

## The DSS WadBOS and EU Policies Implementation

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### Abstract

WadBOS is an information system to support policy making in the Dutch Wadden Sea. WadBOS has been developed to be useful for and usable by the decision makers in the region. From the development process of the WadBOS DSS can be learned that a well-defined partnership of competent authorities, end users, system developers and domain specialists are key to successful development. A clearly defined policy framework facilitates a DSS to become a useful and tailor made instrument. The present EU policies implementation process encourages the further development of WadBOS like DSS systems for coastal zones. Through these integrated tools reasonable expectations for the results of policies over time can be generated and transparently communicated. Strategic environmental assessments using integrated DSS tools enable to define realistic ecological objectives and are thus a basic step in the analytical process for further adjustment of monitoring and assessment plans. As such it facilitates a scientific sound implementation of the Water Framework Directive and provides a broad framework to consider the operationalisation of strategic ICZM principles under the Recommendation for Integrated Coastal Zone Management.

### 1. INTRODUCTION

#### 1.1 History of policy making in the Wadden Sea

Over the last decades water and coastal zone management in the Netherlands has evolved from a sectoral (or disciplinary) approach to integrated water and coastal zone management.

The Dutch Wadden Sea area is a part of the Dutch coastal zone that can boast on possibly the longest Dutch local experience in the principles of Integrated Coastal Zone Management (ICZM).

A large number of (governmental and non-governmental) stakeholders are involved in Integrated Coastal Zone Management of the Wadden Sea area.

Today stakeholders form a complex organisational structure in which integrated policy and management for sustainability has to be shaped.

National Wadden Sea policy making is linked to international targets. The 6<sup>th</sup> Trilateral Governmental Wadden Sea Conference in Esbjerg in 1991 laid the basis for trilateral ecological targets.

Mainly in the context of national policy making, but also in the framework of the trilateral policy developments in the Wadden Sea area, the different stakeholders and policy makers felt the need to support new planning cycles with strategic environmental assessments.

For the coastal manager a good access to available information to assess conditions for new operational initiatives was a major reason to look for new tools.

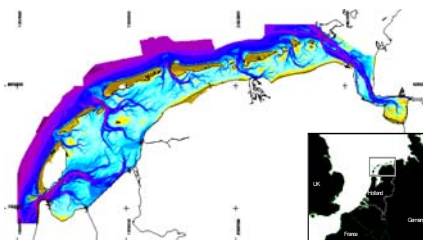


Figure 1: The Dutch Wadden Sea area is part of the larger international Wadden Sea, which further includes the German and Danish Wadden Sea. It is not only a unique nature reserve, it is also an environment in which people live, work and enjoy leisure activities. In particular fishing, shipping, dredging for shells, water sports and military activities take place.

The WadBOS Decision Support System (DSS) feasibility study started in 1996 as a common decision of the joint authorities and with support of the national Land, Water, environment and Information technology programme.

## Box 1: WadBOS Decision Support System

## DECISION SUPPORT SYSTEMS (DSS)

Objective information and transparency of assessments, giving insight to all stakeholders can facilitate the planning and decision making process. For this purpose so-called *Decision Support Systems* (DSS) have been developed. Decision support systems are information systems which primary purpose is to provide knowledge workers with information on which to base informed decisions.

## WHAT IS WADBOS?

WadBOS is a MS Windows based Decision Support System (DSS). It links ecological and economical knowledge and information about the Wadden Sea. Through the system this knowledge and information becomes available for all parties involved in the policy making process in the Wadden Sea. It runs on any state of the art PC.

## SHORT HISTORY OF WADBOS

- . initiative taken in 1996
- . first prototype WadBOS 1. in 1997
- . version WadBOS 2. in 1999
- . version WadBOS-[ES]2 completion end 2002

## 1.2 WadBOS , the Water Framework Directive and the Recommendation on ICZM

A scientific sound implementation of the EU Water Framework Directive (WFD) and some further steps to accommodate the EU proposal for a Recommendation on Integrated Coastal Zone Management are nowadays on the agenda of coastal zone managers, consulting institutes and NGO's.

