Matching Specialist Knowledge
with
End User Needs

Bridging the gap between coastal science
and
coastal management

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MATCHING SPECIALIST KNOWLEDGE
WITH
END USER NEEDS

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Abstract

Historically, the abundance of resources in coastal zones has been a great attractor for human activities and settlement. The coastal zone, however, is a dynamic environment. It continually changes under the influence of natural processes as well as human interference. As a result societal values and interests are sometimes gained and sometimes lost. With increased socio-economic pressures on coastal areas, some form of regulation needs to be imposed in order to ensure safe and sustainable use and development of this fragile environment. In this context, coastal management is a continuous process aimed at harmonizing the drive for economic development and use on the one hand and environmental protection on the other.

Traditionally, specialists in coastal morphology and hydrodynamics play an important role in the above-described coast related decision processes. They may, for instance, assist decision makers in the design of effective and 'responsible' management measures and the impact assessment that is necessary for an objective comparison of alternatives. This interaction between coastal science and coastal management has been established in an attempt to facilitate more or less rational planning for an otherwise uncertain future. A significant amount of research is aimed at advancing the knowledge of coastal processes and the resulting coastal behaviour. The information produced by these 'specialists in coastal behaviour', however, is not always recognised as useful by those responsible for the eventual decision-making. This thesis describes an effort to better understand the nature of this dissatisfaction and get some grip on assessing what knowledge and information *is* useful to coastal policy makers and managers.

Based on first-hand experience as well as practical cases described in literature we may identify a variety of symptoms associated with the above-described sub-optimal cooperation between specialists and users of specialist knowledge. Although the existence of some kind of 'gap' is widely acknowledged, no adequate framework seems to be available to describe what goes wrong and to suggest potential ways to bridge this gap. To remedy this problem, the work reported in this thesis aimed to "contribute to the insight in the situations and processes that are associated with a 'gap' between specialists and users of specialist knowledge that has been observed in practice and use this insight to develop a methodological approach to match specialist knowledge with end user needs".

The framework for analysis, suggested in this thesis, regards coastal management as a chain of interdependent problem solvers that rely on each other for information. Each interaction in this chain involves two actors with a certain degree of knowledge and responsibility. According to the analysis framework, the interaction between coastal science and coastal management -defined in this thesis as a *generalist-specialist* interaction- is basically concerned with the effective introduction of detailed (scientific) physical information into a more aggregated decision process. When a research project has *no* end users -defined in this thesis as *free* research-, the presence of the earlier mentioned 'gap', consequently, cannot usefully be established.

Furthermore the analysis framework assumes a cyclic change of focus in the information need of each problem solver; at the (strategic) level of research funding, as well as the scientific level of the research itself. At a policy level, for example, this cycle can be recognised in the stages of policy development, application and evaluation. Different stages of this policy cycle, logically involve different activities and a different need for information. The same stages can be identified in the development of coastal engineering knowledge. After a development stage, knowledge should be applied and subsequently be evaluated. Although these stages may not be completely separated or even explicitly indicated, they are useful for our analysis. The pace of these cycles may be different at each level. The perceptions of end users as well as researchers vary with the progression of the aforementioned cycles. A divergence between the perception of researchers and end users of the problem at hand and the knowledge and information that is needed to deal with it, is suggested to be a fundamental mechanism underlying the ‘gap’ between coastal science and coastal policy and management.

Analysis of 14 research programmes shows that the usefulness of research is indeed a matter of perception and that the perceptions of researchers and end users do tend to diverge. Development of new policy, for example, is often paired with specific knowledge development. After some time policy makers who initially called for information to support their new policy development may have moved to the next phase of application at a policy level, while researchers are still developing knowledge for the previous phase as a result of a pace difference. At this point, perceptions of policy makers and researchers on what should be done within the framework of the research project start to diverge. Policy makers want to apply existing knowledge whereas researchers are of the opinion that the existing knowledge should be developed further to be suitable for application. When the difference in perception becomes too large, dissatisfaction grows and research programmes may be terminated or discontinued, or otherwise intervened in. Emerging new societal challenges may give rise to the initiation of a new policy cycle. When in reaction a new research programme is initiated, both perceptions are reset to ‘development’ and the process starts all over again.

The framework of analysis already indicated that the above described divergence has no meaning for ‘free’ research projects. However, in cases where end users do have an interest in the outcome of the research -in this thesis defined as *driven* research- this divergence *does* present a problem. Literature suggests improved communication between researchers and end users as a way to bridge this gap. But communication about what? Analysis of the 14 research programmes illustrates that the focus of research projects is often driven mainly by scientific interests. This promotes a continued divergence of perceptions. Bridging the ‘gap’ by a translation of so produced end results has proven hard if not impossible. As a preferred alternative this thesis suggests to balance the research drive by a closer involvement of end users during the project. Practical experience shows that unguided communication between researchers and end users can easily lead to great confusion. A methodological approach is needed to structure the necessary technical interaction in driven research projects.

This thesis suggests a methodology aimed at structuring the discussions that are necessary to prevent or postpone the seemingly inevitable divergence of perceptions. A key element in this methodology is to use the end user's information need as an explicit starting point for knowledge development and to continually match specialist research with the information need of end users. As a guideline we suggest to make the essential components of coastal decision making explicit. A template combining these explicit elements -in this thesis defined as a (basic) *frame of reference*-, may then be used to guide the communication process. Analysis of practical cases indicates that successful policy development is related to a 'basic' frame of reference comprising explicit definitions of both strategic and operational objectives applied in a 4-step decision recipe of (1) a quantitative state concept, (2) a benchmarking procedure, (3) a procedure for CZM measures or intervention and (4) an evaluation procedure. The communication process may be guided by assuming that 'ideally' all elements of the 'basic' frame of reference need to be made explicit. An assessment of the elements that have 'actually' been made explicit reveals so-called 'white spots'. These 'white spots' represent the remaining information that is needed for successful policy development.

Applications of this 'basic' frame of reference approach show its high potential to better integrate coastal engineering science and coastal policy and -management. A test of the methodology's practical use in analysing existing and successful elements of Dutch coastal policy and identifying 'white spots', yielded positive results. Practical application of the approach in support of end user oriented knowledge development in the context of a coastal research project also yielded positive results. Based on these case analyses we conclude that the 'basic' frame of reference approach can be successfully applied in support of efforts to match specialist knowledge with end user needs. Whether or not the method works with respect to preventing or postponing the divergence in perception in the long run is not something we have been able to sufficiently establish during the limited time available for this research project, although the results so far are encouraging.

Mark van Koningsveld,
April 2003

Samenvatting

Door de eeuwen heen heeft het kustgebied een grote aantrekkingskracht uitgeoefend op menselijke activiteiten en bewoning. Ditzelfde gebied is echter ook dynamisch. Het verandert voortdurend onder de invloed van natuurlijke processen en menselijk handelen. Als gevolg hiervan worden maatschappelijke waarden soms gecreëerd en gaan ze soms verloren. Met de toenemende socio-economische druk op het kustgebied is enige vorm van regulering van belang om veilig gebruik en duurzame ontwikkeling van dit kwetsbare gebied mogelijk te maken. In deze context is kustbeheer een voortdurend proces, gericht op het in balans houden van economische ontwikkeling en bescherming van de natuur.

Traditioneel, spelen specialisten in kustmorfologie en hydrodynamica een belangrijke rol in de bovenbeschreven kustgerelateerde beslisprocessen. Zij kunnen, bijvoorbeeld, beslissers ondersteunen in het ontwikkelen van effectieve en 'verantwoorde' beheersmaatregelen en bij het voorspellen van effecten, nodig voor een objectieve beoordeling van alternatieven. Deze interactie tussen kustonderzoek en kustbeheer is ontstaan uit een behoefte om min of meer rationeel te kunnen plannen voor een anders onzekere toekomst. Een significante hoeveelheid onderzoek is gericht op het verbeteren van de kennis van kustprocessen en het resulterende kustgedrag. Echter, de informatie die door deze 'specialisten in kustgedrag' wordt geproduceerd, wordt niet altijd (h)erkend als bruikbaar door diegenen die voor het uiteindelijke beslissen verantwoordelijk zijn. Dit proefschrift beschrijft een poging om de aard van deze ontevredenheid beter te begrijpen en enige grip te krijgen op welke kennis en informatie *wel* bruikbaar is voor beleidsmakers en beheerders.

Op basis van eigen ervaring en in de literatuur beschreven gevallen, kan een verscheidenheid aan symptomen worden benoemd die geassocieerd worden met de bovenbeschreven sub-optimale samenwerking tussen specialisten en gebruikers van specialistische kennis. Hoewel het bestaan van één of andere 'kloof' brede erkenning vindt, lijkt er niet een toereikend raamwerk beschikbaar waarmee de problemen beschreven kunnen worden en op basis waarvan oplossingen voor verbetering kunnen worden gesuggereerd. Om dit probleem het hoofd te bieden is het werk in dit proefschrift gericht op het "bijdragen aan de kennis betreffende de situaties en processen die geassocieerd worden met een kloof tussen specialisten en gebruikers van specialistische kennis zoals die in de praktijk is waargenomen en het gebruiken van dit inzicht voor de ontwikkeling van een methodologische benadering voor het aansluiten van specialistische kennis bij de wensen van eindgebruikers".

Het analyse raamwerk dat in dit proefschrift wordt voorgesteld, beschouwt kustbeheer als een keten van gekoppelde probleemoplossers die van elkaar afhankelijk zijn voor informatie. Iedere interactie in deze keten omvat twee actoren met een bepaalde hoeveelheid kennis en verantwoordelijkheid. Volgens dit analyse raamwerk is de interactie tussen kustonderzoek en kustbeheer -in dit proefschrift gedefinieerd als *generalist-specialist* interactie-, in de kern gericht op het effectief inbrengen van gedetailleerde (wetenschappelijke) fysische informatie in een meer geaggregeerd beslisproces. Wanneer een onderzoeksproject *geen* eindgebruikers heeft -in dit proefschrift gedefinieerd als *vrij*

onderzoek-, kan het bestaan van de eerder genoemde 'kloof' dus niet wezenlijk worden vastgesteld.

Verder wordt in het analyse raamwerk aangenomen dat de focus in de informatiebehoefte van iedere probleemoplosser cyclisch varieert; zowel op het (strategisch) niveau van onderzoeksfinanciering als op het wetenschappelijke niveau van het onderzoek zelf. Op beleidsniveau, bijvoorbeeld, is deze cyclus te herkennen in de fasen van beleidsontwikkeling, toepassing en evaluatie. Verschillende fasen in de beleidscyclus, behelzen verschillende activiteiten wat logischerwijs leidt tot een verschillende informatiebehoefte. Vergelijkbare fasen kunnen worden onderscheiden in de ontwikkeling van kustwaterbouwkundige kennis. Na een ontwikkelfase moet kennis worden toegepast en vervolgens geëvalueerd. Hoewel deze fasen misschien niet volledig gescheiden, laat staan expliciet benoemd zijn, zijn ze toch bruikbaar voor onze analyse. Het tempo van de cycli kan namelijk op elk niveau verschillend zijn. De perceptie van eindgebruikers zowel als onderzoekers varieert met het voortschrijden van deze cycli. Een divergentie in de percepties van onderzoekers en eindgebruikers met betrekking tot het onderhanden probleem en de kennis en informatie die nodig is om met dat probleem om te gaan, wordt aangevoerd als een fundamenteel mechanisme achter de 'kloof' tussen kustonderzoek en kustbeheer.

Analyse van 14 onderzoeksprogramma's laat zien dat de bruikbaarheid van kennis inderdaad een kwestie van perceptie is en dat de percepties van onderzoekers en eindgebruikers de neiging hebben om te divergeren. Ontwikkeling van nieuw beleid, bijvoorbeeld, gaat vaak gepaard met specifieke kennisontwikkeling. Na enige tijd kunnen de beleidsmakers die oorspronkelijk vroegen om informatie in een volgende fase van toepassing zijn beland terwijl de onderzoekers, als gevolg van een verschil in tempo, nog kennis ontwikkelen voor de vorige fase. Op dat moment beginnen de percepties van beleidsmakers en onderzoekers over wat zou moeten worden onderzocht in het kader van het onderzoeksproject, te divergeren. Beleidsmakers willen bestaande kennis toepassen terwijl de onderzoekers van mening zijn dat de bestaande kennis nog verder zou moeten worden ontwikkeld voordat toepassing mogelijk is. Wanneer het perceptieverschil te groot wordt, groeit de ontevredenheid, wat uiteindelijk kan leiden tot het stopzetten of niet verlengen van onderzoeksprogramma's, of andere ingrepen. Nieuwe maatschappelijke ontwikkelingen kunnen aanleiding zijn voor het starten van nieuw beleid. Wanneer in reactie daarop weer nieuw onderzoek wordt gestart, worden de percepties 'ge-reset' en begint het hele proces weer van voren af aan.

Het analyse raamwerk gaf al aan dat de hierboven beschreven divergentie geen betekenis heeft in het geval van 'vrij' onderzoek. Echter, wanneer eindgebruikers wel een belang hebben in de uitkomsten van het onderzoek -in dit proefschrift gedefinieerd als *gedreven* onderzoek-, vormt deze divergentie *wel* een probleem. De literatuur suggereert verbeterde communicatie tussen onderzoekers en eindgebruikers als maatregel voor het overbruggen van de 'kloof'. Maar communicatie waarover? Analyse van 14 onderzoeksprogramma's laat zien dat de inhoudelijke focus van onderzoeksprojecten vaak gedreven wordt door wetenschappelijke interesses. Dit bevordert een voortdurende divergentie van percepties. Het overbruggen van de kloof door het achteraf vertalen van op die manier geproduceerde resultaten blijkt moeilijk zo niet onmogelijk. Dit proefschrift suggereert als oplossing om de onderzoeksaansturing beter uit te balanceren door een grotere betrokkenheid van eindgebruikers gedurende het project. In de praktijk blijkt een ongestuurde communicatie tussen onderzoekers en eindgebruikers gemakkelijk te kunnen ontaarden in grote verwarring. Een methodologische benadering is nodig voor het structuren van de technisch inhoudelijke interactie in 'gedreven' onderzoeksprojecten.

Dit proefschrift suggereert een methodologie gericht op het structureren van de discussies die nodig zijn voor een continue afstemming van specialistisch onderzoek en de kennis en informatiebehoefte van eindgebruikers. Een kernelement van deze methodologie voor het voorkomen of uitstellen van de divergentie van percepties, is het nemen van de expliciete informatiebehoefte van de eindgebruiker als uitgangspunt voor kennisontwikkeling. Als leidraad suggereren we om de essentiële elementen van kustgerelateerde beslisprocessen expliciet te maken. Een slabloon dat deze expliciet gemaakte elementen combineert -in dit proefschrift gedefinieerd als een (basis) *referentie kader*-, kan dan worden gebruikt om het communicatie proces te begeleiden. Analyse van praktische cases laat zien dat de ontwikkeling van succesvol kustbeleid is gerelateerd aan het gebruik van een 'basis' referentie kader met daarin zowel strategische als operationele doelen, geoperationaliseerd in een 4-staps beslisrecept bestaande uit (1) een kwantitatief toestandsconcept, (2) een toetsingsprocedure, (3) een procedure voor beheersmaatregelen of ingrepen en (4) een evaluatieprocedure. Het communicatieproces kan dan worden begeleid door aan te nemen dat in het 'ideale' geval elk element van dit 'basis' referentie kader expliciet is gemaakt. Inventariseren welke elementen daadwerkelijk expliciet zijn gemaakt, levert zogenaamde 'witte vlekken' op. De 'witte vlekken' vertegenwoordigen dan de informatie die nog nodig is voor succesvolle ontwikkeling van het kustbeleid.

Toepassing van de (basis) referentiekaderaanpak onthult duidelijke kansen voor een betere afstemming van kustwaterbouwkundig onderzoek en kustbeleid en -beheer. Op basis van de case analyses concluderen we dat de 'basis' referentiekader benadering succesvol kan worden toegepast bij de aansluiting van specialistische kennis bij de wensen van eindgebruikers. Een test van de praktische toepasbaarheid van de methode in het analyseren van succesvolle elementen van het Nederlandse kustbeheer en het identificeren van 'witte vlekken', leverde een positief resultaat op. Een praktische toepassing van de methode in de ondersteuning van eindgebruikergeoriënteerde kennisontwikkeling in de context van een kustonderzoeksproject leverde ook positief resultaat op. Of de methode ook werkt in het voorkomen of uitstellen van de perceptiedivergentie op langere termijn kon vanwege de gelimiteerde tijdsduur van dit onderzoeksproject helaas niet worden vastgesteld. De resultaten tot dusver zijn echter bemoedigend.

Mark van Koningsveld,
April 2003

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Chapter 1

Introduction

1.1 Central problem definition and objectives

Physical management of the landscape has played an important role throughout the history of the Netherlands. From living on dwelling mounds to the completion of the Eastern Scheldt storm surge barrier, the Dutch went from struggling with nature to living with nature. The development of an effective administrative and social organisation and innovations in hydraulic engineering have played a very important role throughout this development.

This long term cooperation resulted in a well-established and internationally renowned hydraulic engineering community comprising contractors, consultants, hydraulic engineering laboratories and universities and an equally well-established administrative community comprising national, regional and local policy makers and managers, water boards etc. Although, throughout Dutch history, both communities together have been responsible for remarkable feats of engineering, the communication between the two is not without problems.

Traditionally specialists (e.g. in coastal behaviour) have predicted the consequences of newly developed policy or management schemes (e.g. some coastal engineering intervention), where these schemes were commonly assumed to be exactly defined. For policy makers and managers such information is of limited use in cases where flexibility is needed for a balanced management of the multitude of values and interests that are commonly present in coastal zones. In such cases the results from specialist efforts do not ‘match’ the needs of the decision makers. The fact that this type of problem has regularly been encountered in many different shapes and forms, inspired the notion that a ‘gap’ exists between the two worlds. This ‘gap’ impedes effective cooperation, giving rise to frustrations and a waste of valuable money, time and effort. It is in the interest of both communities that cooperation be improved. A grant from the dr. ir. Cornelis Lely Foundation facilitated the research into this topic, that started September 1998 and is reported in this thesis.

The initial assignment was named: “Mathematical models of coastal behaviour translated to coastal managers” (in Dutch: Wiskundige modellen van kustgedrag vertaald naar de kustbeheerder). Its aim was to increase the knowledge on the role of specialists of coastal behaviour in coastal policy and management processes, so as to derive a more proper way of informing decision makers.

