing flooding and coastal erosion, and the conflict of interest between rice farming, fishery and aquaculture.

*Solutions* were discussed including using rainwater instead of pumping brackish lagoon water; developing self-supporting home sanitation units (see CCC III-3-3-6); improved typhoon early warning systems; ceasing to build houses/ hotels/tourist infrastructures in the highly dynamic, active eroding and accumulating zone of the beach and in typhoon-flood prone areas (see Figure 7 and also CCC-II-8-2).

**Wetland management and restoration** training in the Netherlands and on-the-job:

Five Vietnamese VN-ICZM and CCP colleagues from Hanoi, Thai Binh, Hue and Ba Ria Vung Tau participated in two intensive, 4 – 6 weeks, international training courses on Wetland Management and Wetland Restoration, in Lelystad (RIZA/Min.V&W), the Netherlands. The knowledge gained during these courses was used to create an integrated vision on the functions, resources, management and development of Vietnamese wetlands: e.g. the northern part of the Tam Giang lagoon in TTHue Province (see Figure 10). This lagoon is one of the world’s largest coastal lagoon systems, about 70 km long and covering almost 22,000 ha.
Figure 10: View on the northern part of the Tam Giang lagoon system – Thua Thien Hue Province, enclosed between the present and ancient, inland series of white, beach ridges, with the delta of the Bo river and its wetlands in the north. (photo: Google Earth: ©2011 Cnes/Spot Image Image ©2011 TerraMetrics Image©2011 GeoEye Data SIO, NOAA, U.S.Navy, NGA, GEBCO)

Awareness raising at schools in TTHue Province on the role of water as a friend and a foe, involving children, parents and teachers. This activity began with a drawing competition (see Figure 11) covering a wide range of issues: flooding, irrigation, water cycle, sustainable development and integrated management of rivers and coasts. This was followed by the production of an Introductory Booklet: “The role of water” and followed by a comprehensive Training Manual: “Where Waters and Land meet” for school teachers. The Booklet, translated in Vietnamese language, was distributed among all the 5000 teachers of primary and secondary schools in the TTHue Province. Both products are available in this CCC Internet publication (see CCC V-1-2 and 3).

Figure 11: One of the winning drawings of the primary school drawing contest: “The role of water” as a friend = playing with the rain and sometimes as a foe. (source: CCP 2002)
Remote Sensing (RS) application for TTHue province involved transferring knowledge from Netherlands and national Vietnam Remote Sensing institutions to the TTHue province, through two hands-on training courses of each two weeks in Hue with each 40 – 50 participants. Applications of RS were demonstrated: typhoon flooding sensitivities of low lying areas, land-use mapping, soil erosion mapping in mountains effecting the lagoon and coast, fishery developments, meta data base management - see for more information CCCII-8-2.

Impacts of developments in the river basin on the coastal zone: demonstrations and analysis by the GIS water balance model STREAM (CCC III-3-2-6). Spatial outputs of the validated and calibrated STREAM model are generated including water availability in the form of monthly river discharges (m³/sec, Figure 13) for the river basins of the TTHue Province. The free of charge input data are elevation (Figure 12), soil, slope maps, various socio-economic developments and climate change scenarios. Using IPCC scenarios e.g. future rainfall & temperature values for this region, STREAM showed the potential for higher future evapotranspiration rates. The impact of climate change suggested a decrease of 10 to 35% in monthly run off during the peak flow period (September – December). These outputs are valuable for integrated lagoon modelling and provided directions for policy preparation.

Figure 12: One of the inputs for STREAM: GIS digital elevation map. (source: CCP 2002)

Figure 13: Two STREAM-outputs: Simulated drainage pattern of TTHue Province and river discharges in blue colour (m³ per second) for the month November 1999, during which typhoon “Eve” hit the province. (source: CCP2002-Task6, October 2002)

Integration of modelling and monitoring of environmental lagoon quality, coastal dynamics – TTHue Province.
The results of the CCP monitoring and STREAM model runs were inserted in an integrated ecosystem model focused on the carrying capacity of the Lagoon. This integrated modelling was presented and finalised during one of the hands-on Remote Sensing CCP training courses. Effects of socio-economic development (e.g. aquaculture) on the coastal zone of TTHue province, particularly on the Lagoon water quality, were demonstrated in relation to the intrinsic neutralising capabilities of the lagoon system and its wetlands (see CCC II-8-4).

The CCP 2002 Programme was evaluated on its effectiveness by an independent consultant (Global Studio, 2002). The main findings were:
• Satisfaction about the CCP performance was expressed at the Vietnamese national and provincial level. Almost all the CCP-2002 objectives were reached at in a effective manner;
• Different concepts of coastal cooperation were simultaneously executed. The VNICZM project focused on the 'high level' – strategic, institutional issues, the CCP addressed the more 'down to earth' aspects of management. The Vietnamese and Netherlands key officials and experts stated that this division of labour was successful in the execution of the ICZM programme at a provincial level.
This positive evaluation resulted in a continuation of the CCP programme supported by the Netherlands Ministry of Infrastructure and the Environment (former Ministry V&W) in close coordination with the Netherlands Embassy in Hanoi, in order to strengthen the ICZM efforts in Vietnam.

During the extension period 2005 - 2009, CCP focused on the planning of resource use and local community livelihood (MONRE&MA, 2007).

5. ICZM updates and outlooks

In 2006 the Ministry of Natural Resources and Environment published the document “Vietnam’s ICZM Strategy 2020 and Orientation up to 2030”. This document is the result of a participative Vietnamese process, achieved through continuous consultative procedures in which a wide range of stakeholders from relevant Vietnamese authorities at national as well as provincial level worked together, both at technical and managerial level.

Future Vietnam ICZM activities will be based on the principles outlined in the ICZM approach that has been worked out and tested by MONRE (amongst others by the VNICZM Project). According to this approach, ICZM should be implemented through ICZM strategies and action plans at provincial, district and commune level.

The 2030 aim is to develop and manage the coastal zone of Vietnam in a sustainable way through integrated coastal zone management, to preserve its role as an equitable source for peoples’ livelihood, safety and economic prosperity for all present and future generations.

The overall 2020 objective: to implement the Vietnam ICZM Strategy 2020, to reach out to all coastal provinces, by creating sustainable inter-sectoral, interagency and inter-governmental coordination and cooperation mechanisms, working together in harmony with the stakeholders.

The strategy has been drafted as a long-term policy and covering the period 2006 –2020. The strategy will be reviewed and if needed reformulated and adapted every 5 years.

Building on the success of the preceding ICZM endeavours in Da Nang city (ICM demonstration project) and ICZM pilot projects in Nam Dinh, Thua Thien Hue, Ba Ria – Vung Tau, Quang Nam provinces, the Vietnamese government has planned and is executing a national Vietnamese ICM work programme 2008 – 2013. This programme will strengthen the ongoing ICZM efforts, while in 17 other coastal provinces new ICM programmes will start (MONRE&MA, 2007).

International cooperation in the future

In the Netherlands, the government approved a new policy document, the ‘National Waterplan 2010-2015’ (December 2009). The main issue is to be prepared to cope with future’s challenges relating to water. One chapter of this plan is dedicated to cooperation with a number of deltas in the world. One of these deltas is the Mekong Delta. The aim is to cooperate in tackling the unfavourable consequences of climate change.

The Dutch and the Vietnamese Governments are preparing a document, in which they agree to cooperate for 10-20 years in identifying solutions to the struggle against the impacts of climate change, such as sea level rise, more intense rainfall, droughts etc. Integrated coastal zone management will be one of the key ways of identifying problems and solutions to the impacts of climate change. This cooperation will boost the ongoing ICZM-efforts in Vietnam.”

An example of strengthened bilateral cooperation is the preparation of the Delta plan to protect Ho Chi Minh City against flooding in the future. The deputy mayor Nguyen Trung Tin of Ho Chi Minh City and alderman Alexandra van Huffelen of the city of Rotterdam signed an Memorandum of Understanding to make Ho Chi Minh City climate-proof in 2011 (see Royal Haskoning, 2011). The two cities are going to work closely together over the next few years to create a delta plan for the further development of Ho Chi Minh City and the extension of its harbour. In this “Ho Chi Minh City Moving Towards the Sea with Climate Adaptation” action plan, various authorities, the harbour corporation and other parties involved, will work closely together on a longterm development strategy and measures for the city. This strategy anticipates the tremendous effects of climate change on Vietnam, and in particular on Ho Chi Minh City and the Mekong Delta, as analysed in detail by the precedence VVA, VNICZM and CCP programmes.
6. Conclusions
Vietnam has a high economic growth as well as being one of the critically vulnerable coastal countries to the effects of accelerated sea level rise (one of the impacts of climate change).

The ICZM concept is attractive for Vietnam because it supports a holistic view on management and development, including the application of horizontal and vertical integration in policy preparation, and the willingness to strengthen a more decentralised policy- and decision-making process all within the limits set in the Constitution of Vietnam.

Simultaneously executing ICZM activities at national and provincial and district/communal levels requires coordination, which can be expensive in time and money. However, it has been a successful endeavour, as illustrated by the products produced at the provincial and district levels in the pilot ICZM Provinces, and the enthusiasm expressed by the many other coastal provinces eager to join the ICZM process. The Vietnamese government emboldened by the results of the ICZM evaluations is determined to reinforce the future Vietnamese ICZM efforts and the gradual decentralisation of decision-making.

Experience with the systematic application of ICZM in the Vietnamese provinces, proved that it is the best management tool to help the provincial authorities to reach sustainable development in the coastal zone.

In conclusion, three periods of ‘working’ resulted in recognised products:
- 1993: first Vietnam VA steps presented at the World Coast Conference,
- 1994 – 1996: a full VVA and
These periods were preceded by others when nothing seemed to be happening. However, finding the right partners (ministerial partners, knowledge institutions, consultancies) in both countries, ensuring funding, making work plans, all requiring full agreement between the Vietnam and the Netherlands’ initiators that took time, almost as much as the actual ‘working’ time of the projects themselves.

ICZM is a long-term endeavour, but it is worth the effort, helping provide improved economic development and sustainable functioning of the coastal system.

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Websites:
- **Deltres - former Delft Hydraulics**: Dutch-based research institute and specialist consultancy for matters relating to water, soil and the subsurface.


- **UNESCO-IHE, Delft, the Netherlands**: [http://www.unesco-ihe.org/](http://www.unesco-ihe.org/)
Remote Sensing Applications in Thua Thien - Hue Province

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Summary:
Remote Sensing (RS) combined with Geographic Information Systems (GIS) is a powerful tool for coastal policy and decision makers.
Recognising the value of these tools at a national level, efforts were made to introduce these applications at a provincial level through two intensive training courses in Hue, capital of the Thua Thien – Hue (TT Hue) Province. Provincial trainees demonstrated the value of the various applications to the high-level provincial authorities. Remote sensing interactions between the international, national and provincial experts were shown to be useful for ICZM planning and implementation in the Thua Thien - Hue Province.
1. Coastal challenges in Thua Thien - Hue Province at the end of the 1990s

In Thua Thien - Hue Province, the economic development and population growth results in increasing demand for natural resources and a potential overload of the carrying capacity of the natural coastal systems. Depletion of natural resources and pollution of land and water also occur. Moreover, cyclones and related flooding are expected to occur more frequently in the near future due to the anticipated impacts of climate change. These impacts will exacerbate the current problems. Earlier studies of the (environmental) situation in TT Hue Province revealed that there are several areas of conflict between uses and there is a strong need for an improved management system to support decision-making balancing the different competing interests and creating sustainable land use policies. The introduction of the ICZM concept in the provincial planning and decision making process is addressing these issues. ICZM is being introduced at both national level and at provincial level, implementing a range of governmental projects in TT Hue. A number of ICZM projects were supported by the Netherlands CZM-C/Ministry of Transport Public Works and Water Management (Min.V&W) and Ministry of Foreign Affairs (described in detail in CCC II-8-1).

2. Benefits of Remote Sensing (RS) applications

In TT Hue Province, it has been recognised that remote sensing can support:
- Cross checking, correcting and improving data and GIS maps helping the establishment of an ICZM meta database and GIS tools;
- The creation of land and water-use maps, mapping vulnerable and remote areas and drafting a Zoning Plan,
- Environmental and coastal monitoring, especially synoptic overviews, rapid assessments of changes and flood mapping, which are saving time and money by obviating the need for laborious monitoring fieldwork over a large area. Limited, but important ground truth surveys of selected areas are however always needed.

Moreover, other projects in TT Hue can also benefit from Remote Sensing: Forestry programmes (Department of Agriculture and Rural Development) and the Natural Disaster Mitigation initiative.

Although many relevant coastal scientists and policymakers recognised the benefits of remote sensing applications, they were also aware that there was only limited knowledge in their province. Therefore, the challenge was to introduce RS and its applications to the TT Hue Province.

3. Objectives of CCP task5 on Remote Sensing

The Vietnam-Netherlands Coastal Cooperative Programme (CCP) Task5 on Remote Sensing and GIS Applications aimed to:
1. To introduce the technology (available at Vietnam national level) to the TT Hue provincial level;
2. To increase the understanding of dynamic processes affecting the coastal zone of the province.
Specific focus was on the supporting role of RS in aquaculture development, changes in land use and effects on soil erosion, and the design of maps of flood prone areas.

To increase capabilities at provincial level is also recognised in the Vietnam National Remote Sensing Master Plan 2010. Training courses for officials and the development of primary RS facilities and human resources are essential elements.

4. Organisation

To implement this task, a CCP RS Task Group 5 was formed with the participation of the professional remote sensing institutions of Vietnam and the Netherlands.

The main Vietnamese Remote Sensing centres involved were: Institute of Marine Environment and Resources (former name: Hai Phong Institute of Oceanology), and the Hanoi based institutes: the General Department of Land Administration (GDLA) and the Institute of Geography/Vietnam Academy of Science and Technology and CEDIM/FIPI (Centre for Data Information and Mapping). Each Remote Sensing Centre has its own capabilities and capacities to produce valuable RS applications.
The Netherlands based ITC (International Institute for Geo-information Science and Earth Observation, see website), WL-Delft Hydraulics (=Deltarcs, see website), IVM (Free University, Amsterdam) and CZM-Centre/Min. V&W provided expertise and training assistance. The first CCP Workshop on: “Remote Sensing applications for ICZM in TT Hue Province” was held in Hanoi, September 2002. During this introductory workshop, the work plan of CCP Task5 was shared and discussed among the 55 participants. Two capacity building training workshops held in Hue city, each two weeks and with 40 - 50 participants. These two training courses facilitated the transfer of knowledge from the Netherlands and Vietnamese Remote Sensing Institutes to the TT Hue Province. This involved the processing and analysing of images (1992, 1999/2000) of TT Hue Province involving several different RS and GIS fields of activities. The RS and GIS results of these hands-on training workshop were put together with ground-truth monitoring results in an integrated lagoon mathematical model directed at the carrying capacity of the Tam Giang lagoon system (see also CCC II-8-4).

5. Results of Remote Sensing cooperative efforts for the TT Hue Province

The CCP Task 5 activities were directed to increase concrete coastal geo-information delivered by RS & GIS analyses to support the high level provincial authorities (Misdorp et al 2005). These products included a variety of thematic maps on topography and land use, and sequential and spatial RS analyses used for the detection of:
- Changes in land cover and development of soil erosion maps;
- Shoreline changes;
- Rapid aquaculture development;
- Impacts of the November 1999 flooding.

The RS and GIS activities undertaken by the involved Vietnamese and Netherlands RS Centres and Institutes resulted in the following products.

5.1 Updated thematic maps of the TT Hue Province

The Remote Sensing Centre of General Department of Land Administration (GDLA) has created the following set of digital maps at 1:100,000 scale using different kind of satellite imagery such as SPOT, Landsat ETM, Radarsat and other data sources:
- General geographic / topographic map;
- Land use, urbanisation and infrastructure map;
- Ecology and environmental sensitivity map;
- Flooding map.

The updated mapping, using remote sensing, shows the advantage of remote sensing data and technique in thematic map production. Updates of the maps were produced and stored at the Remote Sensing Centre of the General Department of Land Administration.

5.2 Composite RS image of the November 1999 wide spread flooding caused by a fierce cyclone

Tropical Storm ‘Eve’ brought torrential rains to Central Vietnam. The storm made landfall 110km southeast of Da Nang on October 19. It was the first in a series of storms bringing torrential rain to Central Vietnam, which experienced the heaviest cyclone and rainfall to hit the region for 40 years. The floods killed 793 people, made over 55,000 homeless and more than 5,000 ha of rice paddies were damaged. The floods also caused nearly $300 million of damage directly to infrastructure, agriculture and aquaculture (ADPC, 2003). Heavy downpours of rain followed and during the first four days of November this amounted to 2700 mm rainfall in Hue city (Figure 1), which is 3.5 times the annual rainfall in Holland. This caused very severe flooding of the coastal plain and the lagoon.

Impacts of cyclones and flooding can be monitored by satellite images. Analysis of a series of Radar-Sat images acquired during the flooding event in first two weeks of November 1999 shows the very large extension of the flooded area and the slow retreat of water during the following days. A composite remote sensing image was made and shows the flooded area by projecting the 6th of November Radarsat flooding image on top of ‘normal’ Landsat image of the 1st September 1999.
The purple shaded area in Figure 2 represents the flooded area; the deeper the purple hue, the larger the water depth on top of the ground level. The water depth during maximum flooding was about 5m. in the dark purple flooded area around the mouth of the main river, the Perfume River debouching in the Tam Giang – Cau Hai lagoon.

The intense rainfall on the 2, 3 and 4th November 1999 caused strong rise in water level (6m) in a few hours time and extensively flooded the areas surrounding the TT Hue Tam Giang - Cau Hai Lagoon. (source: Meteorological Station Hue, CCP, 2002).

Figure 1: Hourly precipitation at the Meteorological Station of Hue and river water level response of the Perfume River at the Hydrological Station of Kim Long (in Hue city) from October 15 – November 15, 1999. The river water levels in centimetres above National Datum (N.D.);

Figure 2: Composite image of Landsat 1/9/1999 and Radarsat 6/11/1999 to identify flooded areas (purple shaded) surrounding the Tam Giang-Cau Hai lagoon in TT Hue Province; the deeper the purple hue to larger the water depth on top of the ground level. (source: © IMER / Ministry of Agriculture and Rural Development)
The deluge of the flood, both extent and water depth, was very large and was even larger during the very first days of November compared with the 6th November situation. The extensive area flooded reached more than three times the area of the Tam Giang – Cau Hai lagoon under normal weather conditions, as depicted in the 1st September 1999 image.

Sequential analyses of remote sensing images of the lagoon before, during and for some weeks after the cyclone had hit the coast and heavy rain battered the mountains and coastal zone of TT Hue revealed:

1. The Lagoon area was very severely flooded. Four days after the deluge started the flooded area was about three times larger than the reference water area of the lagoon, which is about 225 km² (date 1/9/1999);

2. The receding water of the flood is a slow process: after two weeks the flooded area is still about twice as large as the reference, the 'normal' water area. Notably the low-lying shore areas of the lagoon were still to a large extent flooded (Figure 3).

Figure 3: Water Area of the lagoon including flooded area in km² of the Tam Giang-Cau Hai lagoon, TT Hue before and after the cyclone hit the coast. (source: IMER - Haiphong. adapted by R.Misdorp)

Remote sensing in combination with mathematical flood modelling of a river basin (Villegas, 2004) is a powerful tool for large range of applications from rescue operations to risk analyse. This Perfume River Basin simulation model predicting the areal extent of flooding, water depth, water volume and especially flood duration, can also be effective in assisting rescue operations, damage assessment and post hazard risk analyses. It may also support integrated spatial planning of the vulnerable low-lying areas in the coastal provinces of Vietnam. The PDF report of Villegas, produced under auspice of the CCP, is available in this CCC-Internet Publication (see CCC V-1-3).

5.3 Mapping changes in land use, notably the forest cover in the period 1992 - 2000
Changes in land-use, particularly forest cover were analysed by means of specific techniques of digital image processing using a base map of 1: 100,000 scale. The image of Landsat TM was classified for the lands-use classes: Closed forest, medium forest, open forest, woodland, closed shrub, open shrub, shrub and grassland, grassland, mosaic, bare land, crop land, sand, and water surface (Figure 4). After obtaining two classified images for 1992 and 2000, an analysis of the land-use change was carried out. The preliminary results point to a shift from closed-medium forest to open forest in the TT Hue mountains. More ground-truthing and field observations are needed to confirm this preliminary result. However, this land-use analysis demonstrates the potential value of remote sensing and GIS application for spatial planning, forest management, assessment of soil stability, river and coastal zone management in TT Hue Province.

Figure 4: Classified Satellite Image displaying land-use patterns of the TT Hue Province and the western part of Da Nang Province, 1st January 1992 CF= Closed Forest; M=medium; O=Open; Wd=Wood. (source: © IMER)
5.4 Estimation of soil erosion related to land-use changes in the TT Hue Province

The combination of Remote Sensing data with Geographic Information Systems (GIS) using Digital Elevation Maps, Soil Maps, Land-use Maps and monthly rainfall and temperature maps, resulted into a rough estimate of soil erosion in the wider TT Hue and Da Nang area. Potential soil erosion estimates for this area were carried out for both 1992 and 2000. The 240 m grid of elevation (DEM) was used to compute the slopes. Rainfall information was obtained from a meteorological station located near to Hue, the capital of TT Hue Province. The potential soil loss was estimated using the Universal Soil Loss Equation (USLE). Two maps of potential soil erosion in 1992 and 2000, with erodibility classification ranging from 5 tons per hectare to larger than 150 tons per hectare/year (see Figure 5), were produced for the wider TT Hue Province and Da Nang area.

Maps of potential soil erosion show that the prominent soil erosion classes in TT Hue and Danang area are: 5-20 ton and 20-50 ton/hectare per year. These figures are only a rough estimate; no comparison was made between these estimated outputs and field observations.

![Figure 5: RS-derived map of potential erosion in 1992 in the area: eastern part of TT Hue Province and western part of Da Nang Province (Tn/ha = ton/haeroded soil in the year 1992 (source: Institute of Geography)](https://example.com/figure5.png)

The sequential changes in soil erosion estimates can mostly be attributed to land-use changes in the mountains of TT Hue. Analysis of changes in forest cover in 1992-2000 showed a decrease of closed forest by about 10%, which corresponds well with a remotely sensed observed increase in the potential soil erosion during the same period (Tran Dinh Lan, 2003).

The degree of forestry and related soil development in the mountain ranges of the TT Hue Province determines to a large degree the flushing time of the river) and the residence time of the water in the Lagoon, and can provide some order of magnitude estimates of the sedimentation and erosion patterns in the Lagoon and near shore coastal zone.
This information on the changes in land-use in the mountains is useful in establishing datasets for integrated models that quantify water balance, water discharge and sediment transport towards the sea. Changing soil erosion rates are important for water storage, while lagoon sedimentation rates are relevant when estimating the ‘life-span’ of the lagoon.

5.5 Detected changes in shorelines related to coastal hydraulic conditions
Shoreline changes, detected by RS, during the wet season were analysed in the period of 1992-2000. Ground truth data, important for analysis of coastal dynamic processes in TT Hue, were also examined. Sea level, including surges, meteorological data and coastal profiles at and around the time the satellite images were taken, were all used to correct the representation of shoreline change.
The results show that the coastline in two areas of Thuan An and Tu Hien outlets/inlets is highly dynamic (Figure 6). The range of shoreline movement in Thuan An area was 10 – 30 meters landward or seawards, while in Tu Hien area a 15 m landward movement occurred during the 8-year period. Seasonal analysis showed that the oscillation of the shoreline near the outlets could be larger than the averaged 8-year changes.
The active coastal beach zone is locally many tens of meters wide – an important consideration when developing guidelines for building (see erosion photo: Figure 7, CC II-8-1) and spatial planning and preparation of buffer zones. Seasonal variations in coastal dynamics are as important as annual changes, and involve high erosion rates during storms/cyclone periods, which are followed by

<table>
<thead>
<tr>
<th>Date 1999 RS images</th>
<th>Water surface in hectares</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/09: no-flood</td>
<td>22,600</td>
</tr>
<tr>
<td>06/11: flooded</td>
<td>63,150</td>
</tr>
<tr>
<td>10/11: flooded</td>
<td>56,050</td>
</tr>
<tr>
<td>15/11: flooded</td>
<td>41,700</td>
</tr>
</tbody>
</table>

Figure 6: Eroding dune of Thuan An outlet looking from the sea into the Lagoon

Table 2: Flooded areas

(a) Figure 7(a): Shoreline changes at Thuan An outlet during 1992 – 2000;
(b) Seasonal shoreline changes at Thuan An: 1997 and 2001

accretion during more quiet periods.

Figure 6: Overview of shoreline changes around the outlet of Thuan An, analysed by RS 1992 – 2000: Shoreline 92-00; strong seasonal shoreline changes in the period 1997 – 2000; the photo shows strong erosion of the coastal dune near the outlet. Table with Flooded areas of the Tam Giang- Cau Hai lagoon water surface area from sequential RS analyses before, during and after the typhoon of 2-4th of November 1999, see Figure 3. (source: CCP2002; photo: Mindert de Vries)
5.6 Changes in aquaculture development in the Tam Giang – Cau Hai lagoon

Aquaculture ponds are clearly visible and easy to be recognised along the borders of the Tam Giang – Cau Hai lagoon using remote sensing images.

The area of aquaculture ponds within lagoon system has strongly increased in recent years. Results obtained from analysis of Landsat images of 1992 and 2001, and ADEOS/AVNIR 1997 provides a preliminary estimate of the aquaculture ponds. The areas of aquaculture ponds estimated by remote sensing are:

- 130 hectare in 1992;
- 430 hectare in 1997;
- 2,200 hectare in 2001;
- 8,200 hectare in 2008 (Nguyen Van Thao, Nguyen Dac Ve, Tran Dinh Lan, Do Thi Thu Huong, Nguyen Thi Thu Ha, 2009)

![Aquaculture pond areas (ha) 1992 - 2008 in TT Hue Lagoon](image)

*Figure 7: Strong increase in aquaculture area in the Tam Giang – Cau Hai lagoon, with the locations of the aquaculture ponds indicated on the map. Analysed RS images of 1992, 1997, 2001and 2008; (sources CCP 2002, adapted)*

These data illustrate the enormous areal growth of the aquaculture in the Tam Giang - Cau Hai lagoon system with a factor 16 in 9 years (1997 – 2008). This growth reflects a strong increase of shrimp production and associated economically beneficial export. However, this has been accompanied by a strong increase in the pollutant load in the lagoon.

The detrimental effects of uncontrolled shrimp farming in Thailand is illustrated in CCC II-7-1. A training manual with the Thai lessons learned has also been made available in this CCC Internet Publication, see CCC V-1-1.

Another issue related to fisheries, is the high density of systematically placed “< shaped fishnets” in the entire lagoon system as shown by the high resolution IKONOS “quick look” and even clearly visible on the Google Earth image (see Figure 8), and demonstrates an extremely intensive lagoon fishery.

This relative cheap and simple remote sensing application constitutes a powerful tool in adjusting fishery practices and enforcing regulations for a more sustainable resource use.

The effects of intense uses of resources are furthermore made “visible” through preliminary integrated coastal modelling, (see paragraph 5.9 and CCCII-8-4). These results were provided to the VN-ICZM program.
Two intensive RS training courses of each two-weeks were organised in TT Hue Province with the support of a number of Vietnamese and Dutch based institutes in 2002 and 2003. Between 40 – 50 participants/workshop from the TT Hue Province and ITC Alumni were actively contributing.

Many results were obtained by the hands-on training in Remote Sensing and GIS activities, revealing the geographical and sequential distribution of natural and socio-economic processes in the coastal zone of TT Hue. These included:

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**5.7 Meta-database of RS-imageries**

An inventory of RS images and remotely sensed data regarding the TT Hue Province was made by the previously mentioned Vietnamese Remote Sensing Centres. This resulted in an overview of 33 useful Remote Sensing images for TT Hue Province. A meta-database was setup and made publicly accessible through the VNICZM project website.

**5.8 Remote sensing information as input for integrated coastal modelling of the Tam Giang – Cau Hai Lagoon**

Preliminary integrated coastal modelling for the TT Hue Province (see CCCII-8-4) focused on the changes in land use and its effects of functional uses (settlements, agriculture and aquaculture) on the functioning of the Lagoon and its ecosystems. This integrated approach revealed the effects of agents of change on the carrying capacity of the lagoon and illuminated the effects of strategies such as zoning of land-uses.

**5.9 Two intensive RS training courses of each two-weeks** were organised in TT Hue Province with the support of a number of Vietnamese and Dutch based institutes in 2002 and 2003. Between 40 – 50 participants/workshop from the TT Hue Province and ITC Alumni were actively contributing.
• A new estimate of soil erosion for the TT Hue river basins;
• The strong expansion of aquaculture areas in the Tam Giang - Cau Hai lagoon;
• Shoreline changes along the TT Hue coast and outlets important to defining guidelines for building and spatial planning;
• Flood sensitivity analysis showing clearly amongst other things the areas of maximum water depth and the flooding duration;
• Integrated coastal modelling incorporating all the results of RS and GIS training exercises, the results of ground truth ecological lagoon survey, the results of analyses on the impacts of socio-economic development and of climate change, resulted in a first attempt of determining the carrying capacity of the Tam Giang – Cau Hai lagoon system now and in the future. The Remote Sensing-GIS derived thematic maps, the RS analysed changes in land-use, the effects on ecosystem surveyed by the CCP lagoon monitoring task force, the river basin model STREAM and the coastal hydraulic conditions, that all were integrated in the coastal modelling

These concrete workshop results served to illustrated the values of Remote Sensing & GIS instruments among the participants and to the high level TT Hue decision makers.

6. Conclusions and recommendations

Monitoring natural and socio-economic processes in the coastal zone is required in the various stages of any ICZM programme. Remote sensing is an effective tool to aid coastal zone management and development. It provides spatial and temporal date, improving the knowledge of processes in the coastal zone. Application of remote sensing for coastal management is a new tool for Vietnam at provincial level. It is especially powerful for making rapid assessments of coastal dynamics, land-use changes, flood mapping and aquaculture development. The data combined with ‘ground truthing’ are particularly suitable for monitoring, modelling, integrated spatial and temporal analyses and updating of thematic maps. Remotely sensed data support monitoring and assessment of the existing situation, and changes occurring in the coastal zone.

