Decision Support System for ICMAM

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Contents

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 the ICMAM programme. 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*.*
(source: ©2011 Google–Kaartgegevens
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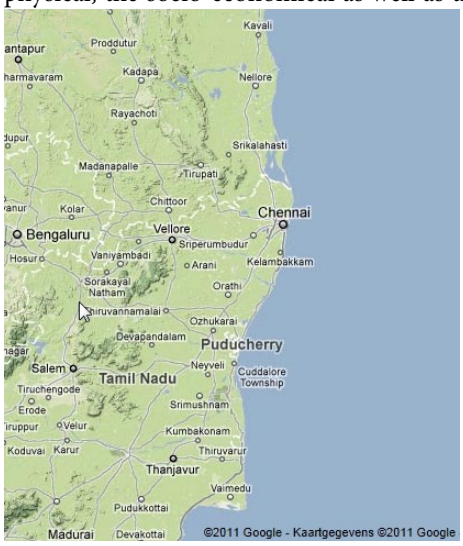
1. Introduction

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.

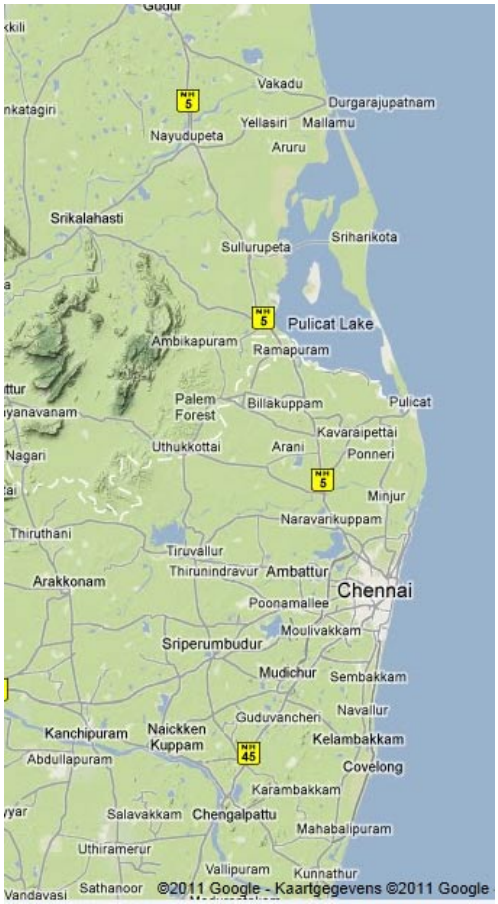


Figure 2: ***Chennai*** *the capital of the State Tamil Nadu.*
(source: ©2011 Google – Kaartgegevens ©2011 Google)

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.

Overviews of various applications of Decision Support Systems - DSS used world wide, is provided by UNESCO-IHE - Institute for Water Education and by WURC - Wageningen UR, see its websites.

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 activites 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."

Furthermore, model ICMAM Plans have been prepared by ICMAM-PD for the coastal zones of 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.

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PDF Reports:

Ministry of Earth Science: Annual Report 2003 – 04: http://moes.gov.in/ayr03-04/ann2003-04.pdf

Websites:

- **ICMAM – PD: Integrated Coastal and Marine Area Management Project Directorate, India,** an attached office of Ministry of Earth Sciences (MoES), www.icmam.gov.in/ and http://www.icmam.gov.in/mandate.htm
- **MoES: Ministry of Earth Sciences, India:** www.moes.gov.in
- **IIT – OEC : Indian Institute of Technology - Ocean Engineering Center- Chennai, India** http://oec.iitm.ac.in/ioi/ioi.htm
- **UNESCO-IHE - Institute for Water Education, Delft, the Netherlands:** overview of Decision Support Systems: http://www.unesco-ihe.org/content/advancedsearch/?SearchText=decision+support+system
- **WURC - Wageningen UR (University & Research Centre. the Netherlands:** search for DSS in: http://www.wur.nl/uk/