An envisaged improvement was to start from existing knowledge on coastal behaviour and reduce from it, a set of 'if ... then' rules which might function as more 'flexible' answers that allowed for small shifts in the policy approach. The suggestion appeared to be founded on the assumption that mathematical models currently produced results that *were* relevant to coastal managers and that the main problem was a lack of flexibility. In the initial months of research, however, it became clear that this assumption was either wrong or only true for a small set of practical problems. Either way, it seemed that maintaining this assumption would not lead to productive solutions for the main problem, viz. helping coastal managers and policy makers to make well-founded decisions, based on state-of-the-art knowledge. The scope of the research was broadened to include the practical problem definition as a possible source for communication failure. This induced a shift in research focus reflected by a change of the original project title to "Matching specialist knowledge with end user needs".

With that, the research had shifted somewhat away from reducing mathematical models of coastal behaviour towards a better understanding between coastal managers and coastal specialists with respect to information on coastal behaviour. This had shifted the focus to what seemed to be the actual problem area, while at the same time it exposed another problem, viz. the lack of a framework for analysis to facilitate discussions on what proved to be a rather elusive subject.

Logically the subject touches on many well-established fields of research such as communication, system analysis, hydrodynamics and morphodynamics, economics, political science etc. During this project, however, it seemed that although the existence of a 'gap' in itself is recognised in literature, the topic of bridging this 'gap' -at least in the context of coastal management and coastal research- has received (surprisingly) little attention. The research reported in this thesis aims to take only a modest first step forward there. For this purpose we wish to develop a methodological approach, based on an analysis of practical cases and existing theoretical knowledge, designed to establish a more productive understanding between coastal science and coastal management. This is expressed in the research objective:

> *"to contribute to the insight in the situations and processes that are associated with a 'gap' between specialists and users of specialist knowledge that has been observed in practice and use this insight to develop a methodological approach to match specialist knowledge with end user needs".*

1.2 Literature review

We can find several areas of literature where relevant information has been produced with respect to the pre-mentioned objective. The above-described gap between coastal managers and coastal scientists has amongst others a bearing to literature with respect to:

- coastal zone management;
- coastal engineering research;
- communication research; and
- knowledge management research.

Besides those areas of literature that are related to elements of the problem we also look at literature that addresses:

- the transfer of science to practice.

In the following we address step by step some (of many) relevant notions that have been described in these areas of literature.

Coastal zone management

The first element addresses one side of the communication gap, viz. coastal policy makers and managers. To understand the problems they are dealing with and paradigms they operate under, we may look at coastal management literature. Many international organizations like for example the World Bank, FAO (Food and Agricultural Organisation), UNDP (United Nations Development Programme), IPCC (Intergovernmental Panel on Climate Change) and IUCN (The World Conservation Union) have published guidelines and/or principles on coastal management which are important sources of information. These guidelines commonly address how to deal with coastal policy and management problems with respect to institutional aspects, public support, supporting information, design and implementation of measures, etc.

Coastal policy and management includes a wide range of practices such as: land-use planning (e.g. natural parks, recreation facilities, industrial and domestic areas); issuing of permits for plant, animal and mineral extraction (e.g. forestry, fishery, hunting, oil and gas extraction); safeguarding the rights of different interest groups; providing safety for functions in the coastal area; etc. (e.g. FAO, 1998; MAFF, 1998a,b; TAW, 1995a,b, 2002). Coastal management is too complex to be handled by traditional sectoral planning and management. To overcome the problems of a sectoral approach, a more integrated approach to coastal management has been suggested in recent years.

Cicin-Sain and Knecht (1998) have written a comprehensive work on the concepts and practices of coastal zone management. They give the following definition of integrated coastal management (ICM):

> *"Integrated coastal management (ICM) can be defined as a continuous and dynamic process by which decisions are taken for the sustainable use, development, and protection of coastal and marine areas and resources. ICM acknowledges the interrelationships that exist among coastal and ocean uses and the environments they potentially affect, and is designed to overcome the fragmentation inherent in the sectoral management approach. ICM is multi-purpose oriented, it analyses and addresses implications of development, conflicting uses, and interrelationships between physical processes and human activities, and it promotes linkages and harmonisation among sectoral coastal and ocean activities"*

The problems addressed by ICM, as intended in the above definition, are very complex in nature. To guarantee "*... sustainable use, development, and protection of coastal and marine areas and resources...*" it is important to carefully analyse the potential effects of human use, natural processes and policy and management measures on the coastal system. Since the mid 1940s the system concept emerged as a key approach in science in quite different disciplines varying from human behaviour and social sciences to the natural sciences (cf. Von Bertalanffy, 1950; Boulding, 1956; Von Bertalanffy, 1968; Forrester, 1968). The wide acceptance of the systems approach is recognition of its use in analysing complex problems. A helpful generic systems approach structuring the elements important to integrated coastal management was developed by Van der Weide (1993).

Besides structuring and analysing problems, it is ultimately necessary to make certain decisions. Decision theory (cf. Arrow, 1956, 1957; Ackoff, 1959; Raiffa, 1968) is a mathematical theory on choices among alternatives which has found wide application. Besides the decision itself, there are many ways to structure decision making processes. Decision processes for complex systems like the coastal system, especially with respect to the structuring of the problem, involve learning processes (e.g. Hisschemöller, 1993; Verbeeten, 1999) in which models play an important role. They can be useful in stimulating communication with respect to problems, solutions, assumptions, beliefs and data between specialists, decision makers and stakeholders, all of which is necessary to come to a management approach. An import part of the learning and communicating takes place at a conceptual level (De Tombe, 1994). From this conceptual level, images of the system's state can be interpreted and explored consequences of alternatives can be valued and judged. It is this two-way learning process which plays a crucial role in integrated decision-making.

The topic of integrating information into coast related decision processes is a rapidly developing area (e.g. Courtney, 2001) from which it is clear that the most suitable procedure is dependent on the perspective from which one starts (technically, strategically, politically). The work in this thesis mainly focusses on the technical aspects of decision making, although these cannot usefully be addressed in complete isolation. From a technical point of view, Miser and Quade (1985, 1988) described that rational decision-making is not a sequential process but consists of a number of logical steps that may be followed in iterative cycles. Coastal management makes use of notions from policy analysis, policy science and the systems approach. They included all these aspects in the term 'system analysis' as they addressed it in their books.

Scientific knowledge has not played a sufficiently clear role in reaching final political decisions. Final decision makers or politicians, themselves, have often concluded that the final decisions were taken based on their own emotions rather than rational analyses (cf. Ducrotoy and Elliott, 1997). Not only decision makers and politicians, as end users of specialist knowledge, may be blamed for this but also the experts who apparently did not present their results in a sufficiently appealing or clear way. Trying to increase the insight into this situation, in order to better deal with it, is the main objective of this thesis.

Although this part of literature has recognised the fact that a gap exists between specialists and end users, no clear image exists of what constitutes this gap and how it may be bridged. That brings us to the second element of our literature overview, viz. the coastal engineering research literature.

Coastal engineering research

One of the things that plays a central role in most coastal engineering literature is modelling. Models are widely developed and applied in order to better understand and predict the behaviour of the coastal system. Changes in the coastal system take place at a wide range of spatial and temporal scales, from individual grain motion through to the evolution of entire coastal systems at historical and geological time scales. This scale range extends over at least ten orders of magnitude. The presence of these different scales is important for the prediction of system behaviour. At different scale levels, we are confronted with limits of predictability, either fundamental, or because it goes beyond our capability.

De Vriend (1998) assumes that there is a certain degree of coupling between space and time scales. Prediction is possible at every space and time scale, but not in every detail. This argument assumes the presence of a cascade of models at different aggregation levels, separated by limits of predictability. The aggregation that is needed to overcome a predictability limit is usually not trivial. The argument is based on the assumption, that no single numerical model will be able to span the entire range of scales from turbulence to coastal cells, however big the computer, however accurate the numerical method and however advanced our detailed process knowledge. If the predictability cascade makes sense, it has the logical consequence that for every step of the cascade a separate model has to be developed, especially designed to describe the phenomena at that scale level. This idea fits into the concept of appropriate modelling, described by many (a.o. by Holling, 1978; De Vriend, 2002), which starts from the assumption that it pays off to make models as complicated as necessary, and as simple as possible. Apart from modelling at the appropriate scale level, it includes modelling at the appropriate level of (in)accuracy and (un)certainty. What is appropriate depends on the information that is to be derived from the results. What results are required may be inspired by scientific interest but also by practical aspects. In this thesis we are particularly interested in connecting science with decision making.

Finkl (2002) analysed 16 years of publications in the Journal of Coastal Research to identify long-term trends in shore protection research. A first conclusion, interesting with respect to this thesis, regards what Finkl identifies as a minor trend: focussing attention on controversial aspects of coastal modelling in the service of shore protection. Next he identifies as an important trend a focus on the response of shore-protection research within the context of rapidly changing political and socio-economic regimes around the world. Finkl states that emerging scientific insights condition policy that in turn steers research directives in the coastal zone. Finkl (2002) also recognises, however, that because most papers focussed on coastal engineering research and technology transfer tend to have an orientation toward basic research rather than on engineering applications, there is a time lag for this knowledge to be widely incorporated in practical applications. As a third trend he recognises an increased debate on the effectiveness on shore protection measures. As an example he mentions how the public might judge a nourishment scheme to be unsuccessful when the 'usable beach' has not improved. From the point of view of the coastal engineer, the project *was* successful although part of the beach was submerged. This gives rise to diverging opinions on the success of the project that may only be reconciled through improved communication. Finkl considers this *rationalisation* of shore protection measures to be a new and productive trend that fosters research and technology transfer to the management sector.

Although there is obviously a lot more to be said about literature on coastal engineering we found that this part of literature has also recognised the fact that a gap exists between specialists and end users. Again, no clear image exists of what constitutes this gap and how it may be bridged. That brings us to the third element of our literature overview, viz. the subject of communication.

Communication

Shannon and Weaver (1949) were the first to publish what they called a 'mathematical theory of communication'. They present a model for the design of communication networks based on an analysis of signals, messages and information. Their theory mainly concerns the capacity of communication networks for the transfer of information. A powerful concept they introduced is the 'amount of information' associated with the occurrence of an event ('or generated by the realisation of a state of affairs'), which they defined as the reduction in uncertainty represented by that event ('or the elimination of alternatives represented by that state of affairs').

For clarification, let's assume that an envelope contains the winner of 8 participants of a design contest. Opening the envelope reduces the number of possibilities to one. One could say that the amount of information was 8, since the number of possibilities was reduced by a factor 8. Or one could say that since 7 possibilities were eliminated the amount of information was 7. Instead Shannon and Weaver (1949) use the number of binary decisions (bits) that is needed to reduce the (equally probable) alternatives, in this case from 8 possibilities to 1, to quantify the 'amount of information'. When simulated by flipping a coin, a first flip selects one of two predetermined groups of four. A second flip eliminates one of the remaining groups of two. A third flip decides between the two remaining contestants. The ‘amount of information’ thus is 3 bits. Similarly the answer ‘Yes’ to the question ‘Coffee or Tea?’ does not reduce the number of alternatives and thus provides ‘zero’ bits of information. The answers ‘Coffee’ as well as ‘Tea’, on the other hand, both provide exactly the same ‘amount of information’, in this case 1 bit. This ‘amount of information’, however, does not shed light on the intuitive difference in meaning of the respective answers. This intuitive difference in meaning refers to semantic properties of information.

Actual quantification of the amount of information presented by some message is in practical cases usually hard, if not impossible, for a number of reasons. It requires, for instance, quantitative information with respect to potential alternatives, which is undetermined in many cases. Nonetheless, the thought of some sign being more informative if it provides a greater reduction of alternatives, is intuitively appealing.

It is commonly accepted to regard communication as a process of conveying meaning. In this process information plays a crucial role. Literature shows us how signs can inform us *about* and *for* something (cf. Borgmann, 1999). As a result of these informing processes, persons can accumulate knowledge on all kinds of things. Dretske (1981) and Devlin (1991) are frequently cited in literature regarding knowledge and flows of information. Audi (1998) provides an thorough overview of the contemporary views with respect to the concept of knowledge. Although communication is a very common term, there are distinctly different views on how, for instance, the role of information in communication processes is to be regarded.

Reddy (1993) (p.184), for example, states that “Signals *do* something. They cannot *contain* anything” [italics Reddy]. It is the interpretation of signals within a certain context that causes certain thought processes. Reddy (1993) provides compelling arguments in his article that this way of thinking about knowledge and information differs in rather fundamental ways from the more generally applied ‘conduit metaphor’ as the paradigm of language. This metaphor advocates that knowledge can be transferred through the ‘conduit’ of language. Reddy (1993) describes how, discussing the transfer of meaning (knowledge, feeling, emotions etc.), the English language predominantly regards words as containers of knowledge. (1) Spoken and written signs are said to be filled with meaning by some sender. (2) These signs then contain this meaning and transport it to some receiver. (3) Finally the receiver can extract the meaning from the signs. Miscommunication occurs when the wrong meaning is put into the words or the words are ‘damaged’ during transmission. He illustrates how this conception is rooted deeply into the English language with a large number of examples, for instance:

1. “He is good at putting a difficult concept into simple words”
2. “The article contains some great ideas”
3. “I want to get the concepts from that report into my head”, etc.

Reddy (1993) argues that the use of this ‘conduit metaphor’ confuses sign and meaning. Assuming that meaning can be located in a sign, successful communication appears to be automatic. Assuming that knowledge transfer is a process of dynamic conceptualisation (Reddy calls it the ‘radical subjectivity postulate’ in his ‘Toolmakers paradigm’-example), expectations are exactly the opposite. Partial miscommunication, or divergence of readings from a single text, are not considered aberrations. They are regarded as natural tendencies of communication, that can only be counteracted by continuous effort and large amounts of interaction.

Thus, rather than an effortless transfer of knowledge with *incidental* miscommunication, Reddy (1993) advocates viewing the communication process as an intensive knowledge inspired effort by a speaker to stimulate the thought processes of a hearer with *continuous* miscommunication. A point of interest is that Reddy’s ‘Toolmakers paradigm’ deals with a communication process where the persons involved are interested in the same thing, i.e. both are toolmakers, interested in making tools for their respective worlds. Investigating the role of specialist knowledge in decision processes, the interests of the persons involved in the communication process may diverge considerably (compare the above example by Finkl (2002)).

Knowledge management research

Coastal policy makers and managers often feel that it is difficult to apply the results of research or studies to policy formulation and practical management. The fact that researchers feel that on the scientific level usually significant progress has been made, suggests that the translation of results may be a knowledge management problem.

Polanyi (1966) identified two different forms of knowledge capital: ‘tacit knowledge’ and ‘explicit knowledge’, the former residing in a person’s head (human capital), the latter being some form of knowledge that has been made explicit (structural capital), e.g. theories and models. Nonaka and Takeuchi (1995) suggest that knowledge conversion may then take place between similar and different forms of knowledge capital. Assuming that the structural capital has been captured in some transferrable form (e.g. report, article, model etc.), this yields four conversion types: human-human (socialisation), human-structural (externalisation), structural-human (internalisation) and structural-structural (combination).

For a specialist in coastal behaviour, structural capital might be a set of equations or a model that better describes dune erosion under storm conditions (information *about* reality). For a coastal manager, structural capital might be a decision recipe for the strengthening of dunes in order to guarantee the safety of the hinterland (information *for* reality). The former knowledge capital may be used to improve the latter. In practice such benefits of specialist knowledge are often not or hardly recognised. Nonaka and Takeuchi (1995) suggest to focus communication on making the largely implicit mental models of the communicating persons explicit, in order to improve the effective transfer of knowledge and thus promote cooperation.

Transferring science to practice

There is a large body of literature focussed on the transfer of findings from basic science to practical application, with an abundance of anecdotes describing how the discovery of practical applications has been the result of coincidence. It has become known as serendipity. There has been a long desire to get a better grip on this elusive process. Governments and other large organisations have always recognised the great benefits of research in stimulating innovation. They are happy to reap the benefits but less eager to make the considerable investments. The fact that research is expensive and the outcomes are uncertain make usefulness and effectiveness of research a topic that is continually on the agenda.

Research managers want more control to increase the chances for useful results. Specialists feel they need to be left totally free to choose whatever they wish to investigate. Stokes (1997) describes the conflict between the different innovation drivers of on the one hand a quest for *understanding* and on the other hand a quest for *use*, and provides ample examples from various sciences (e.g. physics, chemistry and microbiology etc.). He refutes the notion that these different goals should always be separated. It is undisputed that many of our practical findings have basic research of previous decades to thank. Stokes (1997), however, provides numerous anecdotes on how the great discoverers have combined pure scientific efforts with a firm grasp on technological needs in industry and policy. At the same time some of the most applied research projects have thoroughly stimulated our more basic understanding. As such Stokes advocates to forget the linear approach where knowledge development and use are each at one side of the spectrum and adopt a network approach where both communities may learn from each other and stimulate each other all the time. Basic message provided by Stokes (1997) is not to separate inquiry from use but let the two influence each other!

Even though an incredible amount of literature can be found on coastal management, coastal research, communication, knowledge transfer and transferring findings from science to practice, a simple fact remains: coastal managers and coastal scientist still feel that there are problems in their communication. It is not so much a lack of literature that is the problem here, rather we face the challenge of using available insights in getting two groups to communicate better.

1.3 Aim, scope and approach

The research objective was to contribute to the insight in the situations and processes that are associated with the 'gap' between specialists and users of specialist knowledge that has been observed in practice and use this insight to develop a methodological approach to match specialist knowledge with end user needs. From the literature review we conclude that the central problem of this thesis has been widely recognised and many issues relevant to the research objective of this thesis have been addressed somewhere in literature. Nonetheless, it seems that the problem itself, viz. that specialist answers cannot (easily) be used by decision makers, has remained. This is true for many disciplines, from which the interaction between coastal management and coastal science is not an exception. Throughout literature many anecdotes and problems have been described. But, not all anecdotes are comparable. Different anecdotes sometimes describe different types of mismatches and, as far as we know, what exactly causes these mismatches has not yet been consistently described, at least not in the context of coastal engineering and management. As a result we conclude that there is a need for:

(1) a systematic analysis of the problems in the interaction between science and practice in the context of coastal engineering and management, and

(2) a methodological approach to deal with the gap that has been observed in this context.

As we operate under the impression that no adequate framework to analyse the above-described problems has been developed yet, this study would be a first attempt towards the development of such a framework. The aim of this research is to systematically analyse interaction problems in the coastal engineering and management context, attempt to identify potential causes and suggest plausible approaches to deal with these problems in practice.

We aim to improve the interaction, as opposed to attempts to influence decision making. It is outside the scope of this research to verify whether improved interaction will lead to better decisions. On the one hand, successful interaction is influenced by many other factors, on the other hand there are problems with the time scale of many coastal research programmes, which well outlasts the time available for this thesis. The work reported in here is primarily targeted at research managers whose job it is to design the end user-specialist interaction in research projects. Because actually bridging the gap necessarily requires active involvement of end users and researchers, these form a secondary target group. We use case analysis as our primary research approach. Based on the findings from these cases, we formulate a theoretical framework of how we think that things could work in practice.