The majority of WFD-questions for the coastal waters focus on short term requirements as categorising and typology of coastal waters and identifying reference conditions. Further insight is needed in methods for classifying ecological quality related to reference values and the policy consequences of objectives for the ecological potential of heavily modified water bodies. For specific thematic ecological targets, like eutrophication, (inter)national expert groups are using a combination of models, historic data and expert judgement to develop a classification system for the relevant biological indicators.

A WFD tailor made integrated model system, which makes it possible to analyse scenarios and assess reference values in view of thematic objectives and a suite of measures, could be recognised however in due time by all stakeholders involved as a welcome instrument.

The implementation time scheme of the Water Framework Directive is tight and any opportunity to make use of, or build on existing tools will profit from a start as early as possible.

The development-process of the WadBOS DSS starting with version 1. to version [ES]2 shows an increasing focus on clearly defined policy targets. The version WadBOS-[ES]2 in particular is concentrating on strategic policy questions. In the coming decades it is expected that, as a consequence of climate change, the sea level will rise and higher river discharge will occur in winter. These changes will enhance the risk of flooding in the Netherlands. Therefore the Dutch government has decided to take several measures. One of these measures is a study into possibilities to increase the discharge capacity of Lake IJssel to the Wadden Sea with an extra sluice in the Afsluitdijk, the dike which separates the Wadden Sea from Lake IJssel. The possibilities for restoration of brackish water habitats is also part of this study. The different options for the location of the extra sluice in combination with the brackish water habitat will have it's own influence (effects) on economical activities and ecological functions. WadBOS-[ES]2 will support the communication in the decision process on the basis of results of an analysis of alternatives.

The WadBOS DSS is due to its basic technical structure a promising integrated model which model base might be adapted towards the WFD implementation demands and thus contributing equally to further ICZM tools. Present experience with the WadBOS DSS in the policy making process shows that there is not yet one solution to bridge the principle gap between knowledge workers and policy makers. Effectiveness of DSS systems are in theory a function of the quality of the system and its acceptance in the policy making process (De Vries & Zijlstra 2001). While with each further developed version the quality of a DSS system improves and its user friendliness grows, this is no guarantee for a higher acceptance. Active approaches in awareness raising and intensive communication with regional coastal managers and the public are required.

End users and system developers of WadBOS are currently identifying the requirements of a national or international DSS intended as a useful tool in the implementation of WFD. Neighbouring Wadden Sea countries and other European coastal managers might as well be interested to learn from WadBOS, to develop themselves an integrated system or to seek for possibilities to realise a common Dutch, German, and Danish WFD DSS approach.

## 1.3 WadBOS now available on the Internet

In an effort to lift WadBOS from the national to the international scene, a project was initiated to translate the software, as well as its documentation into English. Major aims for this translation are :

- Sharing the experience gathered with the development of the WadBOS tool with European coastal managers to stimulate further development of a similar system by other parties in ICZM policy making.
- further international communication on the WadBOS DSS system and its component sub-models to facilitate a common assessment approach in the WFD implementation.

The release of the English version on the Internet is planned in the second half of 2002 (See [www.riks.nl](http://www.riks.nl)).

## 2. THE WADBOS DSS DEVELOPMENT PROCESS

### 2.1 Stakeholders at the national level

There are six ministries of the national government, three provinces and a number of local authorities responsible for different tasks in ICZM of the Dutch Wadden Sea.

The ministries work together in the Interdepartmental Wadden Sea Commission. Provinces and local governments are further associated in committees. The horizontal coordination between the national government, the provinces and local authorities takes place in the Coordination Board for the Wadden Sea Area. All governmental organisations involved work together in the Commission for the Implementation of the Management Plan for the Wadden Sea (CUBWAD).