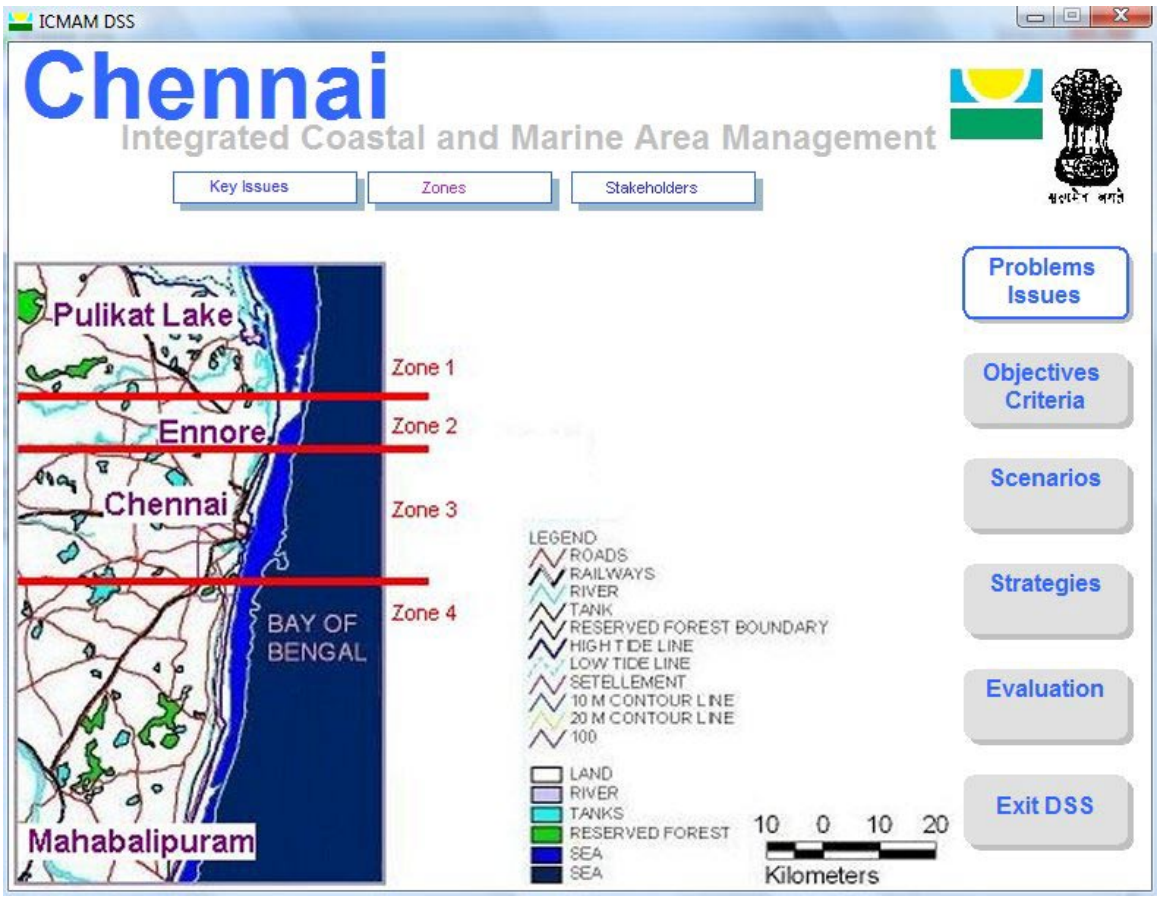


Figure 4: ***Interface DSS: the four zones*** *identified for development of ICMAM plan. The menu on the right follows the Framework for Analysis.*