1.4 Research questions

The above-described research objective can be refined to the following research questions and actions needed to answer them:

1 - Can a generic mechanism be identified that is responsible for (part of) the ‘gap’ between specialists and users of specialist knowledge?

- Analyse the role of specialist knowledge on coastal behaviour in coast related decision processes.

- Develop a framework for analysis that facilitates the analysis of the interaction between experts and users of expert knowledge.

- Derive from that framework a hypothesis on what causes the gap between specialists and users of specialist knowledge.

2 - Can the hypothesised mechanism causing the ‘gap’ be identified from practical experience?

- Analyse the history of Dutch coastal policy and management and investigate the role of knowledge on coastal behaviour therein.

- In this context, test the hypothesis on what causes the ‘gap’ against practical experience by analysing national and international coastal research projects.

- Conclude whether or not the hypothesised mechanism can be identified in practice.

3 - Can a methodology in support of bridging the ‘gap’ be developed, focussed on defusing the mechanism mentioned in the previous steps?

- Develop a generic framework to match specialist knowledge with end user needs.

- Develop a procedure for a problem-driven definition of research questions.

- Develop a template that can be applied in support of efforts to match specialist knowledge with end user needs.

4 - Does this methodology work in supporting efforts to bridge the ‘gap’?

- Test the methodology’s practical use by analysing existing and successful elements of Dutch coastal policy.

- Test the methodology’s practical use in guiding end user oriented knowledge development programs.

- Conclude to what extent the hypothesised method works in practice.

1.5 Outline

The arrangement of this thesis is as follows. To address the first research question, Chapter 2 presents an overview of the role of knowledge in coast related decision processes. To enable clear discussion on the main subject of this thesis, a theoretical framework is presented. Based on this framework we develop a hypothesis on the nature of the gap between specialists and end users of specialist knowledge.

An evaluation of the research goals of 14 coastal research projects against the information need of influential end users at the time is used as a practical illustration of the hypothesised problem suggested in Chapter 2. As such Chapter 3 addresses the second research question as it aims to test the hypothesis derived in the Chapter 2.

Chapter 4 addresses the third research question as it presents a hypothesised solution for the interaction problems described in the previous two chapters. This results in a methodological approach to analyse the information need of end users. To promote practical application, a template containing the key elements of this approach is suggested at the end of this chapter.

The fourth research question is addressed in Chapter 5, that describes efforts to test the practical applicability of the template suggested in the previous chapter. A first case aims to test the use of the template analysing successful elements of the Dutch coastal policy. To test the use of the template in stimulating and focussing ongoing research, a coastal research project in which the methodology is applied is described as a case study.

Chapter 6 and 7 contain a discussion and recommendations and conclusions, respectively.

Chapter 2

The role of expert knowledge in coast related decision processes

2.1 The necessity for Coastal Zone Management

Since millennia the world's coastal areas in general, and estuarine and deltaic areas in particular, have proven great attractors for human activities. An abundance of resources enabled societies around the world to successfully take the coastal areas into use[1]. The colonisation of the world's coastal zones gave rise to a concentration of values and interests in relatively small areas. These areas are physically and socio-economically dynamic and as a result values and interests are sometimes gained and sometimes lost. Societies, at any given stage of development, may not accept the loss of life or livelihood from natural hazards, such as flooding, and apply management strategies to prevent this from happening. Commonly, such strategies involve *physical measures*, e.g. seeking safety from flooding through adaptation by living on dwelling mounds, or protection by defence works like dikes, as well as *administrative measures*, e.g. sustainable fisheries through (spatial) planning and regulation. The potential scope of these strategies varies with the degree of social organisation, developments in the economic context and the availability of technology, combined with a desire to sustain or even expand existing values and interests. The historic development of water management in the Netherlands over the last 2000 years may serve as a practical example (cf. Van de Ven, 1993; Dubbelman, 1999; Van Koningsveld *et al.*, 2001). At the beginning of the 21^{st} century, the set of potential strategies includes physical measures at scales in the order of tens to hundreds of kilometers, e.g. land reclamation and coastal protection schemes, and administrative measures at a global-scale, e.g. emission reduction of CO_2. This requires an integrated approach of coastal management (ICM). The multitude of values and interests, the large number of natural and socio-economic pressures combined with the virtually endless range of potential strategies have made ICM a very complex activity that can be approached at a seemingly infinite number of scale levels. Decision making involves many actors and stakeholdes, and sometimes broad public discussions. In this chapter we introduce a number of concepts to enable a structured discussion on the role of expert knowledge in these coast related decision processes.

[1]According to the 1994 distribution of population in relation to the distance from the nearest coastline, 20.6 percent of the world's population lived within 30 km of the coast and 37 percent within 100 km (Gommes, 1997).

In the next section we introduce one of many systems approaches attempting to structure the above-described complexity. The key to sustainable use of coastal areas is finding a proper balance between economic development and environmental protection. The Driving forces Pressure State Impact Response (DPSIR) diagram, addressed in Section 2.3, is now widely accepted as a methodological framework to address this problem. Together, the systems approach and the DPSIR approach constitute a methodology for dealing with coast related sustainability issues. Social and natural scientists have to work together to set up the theoretical basis and to develop the tools needed for practical application of this methodology to real-world cases. The role of experts in such processes is elaborated and illustrated with a practical example in Section 2.4 and 2.5, respectively. Often, however, techniques and tools used by various sciences are not compatible, which impedes an effective (integrative) approach. Moreover, theories and solutions developed by scientists, often science-driven, do not always match the practical needs of coastal planners and managers due to a 'gap' between these two worlds. With the concepts presented in Sections 2.2 to 2.5 as background information, we (1) analyse interactions in the ICM process, (2) develop a theoretical framework describing these interactions and (3) formulate a hypothesis on what might cause the aforementioned 'gap'.

2.2 A system analogy for ICM

System theory is often used to structure complex problems. It does so by reducing a complex problem into a system of elements that can separately be described and together can be used to explain the overall problem. Added value of system theory is the tendency to regard such systems as entities rather than as conglomerations of parts. This is particularly useful for systems whose output cannot be expressed as a 'simple' function of component outputs (Ackoff, 1959). As such the system approach is also useful to describe the important elements and aspects of coastal problems and their interactions. A useful diagram for coastal systems, developed by Van der Weide (1993), is shown in Figure 2.1a.

2.2.1 Primary system components and interactions

Primary components of the diagram presented by Van der Weide (1993) are the natural subsystem and the antropogenic (man-made) subsystem. The former includes all components of the abiotic and biotic environment in terms of its structure and internal processes. The latter describes in the same way the man-made environment. The cornerstone of the diagram is the interaction between these two subsystems (see Fig. 2.1a). The system diagram constitutes a useful tool in the problem analysis and problem solving and it serves as a basis for models to simulate system behaviour. The system analogy is also useful in showing the interrelation between the various fields of science. The natural subsystem is the field of natural sciences whereas social sciences are required to describe the antropogenic subsystem. Both are needed to formulate and assess the interactions between the two components, in support of decision making.

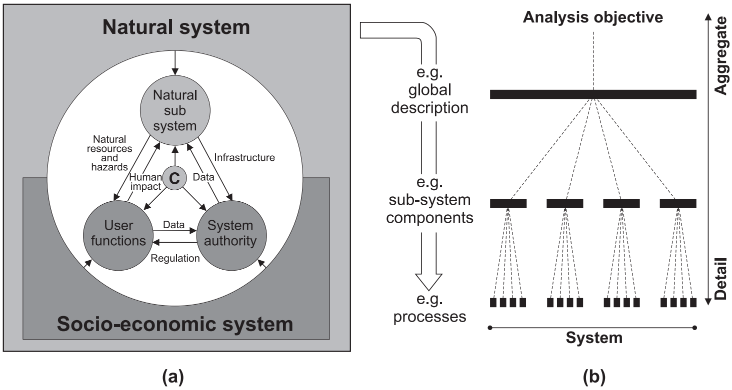


Figure 2.1: *(a) A systems view of coastal zone management (Source: Van der Weide, 1993) (b) Different levels of aggregation in the systems approach*

The interactions between the two main system components are manifold and encompass a multitude of aspects. They can be clustered into the following main categories:

- *Natural hazards*, the negative impact of nature on the man made environment;
- *Natural resources*, the positive impact of nature on the man made environment;
- *Resource use*, the use of space and renewable or non renewable natural resources for social and economic activities; and
- *Environmental impacts*, the negative (and positive) impact of these socio-economic activities on the functions of nature, viz. the production of renewable resources and the regulation of vital processes.

In Section 2.3, these categories are further elaborated by means of an impact matrix. The work performed in Focus 4 of the LOICZ project (Land Ocean Interaction in the Coastal Zone), a.o. Turner *et al.* (1998), can be instrumental for the modelling of these interactions.

2.2.2 System control

With increasing demographic pressures, the above-described interactions may lead to problems, defined in this thesis as the discrepancy between the current state of (part of) the system and some reference state, exceeding some threshold. Problems may lead to conflicts, which should be properly controlled. This is shown in the third subsystem, the institutional subsystem. This subsystem contains all the enabling mechanisms and instruments required for a proper management. Enabling instruments, such as legislation and institutional arrangements, have to be developed to that end. This is where political science enters the picture. In this context ICM can be seen as the system element which links all the above components taking into account both the integration between different levels of government and integration of different sectors. Equally important, however, is the role of ICM in the decision making process and the involvement of the stakeholders in this process as a means to create public support. This complex of management actions is symbolised by the circle in the centre.

2.2.3 System boundaries and cross-border effects

Obviously, this system analogy can be applied for different spatial scales, involving different levels of detail or aggregation (Fig. 2.1b). In their books Limits to Growth and Beyond the Limits, Meadows *et al.* (1972, 1992) apply a system analogy of the whole world. In most instances, however, the system only represents part of this world. In order to account for the interaction with the outside world, cross-border effects have to be included in the system description in that case.

2.3 The DPSIR approach

The OECD first introduced the Pressure State Response concept (OECD, 1994) as a means to achieve a basis for a sustainable development strategy. In a later stage the EU developed the approach further and socio-economic effects were explicitly included as impacts, resulting in the acronym DPSIR (EEA, 1998). The approach is shown schematically in Figure 2.2, which essentially shows a logic flow diagram describing the steps necessary to quantify the components of the above system diagram and their interactions. The flow diagram starts by addressing the interaction between the natural and antropogenic subsystem in terms of a cascade of sequential causes and effects. This interaction is quantified in three steps. First the driving forces (D) and associated pressures (P) resulting from relevant socio-economic sectors are quantified. Subsequently their impacts on the state (S) of the natural system are determined. Finally the impact (I) of these changes on the living

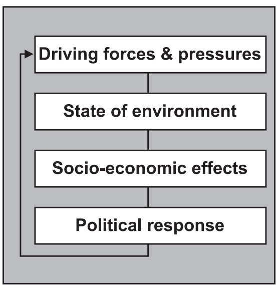


Figure 2.2: *DPSIR diagram (Source: EEA, 1998)*

conditions of man are assessed. When the state of the environment and the effects for society are exceeding acceptable values a policy response (R) is required.

2.3.1 The driving forces (D) and pressures (P)

Driving forces and related pressures may result from one of the groups of conflicts shown in Subsection 2.2.1. An impact matrix is generally used to identify such conflicts. A generalised ***impact matrix*** is shown in Table 2.1. The columns describe actors in both the natural and antropogenic subsystem. The rows represent the components of the two principal subsystems. The cells show the pressures of these actors on the respective subsystems. The two boxes with bold-printed text represent the primary interactions between the natural and the antropogenic subsystem. In most cases, however, elements within each subsystem may also mutually interact. Various users may compete for space and scarce resources within the antropogenic subsystem and natural processes such as floods waves and tsunami's may be detrimental for other processes in the natural subsystem. These conflicting interactions are shown in the remaining two boxes.

	Actor: Natural processes	**Actor: Human activities**
Impact on natural subsystem	Loss of ecological values due to natural hazards, e.g. floods, erosion etc.	***Environmental impacts due to land and resource use, waste emission and engineering works***
Impact on antropogenic subsytem	***Loss of life and property due to natural hazards, e.g. floods, erosion etc.***	Competition in land- and resource use, impact of engineering works etc.

Table 2.1: *Matrix showing typical conflicting interactions and related pressures*

The DPSIR diagram deals primarily with the effects of human activities on the natural subsystem, i.e. the top right box of Table 2.1, resource use and environmental impacts.

2.3.2 The State of the Environment (S)

The impact on the natural system is defined in terms of changes in the state of the natural environment. Changes are monitored by state indicators, selected parameters which are representative of key properties of the natural system. Typical state indicators for the above pressure categories are shown in Table 2.2, grouped according to the components of the natural subsystem: the air, the water and the land.

Throughout this chapter we apply the set up of a shoreline management strategy to illustrate the use of the DPSIR diagram. Coastal erosion is in that case the pressure, which leads to the choice of shoreline position and annual erosion rates as indicators to describe the state of the shoreline.

	Resource use	**Environmental impacts**
Atmosphere (Air)		Climate parameters. Air quality: physical, chemical and biological composition. Noise Level
Hydrosphere (Inland and coastal waters)	Volume of surface and groundwater. Area of ecosystems and habitats. Biomass and biodiversity. Parameters of regulating processes. Existence (LNC) values	Water quality parameters. Water quality: physical, chemical and biological composition. Water quantity.
Lithosphere (Coast, foreshore and hinterland)	Volume of mineral resources. Area of Ecosystems and habitats (Space). Biomass and diversity	***Coastal erosion:*** ***Shoreline evolution and annual erosion rates***

Table 2.2: *Typical state indicators for various pressure categories in ICM*

2.3.3 Impact on socio-economic subsystem (I)

The impact on the socio-economic subsystem is expressed in terms of effect indicators. Examples may be deteriorating health conditions due to an insufficient supply of clean drinking water, declining fish catches as a result of ecosystem losses and poor water quality and loss of economic, ecological and cultural values due to coastal erosion. In our example, the latter are the dominant effects. These are outlined in more detail in Table 2.3.

Effect category	**Pressure: coastal erosion**
Economic values	Land losses Loss of public and private property Loss of production
Ecological values	Habitat losses and related functions of nature such as: Declining biomass production Loss of regulatory capacity (wave damping, erosion control) Reduced biodiversity
Scientific values	Loss of rare and endangered species Loss of geomorphological record
Cultural values	Loss of scenic beauty Loss of historic and cultural monuments

Table 2.3: *Typical effect indicators for coastal erosion*

2.3.4 Response (R)

The last part of the diagram describes how to mitigate adverse effects by means of appropriate measures and strategies. When the above ***state*** and ***effect indicators*** are compared with allowable (legal) ***reference values***, this may lead to a management or even a political response. This might be a response in terms of research and development (innovative technologies), institutional arrangements (coastal defence law) or technical interventions (coastal defence works). The diagram distinguishes between actions of individuals (creation of awareness), the private sector (innovative technologies) and the government (regulation, incentives and enforcement).

All of these enabling mechanisms may be required when setting up our shoreline management strategy. Research and development is needed to understand the erosion process and to develop new technologies (e.g. eco-engineering), technical interventions such as coastal defence works may be considered to combat erosion and a proper legal framework and regulatory arrangements are needed to enforce the Shoreline Management Strategy.

2.4 Expert knowledge in support of the DPSIR approach

The actual solution of ICM problems is extremely complex and involves a large number of aspects and stakeholders. Dealing with those aspects in a responsible and balanced manner requires the gathering and processing of vast amounts of information. Depending on the problem at hand and the resources available, an information strategy needs to be developed. The necessary efforts are likely to exceed the capabilities of one person, in which case the involvement of one or more *experts* may be required. System analysis, as described in Section 2.2, analyses and decomposes complex ICM problems into separate problem areas, for each of which solutions are sought that together should solve the overall problem.

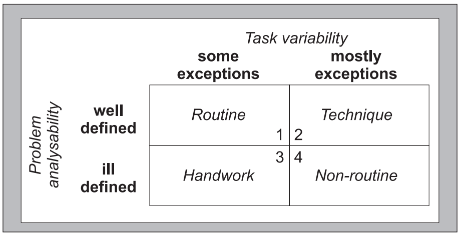


Figure 2.3: *Different types of problems as suggested by Perrow (1967).*

Not all problems, however, are alike. A general definition of ‘problem type’ developed by Perrow (1967) may serve to illustrate this. In his definition, Perrow focusses attention on information and technology. He proposes to discern two aspects in problems and the technology used to solve them: (1) the number of exceptions and (2) the degree of definition of the procedures available to respond to these exceptions. The first aspect is called ‘task variability’, the second ‘problem analysability’. Combining the two yields a 2×2 matrix containing four problem types and associated ways to deal with these (see Fig. 2.3). From this we learn that problems may range from ‘well-defined’ to ‘ill-defined’ and that different problem solving approaches are required along this spectrum. Perrow developed his problem definition for production problems, the next subsections describe an analogous approach customised to ICM problems.

2.4.1 Problem analysis

Figure 2.4a represents the system analysis approach applied to ICM problems, generalised to an abstraction level suitable for this introduction. The left column of Figure 2.4b symbolises the problem decomposition process, distinguishing a 'project'-level, a 'problems'-level and a 'processes'-level. This distinction may be illustrated by our example case, where the project is the set-up of a shoreline management policy, where coastal erosion is the predominant problem and where hydro- and morphodynamics are the governing processes responsible for this erosion. Together they define the state of the environment, that in this particular case is defined by the position of the shoreline and erosion rates in terms of volume of material eroded annually.

2.4.2 Problem solving

Once the problem analysis is completed, the problem solving phase starts, as shown in the right column of Figure 2.4b. Information from different levels may be required to solve the problem. At the process level, empirical or theoretical descriptions of the processes are developed. In general this is a long-term research and development (R&D) effort that ultimately provides the basis for generic tools. When compared to the conversion of theory into tools, these generic tools can then be converted more easily into dedicated tools to solve the problems within the context of the project. Thus, the diagram in Figure 2.4b essentially shows two loops. A long-term R&D loop that covers all elements, and a short term 'Application loop' that skips the R&D phase to apply existing generic tools (proven technology) directly onto a given class of problems.