The introduction of new remote sensing instruments in Vietnamese Provinces provides the policy- and decision-making community with tools to:
1) Strengthen the provincial capabilities on integrated spatial planning, hazard and risk management, fishery management and aquaculture regulation and enforcement;
2) Assess climate change impacts and help prepare appropriate adaptive coastal measures.
Remote Sensing instruments, increasing knowledge on coastal processes, will support more sustainable decision-making, balancing of interests and resolving conflicts of interest,

The two training courses on remote sensing application for coastal management in Thua Thien - Hue Province for about 100 provincial officials and coastal experts, showed how it is possible to develop skills for provincial partners in rapid assessment of coastal matters for management. The TT Hue Province trainees demonstrated the value of the various RS and GIS applications to the high-level provincial authorities.
The exchange between the national Remote Sensing experts of Vietnam as well as the interactions with Dutch experts helped better understanding of the applications and identified new - Remote Sensing - avenues for the province.

Remote Sensing in combination with integrated (river and coastal) modelling is a useful instrument for policy preparation and supports spatial planning particularly in relation to the effects of typhoons as well as the effects of future socio-economic developments and the impacts of climate change on the functioning of the lagoon.

Remote sensing interactions between the international, national and provincial experts and policymakers were shown to be useful for ICZM in the TT Hue Province. This is also illustrated through the RS study of the coastlines in TT Hue Province by Truong Thi Hoa Binh & Tran Minh Y (2008). Furthermore, the experience of the CCP in TT Hue Province were transferred to other Vietnamese Provinces such as Nam Dinh Province, where analysis of remote sensing data was undertaken and initial results were reported (Vietnam National Centre for Science and Technological Information, NCSTI –VISTA).

7. References

Climate of Coastal Cooperation II-8-2


Nguyen Van Thao, Nguyen Duc Ve, Tran Dinh Lan, Do Thi Thu Huong, Nguyen Thi Thu Ha, 2009: Monitoring and assessment of flooding damages in Thua Thien - Hue coastal area using ALOS satellite images. Project technical report, Institute of Marine Environment and Resources, Haiphong, Vietnam


PDF reports:


Truong Thi Hoa Binh*, Tran Minh Y, 2008:

VNCSTI – Vietnam National Centre for Science and Technological Information:

http://www.itc.nl/library/Papers_2004/msc/wrem/villegas.PDF

Web sites

Deltares – former WI. Delft Hydraulics: Dutch-based research institute and specialist consultancy for matters relating to water, soil and the subsurface.
http://www.deltares.nl/en

IMER - Institute of Marine Environment and Resources, Haiphong, Vietnam:
www.imer.ac.vn

Institute of Geography - Vietnam Academy of Science and Technology:

ITC – International Institute for Geo-information Science and Earth Observation – the Netherlands:
www.itc.nl/ and http://www.itc.nl/Pub/study/Course-domains/Earth-Sciences

Institute for Environmental Studies, Free University, Amsterdam:

Climate of Coastal Cooperation II-8-2
• GDLA – General Department of Land Administration – Vietnam supported by ITC:
• Remote Sensing Centre – Ministry of Natural Resources and Environment, Vietnam
  http://rsc.gov.vn/English/index.htm#
Synthesis through integrated modelling
Quantifying carrying capacity and predicting impacts on the coastal ecosystem

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Le Van Thu  *(VNICZM & CCP TTHue Coordinator, Hue, Vietnam)*
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Robbert Misdorp  *(CCP Manager)*

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   4.3. Quantification of ecosystem state using integrated modelling approach
   4.4. Run off and river discharges: Water balance model STREAM
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Summary
One of the main aims of the Vietnam-Netherlands Integrated Coastal Zone Management and the Coastal Cooperative Programme in Thua Thien Hue was to provide the province with tools, to strengthen the quality of the decision-making process for the management of the Hue lagoon area and its surroundings. The TTHue Lagoon is the largest lagoon of SE Asia and provides a livelihood for more than one hundred thousand families.
Training was a fundamental part of the projects. The following actions are urgently needed:
- Physical state - *tools are needed to improve understanding of hydrology, hydrodynamics and sediment transport*
- Water quality and pollution - *Any intensification of activities in the future should be carefully controlled and limited*
- Ecology - *Fishing intensity should be reduced and valuable, shallow habitats should be protected and partly restored*
- Governance: *More ICZM expertise is needed to facilitate and continue the ICZM process providing sustainable solutions*

The Vietnamese – Netherlands Coastal Cooperative Programme organised surveys to quantify the state of the ecosystem, including the impact of human activity and the carrying capacity of the Lagoon. The results, together with supporting coastal hydraulic and water balance models of the TTHue river basins, formed the basis for the development of an integrated river-lagoon-sea model. This model was interactively developed during one of the hands-on training workshop in Hue. One of the main conclusions was that the strong growth in aquaculture poses a serious threat to the functioning of lagoon itself. The rapid increase in aquaculture waste in the near future will add a large amount of contaminants that will cause international water quality standards to be exceeded.

High-level provincial authorities welcomed the results of the workshop and the series of recommendations. One of these was the creation of international and inter-university cooperation in the field of integrated ecosystem monitoring, modelling and policy preparation. The integrated ecosystem approach will help the application of good governance for the sustainable use of resources in the coastal zone, ensuring inter-sectoral cooperation and optimal institutional arrangements.
1. Introduction

The implementation of ICZM relies on quality advice and on a high level of understanding of the interrelated nature of the local coastal system. This requires a thorough understanding of the functioning of the local ecosystem and of the impact of human activities on it. For this, a comprehensive and coherent system of management practice, experts, tools and data collection should be in place. Although this is well understood, successful implementation in governance depends on availability of local expertise and effective financial, organisational and governmental control of the process. In Thua Thien Hue province this approach involved:

- Development of an effective information base and
- Training experts in the implementation of ICZM by means of problem solving in relevant case studies.

An expert training programme was organised and organisational structures were strengthened. Evaluation of the programme proved the relevance of training and tools for improving coastal management capabilities, but also highlighted the deficiency of expertise and organisational capacity in applying ICZM in practice. In this chapter, we show that a bottom-up analysis of the state of the ecosystem using the DPSIR frame (Driving forces, Pressure, State, Impact and Response framework, see EEA website), is a powerful tool for collating and integrating data when developing the knowledge base. We show that data-integration by means of mathematical models provides the predictive capability needed by managers. Finally, useful management information can be produced at a high level of integration, which is a requirement for successful ICZM implemented by trained experts and policy makers within effective inter-departmental structures.

The training component of this project uses an analysis of the functioning of the coastal ecosystem in an integrated way. The work was undertaken as a cooperative venture between Netherlands and Vietnamese experts, within the framework of the Vietnam-Netherlands Integrated Coastal Zone Management (VNICZM) project (1999 – 2004) and the Coastal Cooperative Programme (CCP, 2001 - 2006), by jointly implementing model studies and monitoring programmes. This approach proved to be very valuable in integrating dispersed pieces of information into a comprehensive, coherent and illustrative picture of lagoon hydrodynamics and water quality, linking the rivers, lagoons and coastal areas with the sea. Without an integrated approach and predictive modelling, it is impossible to evaluate the impact of infrastructure development and changes in land use on water circulation or on water quality. Therefore, the ability to make sound decisions with respect to zoning and impacts of present and future lagoon uses requires such a model. This predictive capability also allows analysis of possible impacts of changing climate and sea level on the state of the ecosystem and the consequences for economic development.

2. Ecosystem approach

What does the approach encompass?

The ecosystem approach is a practical methodology for integrated and balanced decision-making with respect to management of land, water and living resources. It provides a framework at various levels, including national policymaking and site-level management. The ecosystem approach promotes conservation and the sustainable use of resources in an equitable way. It recognises that humans are an integral component of the ecosystem. The ecosystem approach provides the framework for action under the United Nations Convention on Biological Diversity (see UN-CBD website), adopted at the Earth Summit of Rio de Janeiro in 1992. Vietnam is one of the 100 parties that ratified this convention. This approach also provides a firm basis for Integrated Coastal Zone Management and it became a practical method for analysing the status of the ecosystem using a set of easily quantifiable indicators for the TTHue lagoon system. This method provides guidance on the sustainable use of resources for a very broad range of socio-economic activities taking place in the coastal zone, that impact on the state of the ecosystem.
What kind of information does the approach require?
The collection of information dealing with resource use, physical, biological, chemical, social and economic characteristics is important to the successful implementation of an ecosystem approach. Information derived from all possible sources has to be integrated into the system and packaged into higher-level information that facilitates communication between stakeholders, planners and decision-makers. A continuous programme of data collation, evaluation and research is needed to identify and bridge strategic gaps in knowledge that are important in addressing the ever changing management challenges. In this project, first steps were made toward collection of information involved setting up an interdepartmental monitoring program, focused on acquiring data on the easily quantifiable indicators in combination with an interdepartmental data sharing and data storage.

3. Toward quantifiable terms of ecosystem state

In view of the complexity of ecosystems, there is a need for a practical method to define measurable and quantifiable terms that express the state of the ecosystem at a given moment in time and to assess the impact of changes in use on the state of the ecosystem. The concept of ‘ecosystem carrying capacity’ is a useful term, recognised by managers, that helps define the pressures that an ecosystem can ‘carry’ without ‘breaking = degenerating’. At a level of too much pressure, the carrying capacity will be exceeded, as it is unable to accommodate or neutralise the pressures. At this point, there will be a loss of natural resources and reduced potential for socio-economic utilisation.

The point at which the system and its use become unsustainable can be a gradual process with some adverse changes taking place before others. Many examples of this transition exist. In the coastal seas of the Netherlands and Norway, there are increasing occurrences of algae blooms sometimes including toxic species. In stratified nutrient enriched areas depletion of oxygen can occur, a clear sign that the system is ‘degenerating’. Changes in natural biodiversity such as species composition and abundance of local fish and bird species can also be indicators of a changing ecosystem. In many systems (such as the lagoons of TT Hue Province) such changes have been observed and may be harbingers of ecosystem damage.

These examples provide clues to the fact that measuring the state of the ecosystem revolves around proper analysis and definition of the problem (Driving forces and Pressures), quantification and valuation of indicators that describe the State of the ecosystem with respect to the Impact on the resource and the policy Response (DPSIR).

In brief, the methodology can be broken down into a series of steps:
1. Problem scoping based on identification of drivers and pressures, based on the DPSIR framework and consultation with the local population;
2. Definition of indicators and standards;
3. Quantification of impact of resource use for present and future situations;
4. Assessment of impacts on ecosystem state;
5. Advice on management for sustainable use.
4. Quantification of ecosystem state

4.1 Problem scoping: identification of drivers & pressure

Thua Thien Hue province is located at the latitudes 16°14' - 16°15' North, longitudes 107°02' - 108°11' East. It is 127 km long and 60 km wide on average, with mountains up 1500 m and forests accounting for up to 70% of the natural land. Most of the population lives on the coastal plain, within 25 km of the coast. The main rivers are Huong (Perfume River), Bo, Truoi and O Lau are relatively short rivers and run eastward on steep mountain slopes. Geographically, Thua Thien Hue Province borders Quang Tri Province to the North, Da Nang City to the South, with Laos P.D.R., separated by the Truong Son range, to the West, and the seacoast to the East (Figure 1). Thua Thien Hue Province covers a natural area of 5,009 km², and has a population of 1,091,000 in 2002 - accounting for 1.5% of the land and 1.4% of the national population respectively.

![Map of Thua Thien-Hue Province](image)

**Figure 1: Thua Thien-Hue Province, its Lagoon system: Tam-Giang lagoon in the north with the Thuan An outlet and Ca-Hai lagoon in the south with the Tu Hien outlet, the main rivers and the administrative districts and the boundaries of the capital city Hue. (source: VNICZM project office GIS group)**

The Tam Giang-Cau Hai lagoon system is the biggest lagoon in Southeast Asia, with an area of 220 km² and is stretches about 70 km along the coast. The lagoon is strongly influenced by both marine and freshwater inflows. Most rivers in the province flow into it, but only two tidal inlets connect to the sea, making it vulnerable to flooding. The lagoon is a dynamic and sensitive system with a complex set of interacting physical and biological components, controlled by dynamic processes varying in time and space. Extreme flooding occurs during cyclones when abundant rain falls on the adjacent steep mountain slopes. Shifting inlets and coastal erosion have also caused major problems. Hence, it is no surprise that sustainable management of such a complex system is a very difficult task.
Approximately 300,000 inhabitants live around the lagoon in 236 villages and earn their living by directly or indirectly exploiting natural resources. The growing population of TTHue Province is exerting more and more pressure on the lagoon system, through increased agriculture, aquaculture, fishing, transportation, and cargo handling, in a limited and confined area (see Figure 4). The economic planning of the National Government of Vietnam has stimulated growth, which has improved the living conditions of many villagers.

Generally, there are three types of communities living around the Hue lagoon - farming, fishing and aquaculture. Conflicts in demands for the use of space and natural resources arise between different users. In Thua Thien Hue Province agriculture is the main activity and especially in the rice growing areas intensive farming causes increased loading of fertilisers and pesticides into the lagoons. Over the last decade, fishing capabilities have increased rapidly in terms of number of fisher people and boats as well as boat capacity. Fish catch however, has not increased as Figure 3a illustrates. There is reason to be concerned about the status of the lagoon fishery itself. The productivity of the lagoon fishery (in tonnes) has been more or less constant over the 1990s. The productivity per unit effort, however is declining: more people in more boats are catching fewer and fewer fish. It seems that the fishery has reached the limits of its productivity (Field study - ICEM: Vietnam – TTHue, 2003).

Aquaculture has become a priority of the provincial government, especially shrimp farming. The area of shrimp ponds and shrimp production has grown with an exceptional large speed (Figure 3b, see CCC II-8-2). The economic revenues of aquaculture and particularly of shrimp farming are high. However, the creation of fish and shrimp ponds reduces spawning and nursery habitats for lagoon and migratory marine species, affects water quality and disturbs the natural water circulation of the lagoon in dry and wet seasons (see also CCC II-7-1: Thai aquaculture lessons).
Consultation of citizens of Thuan An village

Whereas the VNICZM project primarily focused on the “higher-level” strategic ICZM planning activities, the complementary Vietnam-Netherlands Coastal Cooperative Programme (CCP) focused its efforts on monitoring and in depth analysis in specific ‘critical’ fields for ICZM of special relevance to Thua Thien Hue Province.

CCP activities assisted the Provincial Peoples Committee (PPC) in its planning efforts in the coastal zone, which is so intensively used (see Figure 4). For this, a series of so-called ‘Platform’ discussions were organised in the fishing village of Thuan An. Interactive discussions in working groups of villagers were facilitated. These helped identify and prioritise the most important problems and issues in the particular commune. Many detailed problems were identified during the discussions and these were combined into the following list of major issues:

- Sewage and waste disposal problems relating to health problems and quality of aquaculture products;
- Salinity and water quality problems related to drinking water quality and productivity of rice fields and aquaculture ponds;
- Coastal erosion problems related to safety of villages and cemeteries;
- Flooding problems related to safety and continuity of aquaculture;
- Planning problems related to land use, accessibility for transport and availability and quality of public services.
Identification of drivers and pressures
In order to provide a quick analysis of the situation, the DPSIR approach was adopted (see above). Due to the dominance of aquaculture related issues, elaboration of DPSIR focused on this (Table 1).
Table 1: DPSIR - Driving forces, Pressure, State, Impact and Response - elaboration for aquaculture activities

<table>
<thead>
<tr>
<th>DPSIR</th>
<th>Elaboration</th>
<th>Information need</th>
</tr>
</thead>
<tbody>
<tr>
<td>State of the ecosystem based on indicators</td>
<td>Indicators of the ecosystem state could be: The (remaining/destroyed) area of bare mudflats, wetlands, submerged vegetation, Pollution levels indicated by for instance BOD5, COD, Oxygen saturation, NO3-N, TN, TP, Chlorophyll, algae species composition, pesticide concentrations, Bird, fish and crustacean species abundance and diversity Definition of standards for selected indicators.</td>
<td>Mapping and monitoring of historical and present states. Preparation of indicator values per season, per year, per region</td>
</tr>
<tr>
<td>Impacts on ecosystem carrying capacity</td>
<td>Evaluation of impacts on ecosystem carrying capacity, Analysis of spatial and temporal changes of indicators in relation standards and to (extension of) aquaculture activities in the lagoons.</td>
<td>Analysis of maps and monitoring data. Analysis of existing standards Availability of calibrated modelling tools to predict impacts of future scenarios Models will also enable integration of other drivers and pressures.</td>
</tr>
<tr>
<td>Responses needed of stakeholders and decision makers</td>
<td>Diversification, decreasing production intensity avoiding diseases, relocation of aquaculture, Improvement of applied technologies, viz waste water treatment, . Improvement of water circulation, Creation &amp; restoration of habitats, Set-up improved monitoring, planning and enforcement programs.</td>
<td>Clear management information products. Inter-agency, inter-sectoral cooperation through ICZM. Awareness raising at district and commune level. Decisive governance and enforcing</td>
</tr>
</tbody>
</table>

4.2 Definition of indicators and standards for ecosystem state

The next step in quantifying the state of the eco-system is the definition of a comprehensive set of indicators that relate to the pressures mentioned in the previous paragraph. These indicators require an agreed set of reference values or standards. Once indicators and standards have been defined, the present state of the ecosystem can be assessed. Predictions of future values of indicators in relation to aquaculture activities provide a basis for the assessment of the likely impact of development plans, if necessary, in combination with other expected changes or impacts. Mathematical models can improve the predictive capability. The assessment of state of the ecosystem functions (such as providing good water quality), which is based on the analysis of the status of indicators helps define the carrying capacity.
The number of indicators selected is limited by the availability of data, maps that define the historic and present situation and the capability of numerical models that can be used to predict the future state of the ecosystem based on impacts of future aquaculture activities. Furthermore, acceptable standards need to be selected to facilitate evaluation of the measured or predicted indicator values.

A list of quantifiable indicators and standards is given in Table 2. The selection of water quality as an indicator provides a useful start. These indicators can be (and are) measured and used for predictive modelling. Water quality indicators are easily related to accepted standards. Additional relevant indicators of the state of the ecosystem, such as species lists and numbers of birds and fish, surviving habitat (area of bare mudflat, area of submerged vegetation, area of mangrove and salt marsh vegetation) are not used in the remainder of this analysis, due to lack of data and standards, and difficulty of inclusion in mathematical modelling.

Table 2: Indicators and standards of water quality used to measure the state of the ecosystem

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>Standard</th>
<th>Regulations and Provisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total nitrogen</td>
<td>mg/l</td>
<td>0.3 - 0.6</td>
<td>Coastal water standard - Japan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9</td>
<td>Water quality criteria for coastal plain - US</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5 - 1.0</td>
<td>Water quality criteria for fish production area - China</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>mg/l</td>
<td>0.03 - 0.05</td>
<td>Coastal water standard - Japan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.04</td>
<td>Water quality criteria for coastal plain - US</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>Water quality criteria for fish production area - China</td>
</tr>
<tr>
<td>Formalin</td>
<td>mg/l</td>
<td>0.9</td>
<td>Drinking water standard - WHO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.001 - 1</td>
<td>Toxicity data to aquatic life (Sara Graslund, 2001)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Formalin is used to sanitize aquaculture ponds</td>
</tr>
<tr>
<td>Total organic</td>
<td>µg/l</td>
<td>10</td>
<td>Coastal water standard for aquatic cultivation area - Vietnam</td>
</tr>
<tr>
<td>pesticides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total coliforms</td>
<td>MPN/100ml</td>
<td>1000</td>
<td>Drinking water standard - Vietnam - Fishing water - Vietnam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10000</td>
<td></td>
</tr>
</tbody>
</table>

MPN = most probable number

The standard values of selected water quality parameters are preferably based on the Vietnam Coastal Water Quality Standard (TCVN5943-1995) for aquatic cultivation area. Unfortunately, in Vietnam there are no limitation values for Total Nitrogen (TN), Total Phosphorus (TP), specific pesticides and formalin, and standards for Japan, China, US and WHO are referred for those parameters instead. In this study the US standard for coastal plains was used as reference.
4.3 Quantification of ecosystem state using an integrated modelling approach

Analysis of monitoring data

The ecosystem of the lagoon is under heavy pressure. Biological, chemical and physical monitoring of the coastal ecosystem including the Tam-Giang lagoon was pursued by the Vietnam – Netherlands Coastal Cooperative Program (see Figure 5). Water quality indicators such as nutrient concentrations, organic pollution indicators such Biological Oxygen Demand (BOD5), Chemical Oxygen Demand (COD) and Coliforms, chlorophyll concentrations, heavy metal concentrations all point in that direction.

![Image](image.png)

Figure 5: CCP monitoring of the Tam Giang lagoon: biological and chemical survey of the water and sediments. (photo Robbert Misdorp)

The water quality of the rivers and the lagoon deteriorated measurably during the monitoring period of 1998-2003. BOD5, COD, Nitrate and Chlorophyll concentrations all rose. This indicates that the use of resources in the lagoons exceeds its capacity for natural purification. Due to the lack of data before 1998, it is not possible to quantify long-term historical changes to the biology of the entire TTHue Lagoon (Tam Giang – Cau Hai Lagoon). A number of "historical" trends seem to be clear:

1) Productive fish catch is centred on migration periods of marine species into the lagoon. In other periods, the catch is very low. This indicates that practically no natural fish populations remain in the lagoon outside of these periods. Fish catch monitoring shows a steadily decreasing size of individuals since the 1990s (Brzesky and Newkirk) with, a total absence of any adult individuals in the catch data and reduced species diversity today. This is a clear indication of heavy pressure on the lagoons. Fish capture data in relation to number of fishing boats indicates the same (Figure 3a). The strong increasing pressure on the borders of the lagoon is also indicated by the fast extension of aquaculture ponds as shown by Remote Sensing analyses (Misdorp et al., 2005 and see also CCC II-8-2);

2) Bird species count is down; numbers observed are reduced (Misdorp et al., 2003). Practically no birds feed in the lagoon, indicating that there is no food source of any importance remaining and probably indicating that the amount of undisturbed habitats have been reduced;

3) Macrophyte coverage has been heavily reduced due to extension of aquaculture ponds and enclosures into the shallow areas, destructive fishing methods and the increased harvesting of vegetation for fish feeding;

4) Shallow, muddy and sandy areas have practically disappeared due to occupation by ponds and enclosures, reducing feeding habitat for waders and for many invertebrates;

5) Salinity barriers and sluices built to prevent salinity intrusion in the rivers and to preserve fresh water have reduced the suitability of the area for migrating species.

The results of the monitoring program, initiated by CCP project, clearly illustrates the influence of nitrate enrichment in ponds for phytoplankton production (source CCP Task 7 report, 2003). Gradients indicate the role of the ponds as a source of nutrients for the lagoons.
Figure 5: Average nitrate (NO₃⁻ N) concentrations in dry season transects and average phytoplankton biomass and species number in dry season from inside shrimp ponds (.1), nearby channel (.2) to lagoon proper (.3) for three locations QA: monitoring location in the Tam Giang lagoon, VG: location in the Thanh Lam lagoon, LD: location in the Cau Hai lagoon. (Source: Water quality monitoring of Coastal Co-operative Program (CCP) in Thua Thien Hue province in 2002, 2003) NO3-N is the dissolved fraction of Total-Nitrogen (TN). This fraction is during dry season, at high levels of primary production much smaller than the total amount of Nitrogen in the water. The Delft3D lagoon water quality model calculates TN as a combination of dissolved-N, particulate-N in dead organic matter and N enclosed in phytoplankton. This value is later used in analysis of system status against TN-standard. (source: CCP 2003)

Application of numerical models
Based on the results of the DPSIR analysis, consultation with villagers and availability of data and expertise, a water balance model and a 2D lagoon water quality model were selected as first building blocks for a comprehensive modelling approach as shown in the scheme below (Figure 6).
4.4 Run off and River discharges: Water balance model STREAM

STREAM (Spatial Tools for River basin Environmental Analysis and Management), a GIS based water balance model, was developed in response to specific demands for conceptual integrated river basin and coastal management. It shows the effects of dams and changes in land use in the upper catchment on the coastal zone.

The grid-based STREAM modelling concept was also designed to show the long-term impact of climate change on the entire river basin. Within the context of the CCP project, the Institute of Environmental Studies (Free University, Amsterdam, see CCC III-3-2-6) developed a STREAM model for the river basins of the entire TTHue province, including the main Perfume River (Huong). It was calibrated and validated in order to predict river discharges into the lagoon (Aerts and Bouwer, 2002). Figure 7b shows the validation results of the STREAM model for the Thoong Nhat station, (Vietnam VA report, 1995), upstream on the main river Huong (Perfume). The observed and modelled river discharges were a relatively close fit. The STREAM drainage pattern fitted well with the actual river courses (Figure 7c).

This model is able to predict river discharges using land-use (see Figure 7a), soil types and rainfall-runoff relations based on the current knowledge and statistics of the Huong river. Impact of climate change affecting river discharges were also estimated, using IPCC regional scenarios on monthly temperature and rainfall as input data.

STREAM-TTHue provided river discharges, as crucial input to the 2D Lagoon model, thereby linking processes in the hinterland to the coastal area.
4.5 Water circulation and water quality, 2D lagoon model

With this model, many important features and behaviour of the lagoon system were quantified, including:

- Water levels;
- Salinity distribution;
- Sediment transport;
- First order degradable substances.

Figure 7a: Digital land use map of TT Hue Province, one of the series of GIS input data for the water balance STREAM,
Figure 7b: Validation of calculated monthly river discharges with STREAM, using the hydrological data collected at the Thuong Nhat station, upstream Huong river;
Figure 7c: The simulated drainage patterns and river discharges (m3/sec) for November 1999, included the heavy rainfall related to cyclone “Eve”, (first week of November 1999) reflects rather well the actual discharges and the drainage patterns of the river basins in TTHue Province.
The 2D Lagoon Model is used for modelling variable water flow and transport of dissolved matter. The flow is determined by the lagoon bathymetry, tides (tidal inlet bathymetry), river discharges, currents and wind (waves). The model solves the shallow water equations, consisting of the horizontal equations of motion, the continuity equations and the transport equations for conservative constituents (e.g. pollutants). The equations are solved by an implicit finite difference method on a staggered grid. The transport of matter is modelled by advection-dispersion equation in three co-ordinate directions. Source and sink terms are included to simulate discharges and withdrawals. A first order decay rate can be defined for each constituent. Improvements of the model are necessary with respect to the bathymetry (for the lagoon an assumed uniform water depth was 2m), extension of the grid to include land liable to tidal flooding and calibration/validation with better (tidal) data. Because in general locally generated waves are small (below 30 cm) no wave modelling is necessary. The basis for the lagoon model is the existing DELFT3D-FLOW modelling environment (see also: delftsoftware.wldelft.nl).

Figure 8a: An example of the flows at flood and ebb tide in the Thuan An area (above) and
Figure 8b and c: Distribution of simulated salinity (in promilles salt) produced by the 2D hydrodynamic model developed through the VNICZM project: salinity ranges up to 30‰ during dry season (left) and up to 15‰ during wet season (right).
The state of the ecosystem has been evaluated. This was done on the basis of application of the 2D Lagoon Model, the discharge data derived from the Water Balance Model STREAM, the impacts of aquaculture comparing the situation 1990, 2001 and two future (2010 a and b) scenarios regarding land-use (Table 3). The numerical model was used to establish concentrations of the nutrients and pesticides in four major parts of the Tam Giang – Cau Hai lagoon. The 2001 situation was used to calibrate the model results to the available monitoring data (N.T.T. Nguyen, 2004).

Table 3: Situations studied with the 2D Lagoon Model

<table>
<thead>
<tr>
<th>Situation</th>
<th>area of aquaculture (ha)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historic 1990</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Calibration 2001</td>
<td>2976</td>
<td>calibrated to data</td>
</tr>
<tr>
<td>Future 2010a</td>
<td>7104</td>
<td>following master plan, high estimate</td>
</tr>
<tr>
<td>Future 2010b</td>
<td>7104 + reservoir</td>
<td>60% decrease discharge wet season</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40% increase discharge dry season</td>
</tr>
</tbody>
</table>

The calculation results shown that at present the lagoon is polluted somewhat by nutrients during dry season with average concentrations close to the standard. The most polluted areas have been found at river outfalls and aquaculture ponds. Agricultural waste is the main pollution source in 2001 (Figure 9).

Based on the provincial master plan, aquaculture area was expected to triple between 2001 and 2010. This trend is indeed realised (Figure 3b). Subsequently, the total future nutrient load will also be doubled or tripled depending on choice of culturing techniques. In the same way, loads of pesticides from the aquaculture ponds to the lagoon, will increase. This estimate of future waste loads is based on increasing area without increased unit load. This is probably a conservative estimate. In the same period nutrient load from population will increase due to population growth and loading from agriculture will increase likewise.

The future increase in concentrations of the pollutants can be predicted based on the above trends in waste loads and using models which quantify and extrapolate the hydrodynamics and chemical processes in the coastal zone. For the future situation, nutrient level rises alarmingly in the entire lagoon during dry season. With the expansion in aquaculture area by 80% and the increase in waste load per ha by 50% together with the slight increase in agricultural load (the future scenario with low aquaculture load), the future nutrient content is about 1.3 times for Total Nitrogen and 2 times for Total Phosphorus as much as the 2001 concentrations.

Figure 9 shows that the contribution of aquaculture to the total nutrient load in the lagoon increases from the present 15-20% to 60-70% in the future. The selected standards for Total Nitrogen and Formalin are already exceeding in the present situation. Total Nitrogen -TN standard is exceeded in 35% of the lagoon area in the dry season and this level will be surpassed in the future. The difference between dry and wet seasons is striking, due to the drastic changes in river discharge, water residence times and water circulation in the lagoon.

Figure 9: Relative contribution of aquaculture to total nutrient load 2001 situation (left), 2010 situation (right)
With respect to area exceeding standards, the model simulation indicates that in 2010 about 50% of total area could exceed the Total Nitrogen (TN) standard value for the United States of America. As this US-TN standard is a high value in comparison with other standard values (see Table 2), more areas of the TTHue lagoon will exceed the limit if other standards would be applied. The same pattern is observed for Total Phosphorous (TP). The area polluted by nutrients during the dry season is larger than during wet season. However, there is an opposite trend for the third group of pollutants, the pesticides: the polluted area during the dry season is smaller than during wet season. This is related to seasonality of application of pesticides, which is linked to the cropping cycle of rice and the growing season of aquaculture species (see Table 4).