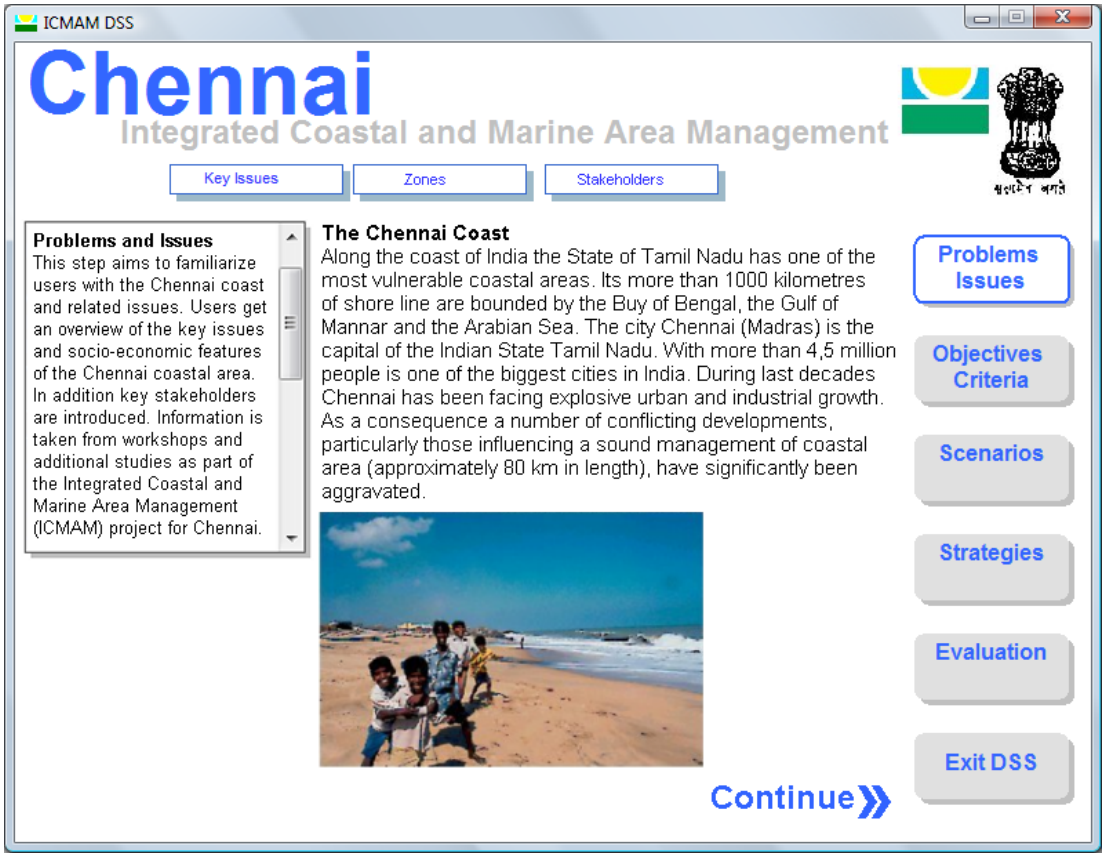
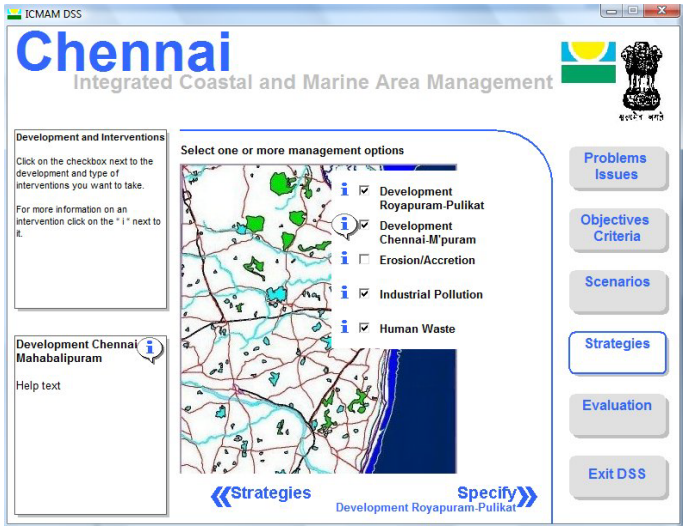
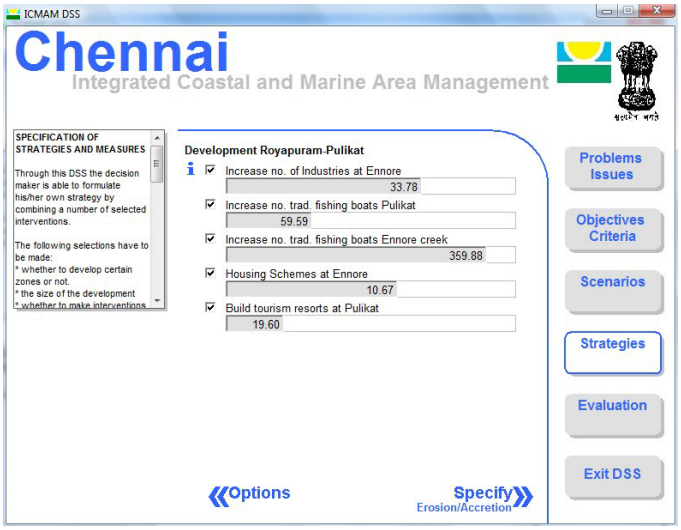