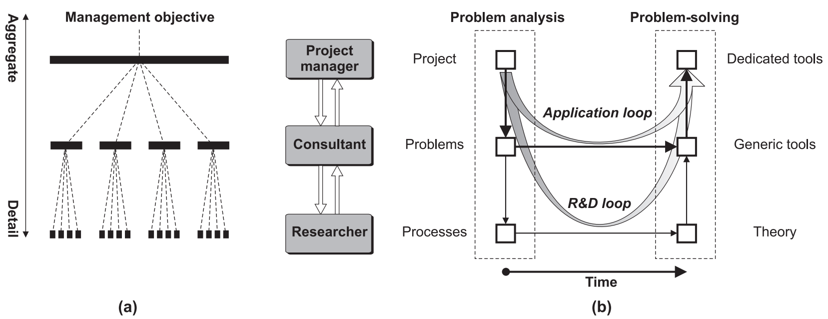


Figure 2.4: *(a) Increasing detail in ICM (b) Coastal management and information*

Related to our example case, various 1, 2 and 3D approaches, describing sediment transport and related morphological changes, are conceivable and research is continued to extend and improve these approaches. This has resulted in a wide spectrum of generic modelling tools tailored to specific classes of ‘well-defined’ problems. One such model is the shoreline model, which predicts the shoreline position in space and time. Following the application loop, this model can be adapted to describe the erosion process in a particular situation and evaluate the effect of proposed measures to combat erosion. In this way a shortcut can be made between the problem, the generic tool and the application at the project level without the need for additional R&D. Such a shortcut, however, usually has its price in terms of uncertainty. The aforementioned model of shoreline behaviour, for instance, is based upon a simplified one-dimensional description of reality, lumping the cross-shore dimension into one point: the shoreline position. It will fail in cases where 2D and 3D effects are important. In those cases the shortcut gives erroneous results and expert input is required to include the effect of governing processes. Specialist effort may be directed towards improvement of existing tools or development of new tools. When the problem needs state-of-the-art knowledge, specialist input may even involve additional research, triggering an R&D loop.

Thus the two loops represent the extremes on a continuum of possibilities (cf. Mulder *et al.*, 2001). Expert input in this continuum may vary from specific support in problem analysis or problem solving (when the problem is ‘well defined’), to an active participation in all stages of the project (in ‘ill defined’ cases). The next section further elaborates on different types of specialist involvement.

2.4.3 On the role of experts

The range of potential expert roles in the above activities may be reduced from a continuum to a limited set of discrete options by introducing the following two aspects of the decision-maker’s perception of his/her state of knowledge (cf. Van Koningsveld and Mulder, 2001):

(1) the required state of knowledge, and

(2) the current state of knowledge.

Let the required knowledge related to a given problem vary between complex and simple, in the eyes of the decision maker. Let the current state of knowledge of the decision-maker compared to this required state, be either inadequate or adequate to actually solve the problem. We may then, like Perrow, construct a 2×2 matrix as shown in Figure 2.5. This figure presents four distinct stages of the aforementioned continuum of possible combinations, based on the generalised flow diagram of Figure 2.4b.

Solid lines in Figure 2.5 represent the critical path followed by the project. Shaded lines indicate loops that can be omitted. Dashed lines indicate parallel supporting activities.

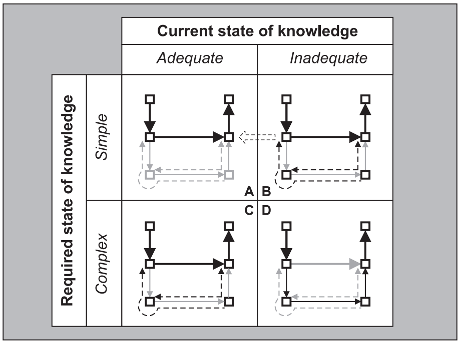


Figure 2.5: *Decision makers perception of the ICM problem type.*

*Combination **A**: The proven technology loop*
Combination A typically represents the application of state of the art and proven technology. The problem at hand is not very complex, in the perception of the decision maker. The current state of knowledge of the end user is adequate to make the shortcut between problem and generic tools, as shown by the solid line. Heavy specialist involvement is not necessary, as indicated by the shaded lower part of the figure. A small-scale routine coastal protection may be considered as an example of this situation.

*Combination **D**: The R&D loop*
Combination D represents the other end of the spectrum, the R&D loop. The problem at hand is now very complex and the current state of knowledge of both the end user and the specialist, is inadequate to provide quick solutions, symbolised by the shaded shortcut between problems and generic tools in the figure. Depending on the scale and relevance of the problem, R&D projects may have to be commissioned to reduce uncertainties. This leads to the full loop as indicated by the solid lines. Large-scale reclamation of land from the sea may be considered as an example of this situation. The method of reduction mentioned in Subsection 2.4.1 essentially reduces a complex situation for which the current state of knowledge is inadequate to one or several simpler situations for which the state of knowledge is adequate, or the lack of knowledge is ‘well defined’. It should be noted, however, that such a reductionist approach may well result in an oversimplified approach that does not necessarily work.

*Combination **B**: The technology transfer loop*
Combinations B and C deal with situations where the choice is not so clear-cut. Combination B describes the situation where the problem is simple and the required knowledge exists, but is as yet unavailable to the decision-maker. Expert involvement may then focus on the transfer of the required knowledge, thus changing the end user’s state of knowledge and leading to a type A situation. This is indicated by the dashed lines, which represent assistance in problem definition and selection of techniques and tools to solve the problem.

The decision-maker may then solve the problem him/herself. A typical example could be the design of a beach nourishment using conventional dredging technology (dumping sand on the beach).

Combination ***C****: The expert consultancy loop*
Combination C represents a situation where the decision-maker's knowledge is adequate, but he is unable to do the job without help, while at the same time the specialist's state of knowledge is adequate, but not easily transferred, due to the complexity of the problem. The specialist may now be involved early in the project to actively participate in the problem analysis and problem solving phases. The early involvement of experienced experts may still enable a shortcut through the application loop thus saving valuable time and money. Again the solid and dashed lines schematise this situation, albeit that the dashed line now represents a greater involvement of the expert. An example illustrating combination C can be the situation where a new type of technology for beach nourishment is considered, e.g. the dumping of sand on the foreshore rather than on the beach.

The application of conventional technology, viz. dumping on the beach, may yield either combination A or B, as the decision-maker may have gained experience with this solution. When the same actor is involved in the application of new technologies, however, the same state of knowledge may now be inadequate, due to the innovative nature of the intervention. In such cases, timely involvement of expert knowledge could enhance the decision-maker's confidence in the applicability of the new technology, thus enabling the application shortcut.

2.4.4 Project phasing

We have seen how the appropriate type of expert input varies, depending on the decision-maker's current and required state of knowledge. Thus the appropriate kind of support is strongly situation-dependent. Moreover, it can also vary per project phase. Larger coastal zone management projects are often phased to enable effective project management. Although in practice these phases may not be completely separated or explicitly indicated, they still provide useful handles for our analysis. There are many different policy cycles presented in the literature (cf. UNEP/MAP/PAP, 1995), but, roughly speaking, most of them contain the following steps:

Diagnosis - A first assessment of problems with simplified diagnostic tools.

Analysis and planning - Analysis of problems and development of mitigating measures, with the help of more sophisticated predictive tools to assess short and long term effects of the proposed measures.

Implementation - The execution of the proposed measures and related enabling mechanisms, where expert knowledge is often crucial for the successful implementation of the selected measure in the system.

Operation, maintenance and monitoring - The management phase where predictive tools may be used together with real time monitoring as a support system for decision making.

These phases can cover a period of e.g. five years. After that period project results should be evaluated and compared with the objectives. The project objectives and criteria should be critically reviewed. This may lead to yet another cycle to effectuate required changes. ICM thus constitutes a continuing cyclic process.

2.5 A practical example

We now provide a more concrete illustration of the different expert support types, by elaborating the role of knowledge in a decision process regarding a coastal erosion problem. Following Section 2.4, the required input of experts in solving this problem varies with (1) the decision maker's current and required state of knowledge given the type of problem and (2) the phase of the project.

2.5.1 The project

We address an integrative approach to a coastal erosion problem in an area where there are significant economical values at risk (see Figure 2.6). The case is based on a real erosion mitigation project but its description here should not be interpreted as a complete project description. Rather the case has been deliberately abstracted to better illustrate the role of expert knowledge in the decision process.

Figure 2.6: *Aerial photograph of threatened area*

The area addressed in this example case is suffering a significant annual retreat of the coastline (shown in Figure 2.7). The actual rate of erosion, however, is as yet uncertain. The erosion itself constitutes a problem for the economic values that have been developed in the area over the years. One of the issues addressed in the management of the coastal zone is when one should actually consider implementing mitigating measures or abandon the area. In this case the rationale behind this choice is based on a comparison of the cost of intervention with the potential loss of property. Other potential effects of the erosion, e.g. increased flooding risk, loss of life, etc., are not included in this example. Some aspects

Figure 2.7: *Coastal erosion threatening property*

of this choice are illustrated in Figure 2.8 - 2.13. Figure 2.8 shows the estimated erosion over time in a section of 1 km wide. Obviously there is a range of uncertainty associated with that estimation. The figures indicate an estimated erosion with a constant rate of 2 m/year.

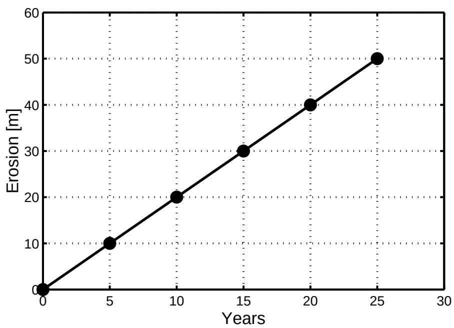


Figure 2.8: *Coastal erosion rate*

A second step is to assess the value of the areas lost as a result of this erosion. In this case a constant value of 500 000 $ /m erosion has been applied for each km coastline. Uncertainties are associated with this estimation as well, as in a practical case large fluctuations may occur. Figure 2.9 represents the losses per km of coastline over periods of 5 years, based on the estimated erosion rate of 2 m/year.

In order to compare the value of these losses with the cost of remedial measures it is common to convert future losses to their net present value. This value takes into account the fact that amounts payable in future require a lower investment now, as interest is accrued

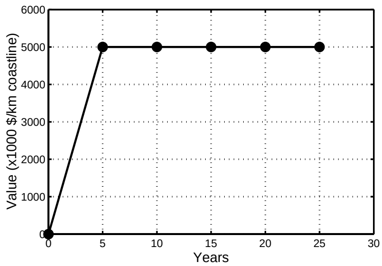


Figure 2.9: *Value of eroded area per km coastline (×1000 $/km/5 yr) coastline*

over time. The net present value is a function, therefore, of the time span taken into consideration and the interest rate applied. For interest rates of about 10%, net present values become small for periods larger than 25 years. This period is therefore often, though not always, accepted for economic evaluations. The third step is to convert the above cost into their net present value, by taking into account the year when the property is actually lost. This is done by multiplying the value of the eroded area with the Net Present Value coefficient. The value of the NPV coefficient for an interest rate of 10% is shown in Figure 2.10.

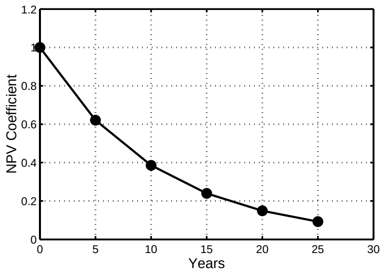


Figure 2.10: *Net present value coefficient (interest rate 10%)*

The fourth step in our assessment of losses is to compute the cumulative net present value of the eroded area over a period of 25 years. This is done by adding the net present values of the five-yearly losses over the total period of 25 years. Figure 2.11 shows the cost of property loss discounted over time. The net present value of property, lost over a period of 25 year amounts to roughly 7 500 000 $.

Figure 2.11 showed the cost of property loss discounted over time. This value now has to be confronted with the Net Present Value of mitigating measures. Let us assume that beach nourishment is proposed as a measure to combat erosion. If we assume that in our

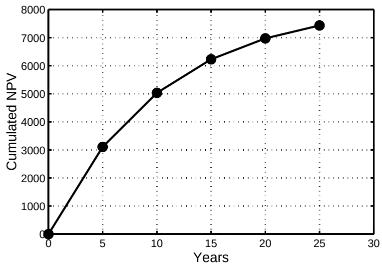


Figure 2.11: *Cumulative net present value of eroded area (×1000 $/km coastline)*

case, the foreshore is eroded up to a depth of 5 m below MSL (Mean Sea Level) and the HW (High Water) mark is 5 m above MSL a total volume of 10 000 m^3 will be required yearly per km coastline to compensate for each m of erosion. If beach nourishment is applied every 5 years, a volume of 100 000 m^3 will be required per km beach length the erosion rate of 2 m/year estimated in the above example. Assuming that nourishment material is available at a price of 10 $ per m^3, the cost will be about 1 000 000 $ per km beach length every five years. If the nourishment is repeated every five years, for a period of 25 years the Net Present Value can again be computed with the NPV coefficient shown in Figure 2.10. The cumulative cost is found by adding the net present values of these costs. This gives a total cost of about 1 500 000 $ per km beach length. Both the NPV of losses and cost have been plotted in Figure 2.12. It appears that losses largely exceed cost and hence a protection strategy is justified in this case.

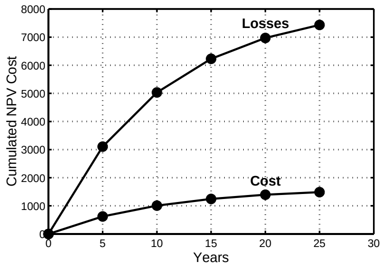


Figure 2.12: *Cumulative net present value of losses and cost (×1000 $/km coastline)*

The solid diagonal line in Figure 2.13 represents the break-even condition where cost of measures are equal to the value of the accrued losses. In practice this is not a solid line but a band bounded by confidence limits. For combinations within this band it is difficult to define a strategy without further studies. If the accumulated value of the lost property is small compared to the cost of measures -the area above the line- the property should be abandoned and activities should be relocated to a safer place. In that case a retreat strategy may be applied. The social impact of such strategies is large, which decision-makers will try to avoid, e.g. by a conditional retreat. In this option low cost temporary measures allow for preparation for the final retreat. In order to avoid similar situations in future, it is common to define a set back zone where in the future no permanent structures are allowed.

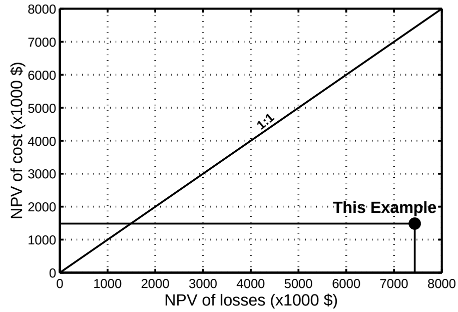


Figure 2.13: *Example: selection of shoreline management strategies*

Setback zones should be related to the erosion rate experienced in the area, e.g. a width of at least 50 to 100 times the annual erosion rate would provide a safety margin for 50 to 100 years. In the Dutch case a similar, so-called ‘reserve strip’ (in Dutch: reservestrook) is designated to facilitate flexibility for future coastal defence activities for a period of 200 years.

2.5.2 The role of knowledge in different project phases

Diagnosis
In this first phase of the ICM process the main issue is whether or not the erosion requires intervention. Figure 2.8 through 2.13 clearly show there are several uncertainties associated with the choice for intervention. The erosion rates and the actual cost of the property loss are uncertain and therefore the decision whether or not to intervene, is a difficult one as soon as erosion rates are less than extreme. In this first phase only a rough estimate of the erosion rate and a quick assessment of the property at risk are usually enough to decide whether this erosion needs immediate attention or not. Because this is essentially a go-no-go decision, the end user will be satisfied with a ‘quick and dirty’ overview of the problem. Limited accuracy is not a problem as far as it does not interfere with decision making. In terms of the typology presented in Subsection 2.4.3 a skilled decision-maker could create a shortcut and apply a simple shoreline model as a first assessment. That would make this a type A problem where the expert is only latently present (off-line), viz. as a developer of the tool.

Analysis and planning

Once the decision is taken that the erosion does indeed constitute a problem that should be addressed, the problem may be investigated more closely. The estimates from the initiation phase should now be investigated in order to reduce the uncertainties. In the first phase the main issue was whether or not the erosion requires mitigating measures. In this phase the goal is to find out which type of intervention is most suitable for the problem at hand. Small erosion rates and a limited life span of threatened property might give rise to soft interventions like nourishment with sand. When it is unlikely that property may be relocated and erosion rates are large one may consider hard interventions like e.g. breakwaters. To be able to determine which intervention is needed where and when, the decision-maker requires much more detailed information. Required accuracy is higher now than in the initiation phase but still only as far as it supports the decisions relevant in this particular phase. Besides an increased accuracy another kind of information is now becoming relevant. Unlike in the diagnosis phase, cause and effect are essential elements that should in fact be included in the analysis and planning of measures. There is a big difference in mitigating effects and eliminating causes of erosion. This could mean that the one-dimensional shoreline model is no longer sufficient. The increasingly detailed information need creates a type B or C situation, depending on the problem, of course. This situation requires active involvement of the specialist with the decision-maker providing the context of the problem. The specialist can then solve this problem by applying his system knowledge in combination with more advanced models. It may be necessary to carry out measurements in this phase to enable a more detailed investigation.

Implementation

Once the decision has been made on if and where measures should be implemented, an even more detailed study of the area is necessary to determine the optimal design of each intervention. This should not only include the functional aspects of the proposed measures (does it work as needed?) but also the structural aspects (can it be built as envisaged?) and the environmental aspects (how does it affect nature and man?). The extra information needs to provide the decision-maker with a certain amount of confidence, as the decisions will now actually influence the system. Reliability is not the only source of confidence, but it is an important one. To obtain a greater accuracy field campaigns may be considered to finetune the models. The gathering and processing of information to better understand the local processes triggers an R&D effort. The expert is now a researcher. A close dialogue with the decision-maker is needed to define a research project with proper attention for the overall objective and a clear target accuracy. The research described is not uncommon for large infrastructural interventions. For smaller projects, however, it may not be necessary to introduce the R&D loop.

Operation, maintenance and monitoring

Once the interventions are in place, knowledge regarding effective operation and maintenance is needed. Most protective measures against erosion do not require operative attention. Breakwaters and nourishments basically operate themselves. Maintenance, however, may consume a considerable part of the project budget. For a soft intervention like nourishment with sand maintenance may indeed prove very costly if system processes are not well enough understood. There are plenty of examples where the actual lifespan of a nourishment proved significantly shorter than expected. In that case additional nourishment is necessary, leading to an increase of cost. Expert knowledge may then be needed to reduce the cost of maintenance. When the required knowledge for this problem is not available an R&D effort may be necessary to increase the system knowledge. This can be considered to be a type D situation.

2.6 Is there a gap?

The previous sections illustrate the knowledge intensive character of ICM processes. The complex nature of coastal problems implies the delegation of responsibility and the involvement of experts to supply all the necessary information. Professionals from the coastal management community and from the coastal science community can give ample examples of problematic interactions between their two worlds, e.g.:

- Advice that cannot be used because it describes (slightly) the wrong phenomenon;
- Advice on the right phenomenon but expressed in the wrong parameters;
- Expert reports that remain unread because the amount of detail makes them unreadable;
- Perfectly good advice that was ignored in the decision process;
- ICM projects that fail to establish integration between disciplines;
- Study or research projects that pursue personal scientific interests rather than practical problems indicated by the coastal managers who commissioned the project;
- Science-driven projects having problems in translating the research findings to potential end users
- New findings that take too long to become implemented in daily practice;
- New findings that are applied too soon to situations for which they were not designed;
- Etc.