<table>
<thead>
<tr>
<th>Situation</th>
<th>TN (US std)</th>
<th>TP (US std)</th>
<th>Total Pesticides</th>
<th>Formalin (toxic effects)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>wet dry</td>
<td>wet dry</td>
<td>wet dry</td>
<td>wet dry</td>
</tr>
<tr>
<td>Historic 1990</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
<td>- 0</td>
</tr>
<tr>
<td>Calibration 2001</td>
<td>0 35</td>
<td>0 50</td>
<td>0 0</td>
<td>- 38</td>
</tr>
<tr>
<td>Future 2010 a</td>
<td>30 50</td>
<td>10 85</td>
<td>35 10</td>
<td>- 50</td>
</tr>
<tr>
<td>Future 2010 b</td>
<td>70 42</td>
<td>25 78</td>
<td>50 5</td>
<td>- 50</td>
</tr>
</tbody>
</table>

Future estimates are based on the possible influence on river discharge by envisage dam construction across the river creating water storage reservoirs. Other activities in the province (changes in land use and soil erosion, new infrastructure,) and climate change (changed precipitation and evaporation) will further affect the state of the ecosystem. These changes can be quantified and related to river discharges, sediment balance, and water circulation in the lagoon itself and can facilitate the estimates on the future exceedance of nutrients and pollutants as a part of the integrated ecosystem approach.

5. Advise to management level

This analysis of the impact of aquaculture on the state of the lagoons is the first attempt to provide a consistent analysis of ecosystem functioning, where both influences from land and sea are integrated and where biological and physical processes are combined. The analysis of historical, current and future states of the lagoons has produced valuable understanding of the sensitivity of the lagoon to increasing use. The application of a standard numerical hydrodynamic and water quality models with a simplified interface provided the decision-maker with a generic tool to analyse the impact of pressures on the lagoons. It is clear that this approach provides managers with greater insight into the possible consequences of economic planning decisions on the functioning of the lagoon.

From the results of this study, it appears that the maximum carrying capacity of the lagoon for waste loads from aquaculture has been reached. The dry season is the most sensitive to pollution from aquaculture. A remaining important issue, which requires discussion, is the allowable area where standards can be exceeded. If only 5% of the lagoon area is allowed to exceed the standard in the dry season, then it is obvious from Table 4 that the present area (2001 situation) in which aquaculture takes place is too high. The level by which the standards are exceeded is not very different between the four sub-lagoons that have been studied. We should also acknowledge that the reference situation chosen was 2001. Since then the actual area of aquaculture has grown rapidly to over 8000 ha in 2008. We need to acknowledge that the loss of shallow natural habitat (needed for spawning of many fish species) is almost 100% due to pond construction and therefore exceeds any sensible definable standard. Impact of reservoir operation in dry seasons will improve the situation slightly, due to extra water supply and dilution. In the wet season, the situation will deteriorate further due to water storage and reduced dilution.
Environmental Carrying Capacity Status Indicator of the TT Hue Coastal Zone

Fishing water

<table>
<thead>
<tr>
<th>O Lao</th>
<th>T. G. N</th>
<th>T. G. S</th>
<th>Thuan Anh - Thu Mon</th>
<th>Ho Trung</th>
<th>Cau Hai</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Figure 10: Simplified model interface allowing analysis of several cases on ecosystem state. This interface overviews the combined results of Water Balance Model STREAM and 2D Lagoon model, provided an ecosystem state evaluation on highest level of integration possible within the CCP project. Analyses provided information in relation to river discharge, precipitation, evaporation, land use, aquaculture intensity and season. Indicators and standards are selected according to issues at hand. For instance, swimming water quality does use more strict standards for Total Coliforms numbers than other uses.
TT Hue provincial leadership is trying to find ways to quantify the impact of aquaculture activities on the environment, and properly guide the rapid growth of aquaculture activities in the province in the future. This is required in order to ensure sustainable further development of this important economic sector, whilst ensuring the maintenance of a healthy ecosystem for the benefit of other sectors and society in the long term. In view of the present situation, the following advice was given to the Provincial leadership with respect to sustainable further development of aquaculture activities:

- Stop further extension of aquaculture areas in order to prevent further habitat loss. Given the present situation, relocation does not seem an effective option;
- Fix the waste load of aquaculture production at the level of the present (2001) situation
- Adopt the experiences of Thai Aquaculture Boom and Bust waves, which provided a few with high economic benefits, many local coastal inhabitants with distress and leaving the Government with expensive rehabilitation projects, see CCC II-7-1, and download the Thai Aquaculture Training Manual see CCC V-1-1;
- Start pilot studies on small- or no-emission culturing technologies that can lead to increasing productivity, while reducing environmental impact at the same time, which is in line with the findings of Gräslund and Bréngtsson (2001). New technologies should replace old culturing systems, without further expanding the area. Nett reduction of total waste load should be the ultimate goal;
- Research the possibilities for reducing the discharge of nutrients and pesticides from the drainage basin into the lagoons (priority area: Cau Hai);
- Research the possibilities for reducing the nutrient input from domestic sources (for instance, introduction of phosphate free detergents);
- Implement measures to reduce bacteria, BOD and heavy metal load to the lagoon system by treatment of sewage and industrial waste and introduce home sanitation units, see CCC III-3-3-6;
- Research options for improving water circulation in order to improve water quality in the most critical culturing areas. If locally applied, this option can lead to better water quality in ponds, but will cause a deterioration of the water quality in the lagoon proper. If applied regionally, in order to improve mixing of seawater with lagoon waters, it could lead to investment in large-scale infrastructure works. This option could be promising but needs detailed numerical modelling studies;
- Study options for creation/restoration of lost habitats. This option could imply reduction of the extent of aquaculture in some areas. It could also result in creation of new habitats in other areas. For instance, a protected island in Cau Hai lagoon surrounded by shallow intertidal areas could be created. Another option is to create mixed aquaculture ponds, with shallow areas that can provide habitat for submerged vegetation or mangroves, at the same time filtering suspended solids, improving water quality, feeding, and sheltering the cultured species;
- Set-up of an improved long-term monitoring programme. This is necessary in order to monitor the future changes of the ecosystem state in relation to the present day situation;
- Set-up a long-term interdepartmental ICZM training programme in cooperation with universities. This program should form the basis for trained experts and provide a source of adequately educated master students and PhD’s that can sustain ICZM in the future;
- Improve the quality of data and modelling, in order to provide greater certainty in model predictions and therefore in management advice;
- Create an international and inter-university cooperation in the field of integrated ecosystem monitoring, modelling and policy preparation. This integrated ecosystem approach will help the application of good governance for the sustainable use of resources in the coastal zone of the TTHue Province and can function as a framework to implement many of the recommendations.

6. Conclusions
One of the main purposes of the Vietnam-Netherlands Coastal Cooperative Programme was to develop tools, examples and capacity, which will help strengthen integrated approach with respect to sustainable decision-making for the management of the TTHue lagoon and its surroundings (extending from the catchments to the coastal areas). Training was a fundamental part of the project. It became clear that the present ICZM capability in Hue is limited, and the capacity building and associated institutional setting at the local level to create ownership took a considerable time. From this perspective involvement of experts from national level institutes proved to be valuable to maintain quality and provide advice to experts at local level. In the spirit of the ICZM concept, the Provincial Leadership received preliminary but integrated and timely answers to their questions on future policy decisions.

Does this help to provide good governance?
The analysis shows that urgent action is needed with respect to the following:

- Physical state: tools are needed to improve understanding and investigate solutions;
- Water quality and pollution: Any intensification and/or extension of activities in the future should be carefully controlled and limited;
- Ecology: Fishing intensity should be reduced and natural shallow habitats should be protected and partly restored;
- Governance: More capacity of ICZM experts is needed to facilitate the ICZM process.

The ecosystem approach can help government to apply good governance for the sustainable use of resources in the coastal zone. Good governance here means sound resource use policies that are responsive to the (economic) needs of the people and maintain a healthy eco-system. Robust and sound resource management systems, practical experience and knowledgeable institutions are required to support these policies. Good governance at all levels is also fundamental to finding a balance between sustainable resources use and maintenance of a healthy and biologically diverse environment. To this end, it is important to ensure inter-sectoral cooperation, optimal institutional setting and reliable funding in the pursuit of good governance of the coastal system. There is an urgent need to integrate the ecosystem approach into agriculture, fisheries, forestry and other production systems that have an effect on biodiversity and on sustainable use of resources.

Long-term capacity building will help strengthen provincial ICZM capability by improving the level of education in local Universities particularly in those fields related to natural (water) resource management (biology, environmental studies, chemistry, geosciences and coastal zone management). This recommendation should include a long-term inter-university cooperation project between National and Provincial levels and between Vietnam and other countries. The creation of such a cooperation in the field of integrated ecosystem monitoring, modelling and policy preparation will strengthen the sustainable use of resources in the coastal zone within a frame of optimal institutional arrangements. A successful example of such an ongoing inter-university cooperation between Vietnam and the Netherlands exists namely the creation and support of the Marine and Coastal Engineering Faculty of the Water Resource University in Hanoi (see CCC II-8-5).

The long-term development objective of this recommendation is to raise the performance level of professionals working in ecosystem research in Vietnam, and to establish a firm foundation for well-qualified graduates to take up positions in research, operation and management functions in governance and business in the coastal provinces of Vietnam.

7. References

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PDF Reports


Websites

• Deltares: http://www.deltares.nl/en


Capacity Building
Hydraulics & Coastal Engineering

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4. In Conclusion
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Summary
Vietnam has a long coastline with two large river delta’s and about 20 smaller estuaries in between. Much of the country is a “coastal zone”. The need for education in coastal issues - Coastal Zone Management and Coastal Engineering - in Vietnam is evident.

Two decades ago a coastal education programme between Vietnam and the Netherlands began. This cooperation resulted in the establishment of a BSc coastal engineering faculty at the Water Resources University (WRU) in Hanoi in the period 2001 – 2005. Staff members were trained, the actual BSc coastal engineering teaching started in 2003. More than 50 BSc students graduated annually. In the second phase of the cooperation (2005-2009), the focus shifted to undertake applied research in two fields: sea dikes and estuaries. Within this framework there were two fields: MSc education and research in Hanoi, and PhD training in Delft. Both strengthen the Vietnamese coastal engineering and ICZM knowledge base. Continuously increasing the educational level parallel with the strong economic growth is the desire of Vietnamese authorities. This capacity building will also help sustainable policies to address the impacts of global change on the coast.

The first Coastal Engineering students at Faculty of Marine & Coastal Engineering - Water Resources University, Hanoi. (photo: WRU - CE)
1. Introduction

Vietnam's coastline is about 3300 km long. With two large river deltas, the Red River in the North and the Mekong in the South and about 20 smaller estuaries in between, much of the country can be considered to be part of the "coastal zone". The need for Vietnamese education in coastal issues, like Coastal Zone Management with specialisations in Coastal, River, Estuary and Delta Engineering, became apparent about 20 years ago. Until then, the population had to adapt more or less to the dynamics of the coastal region caused by flooding due to typhoon surges from the sea, flooding due to typhoon rains from the rivers and estuaries, coastal erosion, salt intrusion, navigation problems due to seasonal closing off estuaries particularly in the dry season. Population pressure on the coastal area in Vietnam has increased considerably: 50 % of the total Vietnamese population (around 86 million inhabitants in 2010) live in coastal provinces. Adaptation, in the sense of 'living with regular flooding' became more and more unacceptable from both an ethical and economic point of view. However, the country at that time had no real coastal engineering tradition and no formal coastal engineering education.

The Dutch Rijkswaterstaat/Ministry of Transport, Public Works and Water Management gave initial assistance to the Vietnamese Ministry of Agriculture and Rural Development in the 1990s and the Royal Netherlands Embassy in Hanoi supported the establishment of a coastal engineering education at BSc-level at the Water Resources University (WRU) in Hanoi from 2001. This was undertaken by Delft Partners (Delft University of Technology, UNESCO-IHE and WL/Delft Hydraulics) from the Netherlands. In the first phase of that programme (2001-2005) a Coastal Engineering faculty was established. Teaching staff were trained in Delft at MSc-level and Vietnamese staff under the guidance of staff in Delft developed lecture notes. Equipment was purchased and installed to support teaching and provide the basis for research (see Figures 1 and 2).

Figure 1: Testing a new wave flume installed in the laboratory, WRU, Hanoi. 
(photo: WRU - CE)

Figure 2: Study on the mechanism sand dune breaching, in the laboratory.
(photo: WRU - CE)

In the second phase of the programme (2005-2009), the focus shifted to research to meet the demands of the Vietnamese society in addition to the ongoing training of teaching staff and support for the BSc-education program. Two focal points for research were defined: sea dikes and estuaries. The need for better sea dikes became apparent during the typhoon season in 2005 when many dikes were damaged by heavy typhoons. This required a better insight in the behaviour of estuaries in Northern and Central Vietnam. The very short rivers show a large seasonal variation in the rate of discharge. This leads to natural closure of the river mouth in the dry season by natural longshore sediment transport. River floods at the beginning of each wet season, remove these natural sandy, closure dams.

Training in Delft at PhD-level took account of these two focal points. These research topics also served as preparation for MSc-education. Teaching staff undertook research in order to help maintain their scientific knowledge. This part of the training programme ended in 2009.
In the period 2001-2009, about 15 staff members of Water Resources University (WRU) studied for a MSc degree in Delft and 4 for a PhD degree. At present about 60 students leave the WRU each year with a BSc-degree in Coastal Engineering, including preliminary knowledge of Coastal Zone Management. The Coastal Engineering faculty at WRU in 2010 consists of 12 lecturers with MSc level and 6 lecturers with PhD level qualifications. WRU undertakes research, on both sea dikes and estuaries, and participates in various national research programmes relating to these coastal issues.

More detailed information can be found on the WRU Faculty of Marine and Coastal Engineering website and includes:

- An overview of training curriculum and lecture notes;
- Relevant references in the library;
- Research facilities e.g. wave flumes, Remote Sensing and Geographical Information System laboratories.

Insert 1:

The relatively low sea dikes in Vietnam lead to frequent overtopping by waves during a typhoon surge. Raising the dikes to avoid overtopping is expensive and difficult in spatial planning terms. The inner slopes of the dikes therefore have to be strong enough to withstand the overtopping.

In the wave flume in the hydraulic laboratory of WRU, overtopping tests are undertaken to study e.g. the influence of a crown wall (see wave flume photo above) on overtopping discharges (photo; H.J. Verhagen)

The strength of inner slopes cannot be tested on a small scale and tests have to be done on real dikes. Realistic overtopping volumes are simulated with a Wave Overtopping Simulator in Vietnam on the sea dike in Do Son – Hai Phong in the same way as is done in the Netherlands. (photo; G.J. Schiereck)

Wave flume testing the reduction of wave overtopping by Vetiver grass. (photo; H.J. Verhagen)
2 Developments

The developments sketched above continue. Most economic growth takes place in the low-lying coastal areas of the country and, hence, the population pressure on these areas is ever increasing. The Vietnamese government has recognised the potential of the coastal and marine zones and has set a target that in 2020 more than 50% of the GDP will come from these zones (either from fisheries, mining, transport, tourism or any other economic activity).

This already offers enough challenges, but climate change makes the situation even more difficult. Vietnam is in the top of the countries worldwide, vulnerable to sea level rise (see CCC II-8.1). Permanent inundation, more frequent flooding by rivers and typhoon surges, more and longer periods of low river discharges, lead to salt water intrusion and lack of fresh water are among the threats to development.

These threats are explicitly covered in the action plan on climate change prepared by the Ministry of Agriculture and Rural Development (MARD). This is part of the overall approach by the Vietnamese government, in which the Ministry of Natural Resources and Environment takes the lead on climate issues, and where MARD is responsible for the implementation in the water sector.

After about 20 years of coastal cooperation in the field of education in coastal engineering and ICZM, the Dutch assistance will gradually reduce, while the Vietnamese efforts will gradually increase.

Insert 2

On top of the natural dynamics of inlets, human interference also plays a role. Sand mining takes place everywhere, in the mouth of the Hue estuary, although until now only on a small scale. (photo: G.J.Schieren)

Coastal dynamics play an important role along the Vietnamese coastline. Here in Nam Dinh, complete villages have disappeared due to coastal erosion. (photo: G.J.Schieren)

Inlets and estuaries, where rivers meet the sea, are widespread and well studied, dynamic areas worldwide. In Central Vietnam, these features show some specific difficulties. The distance from mountains to sea is relatively small (0 –100 km). Such a small catchment area leads to large seasonal differences in river discharge, sometimes even zero in the dry season. The monsoon driven littoral drift causes the growth of large spits and sometimes even closes off the estuary completely. At the start of the wet season, these spits obstruct the river flows into the sea resulting in flooding of the coastal area before these natural sand dams are removed by either the river or waves from the sea. Also in less extreme situations, these dynamics cause problems for navigation to and from the estuary.

3. MSc coastal education in Vietnam
Vietnamese society has shown great resilience in the past and there appears to be enough drive to cope with problems that lie ahead. It is obvious, however, that a higher level of education and research is needed to meet the challenges. In the coming decades plans have to be developed and decisions made that may have far-reaching consequences. Major mistakes could be disastrous from an economic point of view or may be unsustainable. The need for advanced engineering is also obvious, since adaptation to global changes will require major infrastructure development.

Coastal Zone Management is a proper umbrella, for water and coastal management and for spatial planning in the low-lying areas of the country, including the large deltas and the estuarine systems. An integrated approach is the way to achieve the best possible and sustainable solutions for the areas under discussion and to avoid as much as possible, blind spots in spatial planning. In-depth engineering knowledge is in the mean time, of paramount importance, both for understanding the behaviour of the highly dynamic nature of coastal areas and in designing measures to accommodate society’s needs.

MSc-education dealing with coastal issues will become more and more important in the coming years. Such an education should contain both general planning issues as well as engineering specialisations, covering all elements of the coastal and marine environment, including soils and subsoil.

More information for your updating: the first master course of marine and coastal engineering is opened in academic year of 2011 with 20 students. Course will last 1 and half year. Master education will be continued annually.

4. In Conclusion

The coastal zone of Vietnam is being rapidly developed, densely populated and is critically vulnerable to the impacts of climate change. Hence, creating its own Faculty of Marine and Coastal Engineering was a high priority for the Vietnamese Government. Finance and expert assistance in the fields of hydraulics, coastal engineering and ICZM is being offered by the Netherlands. In this way the government of the Netherlands shows its desire to contribute to the exchange and transfer of coastal knowledge as laid down in Conventions (UN-Framework Convention on Climate Change, UN-Convention on Biological Diversity, Agenda 21), Conferences (e.g. World Coast Conference’93) and Memoranda of Understanding.

As this expertise grows Vietnam will become more and more self-reliant by strengthening the application of knowledge from the WRU Faculty of Marine and Coastal Engineering to coastal management and development.

5. Websites:

- Delft University of Technology - Hydraulic Engineering, Delft.  
  http://www.citc.tudelft.nl/live/pagina.jsp?id=4807bf63d-134f-400d-ba64-5806648683e5&lang=en
- Deltares: the institute for applied research in the field of water, subsurface and infrastructure - Delft.  
  http://www.deltares.nl/en
- WRU – CE: Water Resources University - Faculty of Marine & Coastal Engineering, Hanoi:  
  http://coastal.wru.edu.vn/index.asp?lang=en&page=news1 and  
- UNESCO-IHE, Delft:  
  http://www.unesco-ihe.org/
Capacity building and training for ICZM
Experiences from Vietnam

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Summary
Any Integrated Coastal Zone Management (ICZM) programme is based on knowledge of the socio-economic situation and understanding of natural coastal processes. Increasing the knowledge base through training is a crucial element in the establishment of effective coastal management. During the Vietnam-Netherlands ICZM project, much attention was paid to the training aspects and a lot of experience was obtained. More than 500 people, active at all governmental levels and in non-governmental organisations, were trained in the principles of ICZM. It proved to be important that the programme was tailor made, with different objectives for each target group. Training should not only be for the transfer of knowledge, but also for imparting training skills and tools. Valuable training tools such as the ‘Pesisir Tropicana’ simulation game and role-playing were used. In addition, training in new interdisciplinary work, creative thinking and problem-based learning, are important for effective ICZM planning and implementation. Finally, it is essential that the training programme is the start of a capacity building exercise and awareness-raising process that can continue after the training programme has ended. Therefore, ample attention was paid to the aspect of ‘training-the-trainers’ and the provision of training material in the local language.
This approach proved highly successful. The new trainers are now teaching the next generation of ICZM managers in Vietnam, facilitating the implementation of new ICZM programmes at national and provincial levels.
1. Introduction

Training activities form a crucial element in the establishment of effective Integrated Coastal Zone Management (ICZM). It contributes to capacity building, i.e. the development of human resources such that people are capable of executing their assigned tasks. It also includes an element of raising awareness and may form part of an educational curriculum covering ICZM. Because of the great differences in types of training with regard to the objectives and target groups, the training should be tailor made. In this chapter experience in capacity building and training in Vietnam are presented that were part of the Vietnam-Netherlands ICZM project (VNICZM), undertaken from 2001 to 2006.

2. Training programme

During the VNICZM project more than 500 people, active at all governmental levels and in non-governmental organisations, were trained in the principles of ICZM. The entire training programme comprised a wide range of activities, including:

- Workshops on training needs and capacity building;
- An ICZM Promotion Seminar;
- Introductory courses at national (Hanoi) and provincial level (Nam Dinh, Hue and Ba Ria Vung Tau);
- District Level Introductory courses;
- Training on-the-job;
- ICZM Planning tools: GIS and Remote Sensing Training courses;
- Facilitation of Vietnamese staff to international courses.
- High level Management Tours to the Netherlands;
- A Refresher Course for ‘alumni’ in Hanoi;
- In-depth follow up courses.

Training objectives

The training goal used in the VNICZM project was twofold: firstly, training makes people aware of the need for ICZM at any level of organisation and governance; secondly, training contributes to capacity building through improvements of skills and transfer of knowledge on how to undertake the different ICZM tasks. The success of a training course can be evaluated based on a clear and explicit list of learning objectives before the training starts. The set up of the course should meet the expectations of the trainees and should match their level of education and expertise. Therefore, the specific objectives for each training situation depend on the setting, the target groups and specific goals. For each of these situations and target groups different training courses were developed at national, provincial and district levels.
3. **Training: more than transfer of knowledge.**

Many participants stressed the usefulness of interaction and discussion between the participants. The role-play of Pesisir Tropicana (see Box) was always a success, not least because it is a new kind of education tool requiring additional skills, which are relatively unknown. The general situation with respect to higher education and knowledge management in Vietnam can be characterised as traditional mono-disciplinary with a focus on technical knowledge and science, but with less attention to interdisciplinary work, creative thinking and problem-based learning. These latter aspects are important ingredients for a successful implementation of ICZM. Therefore, future training activities should pay attention to this type of learning.

4. **Effective capacity building in ICZM**

A training programme should be the start of capacity building and a process of raising awareness that is able to continue autonomously. Effective capacity building of an ICZM unit entails more than just providing a number of courses. The course participation of each staff member should be part of a consistent career planning, combined with other ways of learning, such as training on the job, feedback and practical experience.

The fact that the work of a civil servant in an ICZM unit differs from most government departments that have line management tasks should be recognised. The ICZM staff should learn to work with the fact that they act mostly in an advisory capacity. Special skills are needed with regard to awareness raising, handling conflicts and persuasion. The staff members should learn how to develop alternative solutions that generate win-win situations.

5. **Training programme to be continued**

The philosophy behind the training programme was to begin a process within Vietnam that would be continue after the VNICTM project had ended. Therefore, there was considerable attention given to training-the-trainers. For instance, the in-depth follow up course contained many practical elements: a mixture of lectures, working exercises and field trips. The attendees consisted of scientists, employees of institutes, departments and ministries and NGOs.
The in-depth follow up course was set up as a mixture of training activities with the trainees expected to become trainers in future ICZM courses in Vietnam. Therefore, specific attention was paid to the Pesisir Tropicana exercise, which forms part of the basic ICZM course. One day of the course was dedicated to specific aspects of preparing, organising and participating as a trainer in a basic ICZM course.

During the training courses, the language barrier sometimes proved to be a constraint in the transfer of knowledge, despite translations of English texts and simultaneous translations during the courses. However, because of the improved ability of the Vietnamese counterparts to perform the training activities themselves, this language constraint will become less important in the future. In the mean time, some of the training modules are being translated in Vietnamese language.

6. Evaluation & Outlook

After the VNICM project ended in 2006, the outcomes and continuity of the ICZM training programme could be seen from several aspects.

Institutionally, ICZM was managed and promoted by the MONRE (Ministry of Natural Resources and Environment) at national level and by DONRE (Department of Natural Resources and Environment) at provincial level:

- First, MONRE supported Quang Nam province to do a 4 year ICZM project (2003-2007) with technical assistance having been mobilised from various people trained in ICZM, many of them had been trained by the VNICZM project.
- At a larger scale, MONRE had developed a national ICZM programme for 14 coastal provinces in the Central Area of Vietnam, which was approved by the Prime Minister in 2007 (Programme 158). To assist the 14 provinces in applying ICZM, MONRE organised a series of ICZM training for different target groups such as provincial leaders, managerial and technical civil servants. Many former members of VNICZM project who are now working for different organisations, including governmental and non-governmental entities, were involved in such training series as trainers and facilitators. The training courses mainly focused on providing basic ICZM knowledge and tools, making use of the training materials left by the VNICZM project and at the same time being adjusted to include experiences and contexts of Vietnam and other regional countries.
- In the provinces, which had been under the coverage of the VNICZM project (namely Nam Dinh, Thua Thien – Hue, and Ba Ria – Vung Tau), the people who had been trained in ICZM are still active in applying their knowledge of ICZM in their respective jobs.
- In addition, MONRE assisted the Government in formulating and issuing a Decree (highest level of legislation that the Government is empowered to issue) on applying ICZM in Seas and Islands Management (Decree 25/2009/ND-CP), in which ICZM expertise was also mobilised from those who had been trained in and practised on ICZM in Vietnam.

Some of the former VNICZM project members now work for non-governmental organisations such as MCD (Centre for Marinelife Conservation and Community Development, Hanoi, see website) and for SNV (Dutch International Development Organisation – Hanoi Office), with a focus on small-scale projects or programmes in the coastal zone. They transfer ICZM knowledge to their colleagues.

MCD is applying an ICZM approach in all its projects in the coastal provinces of Nam Dinh, Thai Binh, Khanh Hoa and is profiling an ICZM model at the community level. In addition, MCD also assisted the Nha Trang University, a dedicated state-owned tertiary education institution, in developing an ICZM course curriculum for graduate students which will soon become part of the formal syllabus of the University.

Looking to the future: Coastal zone management is moving higher on the agenda at all levels. ICZM in Vietnam is now mandated to the VASI, the newly established government body under MONRE in charge of Vietnam’s Seas and Islands Management. The implementation of Programme 158 will be facilitated by capacity building for ICZM. This is regarded as of critical importance and the results of previous training and capacity building will contribute to enlarging the ICZM efforts in Vietnam.
7. Conclusion

From the experience gained in the VNICZM project a number of conclusions and lessons can be drawn for training in ICZM. First, it is important that a training programme should have clear objectives that differentiate between target groups. The programme should therefore contain a variety of training elements, such as courses, training-on-the-job, workshops, excursions and conferences. Second, training people in ICZM is more than just transfer of knowledge. It is perhaps more important to train people in certain skills that are needed in coastal management situations. This requires analysis beforehand of the existing competences of the participants. Practical exercises and role-plays have a prominent place in the course schedule. Thirdly, a training programme should be the start of a capacity building and awareness process rather than the end and be able to continue after the training programme has ended. Therefore, ample attention should be paid to training-the-trainers and the provision of training material in the local language. This approach proved highly successful. The new trainers are now teaching the next generation of ICZM managers in Vietnam, facilitating the implementation of new ICZM programmes at national and provincial levels.

8. References


PDF reports:

**Netcoast Open Learner – UNESCO-IHE:**

1) Short manual for the use of Jesew together with the Pesisir Tropicana case study

2) Policy analysis * Exercise Pesisir Tropicana (via : Return to the exercise!)

http://www2.ihe.nl/we/dicea/polanaly/pes04/default.htm
http://www2.ihe.nl/we/dicea/polanaly/pes04/jesew.htm

Websites:

- MCD - Centre for Marinelifes Conservation and Community Development, Hanoi:

- UNESCO-IHE, Delft:
  http://www.unesco-ihe.org/
Box: Exercise ‘Pesisir Tropicana’

The exercise ‘Pesisir Tropicana’ is a simulation game for decision makers in coastal resources allocation. In this game, the participants first have to understand the interactions between the various functions and use of resources in the coastal zone. The participants have to translate a political statement (a policy) into an alternative for action and investments in the coastal zone. In a meeting, decision makers have to decide on an investment plan in the Pesisir Tropicana area, making choices between various alternatives, and have to overcome several dilemmas, all under a certain time pressure.

Objectives
After the workshop the participant should be:
- aware of the need of interdisciplinary co-operation in the development of coastal zone management schemes;
- aware of the need to organise and implement a coastal management scheme in an interdisciplinary team;
- know the decision making processes in the coastal zone, possible parties involved in this process;
- aware that often non-technical arguments are decisive.

Application
The methodology of this simulation game has been developed for training Netherlands government officers to co-operate with colleagues from different authorities. It has been adapted for different settings, the workshop has been held in several countries of the world (e.g. Indonesia, Colombia, Austria, Poland, Malaysia, Philippines, Brazil) and at UNESCO-IHE Delft for mixed groups of participants, and also for groups of one nationality (Taiwan, Iran). The discussion during the game (in case of the presence of only one language group) can be in the local language. The target group for the workshop are those interested in the decision making process in the coastal zone, so includes representatives from governments, NGOs, universities, etc. The workshop can be in groups with 8 - 16 participants, and will take two days.

The system of Pesisir Tropicana

Pesisir Tropicana is part of a tropical island, where several activities take place. The area is very comparable to many local economies in developing countries. Well established activities in the area are artisanal fishery, agriculture and (tin-) mining. New economic activities are tourism and aquaculture. Wastewater flows freely into the bay in front of the main town, Portharbor. There are plans to clean the wastewater however, that requires finance.