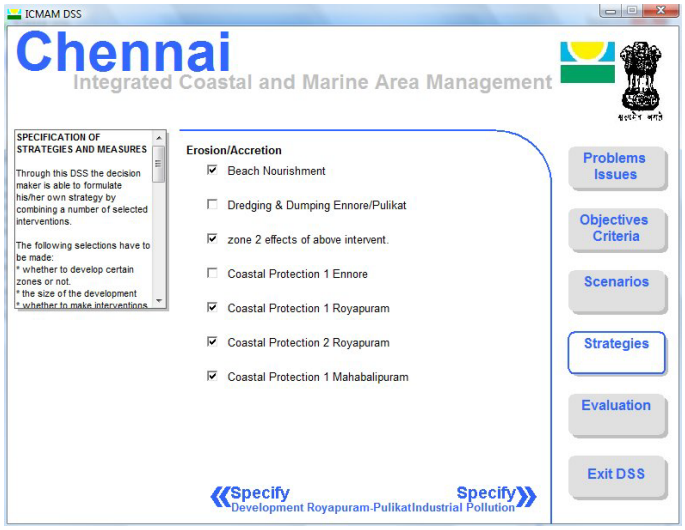
Figure 5: ***Interface DSS: key issues*** *interactively identified and structured along the four coastal zones.*