The above-described problems are often attributed to some mysterious communication ‘gap’ between experts and users of expert knowledge. Suggested causes for the recurring miscommunication range from unclear problem formulation to problems with research management and communication of results (cf. Mulder *et al.*, 2001; EU, 1999; Capobianco, 1999). Both are probably the case. Whatever causes this ‘gap’ is giving rise to frustration and inefficient use of valuable time and money. It is therefore that an investigation into this ‘gap’ and its causes is necessary. The growing demand for a more efficient use of resources and an increased pressure on decision-makers to support their decisions with clear argumentation ensures this subject to be of interest to the coastal management community, as well as to the coastal science community.

A crucial problem in the investigation of this subject has been the lack of a framework to facilitate clear and systematic discussions. A potential remedy to this problem is presented in the next subsections, starting with some general assumptions and requirements.

2.6.1 Towards a framework for analysis

The scale and complexity of coast related problems implies not only the involvement of more than one actor, but also the presence of interactions that encompass different levels of authority and specialisation.

National authorities, for example, may need to develop a coastal policy. In support of this policy, information may be required from regional coastal managers. To actually implement it, regional coastal managers may need more detailed information regarding the specific problems in the area under their control. Experts may be consulted to develop alternative solutions to these problems. Useful development of alternatives requires knowledge of the local coastal system. To effectively design engineering solutions, even more detailed system knowledge is required. Specialists on coastal behaviour may be asked to provide this information. Modellers may be needed to make the available system knowledge operational. Scientists may need to be involved to improve the state-of-the-art of system knowledge, etc.

As a consequence, investigating the 'gap' between experts and users of expert knowledge, we need to regard ICM as a chain of interactions, between actors working at different and comparable levels of aggregation in the same overall problem solving process. We propose the following fundamental assumptions as a foundation for a framework for analysis.

> **Lemma 2.1** *The solution of coastal management problems may be regarded as a chain of interactions between interdependent actors, with mostly different states of knowledge, working at **different** or **comparable** levels of aggregation on (parts of) the same overall problem.*

> **Lemma 2.2** *Miscommunication can be found in every interaction between actors, irrespective of whether they are working at **different** or **comparable** levels of aggregation.*

> **Lemma 2.3** *The communication 'gap' to be investigated herein only surfaces in communication between actors working at **different** levels of aggregation in the same overall problem solving process, and would **not** exist if only one person would identify the problem, investigate potential solutions, implement these solutions and evaluate their effectiveness.*

Lemma 2.4 *The communication problems between **different** levels of aggregation, associated with the 'gap', are caused by the **same** mechanism regardless of the levels involved.*

To find a generic mechanism that causes the presupposed miscommunications between experts and users of expert knowledge, our framework must applicable to 'all' of these knowledge transfer situations. This requires a systematic abstraction of the problem solving process and the necessary communication. Following the above-described fundamental assumptions we need to include as basic elements of a framework for analysis:

(1) communication, between

(2) actors with different roles,

(3) dealing with (interdependent) problems, at

(4) different or comparable levels of aggregation.

2.6.2 The 'problem solving chain'

Based on Lemmas 2.1, 2.2, 2.3 and 2.4, we regard coastal management as a chain of interdependent problem solvers that rely on each other for information. Each interaction in this chain involves two actors with a certain degree of knowledge and responsibility regarding certain subjects.

Decision-makers
A decision-maker trying to achieve one or more management objectives, usually encounters problems that need to be solved. Problems are defined in this thesis as a discrepancy between the current state of (part of) the system and a reference state, exceeding some threshold. When problems are too complex to be solved as a whole, they can be divided, e.g. using a systems approach, into sub-problems that *can* be solved, albeit separately, thus running the risk of sub-optimisation. Rational problem solving requires argumentation supported by objective information. When dealing with complex coastal problems, the amount of information required can easily 'explode' (see Fig. 2.14a). One person will no longer be capable of gathering all required information and make all necessary decisions alone. Responsibility for part of the 'higher level' problem can be delegated and another person is included to deal with that particular sub-problem. This creates a system of coupled problems, illustrated in Figure 2.14b. The problem solving cycle at the top of the chain in Figure 2.14b symbolises the problem solving process at that particular level. This cycle is repeated as an icon at the other levels, purporting to symbolise the problem solving processes at those levels.

Experts
To ensure sustainable development of coastal areas, ICM ought to be based on rational and transparent decision making based on sound system-based argumentation. Thus given

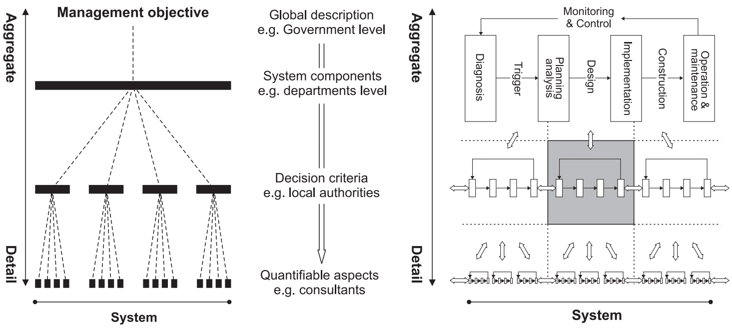


Figure 2.14: *(a) Exploding complexity in system modelling (b) Coastal management process as a chain of problem solving cycles.*

any one of the problems in the above-described ‘problem solving chain’, decision-makers require a certain amount of knowledge and information to enable objective argumentation. Given the complexity of coastal problems, it is very well possible that decision-makers do not posses the knowledge required. It is the role of experts to solve their sub-problem and provide the required additional information.

> **Restriction 2.1** *Within the constraints defined by the higher levels, the selection of a suitable approach to each problem is supposed to be the responsibility of each individual problem solver (decision-maker as well as expert).*

Different and comparable levels of aggregation

When involving advisors, decision-makers usually formulate questions, thus initiating a communication process and at the same time introducing a distinct and potentially vulnerable extra link in the problem solving process. The questions expressing the information required by the decision-maker (the consumer of specialist advice), in turn identify problems to be solved by one or more specialists. These in turn may need to involve specialists to help solve sub-problems, etc. These considerations automatically extend the above-described concept of ‘the problem-solving chain’, as shown in Figure 2.14b, to include consultants, advisors and specialists. The axis labelled ‘System’ is included to indicate that although the amount of detail increases each time a sub-problem is passed on downward, the overall system that is being described given a certain coastal problem remains the same. To describe the same system with less detail requires an aggregation of information, which explains the vertical axis, indicating different levels of aggregation. Each ‘lower level’ problem solver operates within the context provided at higher levels of aggregation! Figure 2.15 depicts an arbitrary isolated problem solver (shaded in Fig. 2.14b) in the above-described ‘problem solving chain’. In our framework, this actor can communicate in different directions:

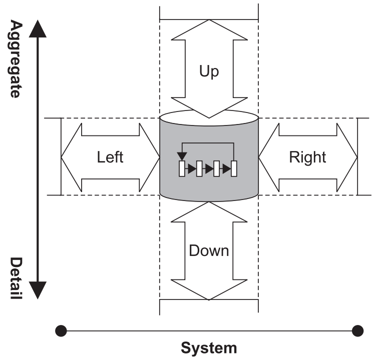


Figure 2.15: *Possible interactions in the 'knowledge chain'*

upward - with the owner of the more aggregated or higher-level problem, by our definition the '*generalist*';
horizontally - with actors that operate at comparable levels of aggregation but not necessarily in the same discipline, by our definition '*peers*'; and
downward - with actors dealing with more detailed or lower level sub-problems, by our definition '*specialists*'.

In our coastal erosion example (see Section 2.5), one can imagine the actor in Figure 2.15 to be e.g. the coastal engineer asked to design some sort of coastal structure to combat erosion. Upward he/she may communicate with a regional coastal manager, planning to implement this structure as an intervention. On comparable levels of aggregation the coastal engineer might need to communicate with peers, other specialists from the same or different disciplines (e.g. economists, ecologists etc.). Downward he/she may communicate with modellers that are able to quantify the representative hydrodynamic conditions and/or predict the impact of the designed structure on future coastal behaviour.

Communication
Communication in each of the above cases takes place through the exchange of information (and data). The (mental) 'meaning' that a person constructs from informative (physical) signs is influenced by many things, a.o. the concepts of 'intelligence' and 'context' as discussed by Borgmann (1999). What we know and believe is part of these concepts and contains explicit and tacit elements (Polanyi, 1966). The explicit elements can be turned into information through the use of signs like words and numbers etc. The tacit elements are not easily visible or expressible. The explicit elements represent only the tip of the ice-berg of what people actually know and believe (we know much more than we can tell). Tacit knowledge is highly personal and hard to formalise, which makes it difficult to communicate or to share with others. Furthermore, tacit knowledge is deeply rooted in an individual's actions and experiences, as well as in the ideals, values, or emotions he or she embraces. In general, what a person knows and believes can be divided into technical and

cognitive elements. The technical dimension encompasses skills and crafts, captured in the term ‘know how’. The cognitive dimension reflects our image of reality (what is) and our vision for the future (what ought to be). Though not articulated easily, these implicit models shape the way we perceive the world around us (Johnson-Laird, 1983).

Mental conceptions of reality play an important role in the communication process. Differences in what we know and believe can cause different interpretations by two people of the same information. As a result, communication can be impeded. The paradigm of communication as a process of dynamic conceptualisation, described by Reddy (1993), suggests that miscommunication is the rule rather than the exception. Its effects may only be reduced through intensive interaction and feedback. Externalisation of (tacit) mental models in a kind of mobilisation process is assumed to be a key factor in knowledge development and in knowledge transfer (Nonaka and Takeuchi, 1995). We will make use of this notion later in Chapter 4.

For the communication element of our framework for analysis, it is important to realise that miscommunication is rule rather than exception, and that it is caused by differences in individual experiences, ideals, values, emotions, mental models, beliefs, perceptions, attitudes etc. Even though the concepts communication, information and knowledge play a crucial role in our investigation of the problem solving chain, we choose not to engage in a deeper philosophical definition of these concepts here. For such information the interested reader is referred to the vast literature devoted to these issues (among many, many others cf. Dretske, 1981; Devlin, 1991; Heil, 1998; Audi, 1998). Even though communication, information and knowledge are crucial concepts in our framework, we are not as much interested in a deeper definition of these concepts, themselves, as we are in using them to characterise the aforementioned ‘gap’ in the context of the problem solving chain.

2.6.3 The ‘analysis molecule’

For a systematic exploration of the interactions in the problem solving chain, two of the symbolised actors and their respective problems as depicted in Figure 2.15 are combined in what we will call the ‘analysis molecule’. Figure 2.16a and 2.16c visualise the resulting possibilities. The distinction between horizontal and vertical interactions is an important result of this analysis. The lines of communication (both *up*, *down*, *left* and *right*) between each two actors are the lines over which questions and answers are communicated.

Separating the communication of assignments and results we can divide the information transfer between actors into four elements (see Figure 2.16b and 2.16d - the Roman numbering is used to refer to these elements in short throughout the rest of this thesis):

- **(I)** the problem and its problem owner,
- **(II)** the communication of a request for information,
- **(III)** the sub-problem to be studied and the receiver of the request for information, and
- **(IV)** the communication of the answer back to the original problem owner.

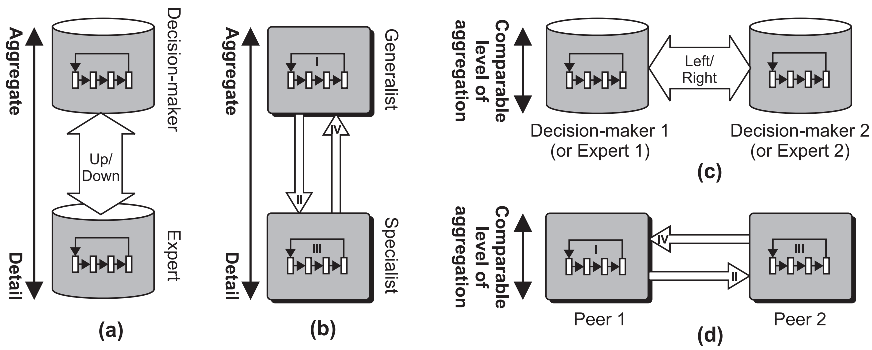


Figure 2.16:
(a)Interaction between generalist and specialist
(b)Vertical analysis molecule of generalist-specialist interaction
(c)Interaction between peers
(d)Horizontal analysis molecule of peer-peer interaction

Based on Lemma's 2.3 and 2.4, we now focus our analysis on the two symbolised actors/problems, at *different* levels of aggregation (see Fig. 2.16a and 2.16b). The higher level actor is by previous definition called the 'generalist', relative to the lower level actor, who in turn is called the 'specialist'. The separate elements of the vertical analysis molecule can now be labelled more specifically, viz.:

(I) the problem and its problem owner at the higher level of aggregation,
(II) the downward communication of a request for information,
(III) the sub-problem to be studied and the specialist,
(IV) the upward communication of the answer to the generalist.

Besides the elements, themselves, the conversions between the elements may also be identified:

(I-II) the translation of problem into questions representing the information need,
(II-III) the translation of these questions into a study designed to gather required information,
(III-IV) the translation of study results into answers, and
(IV-I) the application of specialist advice in solving the generalist problem. We discuss the mismatching element transitions in more detail.

Analysis of mismatches between the above-described elements provides an indication (symptoms) of the quality of the interaction process and the location of potential bottlenecks.

I - II: Problem - question mismatch
A mismatch between question and problem deals with situations where a written or spoken assignment to specialists for further study or research does not contain enough clues on the information needed to solve the generalist's problem. Numerous factors like skill, strategic and pragmatic considerations by the generalist involved may lead to this type of mismatch. In some cases, however, the generalist may have a hard time formulating the problem clearly. We later show that dealing with poorly defined problems has a significant impact on how to deal with generalist - specialist interaction.

II - III: Question - study mismatch
A mismatch between question and study focuses on situations where a study or research project is not effectively designed to answer the question. Again skill, available time and money, and strategic considerations may lead to this type of mismatches. It is possible, for example, that the actual study is intentionally focused on a (slightly) different subproblem to better match personal capabilities or strategic interests of the specialist. On the other hand poor formulation of the question may unintentionally lead the specialist in the wrong direction.

III - IV: Study - answer mismatch
The study-answer mismatch does not refer to a report that simply describes results from a completely different project. Rather it points at more subtle mismatches. Time pressure and planning problems often cause reports to be written 'just-in-time'. Subjects that *have* been studied may not end up in a report by lack of time or perceived relevance. Information on how the generated results may be applied by the end user is usually the first to suffer in those cases.

IV - I: Answer - problem mismatch
The mismatch of a specialist answer, in the form of e.g. a report or advice, with the generalist problem is a clear symptom of what we call the 'gap' between generalists and specialists. This mismatch may occur in many different forms. A report full of scientific terminology may be very hard if not impossible for a decision maker to understand (internalise). But there are other types of mismatch, as will be addressed in the next sub-section. For now it is important to realise that specialist answers that cannot or not easily be applied in the generalist problem solving process indicate the presence of a gap. As yet, we leave the cause of this gap unaddressed.

> **Lemma 2.5** *A mismatch between elements IV and I, or in other words when the specialist answer can not or not easily be applied in the generalist problem solving process, is regarded symptomatic for the presence of a 'gap' between specialists and (end)users of specialist knowledge.*

It should be noted that this thesis focuses on matching specialist knowledge with generalist needs rather than on increasing the impact of specialist knowledge on decision making. This means that we accept the fact that a perfect piece of advice may sometimes remain unused.

Restriction 2.2 *As long as (1) the relevant information is (2) effectively transferred to the end user, we regard the knowledge transfer process to be successful, even if this knowledge has no objectively verifiable impact on the decision process.*

As such, matching specialist knowledge with end user needs is a necessary but insufficient condition for rational decision making. With this restriction in mind, we now proceed with a typology of mismatches.

2.6.4 A typology of IV - I mismatches

The crucial mismatch between element IV and I (see Fig. 2.16b) and the associated gap, may occur at each level of the problem solving chain (Lemma 2.3 and 2.4). This mismatch, itself, may in turn be caused by a mismatch between I and II (a question that does not match the problem), II and III (a conducted study that does not match the question) and III and IV (a given answer that does not match the outcome of the study). The four elements together form one link in the problem solving chain. Each mismatch can carry over into the next element or worse, into other links where it may in turn trigger further mismatches.

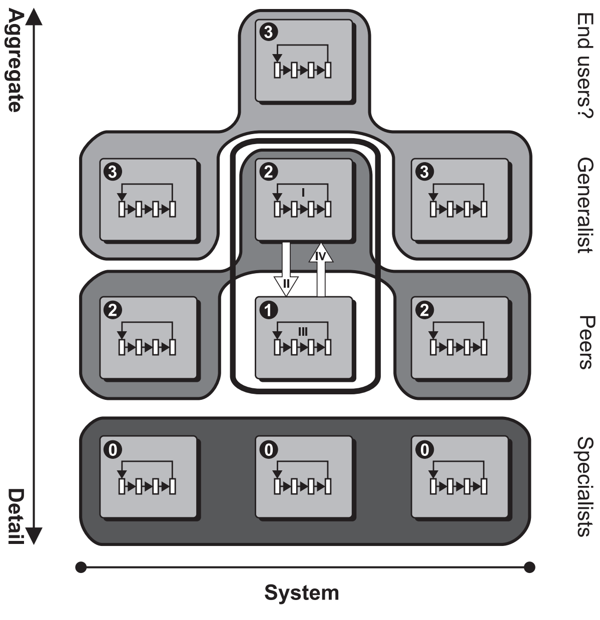


Figure 2.17: *Mismatch molecule.*

Investigation of several cases indicates that that a IV - I mismatch can have different characteristics. To what extent can the framework we developed so far help us identify a typology of mismatches? Although our analysis is focussed on generalist-specialist interactions, the different types of mismatch may not be investigated in total isolation. We investigate a vertical analysis molecule and neighbouring problem solvers in the context of the problem solving chain. We analyse a theoretical mismatch between answer (IV) and problem (I) by looking at adjacent elements as shown in Figure 2.17, together called the 'mismatch molecule'.