Besides these organisations there is also the Wadden Sea Advisory Board in which user groups and interest groups are represented. This board gives advice to the responsible authorities. Finally, there are a number of knowledge institutes involved in (scientific) research in the Wadden Sea area. Over the past decades a vast amount of mainly sectoral or disciplinary knowledge about the Wadden Sea area has been collected. This knowledge is actively collected and maintained by Interwad, a collaboration of several Ministries with the aim to make all available information accessible via Internet ([www.interwad.nl](http://www.interwad.nl)).

### 2.2 Partnership in development

The development of the WadBOS DSS took place in a partnership involving end-users, DSS developers and domain specialists. WadBOS involved thus different kind of organisations and people, each with a specific role in the project and in the creation of this DSS (Figure 2.).

*First*, The CUBWAD, as an organisation of governmental bodies responsible for the implementation of the management plan of the Wadden Sea initiated in 1996 the WadBOS DSS project.

It took this initiative, because it came to the conclusion that the ever-increasing complexity of its management task could possibly be made more transparent through the introduction of an information system enabling the analysis of the cumulative effects of human activities in the Wadden Sea on the natural system.

The first condition for the effective introduction of an information system in the organisation was met, as the organisation decided that *change* was needed in its way of working.

*Second*, the *Ministry of Public Works, Water management and Transport*, represented by its regional directorates North Netherlands, North Holland and its research division RIKZ in Haren acted as principle executives in the development of the WadBOS-DSS. They represented the *end-user* community and gave direction to the context, desired policy content, and the functionality of the end-product.

They took responsibility for the provision and the adaptation of GIS material required for the system, and they used their network of domain specialists actively involved in the area to facilitate the acquisition of data, information and knowledge to be captured into the WadBOS system.

*Third*, a relatively small group (+/-10) of *DSS developers* experienced in the development of this kind of product participated in the project. The members of the developers group were spread out over the entire country but collaborated very effectively. This group consisted of the following specialists:

- Trans-discipline and trans-role domain specialists / scientists / model developers.
- An architect of the model base and integrated model of the DSS
- Flexible and skilful software system designers and developers
- A professional 'communication' specialist (a mediator, or facilitator)
- Project manager. Very many little details matter and must be dealt with in order to deliver a full proof product. A strict management of the project is essential

*At fourth*, the scientists or domain specialists. Finally, there was a large group of some 20 to 30 domain experts. These are technicians and researchers of one of the many organisations active in the region: Ministries, Provinces, Municipalities, NGO's, Universities and other research organisations, and consultants. Many of them have worked in the region for decades and have an excellent knowledge of the working of parts of or the whole Wadden Sea area (Engelen 2000).

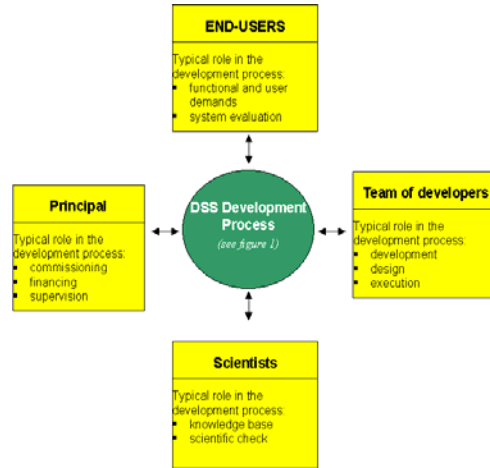


Figure 2: Network of actors involved in the development process

### 3. FUNCTIONAL REQUIREMENTS OF DSS SYSTEMS FOR ICZM

Many problems in coastal zone management await appropriate analytical tools. However, many problems can also be sufficiently solved by approximating their solution as closely as possible. This is where *Decision Support Systems* become useful instruments. Decision Support Systems (DSS) are computer-based information systems developed to assist decision makers to address *semi-structured (or ill-defined)* tasks in a specific decision domain. They provide support of a formal type by allowing decision makers to ‘access’ and use ‘data’ and appropriate ‘analytical models’ (El-Najdawi & Stylianou 1993). The terms ‘semi-structured’ and ‘appropriate’ in this definition refer to the fact that Decision Support Systems are typically applied to find answers for problems that, due to their specific nature and complexity lack an unambiguous solution method. Rather, usage of the most appropriate analytical solution methods available approximates the unique answer. Thus, the DSS provides the decision maker with a suit of ‘analytical models’, which are considered appropriate for the decision domain. Typically decision models, statistical and operations research methods are available from the model base of the DSS.