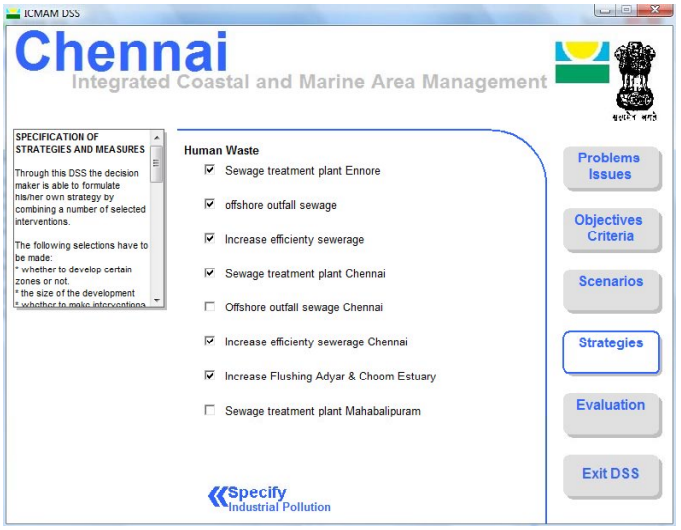
Selection of development interventions



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***

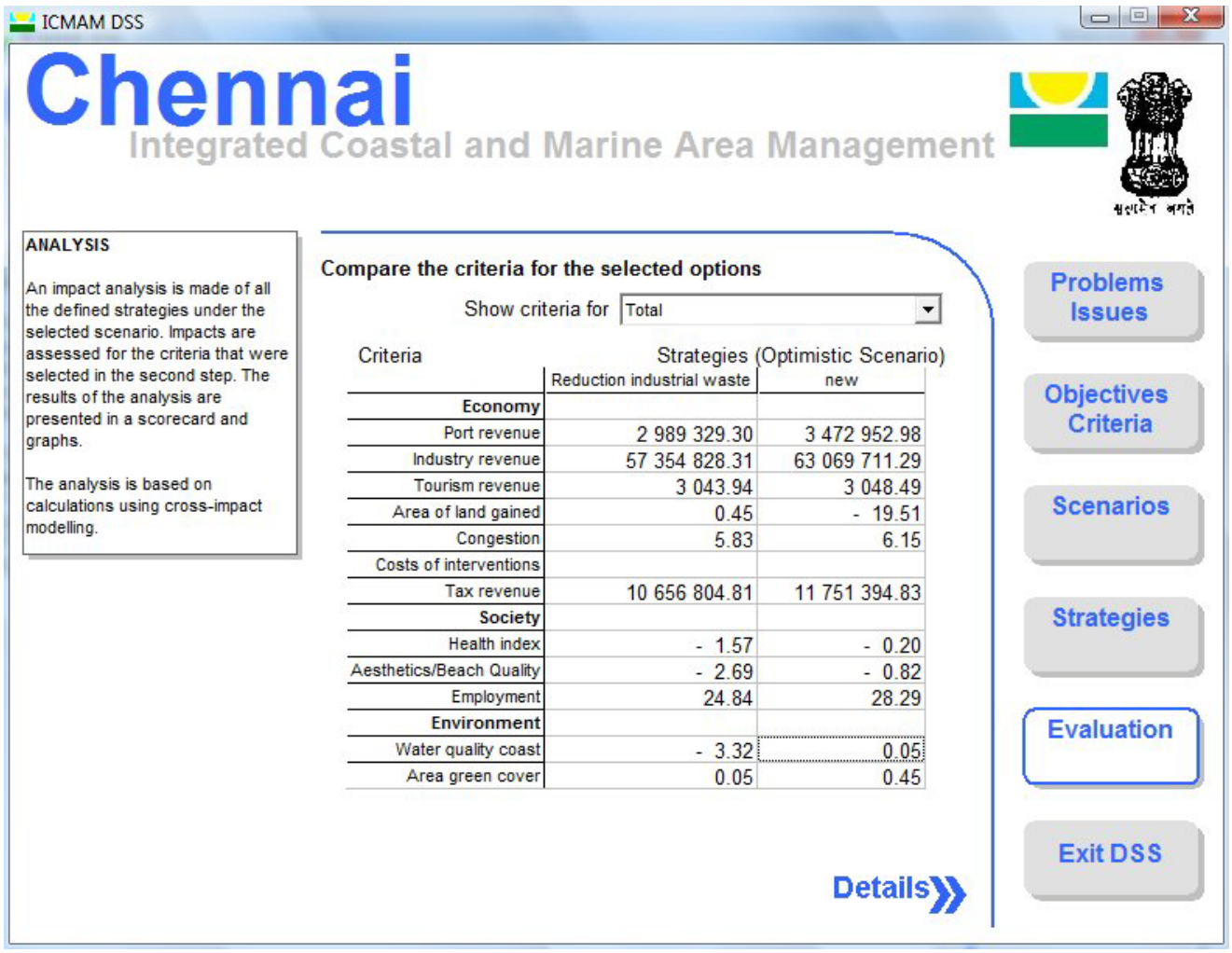


Figure 7: ***Interface DSS for the evaluation of strategies****: comparing a predefined strategy :'Reduction of industrial waste' with a 'New' strategy defined by the participants of the ICMAM-DSS Workshop III; both strategies are analysed under the same 'Optimistic' Scenario.*

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.

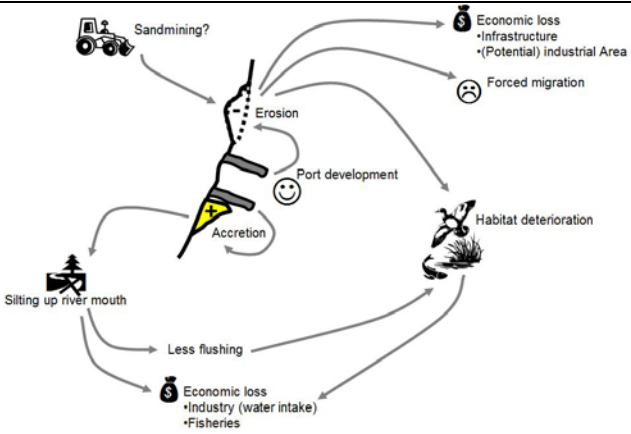
ICMAM-ISSUE & PRIORITY	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**
Erosion/accretion	1*)	1	1	3
Pollution	1	2	3	2
Habitat degradation	1	3	2	3
Institutional arrangement	1	2	1	2
Socio-economic development	3	1	3	1
Community participation	1	2	2	2

**) Priority: 1: short-term priority; 2: mid-term priority; 3: long-term priority*

Box II: Key issues and system diagrams in the DSS

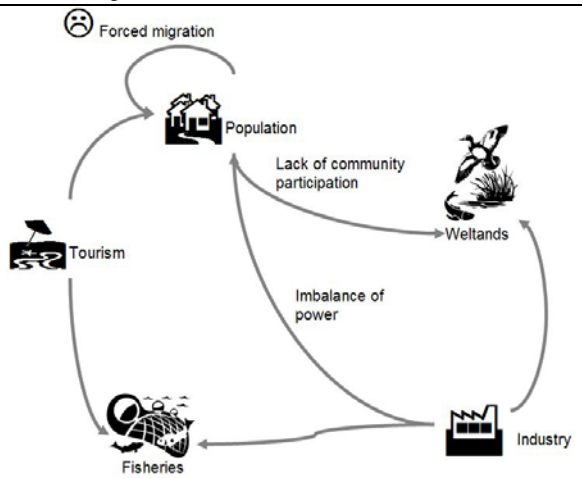
Six categories of key issues, identified during workshops and addressed in the ICMAM plan. These are introduced below together with more detailed problem descriptions.