The economic results of the activities relate to the investments, the availability of labour and some of them depend on the quality of the water in the bay (e.g. agriculture and aquaculture). Plans exist to make a marine sanctuary. However, this requires even more clean water. The mangroves around the bay are under pressure and hence this may compromise their sea defence value.

Decision making

Each participant is assigned a role. There will be a mayor, a representative of the ministry of finance, the ministry of the environment, a grass-root pressure group (an NGO), some captains of industry, etc. An amount of money from a loan is available for investments in the area. They have, under the guidance of a “neutral” chair, to provide (preferably) unanimous advice to the Council of Ministers of the country regarding the investment plan. When they fail to conclude, the money moves to another area of the country. The discussions have to be based on the reports made during the previous parts of the workshop. In this way, participants will experience the requirements for a background report to be used in a decision-making meeting. It will also become clear to them, that very often the results of scientific calculations are not decisive in the decision making process. After the meeting, the process is evaluated by the course observers. Different experiences of the participants are discussed.
The exercise 'Pesisir Tropicana' is a simulation game facilitating decision making in coastal resources allocation. Decision makers have to decide on an investment plan in the Pesisir Tropicana area making choices between various alternatives, and have to overcome several dilemmas all under a certain time pressure.

Conclusions - Vietnam

In the period from 1993-2006 a number of large cooperative projects were carried out, in Vietnam with Dutch expertise and financial support of the Netherlands Ministries of I&E and Foreign Affairs through its Embassy in Hanoi. This contributed significantly to the development and application of ICZM practice in Vietnam on both the national and regional/local levels. The main developments relate to the following topics:

- From vulnerability assessment to ICZM, introduction and development of ICZM;
- Practical ICZM applications at a regional level;
- Capacity building, awareness raising and education.

From vulnerability assessment to ICZM: introduction and development of ICZM

The Vietnamese contribution to the World Coast Conference – 1993, marked the beginning of a long lasting cooperation between Vietnam and the Netherlands. This was followed by the execution of the Vietnam Vulnerability Assessment (VVA) from 1994-1996. The VVA was undertaken according to the UN-IPCC Common Methodology. The VVA concluded that Vietnam is very vulnerable to a wide range of impacts and in a way is comparable to the small island states of the world. The Vietnam-Netherlands ICZM project (VNICZM - 2000-2006) supported by the Coastal Cooperative Program (CCP - 2001-2006) marked the next steps in coastal cooperation, with the VNICZM covering the national and provincial planning level and the CCP aiming at developments and projects at the provincial and local level. In the TTHue province several ICZM tools were introduced, monitoring programmes executed, awareness raised and capacity built.

The achievements of VNICZM include: a national and three provincial CZM Strategies and Action Plans (SAP); the establishment of a CZM Centre for Vietnam; improved accessibility of databases and GIS; capacity building and awareness raising. These national activities were simultaneously executed with the ICZM programmes in three Vietnamese provinces: Nam Dinh (Red River Delta), Thua Thien Hue (central) and Ba Ria Vung Tau (North part Mekong Delta). Pilot projects in these provinces included: coastal dynamics; ecotourism potential; lagoon management; commune level evaluation; subsistence fisheries; and oil spill contingency planning. The CCP was involved with deepening of a number of ICZM tasks, focusing on Thua Thien Hue province and included a variety of tangible projects at the provincial and local level. The CCP – TTHue projects contained morphological, biological and chemical monitoring of the dynamic coastal system, RS&GIS hands-on training, awareness raising through an educational programme and lagoon ecosystem modelling. In addition, attention was paid to strengthening the relationship between the two national governments, and the local governments.

The cooperation program was involved with the whole range from ICZM planning to the first phase of implementation, establishing an integrated management framework and identifying adaptive coastal measures.

2) Practical ICZM applications on regional level

Remote sensing application in Thua Thien Hue province

Remote sensing (RS) techniques can provide valuable support to coastal planning by establishing ICZM databases (using Geographic Information Systems - GIS), the creation of maps of various types drafting zoning plans and for environmental and coastal monitoring. Thua Thien Hue province had limited RS knowledge and no practical experience with RS. The challenge was to provide the relevant TTHue provincial institutions with practical RS & GIS knowledge in possession of the national RS institutes of Vietnam and the Netherlands. Two intensive, hand-on training courses were prepared and organised in Hue and delivered a wealth of results dealing with various digital maps of the province, mapping of flooding, changes in land use, soil erosion, aquaculture and shoreline developments. All this information culminated in an integrated ecosystem lagoon model estimating the carrying capacity in relation the resource uses of the lagoon.
The RS results illustrate the potential for RS in combination with ground analysis, to be a very powerful and useful tool. However, the use of RS also requires adequate resources to be provided by the appropriate authority to ensure continuity in the application of RS.

**Ecosystem approach to Tam Giang-Cau Hai Lagoon**

An ecosystem approach was applied to Tam Giang-Cau Hai Lagoon in Thua Thien Hue province focusing on the assessment of the carrying capacity. It was based on a comprehensive description of the system combining the physical, biological, social and economic information into a framework for decision making. The framework was applied at various levels, addressing and facilitating communication between stakeholders, planners, managers and decision makers. The carrying capacity depends on the pressures inflicted by the various users (farmers, fishermen) and on the natural dynamics. Extensive consultation took place with local people in the fishery village Thuan An on the border of the lagoon. Tools were developed and applied to support a comprehensive model of the lagoon area (water balance model and 2D model of the lagoonal water quality). These valuable results were presented to and appreciated by the provincial authorities.

3) **Capacity building, awareness raising and education**

Capacity building, awareness raising and education are a necessity to ensure continuity in ICZM development and implementation. In the Vietnam – Netherlands coastal cooperation these elements were explicitly included on different levels and in different forms. A broad and multilevel training programme was included as an integral part throughout the programme. In addition, a number of specific activities were undertaken aimed at capacity building in hydraulics and coastal engineering and the education of children at primary school.

**Awareness raising through practical education of children**

With an eye to the future, children are important for raising awareness. They are also enthusiastic communicators, promoters and ambassadors. The most effective way of awareness raising in children is to train primary school teachers. This was the subject of an educational program in primary schools in Thua Thien Hue province as part of the Coastal Cooperative Programme (CCP), involving all the relevant educational institutions and four schools in TTHue Province. The program took place through direct involvement of teachers and children, their parents and included a drawing competition, the creation of an introductory booklet for teachers, the creation of two sets of comprehensive teaching material for training the teachers. This training manual is available through the CCC website.

**Capacity building in hydraulics and coastal engineering**

One of the requirements identified was the need for an adequate Faculty of Marine and Coastal Engineering in order to solve the problem of lack of staff with adequate knowledge of coastal issues. Cooperation between the Water Resources University (WRU) of Hanoi, the Technical University of Delft, Unesco-IHE and WL-Delft Hydraulics/Deltares enabled the establishment of a coastal engineering faculty at WRU. Following an inventory of specific demands, the focus of the new faculty was on sea dikes (flooding, typhoons) and estuaries (sediment dynamics) together with a number of other aspects like ICZM.

**The training component within the ICZM cooperation program**

The training activities within VNICZM involved over 500 people, aiming at both capacity building and awareness raising. The training program was set up as part of a continual process, with specific attention paid to ‘training the trainers’. Training needs of various types were identified at all governmental levels focusing on civil servants. Types of training included training courses, career planning, on-the-job training, feedback and practical experience, and role-playing. One example of a practical role-play exercise for decision making in coastal resource allocation, was based on a hypothetical situation of a tropical island (‘Pesisir Tropicana’). The success of ‘training the trainers’ is demonstrated by the fact that the new trainers are now teaching the next generation ICZM managers of Vietnam.
Synthesis – CCC Part II: Asia

ICZM progress and achievements in the CCC Asian nations and Island States

There is a lot of common ground between different countries and their coastal zones. The exponentially strong growth of population and economic development is present in most countries and particular in the coastal zones. High population density is often caused by coastal urbanisation. Poverty is being combated by strong increase in economic productivity of the Asian population.

These common developments are often accompanied by problems, especially problems in the coastal zone. Among the most general of these are coastal erosion, water and soil pollution, degradation of habitats and natural resources (unsustainable use and overexploitation) and natural hazards related to storm surges, cyclones and tsunamis. Furthermore impacts of climate change will exacerbate these challenges.

Compared with other continents, Asia has a highly valuable but also critically vulnerable coastal zone now and more over in the future. This is why the Asian continent has such a prominent place in this CCC publication.

In Asia, there is a wide variety of development stages with respect to ICZM experience, application and implementation in individual countries. These conditions relate to differences in the seriousness of threats and the potential of the country, region or community to cope with them (in terms of financial resources, technical capabilities and institutional structures).

The examples of the three island states, show that all are quite different in nature, but all three are highly vulnerable to the effects of storm surges and tsunamis. The three island states, each in their own way, have taken steps to reduce their vulnerability to these hazards.

All countries wish to increase their knowledge in coastal and hydraulic engineering, sediment transport mechanisms, bio-geosciences, water quality, integrated ecosystem modelling and the development of decision support systems, and data management. Capacity building, awareness raising and education have been adopted as essential elements in ICZM development programmes in all countries.

The potential for educating children at primary school by involving teachers merits particular attention. Data collection, monitoring and dissemination are also critical factors in ICZM application. As was shown in the Vietnam example, the use of Remote Sensing techniques at a local level is a particularly powerful and promising tool. These common needs in ICZM development thus provide a large potential of sharing knowledge among countries.

All countries considered here have adopted the ICZM approach as a guiding principle for the planning and management of coastal resources. The history and stage of ICZM development may be quite different, however. Sri Lanka and to a lesser degree also Bangladesh have a long history of experience in ICZM. Most other countries have adopted the concept more recently, particularly in the last decade.

Depending on the specific situation, solutions and courses of action may be quite different. Although the application and implementation of ICZM is based on a general approach to common problems, the outcome of the process should always lead to tailor made solutions.

Generally getting ICZM to work requires continuity in coastal planning in order to ensure the implementation stage is reached. ICZM is a continuous process that needs to be embedded in planning procedures and administrative and institutional systems. This is a long-term process which may take several decades. The implementation stage has not been reached in most of the Asian countries. Even in Sri Lanka, where a Coast Conservation Act came into action as early as 1983, experience still show important weaknesses in the powers and mandates of the coastal authorities and the underlying legislation, which is also true for the other Asian countries. This seriously hampers the implementation of the steps beyond the planning stage. Consequently, institutional difficulties and the lack of national focus, effective leadership and coordination, results in many cases in the ICZM policy
and strategy directives remaining unimplemented. Lack of resources (funds and technical capabilities) reinforce these problems.

A very serious common threat comes from the unsustainable use and exploitation of coastal resources. This is manifest in the explosive growth of intensive aquaculture (shrimp farming), which began in the 1990s. The resulting boom and bust cycle in aquaculture development has caused severe damage to the coastal system and the livelihood opportunities of local communities. This illustrates the conflict between maximizing short-term profit for investors with the long-term requirements of the local population. From these experiences, important lessons have been learned but at high cost. The challenge is to prevent the same thing happening again.

An important difference in a particular country and approaches to managing the coastal zone is one of scale. China is an example of a fast growing economy that can generate the resources and skills for large-scale approaches to solving existing problems and to developing new coastal infrastructure. An example of the first of these is the successful, large-scale rehabilitation of water quality in Suzhou Creek and Lake Tai. Examples of the second are the coastal developments following the eco-city concept, which aims to avoid future problems by integrated environmental planning. There are other examples, e.g. related to flood protection structures as in Bangladesh. However, in most cases the causes of problems and the possible solutions are considered at a much smaller scale when it is important to involve local communities and organisations. In the various country cases, there are many examples, which stress the need and potential of such a local approach.

A number of country cases focus on the possibilities of reducing the vulnerability of coastal areas to natural hazards (storm surges, cyclones and tsunamis). Examples of these come from Andhra Pradesh (cyclone vulnerability) and Indonesia and Seychelles (tsunami mitigation). From these cases, it is clear that the possibilities for reducing the vulnerability of coastal regions can and should be an explicit part of ICZM planning and implementation. The Indonesia example reinforces the need for enhanced tsunami protection and preparedness. Whilst the example from the Seychelles demonstrates the enormous benefits that can be achieved if appropriate spatial planning result in successful implemented of measures (e.g. conservation of the vegetation belts).

At last, two important lessons from Vietnam are: Mix the long term, rather abstract ICZM activities with the rather down to earth activities directed at solving a number of short term coastal problems in a no regret way, and secondly plan and implement an ICZM programme simultaneously at national, provincial and local level, strengthening vertical integration enabling problem solving by (inter) national funding and handing (RS) knowledge intensive technology to local level, there where the problems are most manifest.

The commonality of the problems and the differences in ICZM approaches to overcoming them means there is an opportunity to exchange information, knowledge, data and modelling tools.
What is ICZM?

Basic elements of coastal cooperation

Robbert Misdorp

The CCC-Production highlights in Parts I and II the results of a number of coastal projects which were or are actually being executed within an cooperative, integrated framework.

Part III deals with a number of ICZM concepts, planning tools and coastal measures. This chapter ‘What is ICZM?’, shortly discusses the basic elements of such an integrated framework.

Coastal characteristics

Coastal zones are diverse, valuable and productive areas attractive to people who live, work and recreate there. They occupy only 15% of the land, but are home to about half of the world population. They are dynamic places with interactions between, land, sea, rivers and atmosphere and serve many important socio-economic functions. It is here that many human activities are concentrated, increasing the standard of living but at the same time causing serious environmental problems.

The narrow coastal zone can be considered as triple squeezed: from the land and from the sea side through socio-economic pressures and unsustainable resource use, and in time. The spatial squeeze will be felt more intensively by the coastal inhabitants in the future, because of global change e.g. anticipated impacts of climate change (Figure 1).

The coastal system is subsystem of the entire world ecosystem, including the land and the fresh water systems (Figure 2).

Understanding the interactions within the ecosystem is important to both scientists and policy makers and is the subject of scientific programmes such as IGBP (International Geosphere-Biosphere Programme), and ICZM programmes. Increased natural and socio-economic knowledge is more and more applied in integrated spatial planning, where marine planned activities and their impacts are connected with those in the terrestrial part of the coastal zone (see CCC I-2-3 North Sea and CCC I-3-1 EU-Plancoast).

Crowded sandy beaches squeezed between the land and the sea. Beach recreation and tourism are economically important contributing about 4% to the world’s gross domestic product, which in some coastal (island) nations can be as much as 50% of the national GDP. (photo: Harry van Reeken)
**Integrated Coastal Zone Management**

The densely populated coastal zones are valuable and vulnerable areas: a challenge to manage. Sustainable management of such complex systems requires a holistic, integrated approach to decision-making for long-term sustainable exploitation in the face of the challenges of global climate change.

This approach is based on spatial integration between the rivers, coasts and marine areas finding solutions to short and long term problems. ICZM ‘formalises’ coastal cooperation, promoting the structured application of a management system for transparent governance and stakeholder involvement.

Space is becoming a scarce coastal resource, also in the USA. This led to adoption of the US Coastal Zone Management Act (a legal framework for the entire country) as early as 1972. The coastal states of the USA also set up CZM authorities and developed their own CZM programmes (http://coastalmanagement.noaa.gov/).

Many European and Asian coastal countries followed in planning ICZM programmes.

**A definition and elements of an ICZM programme**

Many definitions of ICZM exist. Most involve an integrated approach with both vertical and horizontal coordination. The 1993 World Coast Conference (WCC'93) recognised that: “ICZM has been identified as the most appropriate process to address current and long term coastal management issues, including habitat loss, degradation of water quality, changes in hydrological cycles, depletion of coastal resources, and adaptation to sea level rise and other impacts of climate change”.

The WCC'93 defined ICZM as follows: “ICZM involves the comprehensive assessment, setting of objectives, planning and management of coastal systems and resources, taking into account traditional, cultural and historical perspectives and conflicting interests and uses; it is a continuous and evolutionary process for achieving sustainable development” (see WCC, 1994).

A cycle of ICZM consist of a strategic (‘Governance’) and operational (‘Tasks’) level and four stages/phases (Table 1). The ICZM cycle is an iterative process taking many years and with the involvement of many stakeholders. Understanding coastal, natural and socio-economic processes is fundamental to balanced decision-making.

Another form of cooperation, often in a smaller area, is called Integrated Coastal (& Marine) Area Management with examples in India (Chennai, CCC II-3-2) and in Rotterdam (CCC I-2-2).

**The coastal system captured in an abstract model thinking**

Structured analyses of coastal systems form the basis for ICZM planning tools, facilitate decision-making and include four major interacting components:

- The agents of change are driven by the socio-economic demands, natural processes and impacts of climate change;
Climate of Coastal Cooperation

The socio-economic system encompassing the many functional uses and activities;

The natural coastal system, subdivided into four subsystems;

Five fields of impacts looped cyclic back to the agents of change.

This conceptual model helps quantify the relationship between the dynamic, interactive and highly complex components of the coastal system.

Common concepts for coastal cooperation

There are a number of common concepts, which lay the foundation for coastal cooperation. Sustainable development of coastal resources, increasing coastal resilience, working with nature and working together, form the basis for effective integrated management. Using the analogy of ‘Playing Rugby’ (Figure 3): It is clear that a successful team is one where individuals work together. This holds true when undertaking ICZM. It requires meticulous teamwork, it takes time, the end result counts and

Partnership approach

Figure 2: A coastal system representation with interacting (main) components. (source: WCC’93)

Figure 3: The Playing Rugby Management approach through team-playing: Scoring, reaching the goal is important, who scores is less important = the essence of coastal cooperation; by P. Winsemius, former Minister of Environment, The Netherlands. (source: WCC’93, adapted)
it is not important who finally scores the goal. The rugby analogy emphasises the importance of joint responsibility for the result. Central management, provides the initial vision and leadership, retaining the main responsibility and most importantly helping the partners in passing the ball. These concepts are important for the successful implementation of any ICZM programme.

The CCC cases and planning tools placed in ICZM perspective
The activities, the cases and tools, which are described in the CCC-Publication cover many of the fields of ICZM. Most of the CCC Chapters cover one or just a few of the ICZM elements. Only a few of the CCC chapters cover (almost) all the fields. One of the examples of planning and implementation is the sustainable development of Rotterdam harbour (1993 – 2010). A complete ICZM cycle takes time, considerable effort, endurance and money. The last of these is not always available for the long period of time necessary to complete a cycle of an ICZM programme. However, once fully executed coastal cooperative programmes and ICZM reveal that these efforts are worthwhile in both an economic and environmental sense.

Conclusions
The natural and socio-economic processes in the coastal zone are complex and interactive. ICZM and coastal cooperation help to manage such challenging areas of work in a sustainable way. The CCC-cases and tools cover many of the identified ICZM fields of activities, some cover more than one ICZM fields, but only a few cover a complete ICZM cycle.

References

PDF reports
Why ICZM?

Triggers, impacts and long time series

Robbert Misdorp

Summary

The coastal zone is a complex area to manage and requires a holistic integrated approach. The need for integrated approaches is incited by various triggers, such as the impacts of the unprecedented, strong growth of population, economic development, and concentration of atmospheric greenhouse gases.

Population growth: the world population is increasing exponentially (Figure 1) and the growth was particularly strong during the second part of the 20th century with a doubling of the world population in about 40 years. The present population of Asia amounts to about two-third of the world population and is rising rapidly, especially in coastal conurbations. Will this exponential population increase continue in the 21st century? It is estimated that in the year 2030 the world population will be more than 8 billion inhabitants (WRI) and that is more than 4 times as many inhabitants as in 1930 - a very rapid growth rate. This rate of population growth may possibly continue to 2050. In addition to the fact that our planet has an increasing number of people, many are also becoming increasingly productive.

Economic growth is wide spread around the world. Global economic wealth, expressed as Gross Domestic Product (GDP) per capita has an unparalleled growth (Figure 2). The average world GDP/capita doubles approximately every 30 years, during the last part of the 20th century and has a 2005 value of US$ 5,500. This economic development is an important factor in combating poverty, which is important for many reasons, e.g. it increases the recovery rate for the coastal inhabitants in the aftermath of hazards, as demonstrated in Andhra Pradesh, India. The rapid economic development is, however, all too often accompanied by unsustainable resource use and environmental degradation.

These two triggers combined represent an enormous stressor on the environment to such a degree that the exploitation of the resources is threatened by the unsustainable growth. This is for instance illustrated in the world wide declining fish catches.

The strong rise in emissions of greenhouse gases (such as carbon dioxide and methane) in the atmosphere is the third trigger. The natural carbon dioxide concentration in the atmosphere ranged between 180 and 280 parts per million (ppm) for more than the last 0.5 million years. During this long period several cycles of glaciation and deglaciation alternated, as did the sea level. During the maximum of the last ice age (18,000 years...
Why ICZM

ago), the global sea level was about 120 metres below the present level. The recent rapid increase of carbon dioxide from 280 to 380 ppm (in 2009) began around 1850, is very likely caused by human activity and is expected to further rise during the next decades and possibly thereafter. The sea is expected to rise with 35 - 40 cm in the 21st century according to IPCC mid-estimates, based on linear melting of the Ice Sheets of Greenland and Antarctica. However abrupt melting of the Ice Sheets should not be disregarded and may have very serious consequences for coastal states.

Moving so far beyond known, long term, natural levels of greenhouse gases and a record number of people living in the coastal zone, urge for strong measures:
- Mitigating measures should be aimed at strongly reducing the use of the finite fossil fuels, to be replaced by renewable energy forms,
- Adaptive measures for coastal areas: ICZM is regarded as an adaptive response mechanism aiming at sustainable use of resources and employment of multiple beneficial coastal measures.

The impacts of these three triggers combined are severe. To mention one example: natural hazards seem to increase both in number and the extent of damage caused during the last part of the 20th century (Figure 3).

The rate of growth of these triggers and their impact is a plea for action by governments for coordination to manage their resources and coastal zones in an integrated and sustainable fashion. An integrated approach is needed, for instance to control the development of land, tourism and fisheries, and thus our ecological assets more wisely. ICZM is an appropriate tool. It helps address present and future challenges, is directed toward sustainable development of the coastal resource and forms an integrated framework for combating hazards, and planning and implementing mitigation and adaptive, no-regret coastal measures.

The large economic and environmental benefits of ICZM may be, however, the most convincing driver to plan and implement an ICZM programme. During the World Coast Conference 1993, a concept on the benefits of ICZM was discussed (Figure 4): “The economic and environmental benefits in terms of monetary and non-monetary values are larger than the costs of integrated management efforts executed within an ICZM framework.” That concept was soon proven to be right. In this CCC publication some examples of highly beneficial ICZM, coastal cooperative efforts and multiple-use coastal measures, are mentioned:
- The positive results of the EU ICZM Demonstration programme (CCC I-1-1),
- The extra added values by the sustainable Rotterdam harbour development (CCC I-2-2),
- The large scale mangrove planting in Vietnam (CCC II-3-1-1, III-3-3-7) and
- The conservation of the attractive and protective coastal vegetation belts in the Seychelles (CCC II-5-1).

Figure 1: World population 1700 – 2030: an exponentially growing trigger. (source: Robbert Misdorp based on www.j-bradford-dejong.net + WRI database)
Global GDP per capita


Great Natural Catastrophes, worldwide 1950 - 2009

Figure 3: Natural hazards: worldwide strong increasing annual losses: in US $ billion of the ‘Great natural catastrophes’, during 1950 – 2009. (source: Munich Re, 2010)

Net Production: non-sustainable and sustainable economic development

Figure 4: The benefits of ICZM and sustainable economic development: in terms of reduced damages and increased added values resulting from a relative small investment in ICZM efforts. (source: Hulserbergen & Eid, 1990, IPCC-CZMS 1992). This WCC’93 concept was confirmed to be valid by examples of ICZM and coastal cooperation applying resilient, adaptive coastal measures, as demonstrated in this publication.

In order to facilitate the application of ICZM, some planning tools and examples of innovative, adaptive coastal measures are discussed and made available in the following chapters.
UNEP Statement:
“How to plan and implement ICZM”

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Humanity has long had a love affair with the narrow coastal fringe where both terrestrial and marine resources are easily accessed and economic activity is vibrant. Approximately 3.4 billion people – more than half the world’s population – currently live there, and by 2025, that number will increase to 75 percent. The majority of large metropolitan centres are located near coastal harbours and on low-lying coastal plains. Both subsistence and broad-scale agriculture flourish on the productive coastal floodplains – 25 per cent of global primary production takes place in the coastal zone and 90 percent of the world’s fish is either caught or farmed in coastal waters.

Unfortunately, disjointed or short-sighted coastal management can result in un-checked urban expansion, ribbon development, poor management of coastal watersheds and the destruction of fragile habitat. As much as 90 percent of all inhabited coasts will be heavily impacted by development by 2050, while more than 80 percent of pollution in coastal waters stems from land-based activities in cities, towns and farms.

This requires urgent attention due to the fact that coastal and near shore habitats provide important and valuable ecosystem services, including the sequestration of carbon. Yet these habitats are being lost four times faster than our rain forests and the rate of loss is accelerating. While humanity extends its love affair with the coast, the ecosystems services that are the very foundation of development are showing signs of stress and fatigue, putting at risk our livelihoods, our security and our quality of life.

At the inaugural World Oceans Conference in Manado, Indonesia, May 2009, governments again expressed their concern that coastal and marine ecosystems continue to be threatened by land-based and sea-based pollution and socio-economic pressures. Governments also recognised that “healthy and productive coastal ecosystems … have a growing role in mitigating the effects of climate change on coastal communities and economies in the near term” and that “an integrated coastal and ocean management approach is a key in promoting resilience, and thus fundamental to preparing for and adapting to the effects of climate change …”

In this context, UNEP’s mission is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations (www.unep.org).

One of UNEP’s significant achievements is the Regional Seas Programme which was launched in 1974 and aims to address the degradation of the world’s oceans and coastal areas through the sustainable management and use of the marine and coastal environment. Today more than 140 countries participate in 18 Regional Seas programmes.

One of the first Regional Seas to develop an Integrated Coastal Zone Management (ICZM) Protocol was the Mediterranean. Signed in January 2008, the ICZM Protocol encourages Mediterranean countries to improve the management of their coastal zones and to deal with emerging coastal environmental challenges, such as the climate change.
The ICZM Protocol is a unique legal instrument because:

- It represents innovation in international law – there was no precedent of such a regional initiative;
- It is forward-looking – it aims at preventing as well as reacting to coastal problems;
- It covers key emerging issues crucial for improving coastal management and protection;
- It helps to ensure better coordination of national, regional and local authorities and includes NGOs and other interest groups; and
- It ensures reporting on the implementation of the Protocol, including measures taken, their effectiveness and the problems encountered in implementation.

A Global Environment Facility funded project entitled “The Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem” is implementing the agreed actions for the protection of the environmental resources of the Mediterranean Sea and its coastal areas (2009-2013) and is supporting the implementation of the ICZM Protocol.

The ICZM Protocol was developed as a response to countries asking for a legal instrument to help improve management of the marine and coastal environment. Its success is being followed up by other Regional Seas e.g. the Western Indian Ocean.

Given its unique position within the UN system, as the voice for the environment, UNEP can act as a broker to bring the scientific community and decision-makers closer together. UNEP does this for the coastal and marine environment in two ways:

First, it provides information to convince policymakers about the economic value of marine and coastal environment. We are aware that marine ecosystems are multi-trillion dollar assets linked to sectors such as tourism, coastal defence, fisheries and water purification services, however it becomes more and more clear that these ecosystems are also our natural allies against climate change (the Blue Carbon Report: http://www.unep.org/pdf/BlueCarbon_screen_english.pdf). UNEP stimulates an approach, which take costs & benefits into account as well as trade-offs between economic development and the conservation or improved management/restoration of marine and coastal areas. Examples of trade-offs include the negative effects of water pollution in England & Wales reducing the value of waterfront property and tourism losses valued at US$100 -160 million per year, which far outweighs the water treatment costs mitigating the water pollution. Another example concerns an investment of US$ 1.1 million to restore nearly 12,000 hectares of mangroves in Vietnam, which is estimated to have saved US$ 7.3 million per year in dyke maintenance, increasing the physical protection of coastal communities and the productive fisheries. This is also an important adaptive measure helping to address the potential impacts of climate change.

Second, it helps convince policymakers that the protection and sustainable development of coastal and marine environments depends very much on human activities on the land. Management therefore demand a multi-disciplinary and cross-sectoral response, i.e., an integrated ecosystem-based or Hilltops-2-Oceans (H2O) approach. UNEP provides the Secretariat to the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA-Marine), a multilateral initiative launched in 1995. The GPA-Marine emphasises the importance of the link between watersheds, river systems, coastal estuaries and the marine environment, and focuses on the development of comprehensive, continuing and adaptive programmes of action within a framework of ICZM. This requires changes in policies, institutions and practices in the member countries.

Through multilateral initiatives such as the Regional Seas Programme and the GPA-Marine, UNEP will continue to bring different interests together. It will also bring to the table best practice and successful case studies to guide and ‘show the way’ to countries and regions, which have expressed a desire to improve their marine and coastal environments.

We wish the CCC publication success in its efforts to increase communication between coastal stakeholders through showing excellent examples of coastal cooperative projects and to strengthen the exchange of the needed knowledge on coastal concepts, tools and measures.
Introducing several Tools and Measures

Robbert Misdorp

Leadership, long-term vision and funding are required to set up an ICZM or a coastal cooperative programme for a particular area.

In order to facilitate the first phase of an ICZM programme, which deals with planning activities, specifically identifying and analysing coastal problems, collecting data, preparing policies and decision-making, we have developed a number of tools. These tools, supporting the ICZM planning phase, are related to an imaginary area and to natural and socio-economic developments and are mostly GIS based. They facilitate the analysis of problems and provide possible solutions related to spatial planning and include the impacts of different functional uses. The tools also contain building blocks for Cost - Benefit analysis and Environmental Impact Assessments.

The tools support policy making as well as capacity building. Training is an important element of any ICZM programme particularly for the management of specific coastal regions such as Marine Protected Areas (MPA). A training manual for MPA managers was therefore also developed.

All these tools are described by their developers and made available in this CCC publication (see CCC V-1-1 & 2).

The second stage from planning to implementation faces often serious obstacles.

Adaptive coastal options are subdivided into three categories: Retreat, Accommodate (people continue to use the land, no attempts to prevent flooding) and Protect (IPCC – 1990). These can be applied for different types of land use, such as built-up areas, wetlands and agriculture/aquaculture (see figure : CCC II-3-5).