Even more essential in the model base are the domain specific models capable of grasping the complexities of the system and the problems studied. Integrated models play a key role in the model base of a DSS in the sense that their constituting models are covering, at the least in part, the (sub-) domains related to the decision problem, but more so because a good integrated model features the many essential linkages between the

constituting models and the related domains. Thus, the user of the DSS gets immediate access to very rich and operational knowledge of the decision domain.

A DSS is more than an integrated model or (1) a *model base* alone. Typically three more components can be distinguished (Engelen *et al.* 1993):

- I. a *user interface* enabling easy interaction between the user and the model system,
- II. a *data base* containing the raw and processed data of the domain and the area at study; and
- III. a *tool base* with the methods, analytical techniques, and software instruments required to work in an effective manner with the domain models and the data.

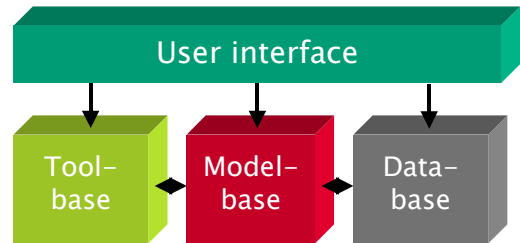


Figure 3: Basic functional components of the WadBOS DSS

### 4. THE WADBOS MODEL

#### 4.1 Geonamica®

For the technical implementation of WadBOS, the DSS-Generator GEONAMICA® has been used. It is an object-oriented application framework, developed by RIKS for use by DSS developers (Engelen 2000).

It is specially tailored for developing Spatial Decision Support Systems featuring models that run at multiple spatial and temporal resolutions. Typically it will combine *system dynamics* models and *cellular models* for this purpose. In particular use is made of *spatial interaction based models*, different kinds of *cellular automata models*, *multi agent* or other kinds of *rule-based models*. It is equipped with highly efficient computational techniques and algorithms for addressing spatial problems, but also with additional analytical tools, visualization tools, and input, import, export and output tools. Further it has a number of tools for interactive map manipulations, in particular: map editors and display tools for 1-D network and 2-D map objects, map comparison, and overlay-analysis.

## Box 2: End user requirements for WadBOS

## END USER REQUIREMENTS FOR WADBOS

- I. *All processes.* The WadBOS model should adequately represent all the important processes necessary to provide the required policy outputs.
- II. *Scale.* The WadBOS model should be spatial and operate at multiple spatial scales. It should provide information at a sufficient level of spatial resolution to reflect the scale of variation in the most important physical, ecological and socio-economic variables and relevant for coastal zone policies.
- III. *Time horizon.* The WadBOS model should be dynamic and operate at time scales and temporal resolutions representing realistically the autonomous dynamics of the system modelled. A time horizon also which is relevant for policy design, implementation and assessment.
- IV. *Routine data.* The WadBOS model should be sufficiently simple to run from routinely measured and available data. In principle, no new data are collected to run WadBOS.
- V. *Output centred.* The WadBOS model should be output centred. It will be judged mostly upon the quality of its output and less upon the scientific or technical innovative character of its models.
- VI. *Policy centred.* The WadBOS model should provide appropriate results using indicators or variables that directly interface with the policy implementation process rather than more abstract scientific or technical variables. These may focus on environmental changes, anthropogenic impacts, and management options.
- VII. *Interactive.* The WadBOS model should be fast, responsive and interactive and should cater for a very short attention span. A response time of 15 minutes per simulation-run covering a period of 10 years should be aimed for. Clever models, fast algorithms, and efficient software code are required to achieve this goal.