1. Study of the wrong thing - content

First of all the study or research project could have been focussed on the wrong thing (element in Fig. 2.17 marked '1'). The answer will then mismatch on what we call the *content* level. Questions posed too vaguely have caused modelling of the wrong phenomena, eventually leading to answers that prove useless in solving the generalist problem. A clear example of a content mismatch is a study investigating the impact of shell mining on nearby coastal areas returning an answer that described the expected beach erosion, instead of the impact on the intertidal shoal area, which was required to assess the impact on nature values.

2. Reporting (on the right thing) in a wrong way - form

Another type of mismatch is provided by answers that can not or not easily be processed by the generalist in dealing with his/her particular problem. A study may report at a useless level of detail or in not directly applicable parameters. A study on wave impact, for example, reported in H_{rms} wave values where H_{max} values were required to deal with the higher-level problem. Such *form* mismatches cause sub-results to be hard or even impossible to integrate in the problem solving process at the comparable and higher levels of aggregation for which they were intended (elements in Fig. 2.17 marked '2').

3. Not answering the question behind the question - intent

Finally, mismatches on the level of the *intent* of the information may render the answer useless to the generalist in his attempts to answer the question behind his question to the specialist (elements in Fig. 2.17 marked '3'). An impact matrix regarding a large infrastructural project, for example, was completed on the requested subjects and in the requested form. Subsequently, however, the impact matrix could not be used in supporting higher-level decision-makers in their cost-benefit considerations; the effort failed in its intent. Coastal specialists are usually quite able to supply content for a 'well-defined' question. Coastal managers often know the intent for which they require information, but have problems formulating a 'well-defined' question including the required content and form.

One may wonder if a typology of mismatches should only be oriented upward from element number 1. After all, sub-contracted specialists (the elements marked '0') may also have been the cause of e.g. a mismatch on content. With Restriction 2.1 we assumed, however, that each problem solver would be responsible for solving his/her particular subproblem, or in other words be responsible for supplying the right content. If we want to trace mismatches to lower levels of aggregation, we may simply shift down the mismatch molecule one level. Higher or equal levels of aggregation supply the quality assessment of advice that is interesting for this analysis. To understand why an actor would or would not be pleased with a certain piece of information we need to look at these levels. Mismatch type '3' even includes a level of aggregation higher than the direct adjacent one. This implies that the evaluation of advice is not limited to the directly client (the elements marked '2') but could include even the client of the client (the elements marked '3'), owner of the question behind the question. Of course one could expand the mismatch molecule even further upwards. Experience shows, however, that such expansions are not particularly useful. It is more practical to regard this as a new situation and shift the mismatch molecule one level upward.

2.6.5 A hypothesis on what causes these mismatches

There are many possible causes of the mismatch-types mentioned above. Some of the reasons why specialist advice may fail to contribute to solving the generalist problem are quite trivial in nature. Generalists may lack the time or skill to fully read and understand the specialist advice. Due to the time involved in study and research the specialist advice may have become obsolete, other measures may have been implemented to solve the problem, the problem may have changed or even have disappeared altogether. We believe, however, that besides all these trivial, circumstantial and pragmatic reasons for mismatch, there is a significant set of mismatches that is caused by a lack of mutual understanding between communities at different levels of aggregation and a lacking ability or will to change this situation.

> **Hypothesis 2.1** *The mechanism mentioned in Lemma 2.4, is the divergence in perception by actors with different roles, at different levels of aggregation, of the problem/situation at hand and the knowledge and information that is needed to deal with it.*

Hypothesis 2.1 basically states that the gap between generalists and specialists is constituted by an implicit difference of opinion of what information or knowledge is relevant and should thus be developed in a study or research project. This implicit difference of opinion may lead the specialist to supply other information than the generalist requires for solving his problem. Such a difference may be the result of e.g. the use of too abstract terminology in the problem setting stage. As a result there would only be *apparent* agreement on the problem at hand while many important aspects remain implicit. Helping the (relative) generalist to set the problem as explicit as possible could be a way to bridge this gap and thus reduce the range of potential mismatches. Specialists, on the other hand can help by carefully considering the type of information required by the end user and adjusting their efforts accordingly.

To test Hypothesis 2.1 we need to analyse different projects and compare their information output with the information need as expressed by the end users of that output. There are many types of projects that we could investigate, e.g. consultancy, studies, research projects, etc. We choose to investigate coastal research projects, because the nature of these projects, in terms of project length and the level of detail of the information that needs to be developed, would probably cause the problems associated with the 'gap' to surface more clearly than in shorter and more 'well-defined' consultancy projects. That does not imply, however, that these problems could not occur in this type of projects.

In the next chapter we confront a significant number of coastal research projects, commissioned over the last 30 years, with the 'larger' questions of that time. This confrontation helps to test Hypothesis 2.1 by comparing the usefulness and effectiveness of coastal research programmes as perceived by coastal managers and coastal specialists, respectively. The test should give us a clearer idea of whether or not the gap as identified in our framework does in fact exist in practice and if it causes significant problems. Furthermore, the analysis can indicate the scale at which this occurs and possible ways to prevent it.

Chapter 3

Usefulness and effectiveness of coastal research: a matter of perception?

3.1 Introduction

In this chapter we test Hypothesis 2.1, concerning the gap between knowledge developers and knowledge users, against experience with a number of intermediate-scale coastal research programmes. The size and cost of such programmes trigger discussions about their usefulness and effectiveness. The impression that the interaction between experts and users of expert knowledge is and has long been sub-optimal was a trigger for this work. Analysing what goes wrong leads to different points of view, which give rise to different suggestions for improvement. Coastal managers, for example, dealing with complex coastal problems, require the help of specialists, in the form of training, advice or research. In their perception, the interaction could be improved if specialists could be persuaded to better consider their needs. Specialists require the help of end users to finance their research and support the application of knowledge to practical cases. In their perception, the interaction could be improved if users of knowledge could only see the benefits provided by the newly developed knowledge. It is in the interest of coastal management as well as coastal science that both communities should optimise their co-operation. The amount of resources invested in coastal research and the interests looked after by coastal managers and coastal policy makers justify the investigation of this subject.

To illustrate how the interaction between coastal science and drivers of scientific research can become sub-optimal, this chapter evaluates the usefulness and effectiveness of a range of coastal research programmes. For practical reasons, the focus is oriented to Dutch and European case examples, but we believe that the findings presented in this chapter are equally applicable to projects in other parts of the world. Judging the usefulness and effectiveness of research turns out to be a matter of perception. For this reason, we describe each program from the perspective of researchers as well as research drivers. To put the programs into perspective, we start with a concise description of the water management and coastal engineering research context in the Netherlands. The next section shows how combinations of technological innovation, organisation and socio-economic context have shaped the Dutch physical and administrative landscape (based on Van Veen, 1962; Terwindt and Walther, 1976; Zagwijn, 1986; Van de Ven, 1993; Bijker, 1996). Against this background we describe the rationale behind contemporary Dutch coastal management and coastal research. This provides a context, crucial to understand why things happen as they do in the Netherlands. The key element of this chapter, viz. the analysis of the usefulness, effectiveness and pitfalls of coastal research programmes, is also interesting for readers not interested in the Dutch background. We evaluate 14 national and international research projects against changing coastal management issues and the simultaneously changing need for information. Analysis of planning documents and final reports of research programs and coastal policy studies reveals an important increase in the complexity of national and international coastal research frameworks over the last 10 to 15 years and a continuing struggle between science-driven and application-oriented research. We summarise the lessons learned from this historical analysis in order to provide handles for the future.

3.2 A concise history of watermanagement in the Netherlands

From 10.000 to 2.000 BP, natural processes were predominantly responsible for changing the Dutch coastal landscape. Relative sea-level rise owing to the combined effects of a temperature rise and subsidence of the earth's surface is one of the best known. It has been only for the last two thousand years that human influence affects Dutch coastal geomorphology. The struggle with water profoundly impacted the Netherlands.

• ***1st to 9th century: Initial human occupation of the Dutch lowlands***
About two thousand years ago people slowly started to occupy the flood-prone coastal regions in the Netherlands. People adapted by building their homes, sheds and stables on dwelling mounds. Over centuries, people increasingly started to cultivate and use the surrounding lands. The peat moors were mined for fuel and salt, and local drainage and reclamation activities caused the land to subside locally and on a relatively small scale.

• ***From 9th to 13th century: Initiation of water management***
The people that had been living on dwelling mounds gradually took the surrounding lands into use. Owing to natural and increasingly human-induced subsidence, the inhabited areas gradually sank one to two metres below mean sea level in the course of centuries. As a consequence, when storms breached the coastline in the Delta and Wadden area, the land behind this coast got permanently inundated. Thus the Netherlands changed from an area with a closed coastline into an area that partly laid open to the influence of the sea, in the Southwest and in the Zuiderzee area. From that moment on, human interference became an increasingly important factor in the physical evolution of the Dutch delta. The increased risk of flooding and complications in the drainage of surplus surface water gave rise to a more collective response against flooding. To protect occupied areas, dikes were strengthened continuously. For effective reclamation, maintenance of the drainage system, and the subsequent diking, a proper administrative organisation was essential. In some communities a special board of permanent representatives was formed to carry out these tasks. Thus, rather than an individual matter, construction and maintenance of the drainage system became a community matter, implying that each community carried responsibility for draining their surplus water into the outside waters. Probably the most

important development in this period is the establishment of regional water-boards, whose task was water management in a certain area, thereby maintaining the drainage system of an entire region or a dike ring. The earlier strategy of adaptation by means of dwelling mounds had changed into a protection strategy. This makes the end of the 13^{th} century a remarkable turning point in the history of water management in the Netherlands. From then on the state of technology would play an increasingly important role.

• ***From 13^{th} to 17^{th} century: Institutionalisation of water management***
In the period from 1250 to 1600, the coastal regions of the Netherlands were still strongly influenced by marine processes. As sea-level rise rates had now decreased to approximately 10 cm per century, this influence was mainly due to storm surges. In most places, existing dikes were insufficient to withstand these storm surges and, time and again, the dikes had to be raised. Whether or not dikes would collapse was closely connected with their maintenance condition. In this period water management became better organised. The structure of water management in the Netherlands reached full growth during the late Middle Ages. The consequences of subsidence for the discharge were now partly compensated by the introduction of drainage by windmills. In the Southwest of the country, loss of land was virtually brought to a halt in the 16^{th} century. Furthermore, the organisation of the water-boards became a constituent part of the government system in the various regions. The nature of the system that has developed in that period has remained unchanged through to the 19^{th} and 20^{th} centuries.

• ***From 17^{th} to 19^{th} century: Large-scale reclamations***
Technological innovation in reactive management measures, such as the introduction of the octagonal tower mill, the open Archimedes screw, drainage in stages (see Figure 3.1) and, later on, of the steam engine, and the favourable socio-economic context (the Dutch 'Golden Century') led to large land reclamations in the 17^{th} through to the 19^{th} century. From time to time, however, there were setbacks and disasters. Storm surges, still the dominant force, occurred regularly and often with disastrous consequences. Yet, storm surges and floods also had 'positive' effects, as they triggered technological and admin-

Figure 3.1: *Drainage by series of windmills (Source: Rijkswaterstaat)*

istrative innovations. A fundamental organisational innovation was the establishment in 1798 of Rijkswaterstaat, a national Bureau for Management and Control of Water-related Issues, which to this day embodies the choice to formalise the necessary technical and organisational capacity in one national governmental organisation.

• ***19th and 20th century: Large-scale works***

Land reclamation from the sea and drained lakes was carried out to an even greater extent in the 19th and 20th centuries. Between 1833 and 1911, 350,000 hectares of land were brought into cultivation, of which 100,000 hectares were gained from the sea and the drained lakes. After two centuries of protective water management the impact of storm surges had decreased. However, two severe storm surges in 1916 and 1953 triggered additional protective measures at an unprecedented scale.

The floods of 1916 and the apparent vulnerability of the Dutch food supply during the First World War triggered the closure of the Zuiderzee (see Figure 3.2). The decision for this was taken in 1918. The project would shorten the coastline by 300 km and 220,000 hectares of land plus a fresh water reservoir of 120,000 hectares would be gained. The enclosing dam of the IJsselmeer, called 'de Afsluitdijk', was completed in 1932 after a construction period of five years. The Wieringermeerpolder (20,000 hectares) fell dry in 1930 and the Noordoostpolder (48,000 hectares) in 1942. After the Second World War, the polder Flevoland (96,000 hectares) was reclaimed, as well. The originally planned polder Markerwaard may never be realised because the need for new land has decreased (as a

Figure 3.2: *The 1916 flood damage, especially in areas bordering the Zuiderzee area (top), triggered the closure of the Zuiderzee by the 'Afsluitdijk' (bottom) (Source: Rijkswaterstaat)*

consequence of new insights into agricultural interests), whereas the appreciation of the IJsselmeer as open water for water management and recreational purposes has increased.

The 1953 disaster, claiming 1835 lives and flooding 165,000 hectares of land triggered another huge hydraulic work: the Delta project (see Figure 3.3). The Netherlands wanted to be secure against such extreme disasters. In the contemporary (post World War II) socio-economic context, the only feasible solution seemed to be the 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). For the first time the defence works would be designed and maintained based on predetermined safety levels. In 1956 the Delta Committee was founded, in 1958 the Delta Act (TK, 1958) was passed and in 1960 the Delta Committee issued required safety levels (Delta Committee, 1960). The Delta works together would considerably shorten the total length of the coastline and thus the length of the potentially vulnerable coastal defences. The set-up of the sequence of the various closing operations was such that the Oosterschelde (in English: Eastern Scheldt), by far the greatest branch, would be closed last. In this way all experience gained in the previous operations could be used for this final one. Initially it was decided that the Eastern Scheldt would be closed by dumping concrete blocks from a cable way (gradual closure - see Figure 3.4). Before this was realised, however, the economically favourable conditions triggered a change in public perception, which favoured the reconciliation of the needs for safety with the interest in environmental values and led to a revision of the Delta Plan. The Dutch Parliament decided to maintain the abundant marine flora and fauna, the rich tidal salt marshes and the high-yield shellfish industry by constructing a storm surge barrier in the mouth of the Eastern Scheldt (see Figure 3.3).

This decision marked a second turning point in the history of the Dutch struggle with water. After one thousand years of adaptation and another thousand years of protection, an accomodation strategy was now triggered driven by public perception.

Figure 3.3: *The 1953 flood (left) triggered the Delta project with the Eastern Scheldt stormsurge barrier as the final and most complicated closure (right) (Source: Rijkswaterstaat)*

3.3 Institutionalisation of national research infrastructure

Until the end of the 18^{th} century scientific progress on water-related issues was promoted by individual efforts. Vierlingh in his “Tractaet van Dijckagie” (Treatise on Endiking) around 1575 reported the knowledge developed since the Middle Ages on the construction of dikes and of wooden sluices and mills. In the following republican centuries scientists such as Stevin, Snel and Huygens, connected to universities such as the University of Leyden, made important contributions to the knowledge. During these centuries surveyors were important for the design and maintenance of dikes and waterworks. The profession of surveyor was a free profession and of high esteem. They had to be well educated and often had followed mathematics courses at universities. These professionals developed into capable hydraulic engineers. Their best-known representative is Cruquius, who realised that a more central, institutionalised approach was necessary. In 1726 he proposed the Government to study the water conditions nation wide for the moderate amount of £2500 (equivalent Euro 4000). However, the concept of local autonomy was still too strong, and the Central Government too weak. Though Cruquius’ proposition was unsuccessful, the seed for institutionalised research had been sown. Private scientific bodies such as the “Bataafsch Genootschap voor Proefondervindelijke Wijsbegeerte” (Batavian Society for Experimental Philosophy) roused public interest in the physical problems of the country and created an atmosphere of research by awarding prizes for scientific progress. Probably influenced by the establishment of the “Ponts et Chaussées” in France in 1750, the Government appointed an “Inspector General of the Great Rivers” in 1754. The real breakthrough on governmental level came with the establishment, under French influence, of the aforementioned Central Authority of the Waters in the Netherlands, Waterstaat (“State of the Water-related Condition”) later Rijkswaterstaat, in 1798. On the educational level this was followed by the establishment of the Royal Academy for Civil Engineers in Delft in 1842. The change of the latter into the Polytechnic School of Delft in 1864 marked the transition of a military to a semi-academic education.

In the 18^{th} century it had become clear that the estuarine and river training works led to sedimentation and thus shoaling of the access channels to the Netherlands harbours, which led to a competitive loss relative to Britain and France. This explains why in the 19^{th} century Rijkswaterstaat concentrated mostly on the water infrastructure, both inland and sea-harbour related. Regarding the latter, the access channels to Amsterdam (1867) and Rotterdam (1872) were the most conspicuous. In contrast to the sluice solution for the access to Amsterdam, the access channel to Rotterdam was an open tidal river branch, based on the speculation that tidal action would maintain a navigable depth. This turned out to be false, but the progress in dredging technology based on steam engines could resolve this problem. Note that the US Army Corps of Engineers still today is the prime responsible for the maintenance of the inland waterway systems.

Near the end of the 19^{th} century, after the completion of the large waterways and the reclamation of the larger lakes, the interest in new reclamation works started to grow again, driven by the strong population growth. This, together with the issue of safety against flooding, has led to the design and construction of the two formidable 20^{th} century works described above, viz. the closure of the Zuiderzee (1927 - 1932) and the Delta project (1954 - 1978). These two projects triggered and strengthened the Netherlands research infrastructure, respectively.

The closure of the Zuiderzee was not just remarkable due to the size of the operation. The construction of the enclosing dam, although only feasible by craftsmanship and centuries of experience, marked the introduction of science into Dutch water management. The Lorentz committee (formally the Committee Zuiderzee Closure, but soon named after its president, physicist and Nobel Prize winner Lorentz) was established in 1917 to advise on the construction and on impact mitigation. Led by Lorentz, the committee developed the now well-known long-wave propagation equations with linearised friction to study the tidal motions in the relatively shallow Wadden Sea before and after the Zuiderzee closure. As a result of these studies, the dam was to be constructed on the ventral segment of the standing tidal wave to minimise adverse effects.

To supervise the execution of the closure works, an independent governmental body was founded in 1927, the Dienst Zuiderzee Werken (Department Zuiderzee Works). Also, in order to deal with the complex problems related to the hydrodynamic forcing on the necessary structures, the hydraulic laboratory 'Waterloopkundig Laboratorium' (currently WL|delft hydraulics) was founded in the same year. Both institutions were led by the same person, Thijsse, who a little later also held the chair of fluid mechanics on the Polytechnic School of Delft. This remarkable fact indicates the strong link that existed between practice, theory and education. Counterparts at Rijkswaterstaat that contributed to this link were Van Veen and Dronkers. All three, be it with different focus, expanded on the knowledge of tidal propagation in shallow tidal basins. Thijsse promoted the use of laboratory tidal models, Van Veen the use of field observations and the electric analogon for tidal motion and Dronkers the advancement of numerical techniques. Undoubtedly, a certain amount of competition has contributed to the knowledge development on this complex issue.