In order to help address some of the current pressures on the coastal zone and the possible future impacts of climate change, a limited number of examples are provided. These include innovative, adaptive coastal measures, presented by those who have helped develop the techniques.

Most of the examples belong to the second category: Accommodate.

The list is not exhaustive but is concerned with practical and applied innovative technology or methods. These options help increase coastal resilience, are environmental friendly and economically beneficial. They are so-called 'no-regret' measures, often with multiple benefits, such as mangrove planting, which increases bio-diversity, provides protection against flooding, generates food from subsistence fisheries, and is an innovative way of adapting to the anticipated impacts of climate change. Mangrove planting, is also very beneficial from a macro-economic perspective, see UNEP – Statement.

You can contact the developers/authors for more information about the planning tools and the adaptive measures; see List of Authors for contact details (CCC V-2).
Introducing several Tools and Measures

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Introduction: The role of Geospatial Technology for ICZM

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Introduction

Geographic information systems are computer systems for the collection, storage, analysis and display of both spatial and temporal information. Spatial information is composed of sets of overlapping single-theme layers. Analysis allows the user to compare different situations over time. These information systems facilitate the analysis of rapidly changing and complex geographic reality in much more comprehensive way than traditional cartography (Scholten et al 2009).

A modern variant of GIS is the Geographical Information Infrastructure (GII), which offers even greater in-depth support to decision makers based on the fact that data and information are shared between the users (Hofstra et al 2008).

Integrated Coastal Zone Management also addresses complex natural and socio-economic issues in a specific geographic area. GIS and GII often and successfully support ICZM programmes.

Geographical Information Infrastructure

In the coastal zone, decision makers often deal with special limitations, conflicting land use and involving many different sectors. Coastal management issues can be particularly complex as they often transgress political and physical boundaries, and incorporate a multitude of interconnected disciplines. The complex planning processes require interdisciplinary and integral data. GIS is a tool of choice to help understand, monitor, anticipate, plan, and to illustrate and communicate management options in the medium and long term.

Not all geographic information systems are able to deal with huge databases and models. A Geographical Information Infrastructure (GII), however incorporates meta databases, large spatial databases, visualisation techniques and tools, spatial models, spatial and temporal analyses, decision supporting systems, and evaluation methods. This range of tools improves the use of geographic information and is particularly valuable in coastal zone management.

The use of the GII evolved from a stand-alone PC, to a Local Area Network (LAN) and is now often web-based and can be accessed by mobile devices.
Two examples of Geographical Information Structures

Monitoring of the Dutch coast

Visualisation is an important part of any Geographical Information Infrastructure helping to present, explore and analysis geographical information (Romao et al 1999). These information systems are used during the processing of coastal monitoring data and result in coastline charts. Coastal monitoring is essential to assess the need for coastal defence measures, particularly of sandy beaches and dunes. Every year coastal measurements are carried out, along coastal profiles with a spacing of 200 to 250 metres. The results of these annual measurements are stored in the so-called JARKUS file. Analysis of these data provides an insight into coastline fluctuations. The sections of coastal accretion (sedimentation) and recession (erosion) are determined and displayed.

The Dutch 1990 dynamic preservation policy has as a reference point, the 1990 coastline, the so-called basal coastline. The position of the coastline is assessed annually. If the surveyed coastline moves from the basal coastline landwards over a wide coastal frontage then there may be a need for sand nourishment. Moreover, it is possible to calculate the trend in coastline movement and predict the year in which it will move from the basal coastline for a specific coastal section. These annual results are shown in the form of "coastline charts" (Figure 2, an example from 1999). This annual coastal atlas of the 350 km long Dutch coast is presented to the coastal managers of the Netherlands only a few months after the coastal survey.

Figure 2: Monitoring the Netherlands’ coastal zone including the GIS data processing of the marine part and the terrestrial part (beach and dunes), results in the "coastline charts" comparing the surveyed coastline with the ‘basal’ coastline.

Figure 3: Coastline Charts on the web, accessible for professionals and public. Screen shot of the Rijkswaterstaat GIS web application: Geotool: http://www.rws.nl/geotool/geotool_kustlijnkaart.aspx?cookieload=true
Recently, the Rijkswaterstaat (RWS)/Ministry of Transport, Public Works and Water Management has made the RWS Geotool website (in Dutch language) available. It contains information on the coast, waterways, roads and other infrastructure works. The coastal element of this web-based GIS encompasses information on all 50 coastal sections of the entire coast of the Netherlands. The coastline charts (Kustlijnkaart) from the last few years (Kaart), accompanied by oblique air-photographs, the coastal profile data (Tabel) and the results of the analysis (Report) of each of the coastal sections (kustvak) are displayed for the public (Figure 3).

**Risk management: ‘Eagle Suite’**

A considerable amount of the information required for risk and emergency management, for example from flooding by rivers, is geographical in nature (Scholten et al 1998). Often this information does not reach the right people at the right time. For this reason the Ministry of Defense and Homeland Security, Vrije Universiteit, Geodan, ESRI and Microsoft developed a new concept in close cooperation with the Middle Gelderland Emergency Service Region (Figures 4,5,6). It consists of a suite of applications and services that allow multiple agencies to collaborate seamlessly in order to increase responsiveness and support fast and effective decision-making in a highly complex environment. Based on the experience of the emergency responders, a list of requirements was provided, which the system had to meet:

- **Situation awareness:** all organizations involved must be aware of the seriousness of any particular situation. All staff must have access to the same, geographic information, displayed in a standard way in a Geographic Information System (GIS);
- **Real-time location awareness:** when trying to manage a disaster, recording the real-time locations of staff, citizens, victims, volunteers or response teams is essential;
- **Sharing data among different organisations:** different organisations must work together and this requires management of communication and exchange of information.
- **Large data flows:** information has to be aggregated and responsive to the type and scale of the disaster, and the amount and type of organisations involved;
- **Allow collaboration between (different) organisations:** security restrictions such as firewalls impede the essential collaboration;
- **Support strategic, tactical and operational levels:** each level has specific requirements for the type and scope of information;
- **Work under extreme conditions:** a disaster management system must be flexible and able to deal with extreme conditions by ensuring alternative access to data. This requires a good data backup strategy.

To meet such a diverse set of requirements “the Eagle Suite” was developed (Figure 4). This suite consists of the following components (see also Geodan Eagle Suite website):

- **The Eagle Command Centre:** the command centre staff can share, add and edit both geographical and textual data. This information is exchanged automatically between all users. The main entry point is a map, showing the current situation in the disaster area;
- **Eagle Mobile:** gives ground staff, fighting the crisis in situ, the opportunity to add and edit geographical and textual data over a mobile data connection;
Climate of Coastal Cooperation

- With Eagle Surface Table tactical or strategic command can view the incident as a map on a Microsoft Surface table device, and is an easy-to-use conference tool;
- With Eagle Wall, a read-only view of the status of the incident is shown on wall-mounted displays in the command centre. It is updated automatically as changes in the status of the incident occur;
- Eagle Live is publicly available, as a read-only view. Since this is a website containing both spatial and textual information, it is visible to anyone online;
- Eagle Playback is a user-friendly playback tool for the command centre, with which the incident can be analysed and evaluated minute by minute.

'Eagle One' emergency drill
In March 2008, a special emergency drill took place in the Safety region Gelderland Midden in the Gelderland province in the east of the Netherlands (Figure 6). The exercise, focussed on the regional level. The idea behind this drill was to assess whether the use of geo-information in crises leads to better understanding and hence better decision-making. The Eagle Suite was applied and had a prominent role in the regional drill with the emergency services ‘playing’ four different emergency scenarios. The police, the fire brigade, medical services and municipalities had immediate and direct access to each other’s information. Sharing information about the ongoing situation and providing access to national geo files were both tested successfully. It was concluded that the Eagle system contributed to both a common operational picture and a shared operational awareness. This was most obvious during the multidisciplinary meetings. Little time was needed to explain the situation, and the participants were able to begin planning their actions immediately.

Based on positive evaluations of the emergency drill, the 'Eagle – Geographic Information Infrastructure' has won the prominent Dutch Public Safety Award 2008 (Neuvel et al. 2010).

The flood disaster in Pakistan that started in August 2010 might be the largest disaster ever, in numbers of people involved, in recent history. The provincial government of Punjab responsible for the disaster management encounters many problems with the information infrastructure, like in all other large disasters has happened (e.g. Haiti). The government of Punjab has asked Geodan to implement Eagle for fighting this disaster (see www.eagle4pakistan.com).

![Geographic Information Infrastructure 'Eagle One' suite](image)

*Figure 5: Geographic Information Infrastructure: the main components of the 'Eagle One' suite.*

![Map of Safety region Gelderland Midden](image)

*Figure 6: The 'Eagle One' emergency drill area: Safety region in the province Gelderland - Midden, dissected by the rivers Rijn, Waal and IJssel (photo: Harry van Reeken)*
Concluding remarks
Integrated Coastal Zone Management addresses complex natural and socio-economic issues in a specific geographic area.
A Geographical Information Infrastructure has much in common with ICZM: both are interdisciplinary and facilitate the interpretation and integration of data. The tool allows users to create interactive queries, analyse spatial information, edit data, maps, and present the results of all these operations. Such a system is applied to the processing of the yearly monitoring of the fluctuations of the Dutch coastline and assists coastal managers in answering the questions: When and where to apply sand nourishment?
A Geographical Information Infrastructure is also very suitable for risk and emergency management activities e.g. during critical river flooding situations. It is a tool for sharing of information during emergency plan preparation. Distributing geographic information through a network leads to improved communication, better and faster decision-making and a more effective emergency response.
GIS and GII often and successfully support ICZM programmes.

In the following chapters the developers of GIS tools introduce their use for ICZM planning and training. Demonstrations of the tools can be downloaded through the CCC website.

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The introduction of COSMO

In 1993 the World Coast Conference took place in Noordwijk, the Netherlands and the principles of Integrated Coastal Zone Management (ICZM) were presented. During the conference, the Coastal Zone Management Centre/ Ministry I&E and the consultancy firm Resource Analysis introduced COSMO (COastal zone Simulation MOdel) to all the participants.

COSMO is a computer GIS-based model that helps familiarise coastal zone managers with methods for evaluating potential management strategies under different scenarios, including long-term climate change. The positive response from the participants, many of whom were high-level civil servants, led to further development of a family of similar software tools (the COSMO-line). These tools have been used to help managers to determine the advantages and disadvantages of alternatives solutions for regional development and climate change adaptation. COSMO is also used worldwide for ICZM capacity building at ‘hands on’ workshops.

COSMO facilitates a structured approach

COSMO demonstrates the main steps in the preparation, analysis and evaluation of Coastal Zone Management plans. Potential users are introduced to the various principles of ICZM. Long-term issues such as climate change are considered alongside short term and local effects such as regional economic development and other uses of the coastal zone. The strength of the tools is that the user is ‘forced’ to take a structured approach to problem solving.

Using the demo-application (learning by doing), involves explaining in simple terms the framework for policy analysis, the trade offs between different policy options and alternative strategies. An interactive tool, it allows coastal zone managers to explore the impacts of development projects on the economy and environment. The user can also investigate a number of predefined cases as an educational tool, or specify new development scenarios and combinations of measures. COSMO-tools offer an opportunity to experience the power of an analytical approach to solve coastal problems.

Steps of the Framework for Policy Analysis

The user interface of COSMO, and the members of its family, developed around the steps of analysis. These steps are now, more than fifteen years after the introduction of COSMO, as valid as they were in 1993:

- The first step is problem analysis. Before considering actions the coastal manager know the state of the coastal zone, its dynamics and all its challenges;
- The second step is the formulation of objectives and the criteria (variables) which can be evaluated if objectives are (or will be) met;
- Definitions of possible measures (strategies, e.g. CZM-plans including different coastal measures) follow and areas of uncertainty to the future situation (scenarios, including e.g. climate change) identified;
- The evaluation of various strategies under different scenarios is possible using a simple simulation tool. Tools, such as Multi Criteria Analysis, facilitate evaluation and valuation of strategies, are included in some members of the COSMO-line.
COSMO-Demo available on CCC-website
The COSMO-Demo version will be made available on the CCC website, allowing you to practice with this ICZM tool. If you are interested and would you like to obtain more information please contact Marcel Taal, one of the developers of the COSMO-line: marcel.taal@deltares.nl.

Box: Overview of the different COSMO-tools used around the world:
- COSMO-W was developed for the area of the Western Scheldt. It also served as a prototype of a DSS for estuary management, focusing on typical West European CZM issues.
- NATWEST. This is an application following COSMO-W. It supports the evaluation and selection of projects for the Nature Rehabilitation Plan for the Scheldt Estuary.
- SAMPAK. This was developed for training purposes, focusing on a typical situation in Thailand, with soft coasts and restoration of shrimp farming areas (CCC-II-7). In this tool a Multi-Criteria Analysis module is included. SAMPAK has also been translated into Spanish.
- COSMOBIO. This tool was created to illustrate the role of biodiversity in coastal zone management and was introduced during the 1998 Jakarta UNBDC-Conference of Parties, and has been translated into Polish.
- COMA was the first version of a CZM Decision Support System for West Africa (from Senegal to Nigeria), to evaluate developments at a strategic level. It is available in both French and English.
- CORAL is a tool that incorporated a methodology for analysing the cost-effectiveness of coral reef protection and management. It was tested in Jamaica, Curacao and the Republic of the Maldives.
- DSMOZ, is a training tool that was developed for the southern coast of Mozambique and Inhaca Island (near by Maputo), it is available in English and Portuguese.
CoastLearn: a training tool that facilitates international cooperation

Maria Ferreira & Carolina Perez (Coastal & Marine Union - EUCC)
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Summary
CoastLearn is an innovative pilot learning package that meets the needs of those requiring a free, multilingual, user-friendly Integrated Coastal Zone Management (ICZM) vocational training tool. CoastLearn’s prime objective is to introduce ICZM principles, benefits, options and processes in countries where they are not yet widely used; to transfer the experiences and lessons learnt; support ICZM processes in central and eastern Europe countries and beyond and develop and test new technologies. The course materials, even though not yet complete, may continue to act as the starting point for an exploratory learning process.

The development of CoastLearn
During an inter-ministerial meeting in Split, Croatia, in summer 2000, 18 governmental representatives of the Baltic, Black, Mediterranean and Caspian Seas made a call for a distance vocational training tool to communicate ICZM information, experience, and ideas. EUCC took responsibility for this request and began the development of CoastLearn, in cooperation with a large international partnership composed of 22 partners from 15 countries. The former Coastal Zone Management (CZM) - Centre of the Netherlands Ministry of Transport, Public Works and Water Management, was one the partners at the beginning of the CoastLearn process. The development of CoastLearn has also been built on the CZM-C’s NetCoast Open Learner.

What is CoastLearn
CoastLearn is a multilingual distance vocational training programme for ICZM. It is openly and freely available on CD-ROMs and the internet (www.coastlearn.org).

CoastLearn targets are primarily:
- Professionals working for the public sector, e.g. coastal councils, administrations (national and local) and planning institutes. Civil servants need to not only be trained in ICZM, but also gain insights into the benefits of involving NGOs, citizens groups, businesses, and other non-institutional organisations or individuals interested in or affected by the management of the coast. They also need to gain insight into the importance of collaboration between central and local authorities;
- NGOs dealing with the sustainable development of the coast. NGOs need to be acquainted with the principles and procedures of ICZM, in order to know when and how to become involved in the process;
- University level students are another target audience.

CoastLearn has been tailored to the training and technical needs of countries in transition, especially in Europe and neighbouring regions, but has also proven to be of value for non-target countries in the EU, Latin America, Asia and Northern Africa as well. CoastLearn currently exists in ten European languages, and features eight modules (Principles of ICZM, Policy Analysis, GIS, Planning, Environmental Risk Assessment, Sustainable Tourism, Public participation, Biodiversity) and CoMPAS/ The CoastLearn Simulation Game. The multilingualism of the tool is highly valued and requests are received constantly for the production of additional language versions. The production of further versions is mainly a matter of identifying the national partner and obtaining the necessary funding. In this way, the Sustainable Tourism module was recently translated into Arabic. Funds have been made available recently for an Albanian version and for producing a western Black Sea version involving Turkey, Bulgaria and Romania.
CoastLearn makes an original contribution to existing European and international vocational training systems and practices. Other ICM training courses are expensive, very much tailored to western European and US situations and problems, and in most cases, they are part of an academic education programme. CoastLearn has become the first widely available course that is available on the internet free of charge.

The main feature of distance learning is that students can study at their own pace and anywhere they want. CoastLearn is moreover a simple tool that does not require sophisticated computers or software for its use. In order to counteract Internet connection problems, CoastLearn is also available on CD-ROM.

The English version of CoastLearn has currently 800 visitors (and many more hits) monthly with a clear upward trend; a conservative estimate for all languages is 2000 visitors/month. CoastLearn's main sponsors so far have been the European Commission through its Leonardo da Vinci and TACIS programmes and the Dutch Government through the MATRA and Pin MATRA programmes.

Multi-national and multi-discipline

The most original aspect of the CoastLearn approach is the co-operation between western European ICZM training experts and their colleagues in neighbouring (including accession) countries of the European Union to develop new CoastLearn products, where the needs of the non-EU partners are paramount.

CoastLearn has also been innovative in developing interdisciplinary training material. Usually, one expert or group of experts who work under the guidance of an editor develop such teaching material. In the case of CoastLearn, a multi-discipline and multi-national partnership has developed new modules. The development process itself was also a learning experience and strengthened network development.

The Tool

CoastLearn has a modular structure. The modules can be studied independently, are illustrated with figures, exercises, and good & bad practice examples and can be supported by tutorial services.

All eight CoastLearn modules present a standardised structure, with intended learning outcomes explicitly presented. All the modules include self-assessment exercises and questions to provide a motivating and stimulating learning tool for the user. The questions relate to the training materials in the package and are included within the text. The answers to the questions are given with explanations. Modules are further illustrated with figures, tables and practical examples, which take the user as close to reality as possible. The practical examples can be accessed either via each module they relate to, or via a separate entry point where all the examples are displayed. Links to other websites, original tests, tools and information sources encourage the user to delve deeper into the subject.

CoastLearn provides printing versions of some modules so the needs of those professionals who have no continuous access to a computer or internet can also be met.

Simulation game

CoastLearn partners have also jointly produced a Simulation game – CoMPAS Coastal Management Practices to Achieve Sustainability. The game is freely downloadable
and can be played by one person, but preferably a small group of users. The CoMPAS game aims to give the player insight into essential processes related to sustainable coastal development such as the inter-relation between economy, ecology and society. The game is played in an imaginary coastal area with sectors typical of the maritime economy, such as paper industry, tourism, water treatment, fishery and aquaculture. Players are requested to invest money in different sectors on a yearly basis over a period of 20 years. After that period, it will become clear whether it was possible to develop the coastal area in a sustainable way or not. Each game session lasts for about 20 minutes, but it is always possible to improve the results in another session.

![Figure 2: Screen shot of the Simulation game CoMPAS](image)

**Future**

CoastLearn is not the final product. An innovative pilot learning package will continue developing according to the needs of its users. So far it seems to have responded to the need for a free, multilingual, user-friendly ICZM vocational training tool. CoastLearn will also support trans-national networks, both of ICM practitioners and trainers Europe-wide and promote trans-sectoral dialogue nationwide, in all the key elements of the ICZM process. The Coastal & Marine Union - EUCC hopes to continue developing, updating and creating new modules while establishing and strengthening network partnerships within CoastLearn.

Try the CoastLearn out at www.coastlearn.org

**For more information please contact us**

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**Website links**

www.eucc.net
www.eucc.net/medcentre
www.coastlearn.org

*Malta coastal view with tourist accommodations under construction. (photo: Erik Devilee)*
RamCo: An integrated assessment tool for sustainable coastal zone management

Hedwig van Delden & Roel Vanhout (RIKS, the Netherlands)

Introduction
RamCo (Rapid Assessment Module for Coastal Zones) is a prototype of an information system for the rapid and integrated assessment of sustainable solutions to coastal zone management problems. It helps policymakers to test alternatives in the wider context of climate change, demographic growth or changing economic demand.

RamCo describes the natural and anthropogenic processes in a coastal zone under the influence of the dynamic behaviour and interaction of agents, such as inhabitants of the coastal area and economic activities (fishery, cultivation of shrimps, agriculture, industry, tourism and commerce). Characteristic of RamCo is the way in which processes are linked on different levels to form one system, and how these sub-models use very detailed data layers from a built-in Geographical Information System (GIS). It is possible to design policy alternatives and to assess their impacts.

The quantitatively defined relationships between the different elements of the natural and socio-economic processes are based on large scale ‘field observations’. Each of these relationships can be changed through expansion and aggregation functionalities. The period under analysis time (in years) can be also be defined.

Application
The current version of RamCo has been applied to a coastal zone near Ujung Pandang in south-west Sulawesi (Indonesia). It shows how, in the next 25 years, the coastal zone will become urbanised under the influence of a growing population (annual growth ± 3%) driven by external economic growth. It shows how this results in increasing pollution of rivers and coastal waters. It also illustrates how the increasing demand for food leads to destruction of the forests, how this in turn increases soil erosion in the mountains, causing river floods in the coastal zone. Policy makers can intervene in these dynamic processes by choosing other settings such as rehabilitation of mangroves, treating sewage waste, management of the Bili-bili dam and reforestation, and with fishery regulations and the development of marine parks. In this way, they can test policy alternatives.

RamCo differentiates between influences that can be controlled by ‘policy makers’, and those that cannot, such as precipitation.

After configuring RamCo with the input values, the calculations will yield results in various formats such as maps, graphs and numerical values that give the policy analyst insight into the evolution of factors such as human welfare or river sediments. These outputs are viewable in RamCo itself, or written to files to be analysed by generic tools such as spreadsheets or GIS software.

Further developments
The CZM-Centre of the Dutch Ministry for Transport, Public Works and Water Management financed the development of RamCo. A consortium consisting of Research Institute for Knowledge Systems (RIKS), INFRAM, University of Twente and Maastricht University, Delft Hydraulics (Deltares) and the Memorial University Newfoundland developed the product.

Since the development of RamCo, its model integration concept and the underlying Geonamica software platform (Hurkens ea, 2008) have been used and further developed in a wide range of products. It has evolved into a platform for spatial dynamic modelling for policy support in an integrated context called Metronamica. This modelling framework is used for developing integrated impact assessment software tools worldwide, in fields such as:

- Impact assessment of agricultural policies and land use changes (LUMOCAP PSS);
- Integrated spatial planning for multi-scale integrated land use (Xplorah);
- River basin management: analyses of scenarios and policy options (Elbe-DSS),
• Desertification (MedAction PSS - Policy Support System and DeSurvey IAM);
• Shifting cultivation in the Ruhunupura area in Sri Lanka (Wickramasuriya, et al 2009);
• The metropolitan area of the city: Belo Horizonte, Brazil.

Recent versions of RamCo include several tools, facilitating the work of policy analysts to define, adjust and compare different assumptions more easily. This uses a flexible model configuration and integrated statistical tools such as Monte Carlo analysis for uncertainty analysis and generating probability maps.

Lessons learnt
From the design, development and use of Decision Support Systems in a wide range of countries and policy contexts, important lessons have been learnt regarding the user interface and the design and development process of these systems (Van Delden, e.a. 2010). Sharper definition of the specific roles of the four parties (end-users, resource scientist, IT specialist, system architect) and improved communication between the parties resulted in a product more suited to the end-user.

A demo of Ramco
A Ramco module for Rapid Assessment for coastal zones, including a short user-guide (www.riks.nl/projects/ramco) is available for demonstration, training and evaluation. The module allows the various functionalities of the GIS based model, including the comparisons of the chosen policy options (strategies) and the scenarios (socio-economic, climate change), and it's geographic and macro-dynamic, schematic computational representations to be trialled.

Figure 1: The initial land use map and available policy options for the coastal zone of Sulawesi, Indonesia.

Figure 2: Output values showing suitability for urban development, simultaneously shown in a map and a number of indicators regarding human welfare and ecosystem vitality - Sulawesi.
For more information about the RamCo system, its approach and recent developments in Decision Support System application please contact:
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Website to download the RamCo software and user manual: www.riks.nl/projects/ramco: and the Metronamica brochure: www.metronamica.nl

References

Figure 3: The Metronamica generic integrated impact assessment tool, a next generation of spatial, dynamic modelling, applied to coastal zones in the Netherlands.
What is an Environmental Impact Assessment?
An Environmental Impact Assessment (EIA) is an assessment of impacts – positive and negative – that a proposed human intervention or project may have in a particular area. It represents a procedure for improving decision-making and helping to ensure that the development project under consideration is both environmentally and socially sound and sustainable. The EIA is concerned with identifying, predicting and evaluating the environmental consequences and social effects, both beneficial and adverse, of public and private (development) activities. It considers alternative policies and mitigation strategies, which aim to eliminate or minimise the negative effects, and optimise the positive ones. EIA is an important tool within an Integrated Coastal Zone Management process, as it visualises long-term impacts and promotes sustainable development of coastal zones.

DR-EIA project
A major challenge for the EIA community is the improvement in both the efficiency and the effectiveness of the EIA process in support of planning and decision-making. For this reason, in 1997 a start was made on the Document Retrieval and Expert System for Environmental Impact Assessment (DR-EIA). It originated from an idea of developing a computerised, internet-based tool, for expert staff at financing agencies in developing countries. The challenge was to develop an appropriate and cost-effective impact assessment tool in support of internet based, participatory decision making. The Netherlands Ministry of Foreign Affairs commissioned the development of the DR-EIA instrument, in order to stimulate the development of understanding of the use of EIA.

The target user group for DR-EIA are representatives from all stakeholder groups in the EIA process including project proposers, competent authorities, EIA experts and representatives of NGOs. The product consisting of a trainings manual, user manual and software package was first introduced to the international impact assessment community during the International Association for Impact Assessment (IAIA, 2001) conference in Cartagena, Colombia. Information at the DR-EIA website, which is maintained at www.dr-eia.org.

The product
The product consists of software-facilitated procedures for screening and scoping projects and plans in combination with databases that structure information on legal requirements. In this way the existing relationship that between proposed activities in a project, as well as physical changes because of these activities and their impacts can be described. A similar structure is used to identify social impacts that may occur as a result of a proposed project or plan.

In the present version, the DR-EIA instrument is suitable for planning and analysing projects on the land and in the water sector. Specific country modules have been developed for the Ministries of Environment of India and Bangladesh. The screening database holds information on many different financing organisations including EU, World Bank and Asian Development Bank. Apart from the procedures for screening and scoping, the instrument also facilitates writing terms of reference (ToR) for a full scale environmental impact assessment study based on the standards applied by selected financiers. One particularly interesting option is the “expert judgement based” procedure for screening and development of an EIA-ToR. This option is based on years of experience by an international team of experts working on the production of the DR-EIA instrument.
Instruction and learning tool

DR-EIA is a valuable instruction and learning tool and has become part of training in Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) in the international MSc curriculum of UNESCO-IHE. Plans exist to continue development of the tool in an open-source environment. This is the preferred approach in view of the complexity of the work that still needs to be done.

One of the achievements of DR-EIA is that many countries are now developing internet-based procedures for policy and planning purposes, including EIA.

A demo of DR-EIA is available through the DR-EIA website at: www.DR-EIA.org

More information

More information concerning structure, input and output of the DR-EIA instrument can be obtained through:

Joop de Schutter, Deputy Director of NESCO-IHE Institute for Water Education, Delft, the Netherlands: j.deschutter@unesco-ihe.org

Website UNESCO-IHE Delft: www.unesco-ihe.org
STREAM: a spatial tool for analyses in river basins

Jeroen Aerts and Hans de Moel (IVM, Free University, the Netherlands)

What is STREAM
STREAM (Spatial Tools for River basin Environmental Analysis and Management) is a GIS-based water balance model, covering an entire river basin including the coastal zone. STREAM is a raster based hydrological rainfall-runoff model for Windows computers. The model provides a user-friendly interface, uses an easy-to-learn script language, and can be used in a Decision Support System (DSS). STREAM was developed in response to the specific demand for models that could be coupled to other models. It allows the input of free of charge, spatial data, from GIS databases and satellite observations. It is easy to use, integrates the water and land components of river basins and land uses. It is therefore a unique tool for integrated coastal zone management.

The model simulates impacts of both climate change and land use change on river discharges and soil moisture availability. The model simulates human activities in the river basin, such as deforestation or reservoir dam construction. STREAM has been used in a variety of catchments worldwide, in combination with climate change scenarios, developed by the Intergovernmental Panel on Climate Change (IPCC). It is used in small river basins and at a global level, modeling the past, present and future situation, as well as over a geological timeframe.

Some technical information
The model is based on a raster GIS calculating the water balance for each grid cell of the basin. The resolution of the model application depends on the size of the river basin and varies between 300 x 300 m to 50 x 50 km. The larger the basin, the coarser is the minimum level of detail in the model. A digital elevation model (DEM) determines the direction of water flow. In STREAM, the water balance is calculated using temperature, rain, snowfall and snowmelt, soil water content and groundwater storage.

The spatial character of the model allows the analysis of water availability patterns and changes in these patterns caused by human activities (e.g. deforestation and drainage) and external influences such as climate change. The model uses so-called Blaise script-files in a Windows interface environment. Experienced modellers can easily modify these script files.

Input of STREAM
The simplicity of the model makes the model suitable for areas where data is difficult to obtain as most of the required data can be downloaded freely from the internet. Different equations for evapotranspiration are used such as the simple Thornthwaite & Mather (1957) equation. This equation uses temperature and precipitation as the major input variables. It calculates evaporation depending on land use and soil moisture. The model runs on a monthly basis generating direct runoff, delayed runoff, groundwater storage (shallow and deep), snow water equivalents and snow melt. The model uses the following five global GIS datasets as input:

- A digital elevation model (DEM);
- Total monthly precipitation;
- Average monthly temperature;
- Crop factors; and
- Maximum soil-water holding capacity.

The basin outlines and flow directions are based on a global digital elevation model at a resolution of 1x1 km Digital Elevation Map (GTOPO30, US Geological Survey 2004). Monthly climate data (precipitation and temperature) can be taken from the global CRU TS 2.0 dataset, which covers the entire globe for the period 1901-2000 on a 0.5 x 0.5 degree grid (Mitchell et al., 2003). The water holding capacity is derived from the FAO soil map. Crop factors used for adjusting the reference
potential evaporation, were adopted from FAO factors for different crop types (Doorenbos and Pruitt, 1977).