The cornerstone of the GEONAMICA<sup>®</sup> application framework is the way in which it enables the DSS-developer to set up a new model base. In fact its model base consists of a set of exchangeable and interchangeable *Model Building Blocks* (MBB) that can be entered, exchanged, re-arranged and re-used nearly as easily as Lego building blocks.

#### 4.2 The integrated Model

WadBOS consists of an integrated model representing the ecological and the economic functions of the Wadden Sea. The constituting sub-models (Economy, Ecology and Landscape) represent processes operating at three different time scales: the tidal, monthly and yearly cycle. They also represent spatial processes operating at three different spatial scales: the whole sea, large homogeneous basins within the sea, and small cellular units of 25 ha each (Figure 5).

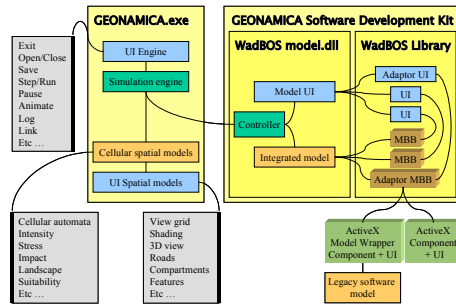


Figure 4: Inside GEONAMICA, The UI (User Interface) gives the user read/write access to all the Model Building Blocks (MBBs) specific parameters as well as to the initial (input) values of its state variables. While a simulation is running, it enables read-only access to all the updated values of output variables

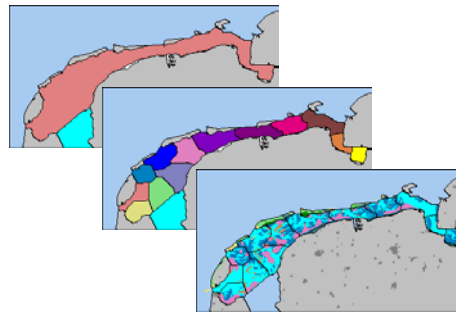


Figure 5: WadBOS integrates sub-models running at one of three spatial scales :a) the whole Wadden Sea, b) twelve compartments. c) 11000 cells of 25 ha each

Most ecological processes are represented at the compartment level and run on a tidal cycle time step, while the economic processes are represented at the level of the entire sea and processes run on a yearly time step

The WadBOS system relies heavily on GIS information for its inputs, but its models need economic, demographic and ecological data from other sources equally well.

For the selection and integration of the (sub) models, issues had to be solved considering the *end-use*, *scientific*, and *technical* aspects of the integration.

*End-use integration* deals with the end-use and the end-user of the model. It seeks an answer to the questions: what is useful to be integrated with a particular end-use in mind and what are the needs, expectations and constraints of the end-user. The integral WadBOS model involved foremost a simplification and aggregation effort with minimal loss of content and accuracy in order to enable policy use of models that were originally developed for research purposes.

*Scientific integration* is about what can and what cannot be integrated from a scientific point of view:

- view. It involves constraints on the type of models (for example: qualitative vs. quantitative,
- dynamic vs. static, equilibrium vs. non-equilibrium, etc.) on the temporal dynamics and time scales, on the spatial dynamics and spatial resolutions, on the details that matter, and on rigorous methods for aggregation and simplification of information. Once sub-models had been selected and integrated, and prior to the calibration of the integrated model, a thorough analysis of the resulting product was carried out in order to find out whether the component models were correctly and sufficiently coupled, whether their synchronization and information passing was correctly handled, and whether the integrated model was an appropriately complete and correct representation of the real world system. This analysis brought about the missing elements and processes in the representation.
- *Technical integration* deals with the ways in which existing models, their software representation, databases, user-interfaces, input and output devices can be coupled into a single system, running on the end-user's computer platform. In the computer sciences, technical integration has been given a lot of attention in the last decade. It has become much easier with the venue of object-oriented frameworks and component based development methods.