In the 1940's the growing insight into hydraulic phenomena, supported by observations, raised awareness amongst scientifically oriented engineers in Rijkswaterstaat that the dike heights in Zeeland would be unable to withstand extreme surge heights. In the period after the second world war this was politically inconvenient and Rijkswaterstaat chose to ignore these insights. Needless to say that the 1953 disaster rehabilitated the engineers that expressed their concerns.

In contrast to the Zuiderzee project, Rijkswaterstaat was this time allowed to create a department, the Deltadienst, to design and supervise the construction of the Delta project. Extensive research work, carried out in the first decades of the Delta Project, focused on technical feasibility of the highly innovative structural engineering aspects. This included

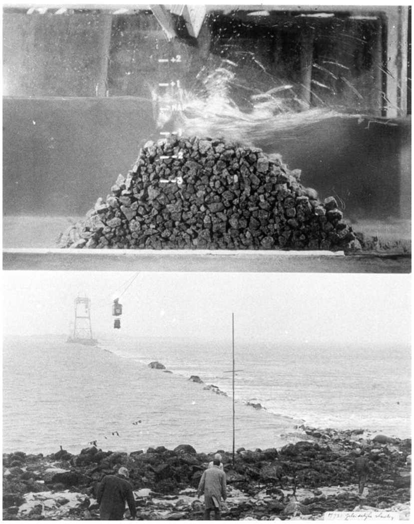


Figure 3.4: *Physical model research (top) for the closure of the Grevelingen (bottom) (Source: WL|delft hydraulics)*

research work on the geotechnical aspects and on the hydrodynamics and morphology of the coastal zone, in order to be able to warrant the stability of the structures (see Figure 3.4). The grounds for the existence of WL|delft hydraulics and its companion institute Delft Geotechnics Laboratories, which were amply involved in the research, was confirmed and strengthened. Nearing the completion of the Delta project, the position of the research infrastructure obviously came under discussion and a new era developed.

3.4 Usefulness and effectiveness of coastal research: drivers and programmes

3.4.1 Applied framework

The Dutch history of water management shows that the emphasis of government efforts to deal with natural threats has changed considerably through time. On the one hand, better technical means have increased the scope of hard engineering interventions. On the other hand, improved knowledge of the coastal system, insight into governing physical processes and changes in public awareness have shifted the focus away from these hard engineering works. It is in this context of coastal policy and coastal management that we investigate the goals and effectiveness of coastal research projects since the 1970's. To focus the analysis, we briefly describe the framework used in the investigation.

The applied framework for analysis assumes a cyclic change of focus at the strategic level of research funding, as well as the scientific level of the research itself. At a policy level, for example, this cycle can be recognised in the stages of policy development, application and evaluation. Different stages of this policy cycle logically involve different activities and a different need for information. The same stages can be identified in the development of coastal engineering knowledge. After a development stage, knowledge should be applied and subsequently be evaluated. Although these stages may not be completely separated or even explicitly indicated, they are useful for our analysis, since it is a matter of perception whether or not the work done in research programmes is useful. This perception varies with the progression of the aforementioned cycles. Analysing these cycles in the context of coastal research and coastal policy reveals a difference in pace with which these cycles progress at different levels. As a result, the perceptions of knowledge developers and knowledge users of what knowledge is useful, diverge over time.

Development of new policy, for example, is often paired with specific knowledge development. After some time policy makers who initially called for information to support their new policy development may have moved to the next phase of application at a policy level, while researchers are still developing knowledge for the previous phase, as a result of the difference in pace. At this point, perceptions of policy makers and researchers on what should be done within the framework of the research project start to diverge. Policy makers want to apply existing knowledge whereas researchers are of the opinion that the existing knowledge should be developed further to be suitable for application. When this discrepancy in perception becomes too large, dissatisfaction grows and research programmes may be terminated or discontinued, or otherwise intervened in. Emerging new societal challenges may give rise to the initiation of a new policy cycle. When in reaction a new research programme is initiated, both perceptions are reset to ‘development’ and the process starts all over again.

In the next sections, we put several research projects from the last thirty years into a broader perspective by confronting the project goals with some perceived ‘major’ issues at that time. The analysis shows that many of the changes in coastal engineering research programmes (termination of research programmes, shifts in research focus, etc.) can be explained from the aforementioned differences in individual perceptions of what should be the goals and effectiveness of these programmes.

The framework appears to restrict our analysis to research programmes with a clear goal and a recognisable problem owner. In other words, one might expect a focus on application-oriented research and not fundamental research. What is considered application-oriented by some, however, is considered fundamental by others. It is not the distinction we are looking for. We discuss application-oriented as well as science-oriented research and distinguish between free and driven research (see Figure 3.5). The term free research is used to indicate that the researcher is free to choose what he or she wants to investigate, while the term driven research requires the presence of someone, e.g. a financier, a problem

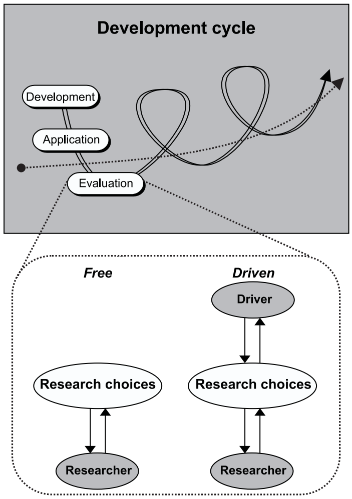


Figure 3.5: *Free versus driven research (modified from Van Koningsveld and Mulder, 2001)*

owner or the public opinion, that has a say in what should and should not be investigated. When money is not an issue (e.g., shortly after a calamity) research may appear to be free. Shrinking budgets appear to correlate with a stronger co-ordinating drive. One could wonder if truly free research even exists. For this reason we include discussions on related ‘driving forces’ in the evaluation of the goals and effectiveness of coastal engineering research projects. For the analysis of different research projects we have made use of Kraaijenbrink and De Vries (1980); Zitman *et al.* (1990); Terwindt and Battjes (1990); Bijker (1996) and the project plans and end reports of the various projects.

3.4.2 An orientation by national research and relevant drivers: 1970’s and 1980’s

In the 1970’s-1980’s, Rijkswaterstaat, in this period the dominant driver for development of coastal engineering knowledge in the Netherlands, was focussed on the finalisation of the Delta project. In 1971 the Brouwersdam and the Haringvlietdam had been completed and the closure of the Eastern Scheldt was imminent. The Delta project was deliberately organised to accumulate experience with the smaller closures, in order to be optimally prepared for the most complex closure of the Eastern Scheldt. The importance and size of the Delta project, combined with faith the benefits of technological development, motivated Rijkswaterstaat to make a huge investment into coastal engineering research. The initiated research programmes were closely related to questions raised by the closure of the Eastern Scheldt.

3.4.3 Construction of the Eastern Scheldt Barrier

• *1970 - 1974: Initial design Eastern Scheldt Barrier*
The period from 1970 to 1974 may roughly be characterised as the initial design phase for the Eastern Scheldt closure. In the perception of Rijkswaterstaat, the complexity of this closure was a clear justification for the development of fundamental knowledge. This would be the driver for the Fundamental Research Program Waterstaat, the FOW program (Fundamenteel Onderzoek Waterstaat). In September 1971, separate efforts in different research projects of WL|delft hydraulics and Rijkswaterstaat were combined in this FOW framework. The coastal part of the program was mainly devoted to the study -from a coastal engineering perspective- of coastal processes with typical time- and length-scales of a year and a kilometre. This was reflected by the eight different subjects, that were represented in this research framework: ‘wave generation’, ‘concentration and velocity meters’, ‘pulsating water tunnel’, ‘velocity fieds in waves’, ‘littoral transports’, ‘prototype measurements’, ‘refraction and diffraction’ and ‘coastal defence systems’. Until 1973 the research was concentrated within one group of researchers. In 1974 the framework was re-organised into eight working groups to reflect the principal subjects. Each working group was headed by a person considered as an authority in that particular field, rather than someone from the funding agency or an independent project manager. This leader was given a large amount of autonomy. The working groups, themselves, were headed by one steering group. The steering group, existing of the eight working group co-ordinators and one chairman, was appointed to make research plans, financial plans and co-ordinate the program as a whole.

• *1974 - 1980: Actual design Eastern Scheldt Barrier*
The period from 1974 to 1980 may roughly be characterised as the technical design phase of the barrier. In the perception of Rijkswaterstaat this required application of the existing and newly developed knowledge in an application-oriented research project. In practice this resulted (1975), in changing the name of the program from Fundamental Research Waterstaat (FOW, Fundamenteel Onderzoek Waterstaat) into Applied Research Waterstaat (TOW, Toegepast Onderzoek Waterstaat). Although the name had changed, the organisational structure of the program remained more or less the same. The TOW programme was organised in nine separate working groups and a steering group. On the one hand, the organisation method led to progress in each individual working group. Many of the concepts that were developed by TOW researchers are the basis of today’s hydrodynamic and morphodynamic process models. On the other hand, it led to problems in the co-ordination of the project as a whole (Kraaijenbrink and De Vries, 1980). The steering group tried to overcome these problems by means of a number of discussion documents which, of course, did not solve the problem. Besides the organisational structure, the topics investigated and the methods used also remained more or less the same as in FOW. Knowledge developed in the TOW project was integrated by directly involving TOW researchers in the design work by the Eastern Scheldt Consortium (OSC), rather than asking specific questions to the TOW project itself.

• *late 1970's: Shift in societal perception towards sustainability*
In the late 1970's, an influential shift occurred in public perception. In line with, or maybe even triggered by the Club of Rome report (Meadows *et al.*, 1972), an increasing attention for the scarcity of resources emerged. This resulted in a desire to assess and foresee the environmental impacts of human activities on the biotic and abiotic environment. This widened the scope of public perception and triggered questions not addressed in the TOW project.

• *1980 - 1986: Driver RWS - construction Eastern Scheldt Barrier*
The period from 1980 to 1986 may roughly be characterised as the actual realisation phase of the barrier. An important part of the work was carried out by the OSC. In the perception of Rijkswaterstaat, the usefulness and benefits of the TOW program became less evident. In response to the shifted public perception, other projects were initiated with an explicit focus on prediction and mitigation of geomorphological and ecological impacts.

- 1982 - 1986: GEOMOR focussed on monitoring, process-measurement and modelling of geomorphological effects on channels and intertidal areas inside the estuary

- 1984 - 1988: VOORDELTA focussed on monitoring, process-measurement and modelling of geomorphological effects on outer deltas

In the mid 1980's the discrepancy between the perception by Rijkswaterstaat of what knowledge was needed answering the higher-level questions and the usefulness of the knowledge generated by the process-scale research performed in the TOW framework caused termination of the programme, even though the knowledge developed in the TOW, transferred through individual researchers, was in fact of great use to the GEOMOR and VOORDELTA projects. This use, however, was not visible (enough) for the driving institute, Rijkswaterstaat.

3.4.4 Initiation of new Coastal Management Policy

• *1986 - 1990: Driver RWS - completion Eastern Scheldt Barrier, orientation on a new coastal policy*
The completion in 1986 of the Eastern Scheldt Barrier marked a crucial step in protecting the Netherlands from flooding, even though a number of defence works still needed to be upgraded to Delta strength. The completion of the Delta works gave rise to a perception that after centuries, the Netherlands had been 'completed'. Yet, accelerated sea-level rise and continued subsidence kept the issue of coastal defence on the agenda. Structural coastal erosion problems became increasingly important. As a result coastal research in the late 1980's became strongly influenced by the design of new coastal policy to counter this structural erosion and maintain the newly gained Delta level security. In 1986 the new Kustgenese (Coastal Genesis) research programme was initiated. As mentioned above, the TOW research programme as such (i.e. organised per discipline, focussing on coastal evolution processes of typical time- and length-scales of a year and a kilometre) had, in

the perception of Rijkswaterstaat, been too limited in scope. As a financier and initiator of the new Coastal Genesis programme, Rijkswaterstaat concluded that the growing interest in the longer-term development of the coast in relation to sea-level rise and other climate-driven changes increased the necessity to address research questions with a wider scope than just the coastal engineering discipline. The variety of geo-morphological processes and the diversity of time- and length-scales to be considered called for the involvement of other than just coastal engineering specialists. Geology, historical geography and physical geography were included as disciplines and a multidisciplinary effort to a holistic understanding of the physical aspects of the Dutch Coast was undertaken. An envisaged product was a physical-mathematical tool for coastal erosion management and eventually coastal zone management. This was at least the specialist interpretation of the project target: 'Assessment for the Dutch coastal zone of large-scale coastal processes and in particular the sediment balance that determines the current and future position of the coastline, in order to enable founded coastal management'. The entire project was to complete the following phases:

- Phase 1 (1985 - 1987) - Formulation and verification of hypotheses regarding evolution and behaviour of the closed Holland Coast

- Phase 2 (1988 - 1989) - Gathering and analysis of additional data and information; the design of an integral large-scale coastal management instrument

- Phase 3 (1990) - Analysis of additional data and integration into the management instrument, testing

This initial setup was downsized later on, but the first phase remained largely intact. It was decided that it would focus on the evolution of the entire Dutch coast over the past 5000 years. In fact, typical time-scales of 5000, 1000 and 100 years were distinguished. For each of these time-scales, a working-group was formed with the task to identify the physical processes dominating the coastal evolution at that scale. The fields of geomorphology, hydrodynamics and physical geography took a leading position in the Working Group 100 and the activities in this group were mainly concerned with coastal modelling and gathering of field data. Central in the Working Group 1000 were the fields of geology and historical geography and for the Working Group 5000 this position was taken by the field of geology.

The research strategy applied in each of these working groups was based on the rationale that the physical processes to be identified constitute the link between the external conditions or constraints that influence coastal evolution (wave climate, currents, availability of sediment) and the corresponding morphological response in the coastal zone. In this respect, reconstructions of the external conditions and the actual coastal evolution have been made. These aspects, called Input and Output, respectively, were determined first. The natural link between the Input and the Output is formed by the (geo-)morphological processes and their interactions, shortly denoted as the System. Put together, this approach is called the ISO-method. Correlating the Input and the Output has led to hypotheses regarding the (potential) relevance of various morphological processes that fit in the System (cf. Stive, 1987; Stolk *et al.*, 1987).

The researchers and research approaches in the Coastal Genesis Project were called upon when Rijkswaterstaat was commissioned by the Minister of Public Works and Water Management to prepare a national coastal defence policy. Until that time all attention had been focussed on the strengthening of flood defence works in reaction to the 1953 flood, based on the Delta Act (TK, 1958). The new coastal defence policy, based on the provisional version of the Coastal Defence Act (later formalised in TK, 1993), would be focussed on maintaining the achieved safety level. To arrive at the different policy options and to enable rational decision making, a large study was initiated. The technical foundation was to a large extent based on the work in the first phase of the Coastal Genesis project. Studies initiated were more or less focussed on (1) collecting existing (conceptual) knowledge from the Coastal Genesis project, (2) quantifying these concepts and (3) developing different coastal policy options. This was the first time that other functions than coastal safety were taken into account.

The outcome of these studies was used to compose a discussion document (Min V&W, 1989) containing four policy options to deal with coastal erosion: (1) retreat, (2) selective retreat, (3) preservation and (4) seaward defence. The different options where developed, based on a large-scale dynamic sediment budget, with an orientation towards intervention scenarios and accompanied by predictions of the coastal evolution for several climate scenarios. Eventually, the option of preservation was selected (Min V&W, 1990), though some elements of the fourth scenario were adopted (a perched beach on the coast of Zeeuws Vlaanderen, a large groyne at the North end of Wadden island Texel). The objective was to provide enough protection from flooding, while at the same time sustaining the other functions present in the coastal zone. The first Coastal Policy Document 'Coastal Defence after 1990' (Min V&W, 1990) implemented this long-term strategy by adopting the following policy goal with regard to the coastal zone: "Sustainable guaranteed safety of the hinterland and the sustainable preservation of functions and values in the dune areas. The coastline will be maintained at its position in the year 1990". To make the concept "…position of the coastline in the year 1990" operational for management purposes, the Basal Coastline concept (BCL) was introduced (cf. TAW, 1995a,b). The BCL methodology as such appears to be the only quantitative definition of a coastline that is formalised in legislation (cf. Van Koningsveld *et al.*, 1999). In the years that followed the BCL methodology would prove to be a powerful coastal management instrument. The most preferred management measure to maintain the position of the coastline was to replenish sand losses in the nearshore zone by means of sand nourishment (see Figure 3.6), at first only by beach nourishment, later extended to shoreface nourishment.

Now that the development phase of the new coastal management policy was completed, the need for the two remaining phases of the Coastal Genesis project became less obvious, in the perception of Rijkswaterstaat. As a result, it was decided to downsize these last two phases. In the perception of the researchers, this was a serious mistake and waste of effort.

Figure 3.6: *Example of a nourishment scheme (Source: Rijkswaterstaat)*

3.4.5 Influential changes

The completion of the Delta Works and the subsequent development of a coastal management policy, both initiated by Rijkswaterstaat, had been the dominant drivers of Dutch coastal research during the 1970's and 1980's. In the 1990's, three important changes influenced the national research infrastructure, viz. increasing international collaboration, growing complexity of research networks and a continuing struggle between science-driven state-of-the-art research and driver-inspired application-oriented research. We mention some developments, at different international levels, illustrative for these changes. A global development has been the awareness of limits to Earth's resources (late 1970's) and the potential impact of resources consumption on the world's climate (late 1980's). This has led to a huge research effort into climate change, including its impact on the coast through accelerated sea level rise. A European development has been the emergence of the European Commission's Research and Technology Development (RTD) Programmes (in the late 1980's and early 1990's), which stimulated European collaboration on coastal research between universities and research institutes from a strategic and pre-competitive R&D perspective. Another development was the tri-lateral co-operation between USA, Australian and European coastal scientists, acknowledging the importance of large-scale coastal behaviour (LSCB) and leading to the LSCB-conferences in Amsterdam, the Netherlands, in 1988 and St. Petersburg, Florida, in 1992.

3.4.6 Influence on research infrastructure

The aforementioned developments clearly influenced the Dutch research infrastructure in the 1990's. Acknowledging the importance of climate change and sea level rise, WL|delft hydraulics contributed to the vulnerability assessments by the ISOS-projects (Impact of Sea level rise on Society (i.e. ISOS, 1991)), which formed an input into IPCC studies (e.g. IPCC, 1992). Rijkswaterstaat took the Dutch lead, played an important role in the international efforts, e.g. via the World Coast Conference (WCC, 1993), and institutionalised these efforts by the foundation of the Coastal Zone Management Centre. Because this development focuses more on application-oriented research and management consequences, we observe a certain detachment of this infrastructure from the more science-oriented infrastructure. The European RTD Programmes were able to fill the budgetary gap that started to emerge as the Coastal Genesis project reached the end of its life cycle in the early 1990's. This, in concert with the international interest for LSCB, relaxed the almost exclusive dependency of the Dutch university and research institutes infrastructure from its main funding source, Rijkswaterstaat. In good co-operation with and involvement of Rijkswaterstaat, the Netherlands Centre for Coastal Research (NCK) was established, allowing the different partners to effectively perform in joint research proposals at European and national levels.