STREAM applications worldwide
The STREAM model has been used in numerous projects. A flood modeling application of STREAM is set up in the central province of Vietnam - the TT Hue province: the Huong River Basin (Villegas 2004).

A number of STREAM projects around the world are highlighted in Figure 4. For more information on these projects, please see the publication section on the website of CWA – Cluster on Water and Adaptation.

Download the model
The model, as well as the manual and some additional files, can be downloaded from this website or ordered from the Institute for Environmental Studies (IVM). Researchers are encouraged to contact the authors to stay in touch on updates of the model. For questions or additional information, they can also be contacted. The website link is: http://www.adaptation.nl/ à STREAM

References


Website and PDF reports
CWA- Cluster on Water and Adaptation: www.adaptation.nl
IVM - Institute for Environemnetal Studies, Free University Amsterdam: www.ivm.vu.nl
Mitchell et al., 2003: Table of climate grids and derived data-sets: www.cru.uea.ac.uk/~timm/grid/table.html
Capacity building essential for management of Marine Protected Areas

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Marine wetlands threatened
Marine wetlands are important areas for people who live on the coast and inland. They provide essential life-support systems, play a vital role in controlling water cycles and help to clean up the environment (Maltby, 1986). About two thirds of the shellfish, commercial and sport fisheries rely on coastal marshes for spawning and nursery grounds. Marine wetlands also deliver many other goods for local inhabitants in the form of medicines, food and security against flooding. Today more and more tourists visit some of the remoter coastal wetland areas. The existence of these wetlands, so vital for coastal inhabitants, is increasingly threatened. Dams and barrages, providing electricity and irrigation, often have impacts on downstream floodplain fisheries, wildlife habitat and bio-diversity. In the hinterland excessive use by agriculture of artificial fertilisers and industrial pollutants, as well as large-scale non-selective deforestation, degrade downstream wetlands. Draining wetlands, to improve agricultural production, further decreases the area of wetland habitat. The estimated annual area loss of the world coastal wetlands varies between 1 – 2 % over many decades (GVA, 1992).

Need for wetland protection
Wetlands are in great need of protection. The signatories to the international 1971 Ramsar Convention agreed the inclusion of wetland conservation in their national planning. The concept of Marine Protected Areas (MPA) was identified by IUCN and further promoted by UNCBD (UN-Convention on Bio-Diversity, Rio de Janeiro 1992) to improve their management around the world.

Subsistence fishing by local fishermen is allowed within the borders of this Mafia Island Marine Park, Tanzania. MPAs yield many benefits to fishermen and biodiversity e.g. foster natural age structures in fish populations, increasing fish catches and prevent bycatch of non-target species. (photo: © WWF-Canon / Peter Dento; WWF-MPAs: http://assets.panda.org/downloads/marineprotectedareas.pdf)

Global distribution of MPAs

Figure 1: Global distribution of MPAs (blue dots): 4600 MPAs covering 2.2 million km². (source: UNEP, WWF; adapted)
According to the widely accepted definition of the IUCN, a MPA is: “Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment.”

MPA is thus a generic term for any marine area that is protected by means of regulating human activities, and includes protected areas differing in purpose, design and management approach.

They include areas where regulation of exploitation, rather than conservation is the primary objective, as well as areas under integrated coastal management programmes, where sustainable use of the marine ecosystem is the primary purpose (multiple-use MPAs).

There are MPAs all around the world. They can be very large (Great Barrier Reef) but also quite small and can be found in arctic, temperate zone and tropical climate zones. Tropical MPAs will often include mangroves, sea-grass fields and coral ecosystems.

**Capacity building is important to ensure effective management**

Strong support for the management of MPAs will contribute to sustainable development of coastal and marine areas. The UN-Jakarta Mandate (1995), outlining the programme of actions for marine and coastal biodiversity within the UN Convention on Bio Diversity (UNCBD, 1992), stressed the importance of capacity building to ensure effective management of these areas. The availability of skilled personnel is fundamental to the success of establishment and management of MPAs. Quite often, protection of these areas has shown an increase in the numbers and diversity of marine life and improvement of the overall health of the system.

The Dutch Coastal Zone Management Centre (CZM-Centre) began a capacity building initiative for MPA personnel in 1998. Training opportunities and modules to improve the management of MPAs were particularly lacking in the East African Region.

It was therefore decided to develop a MPA training programme for the Region in close cooperation with experts from the region, international organisations and with the support of the World Bank.

The geographical distribution of MPAs around the world (Figure 1) offers ample potentials for interregional sharing of increased MPAs management capabilities. The positive results of MPA training activities obtained in the Western Indian Ocean region are used in the Caribbean Islands and in South Asia.

**Development of a regional training programme**

Before this MPA Programme began, an analysis was made of training needs and existing capacities. Much of the existing material had a strong focus on nature protection and marine biology and less on integrated planning, legislation, enforcement, surveillance and management.

After consultation with prospective students and other regional experts during a workshop on Zanzibar in 1999, it was decided to develop a very practical and hands-on curriculum, which would cover a broad spectrum of subjects, from communication and fund-raising to monitoring and surveillance, aimed at mid-level managers.

Through close co-operation with regional organisations, namely with the Western Indian Ocean Marine Science Association, the UNEP Regional Seas Programme for East Africa, the Institute of Marine Sciences of the University of Dar es Salaam and the regional offices of IUCN and WWF, the CZM-Centre was able to develop a truly regional training programme. Courses were organised in the regions rather than inviting participants to attend courses in the Netherlands.

A comprehensive MPA Training Manual was produced using the experiences of the East African MPA training programmes.
Many valuable lessons were learnt by active participation:

- A regional programme has several advantages over national training programmes. Firstly, it is more cost-efficient because the number of potential trainees increases, secondly the students can exchange national experiences, and last but not least, management of marine areas covers cross-boundary issues, best considered within their regional context. Alumni of the course were able to participate in a regional network of MPA managers established under the programme;
- The curriculum was developed mainly by regional experts, and later supplemented with regional case-studies presented by students during the first courses;
- A two-week training programme was developed and carried out three times (Kenya (2000 and 2002) and South Africa (2001) with financial support from the World Bank and the co-operating regional organisations. Either students were sponsored by these organisations, or their government paid the course fees. The courses were as interactive as possible, with plenty of exercises, role-playing and presentations by the students;
- With the closure of the CZM-Centre in 2006, a regional programme for internships for MPA managers and a French-language curriculum were planned but has not been implemented;
- The success of the programme was demonstrated by the fact that it was adopted by regional marine and coastal organisations in East Africa, while other MPA Regions such as the Caribbean have also benefitted from the MPA Training Manual. The South Asian region have created a MPA Training manual, based on the East Africa Region one.

The CZM-Centre also supported regional initiatives to promote policy dialogues on the issue on MPA management and its linkage to Coastal Zone Management. MPAs can be promoted as stepping stones within a broader Coastal Zone Management Programme. Political support for integrated management is an important precondition for the success of MPAs. The training programme was presented at the Ministerial Meeting of the Nairobi Convention (2003). The CZM-Centre has facilitated the production of a video and a vision document to enhance the public and political awareness on the importance of MPAs.

Download the MPA Training Manual
The CCC-web production belonging to this book, contributes to the interaction between East African region with other MPA regions such as in Asia, Pacific and Caribbean Islands. From this CCC-website (www.coastalcooperation.net) you can easily obtain the latest version of the entire MPA Training Manual in the English language. (see CCC V-1-1-4)
A related initiative by IUCN, the MPA toolkit for the Western Indian Ocean, is available at the WIOMSA-website.

Further information
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‘Building with Nature’: principles and examples

Ronald E. Waterman
(Senior Advisor and Member of the Parliament of the Province South-Holland)

Introduction to the principles
‘Go with the Flow’. Find integrated solutions which make use of less invasive techniques and are more in harmony with the natural dynamics. This is the essence of the concept: ‘Building with Nature’.

Although this principle was first applied in the Netherlands, it has gradually been recognised worldwide as a harmonious means of creating land areas for living, working, tourism and recreation, and infrastructure, whilst ensuring the preservation or expansion of valuable environmental resources, nature and landscape. In addition, it also takes into account: climate change and the resulting sea-level rise, more frequent and intense storm-surges, as well as land subsidence and salt-water intrusion.

Today implementation of this concept is gradually being pursued in a wide range of cities, ports and along beaches throughout the world. In recent years, ‘Building with Nature’ has steadily gained more and more acceptance. This is spurred on by the growing awareness on the impacts of climate change, by the increase in natural disasters like the tsunamis in the Far East and hurricanes in New Orleans, and by the loss of low-lying lands, such as the Sundarban Islands in the fragile delta area near the Bay of Bengal.

This approach to innovative coastal measures, with emphasis on soft solutions provides the best hope for long-term sustainable solutions for the restoration of coastlines and habitats and land reclamation.

With approximately 80 percent of the largest population centres in the world situated on coasts and deltas, the need for sound, integrated coastal zone development via ‘Building with Nature’ is urgent and appropriate. The flexible integration of land-in-water and of water-in-land (working with nature) is an environmentally friendly and economically advantageous system which is gaining more and more acceptance worldwide. Implementing this approach can help create a new flexible coastline in a dynamic equilibrium using sand from the sea, which consists of a new primary range of dunes with a new beach in front and with a minimum of solid sea-wall elements. The emphasis is no longer on inflexible solid bulkheads against the sea, like dams & dykes, but instead on flexible soft structures in harmony with the sea, like dunes & beaches.

The Netherlands is a good example of a low-lying coastal country with a high population density. It also has a high motorcar density, a high waste production and a high energy usage per capita. The need for new building sites for living, working, recreation & tourism, for an adequate infrastructure and for a continued town renovation process is clear. At the same time the preservation and expansion of valuable environment, nature and landscape is important. In short there is a need for multifunctional space, which is in short supply.

Apart from the necessity of population stabilisation in due time, in principle three spatial solutions exist to cope with this scarcity of space:

• Making better use of the 3rd dimension (sky-scraping & underground development);
• Using space in the existing hinterland;
• The seaward option with flexible integration of land in water and of water in land.

The emphasis here is on the seaward option, which is based on two important principles: Integrated Coastal Policy and Building with Nature.

Integrated Coastal Policy with a sustainable, integrated approach for many coastal and delta regions worldwide, and to achieve this, many functions, using many different disciplines, have to be considered carefully. The final development should be such that the overall economy is strengthened and the environment is improved. There are many specific functions in the coastal zone which are of great importance and which should be addressed in cohesion, requesting an integrated, holistic approach.
Adaptation

Where nature allows it, the principle of 'Building with Nature' should be applied as much as possible in the creation of new land. The essence of this principle lies in understanding the natural forces and interactions between the land and the sea. Being flexible and working with rather than against natural forces and taking into account existing and potential natural values of the coastal zone and the seabed, is essential. 'Building with nature' uses the mobile material sand/silt and the forces/interactions to which they are exposed being the action of tides, waves, currents, river outflow and interaction vegetation - sand/silt.

Multifunctional master concepts including nature reserve areas and careful zoning, can achieve a net gain in coastal areas. These coastal zone developments can be carried out phase after phase, segment after segment, all fitting in a flexible master plan, leading not only to cost-effectiveness and flexibility but also to environmental improvement. The environment, including nature, has four important basic functions:

1. **Carrier Function**, providing space and habitat/substrate for all living organisms encompassing inorganic matter, landscape and seascape, energy systems and the interactive processes;
2. **Production Function**, through exploration, exploitation, harvesting of inorganic and organic resources;
3. **Regulatory Function**, maintaining essential eco-systems and processes, including the bio-geochemical cycle, the climate and hydrological cycle.
4. **Information Function**, providing information in many forms for increasing the knowledge base of the socio-economic and natural coastal sub-systems enhancing the quality of decision-making.

Strengthening the economy and improving the environment are achieved through the application of the method of Building with Nature, the creation of new nature reserve areas, careful zoning of the various functions and the introduction of a Triple-C approach: Clean Technology, Clean Products, and Cleaning-up Technology.

Advanced technologies, specially dedicated environmental equipment like drag and cutter dredging heads, improved working methods and technologies for site investigations, environmental impact assessments and sophisticated monitoring and database management, have made it possible to undertake the enormous land-creation projects in the Netherlands, Dubai, Singapore, Hong Kong, in a way that supports responsible socio-economic growth.

**Some examples of ‘Building with Nature’ projects in the Netherlands**

Most of the projects have a dune-beach protection in harmony with the sea. They all strive successfully for net nature gain in agreement with economic and social functions.

Two examples are realised integrated multi-functional projects Slufterdune and IJmuiden, and one is under construction.

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**Figure 1:** Index map: Locations of two of the realised integrated multifunctional coastal 'Building with Nature' projects (blue circles): #1) Slufterdune area and #3) IJmuiden, and one project under construction: #2) Hoek van Holland – Scheveningen/The Hague (green oval). (source R. Waterman)

_The Slufter dune area (800 ha) with its successor Maasplain 2 (Maasvlakte 2 ~ 2000 ha) form together a multi-functional peninsula attached to the Port of Rotterdam (Figure 2). The north side is an area designated for port and port-related activities developed in accordance with environmental standards. This includes a container handling area, chemical factories, roll-on-roll-off, bulk storage and distribution area, with pipeline, railway and road systems, cranes, quay walls and harbour basins, and an environment-friendly storage and processing facilities for all types of wastes such as fly ash, slag, waste gypsum._

The large containment reservoir, 90 million m³ (internal depth - 28 m Mean Sea Level and surrounded by 25 m high dunes) is gradually filled with contaminated dredged harbour sediments. The 35 million m³ sand released during the construction of this deep reservoir is used for the construction of the sandy ring walls of the peninsula. The walls and bottom of the special storage basins are impermeable, preventing leakage to the environment. Excess water is pumped into special treatment unit.

_South east of the large reservoir is a triptych of newly designed and existing nature reserves for terrestrial flora and fauna. Next to this is an existing valuable nature_
reserve with over 700 species of plants, varying from the pioneer vegetation near the shore to the climax vegetation in the wooded inland area. Adjacent is a developing seascape (clearly visible in air photo) consisting of shoals and beaches with high water resting areas for birds and nursery habitat for marine organisms, like seals.

In both areas provisions have been made for tourism and recreation facilities. A special designed area is used for sea kite- and wind surfing.

Seaport Marine IJmuiden/Kennemer beach – Project

This project illustrates the beneficial application of Building with Nature in the area, south of the harbour mole. It was primarily created by the long shore net sand transport in northern direction. Since the 1970s, the sand was trapped by the extended southern harbour mole of IJmuiden. In this way the project started to come into being and Building with Nature found its expression. It is a multifunctional land reclamation in IJmuiden, near the entrance channel.
Adaptation

to the Port of Amsterdam, with a marina, a double boulevard, a nautical centre, apartments, restaurants & shops, hotel capacity and an artificial lake, attracting many birds. Parts of the wide beach, close to Amsterdam, is also used for recreation.

Building with Nature in South Asia: Jakarta Waterfront Development Programme: Pantura project

Jakarta is an example of a densely populated coastal urban agglomeration, over 10 million inhabitants, living and working on an area of 650 km². Although Jakarta faces enormous current and future problems, it also presents an important opportunity to solve these problems. A holistic, Building with Nature approach relied on using the natural hydraulic forces and interactions between sand and silt. This approach to land reclamation is relatively cheap, environmentally friendly and more in harmony with nature and therefore more sustainable. The Pantura project comprises the creation of over 3000 ha of new land along 32 km coastline of Jakarta Bay. The development of this newly acquired land is coupled to a complete urban rehabilitation of 2,500 ha of the adjacent hinterland of North Jakarta (Utara). Included are many different functions ranging from residential areas, industry to establishing a segment for a new nature reserve including indigenous flora and fauna, with in sandy beaches, dunes and mangrove coasts. Special attention has to be paid to ensuring a harmonious transition from old to new, including cultural and historical values. Private and public sectors can work together to realise an integrated vision: the Rebirth of Jakarta.

Conclusions

Over recent years, the necessity of an Integrated Coastal Policy via Building with Nature has become more apparent, not only in Europe but also elsewhere in the world. The overall investments and maintenance costs of the methods based on these principles are significantly lower than those that neither use an integrated approach nor use the environment as a basis for development. Furthermore, the proposed method improves the environment and simultaneously strengthens the economy. The concept has proved to be applicable in a large number of countries in coastal and delta areas. Integrated planning aimed at long term sustainable development of coastal areas which addresses complex coastal problems takes time. However this “loss of time” is regained during the execution and the implementation of the comprehensive coastal projects.

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Website

Ronald Waterman: www.ronaldwaterman.com
Sand Nourishment

A flexible and resilient, adaptive coastal defence measure

Tjark van Heuvel (Rijkswaterstaat/Ministry I&E, the Netherlands)

Introduction
In sandy coastal areas, sand nourishment can be considered as an efficient measure to preserve the shoreline and safeguard coastal functions such as recreation and nature. Nourishment is the supply of sand to the shore, to strengthen the coastal profile and add sediment to the littoral budget. Commonly the sand is extracted from the deeper sea bottoms, which may have large reservoirs of suitable sand. In coastal, deltaic areas where the marine sands may be too fine of structure, the use of coarser grained river sands might be an option. This latter option is being explored for the Romanian coast. The sand is usually nourished on the beach, although increasingly in the Netherlands on the foreshore. As the cause of erosion remains, the nourished sand is eroded over time. It is thus inherent in the nourishment concept that the nourished sand is gradually lost and that nourishment requires a long-term maintenance programme. How long a particular amount of supplied sand will endure depends on the forces of nature and coastal characteristics. These need to be thoroughly understood.

Monitoring
A dynamic coast needs intensive coastal surveying. This to ensure proper decision making regarding the preservation of the coastline and coastal zone and to safeguard economic development and associated large capital investments.

The Netherlands has a 350 km coastline length (as the crow flies). About 1600 coastal profiles are yearly surveyed since the 1960s. However the position of the Low Water line, High Water line and dune foot has been monitored already since the mid 19th century. Efficient survey systems (Figure 1) and data-base management allows for a quick process-time and in few months time, the so-called Kustlijnkaarten (Coastline-Maps, see CCC III-3-2-1) are produced. These results are used each year for:
1) Identifying the erosion hotspots;
2) Indicating the sand nourishment locations;
3) Estimating the average life-time of a sand nourishment for a particular coastal stretch;
4) Analysing the economic cost and benefit for each stretch;
5) Evaluating the effectiveness of the national sand nourishment scheme and are used for five-year reporting to the Parliament.

Coastal survey techniques in the Nederlands

| GPS satellites | Differential Global Positioning System (DGPS) |
| Research vessel | Sidescan sonar |
| Flight Direction (parallel to beach) | GPS reference station |

Figure 1: Airborne Laser Altimetry & marine multiple Sounding are modern survey techniques and systematically applied during the yearly monitoring of the 350 km long coastal zone of the Netherlands.
In 2009, a six years research programme began to assess in more detail the impacts and opportunities of nourishment for the coastal ecosystem. This programme covers the whole coastal zone, including the foreshore and the dune area. The programme will result in recommendations for an ecological optimal approach to nourishment.

The coastal manager optimises the coastal defence measures in line with the identified policy goals (Ministry V&W, 1990 – 2005) by means of coastal monitoring and applied coastal research. The development of data sets as well as morphological models supports the analysis and are important tools which contribute to continuous improvement of the way the nourishment schemes are executed.

Efficient method and its effects
In the Netherlands coastal nourishment proved to be successful and efficient. It contributes to a major reduction in maintenance costs of the coastal protection when compared to hard defences. Moreover, it also has benefits for other coastal functions, like recreation and nature conservation. Nourishment is a sustainable method, as it fits within the natural processes of sand transport and sedimentation. The resilience of coastal systems is safeguarded or can even be enlarged.

It is widely considered that the use of sand is a better alternative than the construction of hard structures, for instance groins and dams, to protect a sandy coast. This is not only from an ecological perspective but also from an engineering point of view. The use of sand causes less serious side effects in the longer term than concrete structures. However, even though nourishment may be the best option from the ecological point of view, it also brings about some changes to the sandy ecosystem. These are being monitored to determine the recovery time on the locations of the sand extraction and nourishment sites.

The nourishment influences the morphology of the foreshore, beach and the fore-dunes. In the Netherlands not only 6 million cubic metres of sand is annually supplied to the beaches and in the near shore zone, but also about 5 million cubic metres in deeper water (up to 8 meters below MSL), in order to compensate the effects of sea-level rise. After 20 years of dynamic preservation of the coastline, the policy is changing into one of compensation the erosion in the coastal foundation, in the deeper part of the coastal profile. New special dredging techniques and contracts are then required.

The ‘Sand Engine’
In recent years, the possibilities of using very large nourishments as a new strategy for coastal management are being discussed. An example is the innovative pilot project ‘the Sand Engine’ in front of Delfland in the Province of South Holland, the Netherlands. The pilot consists of depositing a large amount of sand (21.5 million m³ - 2011) in a depot just off the coast that will serve a multitude of functions: coastal protection, nature and recreation. The idea is that the natural longshore sediment transport processes will gradual redistribute the sand along the coast towards the North leading to coastal growth and protection and thus increasing space for coastal development (Province of South-Holland, 2009). The pilot Sand Engine will be accompanied by monitoring and research. If this pilot
proves to be effective, then this method of creating large-scale coastal sand buffers can be applied in the future. This will help to reinforce the coast providing greater resilience and a more flexible way of accommodating the potential impacts of climate change, particularly accelerated sea level rise and increasing storminess. It is a no-regret measure, to be applied after the impacts of climate change are starting to become visible.

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Figure 2: The large Sand-Engine of along the coast of South Holland will act as a huge sand buffer, an artist impression. (source: Sand-Engine - Provincie Zuid-Holland)

Figure 3: Management cycle for the yearly coastal nourishments; monitoring, data management and analyses are important elements.
Flood proof architecture

Concepts and constructive solutions to adapt to rising water levels

Johan van der Pol (Dura Vermeer, the Netherlands)

Introduction
Soil compaction and subsidence, urbanisation and climate change increase the vulnerability of (urban) areas to floods. The government is going to invest heavily in the necessary knowledge development, to be able to face climate change.

For this task, the building trade can and should make a crucial contribution with new concepts of "building with water." Especially in highly populated areas, living with water may be a sustainable adaptive solution for future challenges. More and more Dutch designers are getting into "flood proof" architecture. This has already led to a whole range of concepts and constructive and non-constructive solutions. Noticeable examples of building methods are: floating construction, amphibious construction, construction on piles, elevated construction, dry- and wet proof construction. Practical examples are floating- and amphibious houses, platform houses, artificial islands or reefs, floating offices and floating greenhouses. These items are the specialism of Dura Vermeer, a construction and development company in the building industry. This article illustrates some of their concepts.

Floating greenhouses
Floating greenhouses offer the opportunity to combine two functions on the same square metre: greenhouse horticulture and water storage. There is an increasing demand for this multiple use of space, because space in The Netherlands is restricted, while the demand for living-, working- and recreational locations is increasing. In the years to come many tens of thousands of hectares will be used for water storage, taking up valuable space. Creating space for water storage is not simple in a densely populated country as the Netherlands. Combining water storage with an economic function may more easily create the necessary space.

The concept of floating greenhouses has been developed from the idea that it contributes to the solution of spatial limitations that arise from the redevelopment of greenhouses and will create space/room for water storage.

A pilot project for a floating greenhouse is to be realised in the province of South-Holland. The lowest point of The Netherlands is situated in this area: 6.76 metre below NAP (NAP = about average sea level). The idea is to plan an area where a pilot project floating greenhouse can be realised on a commercial basis. The pilot will be an example of a sustainable development of glasshouses combined with water storage. Apart from the development of a floating greenhouse, the business case also comprises a research programme covering the environmental effects. A public-private partnership has been working on the business case for two greenhouse growers since 2005. In 2012 we hope to finally celebrate the opening of the five hectares floating Greenhouse: the Floating Roses.

First built floating greenhouse in the world - Demonstration version, municipality of Westland (photos: Dura Vermeer).
Amphibious and floating homes
Unlike the houseboats that line many Dutch canals or the floating villages of Asia, these amphibious homes are being built on solid ground — but they also are designed to float on flood water. They look much like regular houses; the only difference is that when the water rises, they rise. Each house is made of lightweight wood, and the concrete base is hollow, giving it ship-like buoyancy. With no foundations anchored in the earth, the structure rests on the ground and is fastened to 15-foot-long mooring posts with sliding rings, allowing it to float upwards in times of flood. All the electrical cables, water and sewage flow through flexible pipes inside the mooring piles.

Realisation in Maasbommel
The desire to integrate water management issues in the Netherlands in sustainable spatial planning, has led Dura Vermeer to translate this aim into the development and realisation of 32 amphibious and 14 floating houses in Maasbommel in the Province of Gelderland. The houses are the solution to the demands for living-, working- and recreational space and the need for a sound and sustainable water storage. The location in Maasbommel is just outside the dyke ring in a water recreational area, connected with the river Maas. Recent flood events and the subsequent strengthening of the dykes in the river basin have led to the development of houses by an entirely new concept: houses that will float at high water. In order to enable the houses to move with the fluctuating water level, the houses are fixed on concrete floating platforms with a suspension mechanism. At a low water level, the houses rest upon a foundation of concrete. To keep the houses as light as possible the framework consists of timber. To prevent the houses from floating away at high water they are fixed to flexible moorings, with which tugs can be absorbed. It is expected that once every five years the water level will rise so much (over 70 centimetres) that the houses will indeed float. The houses can cope with a water level difference of up to 5.5 metres. That is above the height of the top of the levee.

Residential district on water
In the framework of expertise development, Dura Vermeer made a design for a residential district on water, applied to a pilot location in the low-lying polder Haarlemmermeer, south west of Amsterdam. In this concept, urban functions are integrated with water retention and storage. The result is an environment that not only respects the water system level, but moreover, creates a high-quality living environment and a net saving on space. To answer questions about the feasibility of a pilot residential district on water, a study is to be carried out. This study will show under what circumstances a residential district on water in the Haarlemmermeer is likely to be successful. Based on this, the parties involved can decide whether they want a pilot residential district on water. The developed expertise on the possibilities to combine water storage and construction will first be applied to the Haarlemmermeer. However, since this expertise is also applicable elsewhere, ideas for other locations can also be submitted.

Conclusions
In recent years, the knowledge and experience in the field of flood proof construction has increased strongly. It is an issue, which is not only relevant to the Netherlands, but has also been taken up by other countries. Some remarkable examples of practical applications have been realised, from which learning points are being shared. These experiences are subsequently used in developing the expertise and concepts further and its translation into daily construction practice. This means that expertise is now available for modelling damage because of flooding, construction concepts have also been elaborated, which are based on a sound financial footing, situation-specific and solutions offered and cost-benefit analyses made. The concepts of flood proof architecture can be an efficient method for adapting to the potential impacts of climate change.

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Shelters and Schools

Adapting to Cyclonic Storm Surges: Bangladesh

Atiq Rahman (Bangladesh Centre of Advanced Studies, Dhaka)
Rafiq Islam (Manly Council, Australia)

Introduction
Bangladesh is one of the most natural disaster prone countries. Over the last 40 years many cyclones have affected the country accompanied with loss of lives and property. Global climate change will make the country even more vulnerable to cyclones and floods. For low-lying countries as Bangladesh it is very important to adapt to climate change, to reduce impacts, which may lead to increased human misery, social injustice, and damaged ecosystems.
The poor people have the least capacity to absorb shocks and adapt to the adverse impacts of climate change. Thus, the poor are the most vulnerable to climate change impacts and disaster risks (Rahman, 2009).

Adaptation
Adaptive measures are necessary to reduce the vulnerability of people to flooding. The construction of shelters at a household scale save lives and properties, as shown during the last decade. Adaptation should reduce risk and vulnerability from extreme events: cyclones and storm surges and impacts of climate change. Adaptive measures should be geared to increase resilience and provide security in terms of food, water, and energy supply as well as safeguarding livelihoods and social coherence. Some examples:

Shelters as a way to adapt
The construction of shelters save lives and properties.
A cyclone shelter is basically a solid building, an elevated construction that provides security from the cyclones and associated storm surges. The foundations are such that they dissipate energy from upcoming cyclonic storm surges from the sea or from riverine floods. Above it, at some metres from the ground, one or more floors are constructed to provide shelter. Sometimes they are built in a semi pyramidal shape to withstand the storm surges better.
Each shelter is designed to serve approximately 2000 people and also to function as schools. Access ways are major issues. Studies have shown that unless a cyclone shelter is within 1.5 km of a house, it may be too distant. The local people, afraid for theft, postpone their withdrawal to the shelter to the eleventh hour. Moreover, women going at the last moment in case shelters are lacking proper women toilets and are therefore disproportionate victim of last minute drowning. New generation of shelters are better equipped.

A cyclone shelter in Dublar Char, Bangladesh, recently withstood a cyclone and saved many lives. (photo: Gerhard Tauscher, International Federation of Red Cross & Red Crescent)
Shelter programme
The first purpose-built cyclone structures were built in 1960s. Since the Great Bhola Cyclone of 1970, a Category 4 cyclone that brought a storm surge of up to 27 feet and killed an estimated 350,000-550,000 people, Bangladesh embarked on program to build concrete cyclone shelters. However, these efforts were insufficient and in 1991 more than 140,000 people died from another tropical cyclone. After this cyclone, the Bangladesh government with the support of different foreign agencies, have been building multi-purpose cyclone shelters so that these can also be used as primary schools during the normal period of time. According to Local Government Engineering Department, in 2006 there were about 2500 cyclone shelters in the country (Islam, 2006). Bangladesh has developed a GIS-based information system for all existing cyclone shelters. Quite a number of cyclone shelters have been neglected, others have been abandoned altogether.

More shelters needed
As the shelters can accommodate only 27% of the population at risk (Islam 2004), 2000 more cyclone shelters are planned to be built soon in the low-lying coastal districts.

The May 2009 Cyclone Aila confirms the importance of shelters. The Cyclone struck the coastal areas of Bangladesh with very high wind speeds. According to the Government of Bangladesh, the cyclone killed 190 people, injured more than 7,000, and damaged or destroyed more than 500,000 houses (www.usaid.gov). The lower death tolls in recent years can be attributed to a network of cyclone shelters after the 1970 disaster and a SMS warning system recently introduced (AFP, June 2009).