Figure 6 shows the *System diagram* of the integrated model at the highest level of abstraction. The boxes (Model Building Blocks) represent sub-models and the arrows between the boxes show the main data flows in the model. The different sub-models are linked to each other in a network of mutual, reciprocal influence. When a box is clicked, the details of the underlying model are shown, which is either a new system diagram of the sub-model, or a dialog window relative to that sub-model. This diagram is also the user interface of the model. It features the *System diagram* view, the *Scenarios* view, the *Policy options* view and the *Impact* view (Figure 7). Each view shows in a graphical manner how policy relevant features relate to the processes modelled.

In general the indicators (represented in the Impacts view) are taken from the management plan of the Wadden Sea. For most indicators norms and criteria are available which can be entered as reference values in the score-tables or multi-criteria analysis. Indicators expressing the economic, social, ecological, biological, chemical and physical state of the system are calculated and can be viewed.

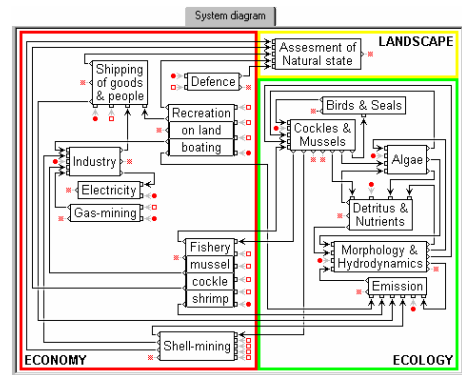


Figure 6: System diagram of the integrated WadBOS model at the highest hierarchical level of the user interface.

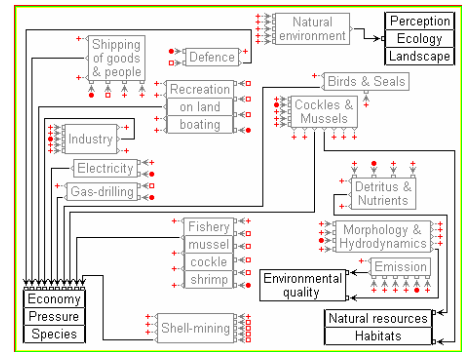


Figure 7: Impacts view shows the parts of the model containing the summarised information and policy indicators required to evaluate the scenario or policy options

The outputs are visualised by means of a large number of dynamic maps, tables and text boxes in dialog windows, each of which is updated at every time step during the simulation.

Outputs are also presented in the form of MS Excel tables and time graphs. Dynamic maps generated during a simulation can be stored on file for interactive comparison and further analysis by means of the ANALYSE-Tool. The input maps can be prepared in a commercial GIS package and imported into WadBOS. Once imported, each input map can be edited by means of an appropriate editor. Thus, spatial policy measures can be localised and tried out.

The interactive generation of the Zoning and Suitability maps is supported by means of the OVERLAY-Tool. OVERLAY and ANALYSE, and many other similar instruments are part of the Tool base of WadBOS.

Ample and more exact descriptions of the models and tools used are to be found in the on-line documentation of the WadBOS DSS (see [www.riks.nl](http://www.riks.nl)).

#### 4.3 Strategic assessments with WadBOS

Interesting opportunities for communication between the different stakeholders in the process of decision-making are created when the effects of different policy options and /or scenarios are compared. For instance in terms of time spans required for reaching ecological objectives, the combined or separate effect of different measures on ecosystem qualities as a whole, or the effect of climate change and trend cracks in economic growth.

Stakeholders are able to define their own set of socio-economic and ecological objectives for sustainability and compare the effects of policy measures thereon.

Scenarios are the major buttons to define alternative boundary conditions. They are defined in the model as factors beyond control of the policy maker and include: levels of prosperity, economic development, temperature, irradiation, nutrient levels and nutrient loads from different sources.

Policy options consists of sets of measures to influence the economic activity or natural developments, by for example:

- Infrastructure restrictions (boating, bathing, fishery on mussels and cockles)
- Closing of areas permanently or temporarily (defence, boating, transport of goods, fisheries)
- Quotation measures (fishery on shells, mussels and cockles)
- Subsidies (employment, investments).