Erosion/accretion



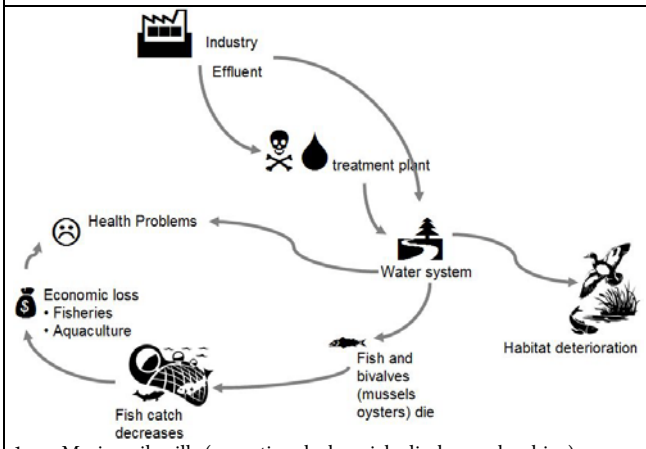
1. Erosion at Royapuram (Lakshmipuram, Periakuppam, Chinakuppam) and north of Ennore port.
2. Threat to the protective shoals at Ennore and the sand spits at Pulicat Lake.
3. Accretion at Adayar mouth, Ennore Creek and Cooum, decreasing outflow of water, eg decreases the cooling capacity for the power plant.
4. Dredging hinders fishing operation. Dredged sand dumped in near-by 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.

Conflicting Land & Water uses



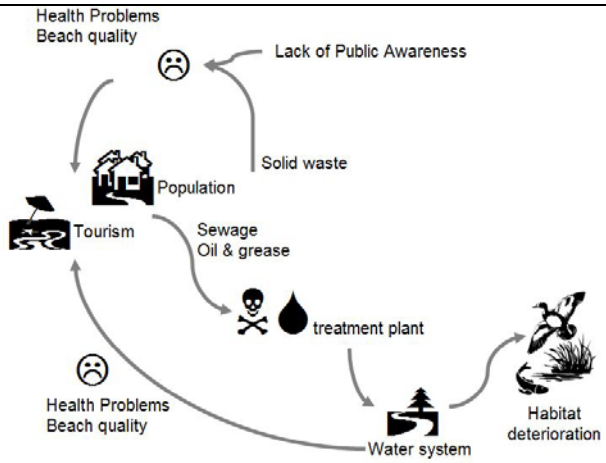
1. Forced migration of local communities from coastal areas due to increasing development and coastal erosion.
2. Tourism development conflicts with traditional fisheries. Hinterland denied for the utility of the coastal people.
3. Industrial development requires land acquisition near Ennore port and 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.

Industrial Pollution



1. Marine oil spills (operational, chronicle 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.

Human waste



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, Buckingam 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.

Institutional arrangement	Community participation
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. 2. State Coastal Zone Management Authority under the Central Government does not delegate subordinate bodies. 3. Lack of integrated approach to address erosion & accretion. 4. No plans for restoration of degrading ecosystems. 5. Unsustainable coastal tourism due to non-assessment of the carrying capacity of the area. 6. Inadequate co-ordination among water management, research and monitoring agencies. 7. Inadequate enforcement of water policy and existing legislation for sewage disposal into the sea. 8. Inadequate funding for implementation of coastal protection measures.	1. Lack of community participation in resettlement and rehabilitation of slums of Chennai. 2. Lack of public awareness on water conservation. 3. Lack of awareness among the beach users disposing solid wastes contributing to anaesthetic appearance of beaches. 4 Imbalance of power of stakeholders & difficulties to make communities participate in decision-making process. 5. Difficulties in enforcement of CRZ regulations in suburban areas. 6. Limited involvement of local fishing people in official meetings and discussions.

[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.