Construction of new cyclone shelters has started under different donor-funded programmes.

Raised plinth height
Another example of living with floods is the raising of the plinth height above the flood level. It is a method, which can be promoted at the household level. The plinth, which is often build of earth and tends to be completely washed away during floods, can be made stronger with a little cement and some pieces of stone and brick. In this way, the plinth may last through repeated floods (IFRC, 2008). Similar raised ground constructions are being integrated into the design of coastal embankments for isolated communities.

Installing toilets on raised ground
Most of the toilets in flood prone areas are built by digging the earth and setting up the rings made of concrete in it. During the flood season toilets go under water, cause problems for people especially for women. This creates furthermore water pollution problems. In order to overcome this, people install toilets on raised ground (Rahman, 2008).

Raised tube well
Tube wells are the most common clean water source in Bangladesh. There are an estimated 8-10 million tube wells throughout the country. The water source can be protected against floods, by raising the suction head of the tube well above the level of rising flood water by using an additional pipe.
Food preservation
Floods create scarcity of food. For this reason, people of flood prone areas preserve dry foods for use in flood emergencies. The food which is preserved before the flood are Muri (puffed rice), Chira (pressed rice), Sugarcane Molasses, Naru (made of coconut and molasses), dried jackfruit seeds (Rahman, 2008). Clean freshwater is also a scarce commodity during floods. The food and water are stored above averaged flood level.

Conclusions
Adaptive measures such as the construction of (multi-purpose) shelters and measures at a household scale, are important to save lives, property and livelihood. Community-based initiatives empower the communities to build on their existing local knowledge and provide confidence to the most vulnerable people to explore the long-term benefits of investing small amounts on flood-resistant construction towards making safer homes (IFRC, 2008).

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Solar energy: desalinating sea water into fresh water

Innovative coastal adaptive & mitigation measure

Hugo Niesing (Wattpic, Barcelona/Amsterdam)

Introduction
Lack of fresh water is a general concern and will increasingly become a threat to societies in the future. The Southern European nations like Spain, Italy and Greece, have regions which are already experiencing serious fresh water deficiencies. This problem is particularly acute during the summer holiday season in the Mediterranean region, when the number of people staying there increases considerably. The number of tourists is expected to double by 2025. Drinking water scarcity is likely to increase because of a changing climate. This represents a massive economic, social and environmental threat to semi-arid regions such as the Mediterranean.
An important technology to tackle this problem is desalination: making fresh drinking water from saline seawater. Most of current methods however are neither cost efficient nor environmentally friendly. Therefore, there is an urgent need to develop a technology that would fulfil both criteria.
As the name suggests, the DeSol (Desalination by Solar heat) project will rely exclusively on solar energy to reach this strategic goal.

Objective of the DeSol project
EU - DeSol project (2006-2009) developed an environmentally friendly and efficient method that desalinates seawater using thermal energy provided by solar collectors. Efficiency is increased by running the processing at sub atmospheric pressure. The low, almost vacuum, pressure causes the water to evaporate at low temperature. This characteristic makes the system useful for low-grade heat sources, such as solar heat.

The vacuum is generated by gravity generated by a continue flow of the condensed fresh water falling from a predetermined height. No additional energy or equipment is required to obtain and preserve the vacuum. The desalination system is developed, tested and demonstrated in the Mediterranean climate.

Status of the DeSol Project
The initial developments are completed. The system has been transferred from the two laboratories in Fraunhofer Institute of Physics, Stuttgart and CRIC-Wattpic, Barcelona and jointly installed near
Barcelona. Desalinated water production rates with the given prototype installation are between 20 to 35 litres per solar hour. A university study on the potential market for this technology, and its developments, has also been carried out. The EU-DeSol project consortium includes a potential end-user.

**Future developments**

Small-scale simple technologies that do not require fossil fuel can provide a significant contribution towards a more sustainable use of the Earth’s natural resources. The DeSol consortium is confident in this technology and is seeking opportunities to optimise the system (components, costs), installation procedures, maintenance requirements (materials, knowledge availability), and the process (dependence of direct sun, heat storage, recovery etc.). Upgrading the system’s current capacity to a production level of fresh water of 20 m³/day is the next step. Applications in developing coastal countries deserve special attention as such technologies converting polluted - salt water into fresh drinking water will improve quality of life, without harming the local ecosystem.

**For more information**

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**Websites**


Wattpic - Wattpic Energia Intelligent S.L.: www.wattpic.com
Innovative Home Sanitation

saves water, lives and money

Daniel Vandy (ECOSAVE, Flevoland, the Netherlands)

Introduction

The rapidly increasing population requires more and more water, which puts enormous pressure on our water resources. Water is thus becoming a scarce product. Fulfilling the ever increasing demand for fresh water requires a holistic approach at all levels from international to local.

ECOSAVE, in the Netherlands, has created an integrated solution to water conservation in the home by linking several approaches:

- **ECO-nomical**: providing water saving device on taps and showers saves 50 – 70% of drinking water;
- **ECO-sanitation**: providing dry- or composting toilets, with closed collection and no or little water use;
- **ECO-purifying wastewater**: providing simple but reliable systems cleaning more than 95% all the waste water from the household;
- **ECO-collecting of natural water sources**: collecting and purifying rainwater.

In this way, a household is made ‘self-supporting’, requiring 20-30% of normal fresh drinking water usage, producing no wastewater sewage or contamination of the natural habitat and keeping the environment clean.

Using this approach in the rural and coastal areas of the Netherlands and Spain, we have carried out projects where the water usage required only 30 litres of drinking water per person per day instead of the usual 130 litres, without giving up comfort.

Apply this technology on a large scale could mean a huge reduction in the pressure on water resources.

Our ECOHOUSE & ECOSAVE Office, Flevoland, Holland, trapping the solar radiation in the central greenhouse part of the building, with solar PV and thermal panels and rain water collection and waste water purification in the garden. (photo: D. Vandy)
Adaptation

**Home Sanitation units - Dry Toilets:**
ECOSAVE Separett provides toilets in houses, in holiday and garden complexes, boats and campers. After 25 years of development, these toilets are technically very sound. They each contain a built-in aerator and are as a result odourless. They require little maintenance, are noiseless, very efficient and driven by solar energy on request. The aerator prevent odours and therefore does not attract insects. The aerator also contributes to the purification of the human waste converting it into valuable natural compost rich in nitrogen. Within a half to one year the first few litres compost (after >90% reduction of organic mass) can be collected and safely used.

The benefits of the Home Dry Toilets are:
- Simply to install, with no very costly sewage pipe line constructions;
- No water usage;
- Contaminant free;
- Odourless and do not attract insects which diminishes the spreading of diseases.

An additional advantage of this ECO-concept is that the purified compost and compost tea can be safely used in gardens for growing vegetables. Research has shown that the human excrement was safely processed and the quality of the compost was rich and valuable to farmers.

A video of the simple installation is available at our website (www.ecosave.com).

ECOSAVE provides a 5-year guarantee on all the original toilet material. The prices of the different types of Dry Toilets varies between €300 and €700. Shared production of a large number of locally constructed Dry Toilets however is also possible, which will reduce the costs considerably.

**Some examples of Home Sanitation Units installed**
ECOSAVE is successfully applying the integrated approach to water management in different countries.

**Holland**
In Holland about a quarter of a million houses are not connected to sewage system. These houses are often located at remote rural areas. Home-sanitation units are well in place in such locations.

**Egypt**
Ecosave was involved in preparing and executing a sanitation project in Egypt. The large coastal lake Manzalla in the eastern part of the Nile Delta, has a multifunctional use: firstly for drinking water, secondly fishing and thirdly for recreational purposes. The major threat to the functioning and future exploitation of the lake comes from the fact that all sewage of the megacity Cairo (18 million habitants) is dumped in this lake. By introducing ECO-sanitation and ECO-purifying systems, it was possible to realise small-scale improvements, which will have considerable benefits for the quality of life and would help ensure the future of the lake.

**USA**
In the US, large-scale ECO-sanitation is used in beach clubs and a large nature visiting centre in a nature reserve in Florida, which has more than one million visitors per year. In 2009, a special programme began collecting urine, from a school, for agriculture use. Urine is rich in nitrogen and can be efficiently used in agriculture instead of artificial fertilisers.

**Israel and Jordan**
Economical use of water in the agriculture by drip irrigation is well known. However, a household may use up to 250 litres fresh water per person per day. The fresh water resources in this region are under increasing pressure. As a result the level of Lake Tibereas (a major fresh water resource for Jordan, Israel and Palestine) is falling dramatically.

By initiating ECO-nomical use of drinking water in the homes and other uses, it was possible to reduce, at a pilot scale, fresh water usage by 50%. Additionally by using ECO-collecting and re-using purified waste water it has been possible to gain another 30% reduction in water usage. Using purified wastewater for the garden or even agriculture was not widely known but can have surprising results, such as has been shown by the date palm nurseries, south of Jerusalem. “Ecological working with water”, sharing new water technology directed at conservation of water and safely re-using water will reduce the pressure on the resource and may even be a building block for peace!

**Concluding**
We must use drinking water more efficiently. ECO-sanitation using closed toilet systems, which use a little or no water and produce no wastewater. With ECO-purifying and – collecting we re-use all the water that is possibly to be re-used. The result is a cleaner, healthier environment, with opportunities for use of purified water on garden vegetables or agriculture. In this way the ECO-circle is round.

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Mangrove replanting

Disaster preparedness and many other benefits

Dang Van Tao and Nguyen Hung Ha

(International Federation of Red Cross and Red Crescent Societies - IFRC)

Introduction
The Vietnam Red Cross (VNRC) is a mass organisation and is considered the core body in all humanitarian work in Vietnam. Since 1990, the VNRC considers disaster preparedness one of its core tasks with focus on community-based disaster preparedness in order to enhance the communities’ capacity to respond to disasters, such as cyclones.

Within this framework, in 1994, Vietnam’s Red Cross adopted a pro-active approach to storm surges by launching a programme of mangrove tree reforestation and management. Vietnam’s mangrove forests had been seriously degraded by intensive socio-economic development. The main objectives of mangrove planting are to protect sea dykes and people’s lives and property, to build the capacity of the Vietnam Red Cross in Disaster Preparedness to improve the coastal environment and to create job and income for vulnerable people.

Since 1994 Red Cross members, volunteers and local people planted more than 22,000 ha of mangrove forest in the coastal zone of Vietnam, which helps provide a defensive ribbon of forest. VNRC has worked with related ministries and governmental bodies and obtained the approval from the Prime Minister of the country to continue caring, managing and protecting the planted mangrove forest.

Role of the community
To replant mangroves, the Red Cross makes use of an integrated approach, in which the community plays an important role and is actively involved. To assist the local community in fulfilling their role, many training courses on, for example, how to plant trees have been given to local staff, teachers and children. Furthermore, local communities organised awareness-raising activities, such as drawing competitions, theatre drama, folklore songs etc. The communities are also involved in the maintenance and protection of the mangroves, by establishing teams, who take care of mangroves just after the plantation. Because of these activities, the people at the commune level, including children, are very aware of the significance and benefits derived from the mangrove forests.

Children planting mangroves, the trees will help prevent land erosion. (photo: International Federation of Red Cross and Red Crescent Societies - IFRC)

Mangroves are salt-tolerant evergreen coastal forests providing many services, one of which is protection against cyclones & flooding. They are found in most of the tropical and subtropical countries (photo: Tjark van Heuvel)
Box: Red Cross/Red Crescent Climate Centre (RCCC)
Madeleen Helmer: Director RC/RC Climate Centre, The Hague, the Netherlands

The Red Cross/Red Crescent Climate Centre (RCCC) was established in 2002 to support the 186 national RC/RC Societies to better address the humanitarian consequences of climate change. The projected increases in precipitation, drought, sea-level rise, heat waves and more intense storms are likely to lead to more disasters, insect plagues and diseases. These will likely affect the most vulnerable people, the poorest of the poor, most. The Preparedness for Climate Change programme of the RCCC is implemented in more than 60 developing countries. Key components of this programme are increased cooperation between the RC/RC and knowledge centres like the meteorological offices. This leads to appropriate adaptation measures in the main RC/RC programmes related to disaster management, disaster risk reduction, food security, health and care.

The RCCC is supporting a strengthened early warning and early action approach, through matching available climate information at all timescales (from climate change scenarios to seasonal forecasts to weather alerts) with appropriate early action (from mangrove planting, to contingency planning to evacuation). Climate change is no longer a distant risk but integrated in existing disaster risk management practice.

The RCCC observes that often adaptation measures are translated into ‘hardware’ measures like dykes, infrastructure and building codes. Through many years of experience the Red Cross/Red Crescent has learned that a good combination with ‘soft ware’ (people centered measures: risk awareness education, health and care measures, early warning system) is essential to strengthen the resilience of people against the unavoidable impacts of climate change.

For more information: www.climatecentre.org

Mangrove planting to reduce effects of typhoons and flooding risks: the Vietnam Red Cross has planted over 22,000 hectares of which nearly 9,000 ha cover muddy sediments along the seaward side of over 100 kilometers of sea dykes in eight provinces (2010). Here, a group of Vietnam Red Cross volunteers from the Hai Phong branch makes a routine check on the condition and growth of the mangrove trees. (photo: Yoshi Shimizu, International Federation, 2003)
Benefits

Mitigate dyke erosion

Planting mangroves is a proven technique, which helps to protect coastal communities and environments by reducing the impact of strong waves. The complex root system of the mangrove trees buffers the forces exerted by storm waves, improves the resistance of the earthen dikes and decreases soil erosion. In 1997 a Japanese researcher observed that a sea wave of 1.5 metres high moving through a wide mangrove ecosystem, was reduced to nearly zero. The value of mangroves became clear in 2003, when two typhoons struck Northern Vietnam. Only four people died, no rice fields were flooded and the typhoon forces weakened rapidly.

Socio-economic benefits

Reforestation has brought income for poor families living in coastal areas from directly participating in plantation and forest protection. Most of people state that their economic situation is now getting better than before. The main reason for this improvement is the increased income derived from the programme's activities such as planting, guarding, collecting sea products and the jobs created by fish and shrimp pond service works. All of the pond owners interviewed said that they directly benefited from the mangrove forest. This economic benefit is one of the most important factors helping to ensure the sustainability of the project.

Fishing industry

Mangrove tree reforestation also benefits Vietnam's fishing industry. The fish, shrimps, prawns, and crabs that populate the coastal areas now have an increased number of secure spawning areas to rear their young. The increase in number of juvenile crabs, for example, has been clearly recognisable in the past years.

Increased pond operation

People were encouraged to invest and develop fish and shrimp farming in areas secured by protective belts of mangroves. In fact, a good number of the fish ponds are now directly protected by the mangrove forests. Due to this protection, each pond owner can save pond maintenance costs from 2 million to 2 million and half Vietnam Dong/ year (data given by pond owners in Thai Thuy District, Thai Binh).

Bio-diversity

The mangroves forest provides a valuable habitat for many species of insects, crustaceans, gastropods, molluscs, amphibians, reptiles, and birds. Local people were very impressed by the re-colonisation of birds in the mangroves forests of coastal and river mouth., especially in mature mangrove areas.

Increase mud flat and land reclamation

The increase of alluvium at the river mouth is a natural phenomenon and it is easy to see that the speed of this process increases because of the presence of mangroves. In muddy areas, an elevation speed of between 5 and 7 centimetres sedimentation per year occurred!

Future

Mangrove forests are becoming increasingly important, as they mitigate the negative impacts of climate change, which is predicted to be especially severe in Vietnam. Disaster preparedness through mangrove plantation and the protection of mangrove forests from logging remains a major activity of the Vietnam Red Cross (IFRC, 2009).

Some programme results in Vietnam

- Over 22 thousand ha have been planted with mangroves in 8 provinces. These mangroves can protect over 100 km of sea dykes (the length of the sea dyke system is about 3,200 km in Vietnam). Mainly three mangrove species were used: Kandelia, Rhizophora and Sonneratia species;
- Over 70 planting ceremonies have been organised in 8 provinces since 1997;
- Over 7,750 of poor households in 89 communes were directly involved in planting mangroves. They earned above USD 20 per hectare;
- Over 130 technical training courses were organised for nearly 10,000 people;
- 160 RC staffs at district and provincial level were trained about disaster management;
- 18,000 teachers at primary schools in 8 provinces were trained and they trained nearly 600,000 children about disaster preparedness.

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International Federation of Red Cross and Red Crescent Societies, 2008: Annual report Viet Nam


Websites

IFRC - International Federation of Red Cross and Red Crescent Societies: http://www.ifrc.org/

Red Cross/Red Crescent - Climate Centre: http://www.climatecentre.org/site/home

Floating Vegetable Bed Cultivation

Atiq Rahman (Bangladesh Centre for Advanced Studies - BCAS, Dhaka)

Adaptation to climate change and risk reduction

A vast area of Bangladesh is situated more than two meters below mean sea level and vulnerable to high tides. Flooding and water logging is a common problem in Bangladesh. Climate change will aggravate this problem. There is evidence already of these adverse impacts, which affect the livelihood of people by reducing crop production and increasing food insecurity. Many communities have developed baira cultivation as an adaptive strategy to reduce their vulnerability.

Floating Vegetable Bed Cultivation, an Adaptive Option in Coastal Bangladesh

The Bangladesh Centre for Advanced Studies (BCAS) and its local partners promote floating vegetable beds, which grow in water logged and salinity prone areas along the coast. This provides employment, income, food and nutrition for the farming families and local communities. Furthermore, it helps the coastal flood prone population adapt to the changing environment, which is increasingly influenced by global climate change. Floating vegetable bed cultivation has been a local practice in some villages for many years. It involves planting crops such as water hyacinths and other aquatic plants on soil-less rafts on water and is called a 'floating garden', locally known as baira. The platform provides a base to raise seedlings, vegetables and crops on it. The plants grown on baira get nutrition and food either from composted organics or from the water. During periods of flood and water logging field crops often perish, but crops on baira can survive. The local practice was improved with scientific and technological input in close cooperation with local communities. This resulted in longer and stronger beds, cultivation of diversified vegetable and crop rotation. This is now widely practiced in hundreds of project villages. The BCAS project on 'Climate change adaptation' played a key facilitation role for local innovation and extension of the practices across many villages.

Material for floating beds locally called Baira

In addition to water hyacinth, deep water rice straw and different types of aquatic vegetation (e.g., Kochuripara-Eichhornia crassipes, Khudipara-Lemna trisulca, kuti pana-Azolla pinnata, Shayala – Bluxa japonica) and pieces of bamboo are required to make a baira. Initially, the farmer lays a bamboo
pole on dense water hyacinth to stand on and then piles more water hyacinth to make it compact. The thickness depends on the duration of water logging, as it needs to float for the whole time of inundation. The *baira* is movable so the farmer can choose suitable locations for better management. After selecting a good location, the *baira* are usually fixed with bamboo poles. After 10-15 days, the farmers may transplant seedlings or broadcast vegetable seeds. They usually also plant additional crops between the main cultivation and can harvest crops 2-3 times a year from one *baira*. There is no need to use chemical fertilisers for growing crops on *baira*.

**Crops and vegetables on Floating Beds**

Crop cultivation varies in seasons. However, more than 20 varieties on vegetables like red amaranth, Indian spinach, coriander leaves, cauliflower, cabbage, tomato, lady’s finger, cucumber, bitter, gourd, bottle gourd, snake gourd, ash gourd, sweet pumpkin, bean, radish, brinjal (eggplant), potato and spices including chilli, onion, garlic, turmeric and mustard are grown on *baira* in different locations in Bangladesh. The formation of a *baira* and cultivation starts in the month of June and continues until November. However, *baira* cultivation on permanent water bodies can continue round the year.

**Multiple Benefits: Food, nutrition and employment**

During flooding and water logging, many people suffer from shortage of food and lack of nutrition due to loss of standing crops and of income. Importantly, people can get food and nutrition from their own grown vegetables on *baira*. In the dry season, composted material from *baira* is used as organic manure for field crops. Usually, there is no employment available during flood periods and life of the poor is difficult. However, by cultivating various crops on *baira*, it is possible for people to meet their household food requirements and earn an additional income.

BCAS with local NGOs provide training and material to local communities to improve the practice of floating bed cultivation. This helps increase the productivity of the bed cultivation, and thus reduces seasonal food insecurity for the flood-prone inhabitants of coastal villages in Bangladesh.

**Fore more information**

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Conclusions on concepts, tools and measures

Gerrit Baarse (BB&C the Netherlands)
Robbert Misdorp

The CCC Publication considers how coastal cooperation contributes to the process of Integrated Coastal Zone Management (ICZM). This is regarded as a key concept in structuring the approach to managing coastal problems, through the identification of coastal zone management tasks and formalising cooperation between stakeholders. Part III of the CCC Publication describes the “what”, the “why” and the “how” of ICZM.

The “what” of ICZM
Defining the zone within which ICZM operates is complex. From a physical perspective the zone includes the area governed by the interactions between the land (including the hydrological system) and the sea. From a socio-economic and ecological perspective, the coastal zone is subject to a multitude of different functions, interests and pressures. ICZM provides a way of managing the delicate interplay between the natural coastal system processes and the use and exploitation of the zone as a socio-economic system.

The nature and function of ICZM can be viewed from different angles, as follows:
- ICZM as a concept for identifying and defining the elements of the coastal system and their causal relationships;
- ICZM as a process for identifying coastal management tasks and developing coastal zone management programmes;
- ICZM as a set of instruments and methodologies for the execution of coastal zone management tasks within the coastal zone governance framework.

ICZM as a process includes the main phases: problem recognition, planning, implementation and evaluation. In view of the many stakeholders and interests involved, the ICZM tasks are defined and carried out in a multi-actor setting. The key to successful ICZM application is teamwork and coastal cooperation. This is the focus of this publication.

The “why” of ICZM
The main reasons underlying the need for coastal zone management are:
- The importance of the coastal system;
- The vulnerability of the coastal system;
- The increasing pressures on the coastal system.

Importance of the coastal system
The coastal zone is the home of a substantial part of the global population and directly provides a great many products and services on which society depends. These include providing a livelihood through income generation, food and a place to live. In addition, the state of the natural system is vital for coastal stability, flood protection and the regeneration and productive capacities of ecological systems.

The complexity and vulnerability of the coastal system
The coastal system is highly dynamic and complex. The various processes and interactions are easily disturbed by human action and there are clear limitations to the carrying and productive capacities of natural systems. Adverse effects on coastal systems have become manifest in various ways, posing serious threats to the continuity and sustainability of their essential ecological and societal functions.
The increasing pressures on the coastal system
In the last few decades, the trends in the development of these pressures and their adverse effects have become clearly visible. Population growth, in combination with increasing economic demands, is the main cause of rapidly increasing resource use. These often lead to overexploitation and environmental degradation. The effects of climate change, both through sea level rise and increased storminess, may seriously aggravate these threats.

Sound and effective management practices are required to protect and preserve coastal systems and to ensure their sustainable development. The application and implementation of ICZM is the main vehicle for securing these management practices. Above all, implementing ICZM and strengthening coastal cooperation are both economically and environmentally beneficial, as illustrated by the application of integrated, multiple functional and resilient methods leading to sustainable solutions.

The “how” of ICZM
The “how” of ICZM mainly concerns the execution and facilitation of the various ICZM tasks aimed at the identification, analysis, selection and implementation of management actions. The focus of the CCC Part III is on:
- Tools and capacity building for ICZM;
- Innovative and adaptive coastal measures.

Tools and capability development for ICZM
A great many tools have been developed in support of ICZM tasks, covering a range of requirements including:
- Development of Geographical (spatial) Information Systems (GIS);
- Analysis of specific coastal problems and their context;
- Undertaking integrated planning analysis and developing decision support systems.

As described in this CCC publication, developments in the last 2 decades have resulted in a wide variety of tools and applications covering the above requirements. Within these developments, supporting policy preparation, emergency planning and crisis management, and training and capacity building have played a dominant role. The following briefly summarises some of the main developments.

GIS-based modelling systems have become an indispensable tool for data collection and processing and the analysis and monitoring of coastal systems. Ongoing developments are moving in the direction of further integration of GIS applications in interactive planning and management tools and decision support systems, as reflected in the Geographical Information Infrastructure (GII) concept. Examples of more specific applications include monitoring of coastline development in relation to coastal erosion and accretion and the use of GIS-based tools for risk and emergency management. An important development within the field of GIS-based tool applications includes providing information to the public at large as well as data sharing with professionals through the web.

An important focus for tool development has been providing support for the integrated and interactive planning process within an analytical and structured framework. Developing GIS tools within an ICZM framework has been strongly supported by the CZM-Centre (the Netherlands). An example of such an approach is the model COSMO (COastal Simulation M0dell). This facilitates all relevant steps in policy analysis aimed at the identification, impact assessment and evaluation of alternative measures and strategies, based on future scenario projections. The COSMO approach has evolved into a ‘family’ of interactive tools, which have been developed and applied for different areas in the world. RAMCO (Rapid Assessment Model for COastal zones) is an integrated, interactive planning model linking a GIS-based representation of land use and spatial planning with the effects of economic developments at different spatial levels.

Other tools and applications have been developed emphasising more specific aspects of ICZM. One example is DR-EIA (Document Retrieval and expert system for Environmental Impact Assessment),
which focuses on integrating the existing procedures for Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) within ICZM. It provides software facilitated procedures for screening and scoping projects. DR-EIA also facilitates the writing of terms of references (ToR) for executing EIAs according to the standards applied by financing organisations.

Another example is the model STREAM (Spatial Tool for River basin Environmental Analysis and Management). The model facilitates the assessment of water balances and river flow based on a Digital Elevation Model (DEM), integrating the water and land use components of entire river basins in the context of ICZM. In particular, the model is capable of simulating the impacts of land use and climate change on river discharges and availability of surface and groundwater. STREAM has been applied in a wide range of river basins around the world.

Aspects of training and capacity building have been a part of all the above tool developments and led to the development of specific programmes. Following an initiative of the CZM- Centre, the programme CoastLearn was developed by the Marine & Coastal Union-EUCC in cooperation with an international partnership of over 20 parties from 15 countries. This programme is freely available on the Internet, facilitating the training of a wide international audience. The programme has a modular structure covering all major aspects of ICZM (including a simulation game) and is available in ten European languages.

A more specific example relates to the development of a training programme for the management of Marine Protected Areas (MPAs), as it was recognised that the availability of skilled personnel is a key factor in their successful management. A regional training programme and a comprehensive training manual for the East African Region was developed by the CZM-Centre in cooperation with regional and international organisations (United Nations Environment Programme - UNEP, International Union for Conservation of Nature - IUCN, WWF-World Wide Fund For Nature - WWF) and with support of the World Bank. This MPA training manual is also used in the Caribbean and South Asian regions and is now available as an PDF report (see CCC-V-1-1).

From the above developments on tools and capacity building it is concluded that:

- A wide variety of tools have become available in support of policy preparation and execution of the ICZM tasks, ranging from holistic approaches to more specific aspects of ICZM;
- Although the aspects addressed in the various tools have a common base, their use generally requires dedicated applications. The examples provide a broad basis for developing such situation-specific applications;
- When developing tools, there has been considerable emphasis on training and capacity building;
- The joint development and application of tools provides an excellent basis for (inter)national cooperation.

The CCC Production aims to increase coastal cooperation and makes the (demonstration) versions of these GIS-based tools available through its website (see CCC-V-1-2). For more information about the tools, contact the authors, who are the main developers.

**Innovative and adaptive coastal measures**

In view of the uncertainties of the impact of the increasing pressures on coastal zones, adaptive measures should be the primary focus. Based on past experience there are a number of guiding principles that help to identify promising solutions to problems. These include:

- Working with, rather than against, nature;
- Restoring and preserving essential natural functions;
- Smart combinations of objectives and functions through innovative approaches;
- Involvement and responsibility of local stakeholders;
- Following these principles, the CCC publication has identified a number of examples.

The application of ‘soft’ solutions through building with nature including sand nourishment schemes provides considerable potential for flood protection and land reclamation, while preserving and restoring natural functions. There are many successful examples from the Netherlands and various other places in the world.
Mangrove planting by the local population (including the maintenance and protection of the mangrove forests) also provides numerous benefits. In addition to flood protection and mitigating coastal erosion, such benefits include increased (shell) fish production by providing spawning areas, protection of fishponds, increase in natural land reclamation and in biodiversity, most of which directly benefit the local population. This multiple functionality of mangrove planting proved not only beneficial for the local inhabitants and the environment, but also for the national and local economy.

Innovative adaptive approaches include the possibility of creating floating structures combining a number of vital functions, such as housing, high-yielding production facilities (e.g. up to 5 ha floating greenhouses) and emergency water storage. Other developments aim to achieve a smart combination of functions responding to local needs and possibilities. Examples of the latter are the development of multipurpose flood shelters combined with school facilities and household scale measures providing essential functions during flood conditions (such as toilets, wells for water supply, storage and food preservation). Floating vegetable beds are increasingly applied in the Ganges-Brahmaputra-Meghna delta, successfully enlarging food security during flooding, generating of jobs and can be considered as an adaptive measure addressing the potential impacts of climate change.

Present and future shortage of freshwater is a pressing problem in coastal zones. In order to reduce this pressure, there are two promising developments:

- Using solar energy to desalinate salt seawater and provide fresh drinking water. This is in a semi-operational phase of development;
- Innovative, water-saving measures, which ensure home water supply and sanitation, while reducing waste water flows to the natural environment. Such measures include the use of water saving devices on taps/showers, dry/composting toilets with closed collection (no water use), reuse of purified wastes, and the use of simple systems to purify household wastewater and to collect and purify rainwater.

**Conclusions**

- In preparing for future coastal problems, the emphasis should be on adaptive, innovative and resilient measures;
- As much as possible, measures should be based on relatively simple solutions that can be developed, applied and maintained within local means and capabilities;
- Local stakeholders should be directly involved with and made responsible for implementation of management action, while benefits should accrue to the local population;
- Ongoing technical developments can considerably increase the potential for sustaining vital living conditions;
- Communication is an important element in coastal cooperation. The authors of chapters on the innovative adaptive measures are also the ‘developers’ of these measures and are willing to provide more detailed information to the reader of this CCC Production.
Learning experiences and recommendations for actions

Gerrit Baarse (BB & C, the Netherlands)
Robbert Misdorp

The previous parts of the CCC publication have illustrated a range of coastal problems that have become manifest in many coastal countries in the last decades. A variety of approaches and solutions have been developed to counteract the different problems. Although the specific problem setting in each country or region has to be considered unique, there is a lot of commonality in the types of problems encountered and the potential measures to be applied. Hence, there is great potential in developing a common understanding on promising ICZM strategies by sharing experiences and knowledge, to the mutual benefit of all coastal countries.