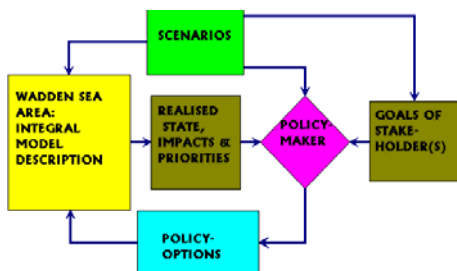


Figure 8: The policy maker has a central role in the use of WadBOS for policy analysis and communication

#### 4.4 Evaluation of WadBOS development process

The stepwise WadBOS development process was evaluated after each step. For reasons of transparency and to communicate lessons learnt, the evaluation of the overall process was reported (Infram 2001). The effectiveness of its development process was considered excellent thanks to the very enthusiastic and motivated principles, a dedicated project team and the willingness of scientists, experts and institutes to provide knowledge and data. The step-wise procedure was a guarantee for adequate communication and feedback between developers and end-users. WadBOS was financed through a technology R&D program. It is expected that the development costs of like instruments can be cut down if these will be developed on a more regular basis.

Although testing of the analytical functions of WadBOS 1. and 2. had taken place, these versions have not been used in an actual policy making context. This is now being done with the WadBOS –[ES]2 version. These results are not yet available.

Formal acceptance of the instrument by all stakeholders is a basic condition for successful use in a concrete policy making context. An important dilemma is that the instrument asks for concrete targets for indicators. Considering biological parameters, scientists and end-users so far realise that reference values are not easily identified in a common approach.

Acceptance of the model instrument and transparency of policy targets are a key to successful DSS development (Infram 2001). The Water Framework Directive requires to report water quality of water bodies using a classification of biological and chemical elements. Therefore the WFD implementation process will enhance communication on setting values for targets to specific indicators and sets of indicators related to classification. As a consequence future application of WadBOS will profit from this approach in policy making as well as further DSS developments.

#### 5. THE WADBOS TOOL AS POSSIBLE MODEL BASE OF DSS TOOLS IN EU POLICIES IMPLEMENTATION ?

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (The Water Framework Directive).

The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific understanding of the Water Framework Directive.

In the context of the WFD common implementation strategy, the National Institute for Coastal and Marine Management/RIKZ will examine the possibilities of using WadBOS in a pilot study to screen methodologies involved in the representation of ecological quality (classification) as well as clear descriptors for economic pressures.

Transparent presentation of scenarios of socio-economic pressures, the indicators involved, definition of ecological quality objectives in WFD terms for the Wadden Sea and the expected ecological state thus have to be considered in an integrated approach. From this exercise it might be concluded that a newly designed model using various WadBOS Model Building Blocks might be the most effective way forward.

From this paper, it will be clear that the WadBOS methodology and the technical components that constitute WadBOS are transferable to other coastal zones in the Netherlands, Europe and the world beyond. There are examples to prove this point (Engelen *et al.* 2001). Such transfer could take place on a site-by-site and application-by-application basis. However, a more systematic approach in which databases and model bases are developed and maintained that cover more than a single region or application holds much more potential.

In the Netherlands, an initiative has started as part of the GEOMOD project to transfer the WadBOS concepts and tools to the Dutch Scheldt estuary. One of the aims of this initiative is to find out precisely what the contents would be of the national database, model base and tool base enabling the implementation of a WadBOS like system in other coastal zones of the Netherlands.

In view of WFD implementation and the proposal for a European Parliament and Council Recommendation on Integrated Coastal Zone Management Strategy, Member States are encouraged to enter into, or maintain, dialogue with neighbouring countries in the same regional sea, to establish mechanisms for better coordination of responses to cross-border issues.

Exchange of information on existing methodologies and of tools capable for strategic impact assessment is an important proactive step for a

scientific sound implementation of these EU policies. Further DSS developments will contribute to these aims.

#### ACKNOWLEDGEMENTS

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