Based on the country examples described in this CCC publication, the following summarises a number of main, common learning experiences. These provide an important basis for the identification of recommendations for actions as specified in the second part of this chapter.

1-1 Main learning experiences

ICZM pays off

Considering the economic and environmental benefits of ICZM and coastal cooperation efforts, it follows that the benefits achieved may exceed costs many times over. This was clearly demonstrated by comparing the costs and benefits of a great many projects in the EU demonstration program (2000). The EUROSION project (2001-2004) concluded that the costs for society to counteract erosion problems would only amount to a small fraction of potential benefits. The Netherlands sand nourishment scheme ensures the protection of the natural coast in a sustainable way at relatively low cost. Investments in the Rotterdam harbour area development based on integrated spatial planning of the coastal area were proven to be very beneficial economically and ecologically. The Seychelles have been able to protect and maintain their valuable vegetation belts through effective coastal planning which basically saved the island state from tsunami disaster and provides in the mean time a large contribution to the GDP through tourism.

Considerable improvements of the flood protection situation have also been achieved in other Asian countries such as Bangladesh, Indonesia and India (through flood protection measures, polderisation, re-plantation of forest area and mangroves, early warning systems, evacuation schemes and cyclone shelters). Other important benefits are associated with the protection and restoration of natural production systems, related to e.g. water supply (restoration of the water supply system of the greater Shanghai area in China) and the co-management efforts directed at more balanced fishing practices, combating overfishing and destructive fishing in coastal waters of Thailand.

In addition, there are successful examples of ICZM applications at the grassroots level through direct involvement of local communities and NGOs, such as the enhancement of fish production by applying small scale artificial reef units in the State of Tamil Nadu (India) and the management of Tam Giang-Cau Hai Lagoon in cooperation with the people in Thuan An village in Vietnam.

Integrated spatial planning is a strong instrument for ICZM

Integrated spatial planning exercises provide a strong basis for addressing the complex problems and trade-offs involved in ICZM. In particular, this often legally-based instrument will have a stimulating effect on the implementation of ICZM programs by embedding ICZM in existing national and regional planning procedures. The beneficial effects of spatial planning supporting ICZM have been shown in projects in Romania, the Netherlands and several European regions in the Baltic and
Adriatic Sea and has also been demonstrated in the EU-PlanCoast project. Asian examples illustrating this need, include the experiences with devastating aquaculture developments and the importance of maintaining the protection from coastal natural systems, such as mangrove forests and coral reefs.

ICZM takes time and patience
Due to its complexity, its iterative cyclic nature, and its multi-actor setting ICZM is a slow process with many potential delays and obstacles. For instance, the time spent in preparing an ICZM phase e.g. searching for funding, partners, and office accommodation, can last as long as the actual execution of that ICZM phase.

But the learning experiences and commitments achieved in each step in the cycle, and in each cycle, will ultimately result in speeding up the process.

The integrated planning and sustainable development process for the Rotterdam harbour area took 17 years of cooperation. The process is now entering its second cycle. The results and consensus achieved in the first cycle, which are firmly anchored in regional laws for development, will considerably reduce the efforts required for the further planning and decision making process. The Sri Lanka example shows that after more than 30 years of ICZM practices, the powers and mandates of the coastal authorities and the underlying legislation need strengthening.

Balanced, vertical integration is essential
The participation of relevant actors on all levels is essential for successful implementation of ICZM. However to warrant sustainable long term development of a particular coastal area, the responsible national agencies must remain in control of the decision making process and the application of integrated spatial planning regulations.

An uneven distribution or representation of power, in the absence of clear, authorised development plans or planning procedures, may lead to non-sustainable, coastal development directed at short term profit. Any local or regional plan should fit the long term sustainable, legal frames that are set on national and sometimes international levels.

The benefits of balanced vertical integration is illustrated in Vietnam, where simultaneously at four levels ICZM is practised and efforts to increase awareness raising, communication and capacity building were successfully undertaken.

Monitoring plays an important role in ICZM
A fair amount of knowledge of the coastal system is a prerequisite for integrated planning and proper decision making on coastal zone management. This emphasizes the essential role of monitoring in all phases of ICZM. Monitoring data provide the basis for problem recognition. Monitoring data support the planning and implementation of the proper measures at the right place (what to do where?). And finally, the evaluation of ICZM efforts is based on monitoring results. This evaluation is to illustrate the effectiveness of the coastal measures applied and to identify the new or remaining problems observed, marking the beginning of a next cycle of adjusted planning, implementation and evaluation.

The potential of Remote Sensing techniques in supporting the monitoring function was extensively demonstrated in the Vietnam cooperation projects in the period 1993-2006.

Innovative small scale adaptive measures
Various cases described in the CCC publication provide examples of promising, relatively small scale adaptation measures and activities, including e.g.:
- Local reforestation and afforestation projects;
- Small scale artificial reefs;
- Water quality improvement and waste management;
- Development of early warning systems;
- Cyclone shelters and safe havens for flood protection;
- Decentralised solar energy applications, e.g. for lighting of houses and desalinate sea water;
- Sustainable coastal fishing practices through co-management;
- Establishment and management of coastal, delta and marine reserves;
- Ecotourism developments;
- Subsistence agriculture development in the form of floating bed cultivation.
Proper introduction of these measures have been accompanied with training and awareness raising activities for, and with, the local coastal communities concerned.

**Innovative adaptive measures at a larger scale**

The need for space is felt in many coastal areas around the world and this urgency for more space will increase in time. ‘The building with Nature’ concept is being applied by many coastal nations. Large scale land reclamation, creating land in water, may reach more than 300 km² in Bohai Bay (China). Large scale soft, resilient and efficient coastal protection, e.g. sand nourishment up to 10 – 25 million m³/year is being applied in some countries in Europe. Particularly promising is foreshore nourishment. Some examples of applying measures directed at sustainable development and adaptation in the Netherlands are:

- Creating water in land: combining river flood water emergency storage with dwelling and high technological horticulture - floating houses and greenhouses up to 5 ha are being constructed;
- Experimenting with sustainable energy generation at the border of the sea, by means of large scale fresh – salt water interactions which will soon begin;
- Pursuing win – win solutions, e.g. resulting in large, economic and ecological benefits of sustainable harbour development through effective cooperation between all stakeholders.

**Knowledge and experiences have to be shared!**

The ICZM practices in Europe and Asia have confirmed that ICZM is needed and do-able, and has produced successful results. More importantly, the experiences gained in the various countries provide a wealth of knowledge and insights to be deployed to the benefit of other countries. NGOs play a specific role to facilitate transferring of knowledge and exchanging experiences between the various participating stakeholders as illustrated for instance in the cases of the Baltic Sea, in Bangladesh, Thailand and Vietnam.

GIS based information regarding the annual movement of the Dutch coast-line is nowadays publically available on the web, an astonishing step forward in data dissemination. Geographic Information Infrastructure (GII) provides real time dissemination of information combating natural hazards, such as flooding, exercised in the Netherlands and recently applied during the extreme flooding in Pakistan. Among the coastal countries in Europe and Asia there is a general willingness to share these experiences and take part in coastal cooperation. The initiatives underlying the present publication illustrate this fact.

### 1-2 Recommendations for actions – the way forward

Required actions should focus on the identification and implementation of measures to prevent or to solve coastal problems. However, for effective ICZM application a number of essential management and implementation conditions need to be met.

Therefore firstly some main conditions are briefly discussed. Secondly attention is paid to the identification and implementation of promising measures in relation to country specific conditions and possibilities for expanding international cooperation.

**Ways to improve the conditions for management and implementation**

As described, an important part of getting ICZM into action deals with creating the necessary conditions. Based on the many examples and experiences considered in the CCC publication, the following provides an overview of the most important conditions to be achieved:

**A long term look ahead**

Develop a long-term vision on expected coastal management problems and required actions and developments to ensure continuity within a longer time perspective on a national level. Short and medium term coastal management plans and activities for designated regions or coastal areas are to be developed, merging concrete no-regret actions and nearby targets with long-term activities such as drawing up a strategy and action plan.
Adopt ICZM in spatial planning
Anchor coastal management planning in existing planning and decision-making procedures, using the underlying legal and institutional frameworks. In particular, investigate the possibilities to directly connect ICZM to the process of regional economic development and spatial planning. Water management and coastal development should be considered as leading or guiding principles in integrated spatial planning of low lying coastal and marine areas.

Full participation
Ensure the timely participation of the relevant actors on all levels, including local communities and stakeholders. Provide clarity on leadership and roles, especially in cases of shared competences and responsibilities. National agencies should be in control and provide institutional frames, legal arrangements, knowledge and funding to facilitate the management tasks of regional authorities. NGOs should be involved in assisting problem analyses, dissemination of knowledge to local stakeholders and in the daily management of coastal areas and ecosystems.

Proper monitoring and effective communication
Increase the role of monitoring, including data collection, data management and dissemination of information, and evaluation. Monitoring and data collection is required at all stages of the ICZM process to develop and improve the knowledge base. This knowledge is needed in order to understand the coastal system and the problems observed, to identify, plan, design and implement sustainable measures and to provide the basis for evaluation. This increased knowledge on the natural and socio-economic coastal processes and the analyses of impacts of developments and global changes should be communicated with the local stakeholders, in order to increase the awareness of the coastal problems and in finding local solutions. On the other hand, the coastal knowledge should also be made available in a form that the national and provincial/state policymakers can draw up long term planning and reserve the necessary funds for their coastal zone.

Increase international cooperation
Further develop and facilitate the possibilities to exchange and share knowledge and learning experiences in order to better address the main triggers for ICZM: population growth, unsustainable economic development and anticipated impacts of climate change. Increasing food, health and livelihood security and education will contribute to an early stabilisation of the world population. Integrated river basin and coastal zone management are important mechanisms for sound economic development and ecological and environmental security. Regional cooperation in flood and drought management is already essential and will become even more critical for dealing with the impacts of climate change effectively in the future.
Given the different ICZM development stages in different countries and the common nature of many of the coastal problems observed, there is a great need as well as potential for learning from each other. The exchange of knowledge and experience can be facilitated by improving and expanding already existing mechanisms, such as:
• Regional cooperation projects funded and initiated by the EU and international organisations;
• Bilateral arrangements for cooperation between countries;
• Development of information exchange networks.
In addition, new possibilities are to be investigated. These might include the establishment of broad international expert teams or the development of a global database of coastal management experiences (problems, solutions, successes, failures and determining factors). Another new possibility may be the establishment of internet based communication platforms for on-line ICZM consultation and support.

Identification and implementation of promising measures
This section starts with the description of four categories of ICZM measures. The feasibility of the measures however, will highly depend upon the prevailing country conditions. The key to the success of small scale adaptive measures, is the involvement and cooperation of local communities.
In addition, the emphasis should be on innovative technological developments which may substantially increase the potential for effective, locally operated measures.

**Four categories of ICZM measures**

Types of measures within ICZM fall into a number of different categories, as follows:

- **Prevention.** The first focus of ICZM should be on the prevention of coastal problems. This category of measures is involved with all aspects of spatial planning including decisions on resource use and exploitation on a national and regional level. Decisions and measures to be taken should be based on the knowledge of all relevant coastal mechanisms and the capabilities and limitations (e.g. carrying capacity) of the coastal system. Measures should aim at avoiding unsustainable use and overexploitation and preventing short term, irresponsible actions disrupting essential coastal functions.

- **Protection.** The category of protection includes all measures that will prevent or reduce the risks of flooding events and natural hazards, such as the building, adjusting and maintaining of man-made and natural flood protection systems. Preferred measures to counteract coastal erosion are to strengthen the natural protection of coastal vegetation belts or maintaining the protective dune systems. Ongoing coastal erosion may also be combated in a soft way by supplying sand to the coast. If absolutely needed many alternative hard coastal constructions can be applied such as to protect harbour entrances.

- **Adaptation.** Adaptation measures include a wide range of possible measures to be associated with human activity and living conditions on different scales, aiming to prevent or reduce the consequences of adverse effects. Examples are: the adaptation of houses and the creation of safe havens for flood protection; adjustments in agriculture, aquaculture and fisheries practices; waste water flow interception and treatment; development of ecotourism.

- **Restoration.** Restoration measures are involved with undoing the effects on the coastal system of undesirable and disruptive activities that have already taken place. These measures may include the restoration of natural systems such as coastal forests, mangroves and coral reefs; cleaning up water and soil pollution sources; limiting destructive coastal fishing and over-fishing in the high seas, and the rehabilitation of destroyed coastal systems such as abandoned aquaculture ponds.

**Feasibility of measures depends on country conditions**

The various parts of the CCC publication include a wide range of examples and experiences which hold important lessons on the failures and successes of the implementation of coastal measures. It is noted that the feasibility of measures, both from the viewpoint of implementation and functioning, very much depends on prevailing country conditions. In this respect, two more or less extreme country development situations could be considered: (1) a situation where a well developed institutional system is in place and sufficient resources and technical capabilities are available and (2) a situation where most or all of these conditions are basically lacking.

The first situation allows for the application of the whole range of options related to all the above measure categories. In particular, these options include the development of integrated approaches involving long-term planning and large-scale investment schemes. This situation applies to most of the coastal states in the EU and in particular the Netherlands, as described in part I of the CCC publication. However, examples of successful and promising coastal planning approaches can also be found in other countries.

The actual challenge is in the second situation, which unfortunately still applies to a large part of the coastal countries around the world. In this situation there are basically limited options for large investment schemes to prevent, protect or restore. Instead, there is a serious risk that ongoing coastal developments and short term profitability objectives will further disrupt coastal systems. Main threats include the cutting of coastal forests and mangroves; destruction of coral reefs; pollution of natural systems, overfishing of coastal waters; and the degradation of coastal areas by aquaculture development. Numerous examples of such problems have become manifest in the last decades.

The challenge is here to start at a small scale, to enlarge the ICZM efforts stepwise and to propose simple solutions to be executed and maintained by the local coastal inhabitants.
Emphasis on small scale adaptation measures

Obviously, the first priority is to stop and prevent devastating developments. This can only be achieved by developing sustainable coastal zone management practices, to be founded in appropriate governance and institutional structures. In identifying promising measures, the emphasis should be on relatively small scale adaptation measures aimed at immediate improvements at the grassroots level. In addition to direct costs and benefits, a number of other factors are particularly important in determining the potential success of such measures. These include a range of characteristics in relation to specific country or region conditions, such as:

- Extent and complexity of implementation requirements;
- Implementation time;
- Involvement and responsibilities of local stakeholders;
- Suitability with respect to local culture and customs;
- Maintenance requirements in relation to local maintenance capabilities;
- Opportunities for local implementation (production and construction);
- Simplicity and reliability;
- Proven success under comparable circumstances.

Good examples of such measures are the mangrove planting and the floating bed cultivation.

Need to widely apply innovative measures

The pressure on the coastal zone and its resources will increase strongly in the future. Innovative, resilient, no-regret measures are needed in order to sustainably develop the coastal zone in the future and to respond to the impacts of anticipated climate change. Examples of adaptive measures are found in Asia and in Europe. Large scale application of these multiple use measures should be pursued.

Involvement and cooperation of local parties required

Successful adaptation requires the involvement and cooperation of all relevant local parties. The conditionality for implementation, operation and maintenance is to be provided by the national government. The local community, being the main beneficiary and mostly well aware of the local coastal problems should be involved in proposing solutions and during the execution of the measures. Commitment of all relevant parties is essential in terms of the responsibilities, efforts made and benefits incurred. Strong vertical cooperation is key to the success of the planning and execution of local, adaptive measures.

Possibilities for expanding international cooperation

There is a great need for coastal countries to learn from each other, to increase communication and to exchange experiences. This need for improved communication was also recognised by Jens Sorensen in his 2002 survey of more than 700 ICZM projects throughout the world.

This CCC publication in the form of this Book and the extended Internet edition on the CCC website has been produced through the cooperation of 101 authors. All authors of Part I and II were involved in the execution of the projects described. The authors of planning tools were the developers of these tool, so are the authors of the innovative adaptive measures closely linked with the execution of these measures.

These 101 authors are listed in alphabetical order, with their e-mail addresses in the CCC Part V, this to facilitate communication between the authors and between the reader and the authors. The cooperation with the ‘CCC-dignitaries’ was much appreciated, provided a insight in their commitment to the sustainable development of the coastal zone, and to mitigation and adaptation. Their details are public and also listed.

The interested reader can read the CCC Book and the extended version including the full chapters of the Part I and II cases on the CCC website, can download the demonstration version of the GIS based planning tools, can use four full Training Manuals, can scrutinise selected PDF reports and can contact an author.
These activities may be considered as a simple start of a community. We will see how this will evolve in the near future.

During the production of this CCC publication several ideas came up to strengthen the communication and exchange knowledge and transfer technology, such as:

- To establish some broad international expert teams regarding ICZM and coastal cooperation;
- To develop a global database of coastal management experiences (problems, solutions, successes, failures and determining factors);
- To establish an internet based communication platforms for on-line ICZM consultation and support;
- To safeguard very valuable websites loaded with coastal information gathered during many years of hard project work, which could be lost in a split second;
- To organise a second World Coast Conference preferably in Asia in 2013, twenty years after the first one in Noordwijk, Holland, to evaluate the worldwide progress made and how to address the future coastal challenges.

You are invited to communicate your ideas and initiatives related to strengthen international cooperation to for instance the Netherlands Water Partnership, Delta Alliance, UNESCO-IHE or the Coastal and Marine Union - EUCC.

Finally, the two following contributions by Luitzen Bijlsma and Pier Vellinga describe their interesting perspectives on coastal cooperation.
The key for adaptation is development

Development in a sustainable way, governance and an outlook for international cooperation

Luitzen Bijlsma (Centre for Water Management/Ministry I&E, the Netherlands)

Water related problems are increasing in low-lying populated coastal areas. Witness the recent typhoon Ketsana, which battered South East Asia and took lives, affected several million people and caused large scale damage to properties in Thailand, Cambodia, Lao, Philippines and Vietnam. In many coastal areas sea level rise will contribute to increased vulnerability. However, mismanagement of local resources and their over-utilisation has in many cases already made them highly susceptible to change. Subsidence in deltaic areas caused by large-scale mining, extraction of oil, gas and groundwater, and intensified drainage, inevitably leads to soil compaction and is one indicator that there is a limit to resource utilisation. In many occupied deltas and other low-lying coastal areas, the rate of subsidence is far larger than the present rate of sea level rise. The ongoing uncontrolled encroachment of unprotected low-lying areas makes them even more susceptible.

The fifteenth Conference of the Parties of UNFCCC in Copenhagen (December 2009) failed to look at the issues of water management in an integrated manner during the discussions on adaptation to climate change.

Development

We are surrounded by uncertainties when dealing with climate change and we have to prepare measures that take account of this. Although there may not be an impending catastrophe, neglect of proper resource use will inevitably lead to hazards and hazards lead to hazard driven responses. If not managed, the burden will shift to the most susceptible individuals, groups, sectors and industries, such as shown in the poverty-stricken and cyclone prone coastal areas of the Indian State of Andhra Pradesh (see CCC II-3-4). If individuals, groups sectors and industries cannot adapt, the threat from exposure to these hazards will increase, leaving them increasingly vulnerable. This is a major problem for the sustainable development of coastal areas and requires urgent action now.

The answer lies in better resource management and better management of related infrastructure for service delivery. This is not about bigger governmental institutions, but better service by public or private providers. A prerequisite to good governance in service provision is an appropriate legal, institutional and financial framework. In many countries, the legal basis for development control is often present. Institutional reform is however still needed for effective implementation of policies to address the complex challenges associated with sustainable development and impacts of climate change. Good governance is the key!

Governance

Good governance is prerequisite for an attractive investment climate. An attractive investment climate is important for economic and social development. Sustainable development increases the resilience of society to future uncertainties, including climate change. Drainage, water supply, sanitation, flood protection, land use planning all require a competent and a public, service and user oriented organisation. As an example the Water Boards in The Netherlands are decentralised public service providers that have been at the grass roots of development for many centuries. In providing drainage, irrigation and flood protection and sanitation, they work in a legal and financial framework, where the user pays for the service and the users have a vote in electing the governing council of the Water Board. In many countries, the water services are centralised. As a result, these organisations tend to become unwieldy and solely oriented towards engineering solutions, with services that are disconnected from local needs and where there is no recovery of maintenance costs from the users. As a result, the growing bureaucracy becomes an obstacle to sustainable development.
There is a long way to go but step by step reform, is possible using experimental situations, pilot projects and improved knowledge. International financial cooperation is partly driven by infrastructure damage, leading to the transfer of financial resources for recovery after an event has taken place requiring rehabilitation, which is sometimes hastily undertaken. Sustainable international cooperation on the other hand should be focused on long term exchange of experience and best practice in organising services at all levels of governance and on professional cooperation between service providers. Coastal countries and deltas that succeed in improving the basic services, including water services, are in a better position to address future uncertainties, especially in relation to climate change. Looking only at the impacts of climate change in an isolated, non-integrated way may lead to inappropriate decisions.

From my professional position as Director of the National Water Service/Ministry of Infrastructure and the Environment (Ministry of I&E) in The Netherlands, dealing with water quality and quantity, flooding and erosion – I can state that professional, international cooperation can have mutual benefits. To learn from each other's experience can hasten the process of reform. For instance South Africa, Ukraine, Indonesia, Egypt and Bangladesh have all developed first steps in decentralisation. The USA, Great Britain and France are rethinking the way they deal with protection from erosion and flooding, in order to reduce the loss of lives, property and economic damage given the recent increase in storm surges. Hazards such as typhoon Ketsana will continue to occur. However, it is possible to reform the way we work and protect both lives and property from natural hazards in a more effective manner. Can we do it without hazards? Yes we can.

Outlook for international cooperation
In December 2009, the Netherlands Cabinet adopted the National Water Plan 2009 – 2015 (see website) created by five Ministries. This plan outlines the policy the State will implement in order to achieve sustainable water management in the Netherlands. Long-term cooperation with other deltaic countries is also addressed. The Cabinet of Ministers wants the Netherlands to cooperate with countries in low-lying delta areas by assisting in protection against floods and in providing sufficient, clean water. The Cabinet is focusing its attention on five deltas: the Jakarta, the Mekong, the Ganges/Brahmaputra, the Incomati and the Nile. The Netherlands will be entering into long-term water partnerships, firstly through the existing "Partners for Water" programme (extended to 2015), but aiming to last 10 - 20 years. The Netherlands is also using a number of other financial instruments to assist water management in other countries.

International cooperation will contribute to climate adaptation and to the millennium goals for creating and utilising mutually beneficial, economic opportunities.

Reference:
Ketsana: http://globalvoicesonline.org/2009/10/02/typhoon-ketsana-batters-southeast-asia

Netherlands National Water Plan 2009 – 2015:
http://www.verkeerenwaterstaat.nl/english/topics/water/water_and_the_future/national_water_plan
A call for action and cooperation

Towards an Alliance of Deltas

Pier Vellinga (IVM, Free University, Amsterdam, the Netherlands)

Competing claims on land and resources, subsidence in urban areas and climate change are the most serious issues in coastal zones. It is evident from experience that a sectoral approach is inadequate to address these issues. Innovation across sectors and multifunctional use of land and resources is required. From a technical and macro economic perspective most of the issues can be solved. A major barrier is the development and implementation of solutions across the sectors, not only in government, but also in industry.

I would like to illustrate this with three examples. One, fresh water for industrial and human use is often harvested from groundwater resources, causing subsidence in mega cities such as Bangkok and Jakarta. Major parts are now at or below sea level. As a result, storm surges, typhoons and hurricanes will cause an increasing amount of damage and loss of live in such mega-cities. Macro-economically it will pay to invest in alternative water production schemes, such as conservation, underground storage and desalination. Solar energy can be an attractive energy source to make this happen. But, how to develop a business case for such investments? Some countries are experimenting in this field. We need more attention for successful examples and we need mechanisms to multiply them at international scale.

A second example is food production and habitation in flood prone areas. Interesting concepts are coming up such as floating agriculture and floating urban development. Brackish agriculture is another opportunity. Sharing technical and institutional experience will greatly stimulate such developments and will help to make such solutions more cost effective.

The third example is the double challenge to develop low lying areas in a way that is both climate neutral (no greenhouse gas emissions) and climate proof. Energy, water and food production are separate sectors each with their own rationale. Now that the pressure on space and resources is reaching the limits of sustainability, it pays to develop solutions across these sectors. Food residues, solid waste and waste water are excellent energy sources. Water can be used to store and to transport energy. Heat pumps using water as a medium can be used to heat as well as to cool houses, offices and factories. Where water and energy meet many new solutions can be found.

All three examples illustrate that major resource efficiency gains can be found by linking issues and looking across sectors. Such linkages appear to be difficult as in many cases there is a technical, economic and institutional lock-in within the specific sector. Business cases can only be developed when the investing parties can also become the beneficiary parties. This requires institutional change. Existing power structures are very often a barrier for the institutional change that is required to implement cost effective solutions.

Specific initiatives and efforts to remove such barriers and exchange the knowledge and experience gained at international scale will surely help in the diffusion of innovative cost effective solutions. Fortunately there is a growing number of initiatives in this field. In practise climate change can be seen as an important driver for the development of such initiatives, even when it is not the most pressing issue. However, climate change does provide the inspiration for a long term and international perspective on solutions to shorter term problems. It helps to look beyond traditional boundaries and institutions.

In major parts of the world it is not climate change, but rapid urban development and overexploitation of delta resources such as water, soils and natural resources that cause the most acute problems.
Climate proofing requires taking a longer term and a geographically wider perspective. Experience shows that taking climate change and sea level rise on board in early planning phases generates more robust and more sustainable solutions, with more beneficiaries and benefits than in the case of sectoral short term oriented solutions.

In this article I want to make a plea for the development of an Alliance of Deltas. An Alliance that works as a common interest group, to raise international awareness and generate support for effective solutions. It will help to multiply effective solutions and it provides a common ground for countries and their experts in addressing the issue.

Fortunately, two early initiatives in this direction can already be identified. One is the C-40, the group of Delta Cities cooperating under the umbrella of the Clinton Climate Initiative. The second is the Estuary Alliance launched in Shanghai in June 2010, by the World Wide Fund for Nature (WWF). It promotes the conservation and use of natural habitat for estuarine management and coastal protection. The International Delta Alliance, was launched at the Rotterdam Conference: "Deltas in Times of Climate Change" (September 29 - October 1, 2010.) The Delta Alliance is focussed on the international cooperation among scientists/experts, practitioners and policy makers. It addresses full delta management, including water, food, urban management and development and natural habitat conservation and development.

In this contribution I call on all those involved to reinforce and broaden the mentioned early initiatives towards a truly international effort in promoting and sharing Delta Knowledge and Experience. Specific actions to be included are:

- The development of major international exchange programs,
- The organisation of bi-annual international delta conferences including all low lying countries of the world, international cooperation and funding programme's on climate, sea level rise and delta planning.

I suggest that all governments of low lying countries and all relevant multilateral organisations join efforts in the support of the mentioned initiatives towards a truly international Alliance of Deltas.

www.deltaalliance.org
V-1  List of downloadable Training Manuals and Tools

The CCC production aims to increase the exchange and transfer of applied coastal knowledge and technology. The reader is encouraged to get acquainted with some concepts and tools through downloading and using the Training Manuals and ICZM Planning Tools – Demos. You can download these manuals and tools free of charge on condition of proper referencing to the developers of the manuals and tools, and with citation to the CCC Book & CCC Website.

V-1-1 List of Training Manuals
Downloadable via www.coastalcooperation.net

V-1-1-1 Coastal Protection Guidelines
A guide to cope with erosion in the broader perspective of Integrated Coastal Zone Management. RIKZ/CZM-C 2001

V-1-1-2 Thai Aquaculture experiences in an ICZM frame
Leewis, R.J. and S. Boromthanarat, 2003:

V-1-1-3 Where waters and land meet
Marta Vahtar, Robbert Misdorp, Pham Toan, Le Van Thu, Le Ngo Hung, Phan Thi Le Dong and Maja Zdesar, 2005:
Water, Water-Management and Coastal Zone Management Education in the Context of Regular Primary School Education” - Teaching material for Grade 1 to 12.

V-1-1-4 Training for the Sustainable Management of Marine Protected Areas
Julius Francis, Carien van Zwol, Dianceta Sadacharan,
A teaching manual for Training Managers – Western Indian Ocean Region; CZM-Centre, WIOMSA, World Bank, The Hague, 2000

V-1-2 ICZM Planning tools – Demos
Demonstration versions of the following Planning tools are downloadable through the CCC website: www.coastalcooperation.net or through the indicated website links

V-1-2-1 The COSMO - Demo version
Information: marcel.taal@deltares.nl

V-1-2-2 The CoastLearn – Link: www.coastlearn.org
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V-1-2-3 The RAMCO – Link: www.riks.nl/projects/ramco
Information: hvdelden@riks.nl

V-1-2-4 The DR-EIA – Link: www.dr-eia.org
Information: j.deschutter@unesco-ihe.org

V-1-2-5 The STREAM – Demo version - Link: http://www.adaptation.nl
go to: STREAM, Downloads, download STREAM Demo (77mb) and follow the instructions
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The Cisland Empire

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Fields of interest:  
- Networking and participation in ICZM;  
- Communications for coastal sustainability and development;  
- International cooperation and knowledge exchange.  
The Netherlands
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Positions:
- Executive Secretary: World Indian Ocean Marine Science Ass., Zanzibar-Tanzania, 2002–
- Director: Institute of Marine Science, University of Dar es Salaam, 1995 – 2001
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- dialogue knowledge centres-end users; linking local actions to global policies.

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Andre Akkerman designed, a long time ago, the logo of the World Coastal Conference -1993 symbolising the integration of interacting spheres embracing mother Earth. After the WCC we continued to use ‘your’ logo as the CZM-Centre logo.

Andre unfortunately passed away at a young age in August 2010.

We appreciated his artistic and enthusiastic input, and hope that his valuable contribution, together with all others, will lead to a more sustainable, long term approach to coastal zones around the world.

Logo of the World Coast Conference 1993 and the CZM-Centre (1993-2006)