3.5 An orientation by national and international research: the 1990's

3.5.1 Influential drivers for knowledge development

In the following sections we describe three influential drivers in the development of coastal engineering knowledge in the 1990's, more or less in chronological order. First, at the national level, the 5-year cycle of Rijkswaterstaat-driven, application-oriented research in support of Dutch coastal policy was continued, establishing a steady interaction between research and application (Coastal Genesis 2 - Coastal Policy Document 1995, Coast*2000 - Coastal Policy Document 2000, Coast*2005 etc.). Second, at the European level, a series of RTD proposals and projects was triggered, initially focussing on fundamental process-scale research (G6-M and G8-M), later focussing on larger temporal and spatial scales, the development of guidelines and the exploitation of results for coastal management (NOURTEC, PACE, SAFE and COAST3D). Thirdly, again at the national level, revenues from Dutch natural gas resources were invested through the ICES-KIS programmes to advance the national state of knowledge through the application-oriented LWI programme, later on followed by the more science-oriented Delft Cluster programme. The description of these three drivers highlights the aforementioned internationalisation and increase in complexity, while at the same time it illustrates the struggle between science-oriented research and driver-inspired application-oriented research. Especially the international examples from the EU RTD program suggest that the observations made herein are not limited to the Dutch coastal engineering community.

3.5.2 Driver 1: Rijkswaterstaat, coastal science in support of Dutch coastal policy

The aforementioned 5-yearly cycle in Dutch coastal policy and research was continued throughout the 1990's. The knowledge developed in the first phase of the Coastal Genesis project had been effectively integrated into the development of a new Dutch coastal policy by closely involving the Coastal Genesis researchers in the supporting technical studies. Once the new coastal policy was set, the driving force Rijkswaterstaat shifted its attention to the implementation of the new policy, thus entering an application phase.

• *1989 - 1993: Coastal Genesis - Phase 2*

In the second phase of Coastal Genesis project research still focussed on the development of system knowledge at larger time scales. The working groups were now structured around the themes geological reconstruction, interrupted coasts and uninterrupted coasts. These themes reflect the main types of Dutch coast and thus would supposedly provide information more closely related to the coastal management problems encountered with these types of coasts. In the perception of Rijkswaterstaat, however, the implementation of the newly developed coastal policy raised questions that were not addressed in the second phase of the Coastal Genesis project. Hence, in their opinion, the researchers wasted their time by staying focussed on 'old' research questions, viz. the sharpening of hypotheses formulated in Phase 1. In the perception of the researchers, money and great opportunities would be wasted when the carefully developed hypotheses would remain untested. Many researchers were still used to research culture from the Delta project, characterised by large research budgets without much need for detailed programming. Times had changed, however, and so had priorities and conditions for budget allocation. This discrepancy in perception was growing, though not big enough yet to kill the project. As compared to the initial plans, the efforts in this second phase were scaled down.

• *1994 - 1995: Coastal Balance 1995 - Second Coastal Policy Document*

In 'Coastal Defence after 1990' (Min V&W, 1990), a choice was made to combat structural erosion, meeting the objectives of sustainable guaranteed safety of the hinterland and preservation of functions and values in the dune areas. For that purpose the coastline would be maintained at its position in the year 1990, applying the BCL methodology. Only five years after this policy was implemented, not much could be said about the effects and effectiveness of the dynamic preservation policy. Some intermediary reports attempted an evaluation by looking at the nourishments, carried out, including those of before 1990 (e.g. Roelse, 1988; Roelse and Hillen, 1993). Careful monitoring helped to assess the sand losses at deeper water. The second Coastal Policy Document 'Coastal Balance - 1995' (Min V&W, 1996) added the following to the 1990 policy objective: "In order to maintain the policy of dynamic preservation over a period of decades, sand losses at deeper water should be compensated for, as well".

• *1996 - 2000: Coast*2000*

At the start of the Coast*2000 research project, research institutes and consultants were invited to perform definition studies to indicate subjects that would require further research in the future. The definition, as such, of research topics related to practical problems went well. The persons defining the research needs, however, used as they were to the culture in the TOW and Coastal Genesis projects, seemed to overlook a change in appreciation of the time available for bringing new knowledge to application. Around this time a change in culture was taking place that drastically reduced the acceptable time-to-application. As a result, the proposed research plans were science-oriented, whereas the end users were more interested in application-oriented research. The difference in perception, was too large and the National Institute for Marine and Coastal Management, RIKZ, was commissioned to develop a new research proposal. The dynamic preservation policy developed in 1990 had been tested for five years and several evaluations claimed that the nourishment policy had been successful (cf. Roelse, 1988; Roelse and Hillen, 1993; De Ruig, 1995, 1998; De Ruig and Hillen, 1997). After the Second Coastal Policy Document from 1995, Rijkswaterstaat had indicated an interest in specialist support for practical problems encountered during the actual implementation of the coastal policy. It was for this reason that the Coast*2000 project was eventually designed to solve specific coastal management problems. Thus the new research project had become much more application-oriented than the researchers had originally envisaged. For example, following the Second Coastal Policy Document of 1995, the Coast*2000 research project included the development of a method to compensate sand loss on deeper water, with so-called system nourishment. In the resulting method, the coastal system is subdivided into littoral cells (see Figure 3.7) called Sandboxes that are assumed to be morphologically independent on a time scale of 50 years (Mulder, 2000; Van Koningsveld and Mulder, 2002). The overall approach is quite similar to the BCL approach, although the time and space scales involved (order 100 km - 50 Years) are an order of magnitude larger than those of the BCL approach (order 1-10 km - 5 years).

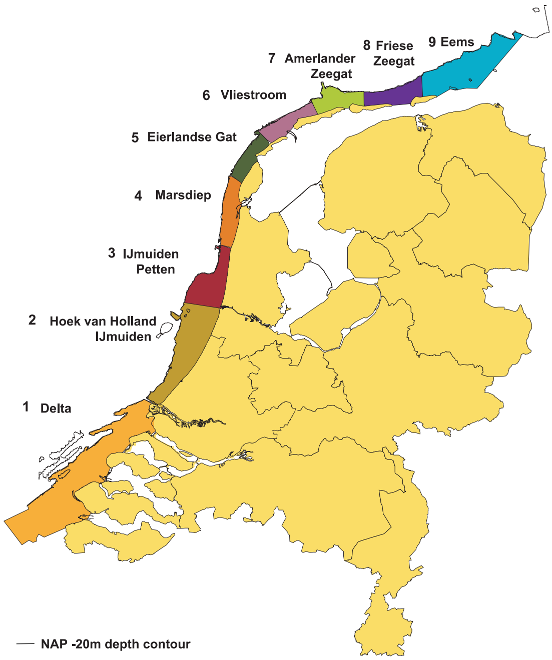


Figure 3.7: *Proposed division of the Dutch coast into nine independent cells (Source: Mulder, 2000)*

• *1998 - 2000: Tradition, Trends and Tomorrow 2000 - Third Coastal Policy Document*
The Fourth Water Management Policy Document of 1998 (Min V&W, 1998) extended coastal policy with the intention to work with natural processes, rather than against them. Necessary conditions for such a policy are that the dynamic nature of the coast is known and respected and that interventions are of a 'soft' nature. In the third Coastal Policy Document, 'Tradition, Trends and Tomorrow 2000' (Min V&W, 2000), long-term coastal stability is emphasised. Sea-level rise requires the Netherlands to 'grow with the sea', which means that all sand deficits in the coastal system are to be compensated. For that purpose the nourishment budget was increased from 60 Mfl to 90 Mfl (from app. 27.2 MEuro to 40.8 MEuro), based on the approach to long-term coastal management developed in the Coast*2000 project by Mulder (2000). The complete nourishment effort is expected to increase from 6 Mm3 to approximately 12 Mm3 of sand per year after implementation of the system nourishment approach, assuming a sea-level rise of 20 cm/century. The Policy Document on Nature Conservation (Min LNV, 2000), the Fifth Policy Document on Spatial Planning (Min VROM, 2000), the Fourth Policy Document on Water Management and the Third Coastal Policy Document form the administrative basis for policy decisions and maintenance activities. For the first time the sectoral approach has been overcome and an attempt is made to integrate policies across administrative borders. As a result, this Third Coastal Policy Document attempts to emphasise the link between coastal safety and spatial planning.

• *2001 - Present: Coast*2005*
Research managers of the Coast*2005 program realised that the Coastal Genesis project had yielded a great deal of system knowledge whereas the Coast*2000 project, apart from the newly developed long term coastal management strategy, was mainly aimed at solving specific coastal management problems. The Coast*2005 project would try to combine the best of both worlds (Dunsbergen, 2001). Based on the experiences from previous research projects and coastal defence studies, and influenced by a new approach developed in the European COAST3D project (Mulder *et al.*, 2001), the time-scale approach, first applied in the Coastal Genesis project, was further refined, so as to accommodate the interests of coastal management as well as coastal science.

The rationale behind the new approach was the notion (1) that the state of values and interests in a coastal system can be evaluated at various time scales and (2) that these time scales provide an important indication of the system behaviour that is relevant for coastal management (Van Koningsveld *et al.*, 2000). Coastal safety, for instance, needs to be guaranteed at time scales ranging from seconds to centuries. At the scale of hours and days one might consider dune erosion due to storm activity. At a scale of decades to centuries one might need to focus on processes involving sea level rise etc. Relevance to end users of research with a given time and space scale can thus be coupled with functions that are evaluated on that particular time scale (see Figure 3.8). The user functions should provide handles for the definition of relevant system indicators and reference states, while research should use these indicators to express their knowledge of the relevant system

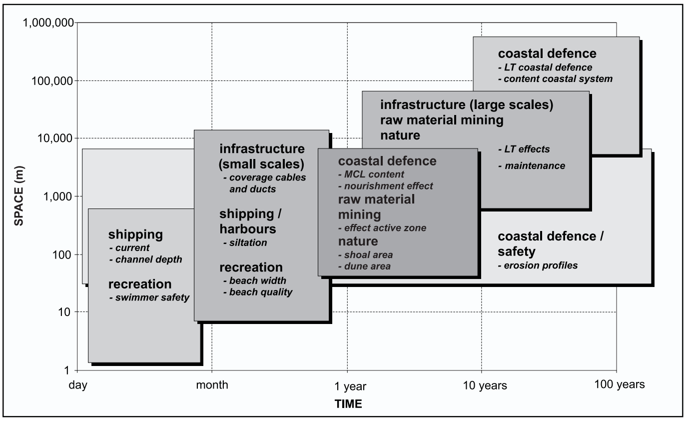


Figure 3.8: *Range of CZM issues coupled with time and space scales (Source: Mulder* et al.*, 2001)*

behaviour in terms that are useful to coastal managers. This approach aims at facilitating the development of generic system knowledge, but only that knowledge that is needed for coastal management practice. Thus, it also leaves room for an application-oriented approach. Besides the generation of knowledge, its documentation, accessibility and dissemination are equally important. For this reason, knowledge management was explicitly included in the Coast*2005 project.

The time lag in the reaction of researchers to the above-described change in culture was promoted by their possibility to remain focussed on science-driven research through the European RTD programmes. In combination with the continuing natural cycle in policy development, this has caused an apparent increase, or at least a continuation, of the discrepancy between the information needed by end users and that provided by researchers.

3.5.3 Driver 2: European RTD programme

The European Union is a major sponsor of research activities in many areas, in support of Community policies and priorities. Through its research funding, the EU aims at advancing European integration via the development of scientific and professional networks, European competitiveness via the development of state-of-art knowledge and a Europe-wide improvement of the efficiency and effectiveness of policy making and decision making. The main vehicle of European Union research are the Framework Programmes for Research and Technological Development (RTD), a multi-year plan drafted by the European Commission, and approved by the Council of Ministers and the European Parliament with input from the Member States and the Economic and Social Committee. The Framework Programmes provide legal and administrative structure, scientific and technical objectives, and financial resources for EU-sponsored research. The programmes are financed from the General Budget of the European Union, consisting of Member States' financial contributions. Projects that receive research funding under the Framework Programme must involve participants from industry, universities or research laboratories from at least two EU Member States. Projects are selected competitively on the basis of scientific merit, whence countries cannot automatically expect their research institutions to receive funding in proportion to their contributions to the budget.

In this RTD framework the Marine Science and Technology Programme (MAST) was initiated in 1989. This was the first Community programme in the field of marine research. Other programmes (e.g. environmental protection, climatology and natural hazards, fisheries, technological development in the hydrocarbons sector, non-nuclear energy and some activities of the Joint Research Centre) had a bearing on topics in marine science and technology, but none were directed specifically to marine research. The objective of this programme was "To contribute to a better knowledge of the marine environment, an improvement in its management and an enhanced capacity to predict changes within it on the basis of cooperation with national and international programmes in this field. Furthermore, to encourage the development of new technologies for the exploration, protection and exploitation of marine resources.". The MAST programme extended over three Framework Programmes (FP2-FP4), from 1989 through 1998. It has been a significant driver for coastal engineering research throughout Europe during the 1990's. In the next subsections we provide a concise, more or less chronological, description of consecutive coastal research projects under the MAST programme. Note that the projects mentioned are not all the coastal research projects in MAST. Their common denominators are rather a heavy Dutch involvement and a strong coupling with the RWS-funded research.

• *1990 - 1992: G6-M Coastal Morphodynamics (MAST I)*
G6 Coastal Morphodynamics (G6-M), a cluster of six interrelated projects, was initiated under the EU Marine Science and Technology Programme (MAST-I). In the perception of the EU the early stage of a Europe-wide coastal research initiative should warrant (1) a fundamental effort to equate the state of knowledge across Europe and (2) an emphasis on creating scientific and professional networks. The G6-M project was executed by a group of six European hydraulic laboratories, with fourteen associated contractors. Its overall objective was to develop agreed, validated and balanced numerical modelling concepts for morphological problems in coastal areas, to be implemented, applied and tested by the leading European advisory institutes in this field. The project objective was to be achieved by bringing basic process knowledge and modelling techniques between the partners to an appropriate level and integrating them into research versions of wave, current, sediment transport (cohesive, non-cohesive) and morphodynamic simulation models. The concepts were tested and validated, and the results were to be laid down in a handbook on coastal morphodynamic modelling. A wide range of methods were used, ranging from linear and non-linear theoretical analyses, laboratory experiments and field investigations through to numerical modelling (cf. De Vriend, 1991, 1993a,b).

• *1992 - 1995: G8-M Coastal Morphodynamics (MAST II)*
G8 Coastal Morphodynamics (G8-M), the successor of G6-M, was also a cluster of projects in the framework of the EU Marine Science and Technology Programme (MAST-II). It was led by the "Group of Eight" (G8), which was formed by the major European hydraulic laboratories involved in coastal research. The overall objective of the G8-M project, remained "to develop agreed, validated and balanced numerical modelling concepts for morphological problems in coastal areas to be implemented, applied and tested by some of the leading European advisory institutes in this field, in collaboration with specialised university groups" (cf. De Vriend, 1995; Stive *et al.*, 1995).

At the end of the G8-M project important advances had been achieved. Most researchers involved pursued a continuation of the research direction initiated in the G6-M and G8-M projects. A valid desire in the perception of the researchers, as from a scientific and networking perspective this programme had been very successful. In the perception of the EU, the networks created in the G6-M and G8-M projects were so strong and hard to penetrate (the word 'cartel' was used) that it would complicate competition. Furthermore, after a period of six years, knowledge development alone was no longer a priority. The other objectives of initiating the RTD programmes, e.g. the improvement of the efficiency and effectiveness of policy and management, became relatively more important. The coastal research projects that followed would be clear descendants of G8-M. In fact many of the researchers involved in these new projects had been involved in the G8-M project, but a shift in focus could be detected. The G6-M and G8-M projects were process- and modelling-oriented research efforts, as would be the later modelling-oriented SASME (1997-2000) and the process-oriented SEDMOC (1998-2001). Most of the projects following G8-M, however, viz. NOURTEC, SAFE, PACE and COAST3D, would be smaller, with fewer partners, oriented on larger scales than just the process scale and focussed more on the practical applicability of results. To illustrate this, we briefly describe the latter type projects in the following subsections.

• *1993 - 1996: NOURTEC (MAST II)*
NOURTEC aimed at a set of generalised conclusions on the design, the effectiveness and the feasibility of shoreface nourishment techniques in different coastal environments (cf. Hoekstra *et al.*, 1994; Mulder *et al.*, 1994; NOURTEC, 1997). This was to be achieved through a comparative analysis of three full-scale experiments of different nourishment techniques (i.e. shoreface nourishments and combinations of shoreface and beach nourishments) implemented in three countries bordering the North Sea (Netherlands, Germany, and Denmark) and covering a range of hydrodynamic and morphological conditions. Common design parameters would be defined for all three experiments, describing the different design objectives. These parameters, together with the dominant processes, would constitute the basic elements in the monitoring and measurements programme. Correlations were then derived between the design parameters and the pertinent physical parameters. Whilst the analysis of the field data was based on statistical methods, state-of-

the-art mathematical models of coastal morphodynamics were used in a diagnostic mode to analyse the dominant processes and to derive indications of future effects on coastal preservation. As such the NOURTEC project was an attempt to aggregate process measurements to larger scale morphological behaviour.

• *1996 - 1999: SAFE (MAST III)*
SAFE was initiated in support of coastal management authorities and the European Commission to consider fundamental design, maintenance and performance assessment necessary for objective evaluation of beach and shoreface nourishments. Consistent application of evaluation criteria was necessary for the identification of coastal hazards, like flooding and erosion. The programme objective was to develop a new methodology to predict the medium (several months) and long (a few decades) term performance of artificial nourishment schemes by introducing reliable and validated numerical modelling tools, which need to be robust and general enough to deal with a wide variety of field situations from dune restoration to shoreface nourishment. The SAFE project was able to describe the history of nourishments in Europe and the different strategies of individual countries that have emerged over the last decades. The synthesis of these strategies has led to recommendations which may assist countries to harmonise their strategies.

• *1996 - 1999: PACE (MAST III)*
The PACE project aimed to validate, improve and extend engineers' and scientists' capabilities to understand and reliably predict the large-scale morphological behaviour of sandy coasts and to bring this product closer to the end users (coastal zone managers, public decision makers) (cf. De Vriend, 1997, 1998). To that end, coastal morphodynamic processes were observed, analysed and modelled at scales much larger than those of the predominant variations of the system's input and its constituent hydrodynamic and sediment transport processes. Four interwoven avenues were followed to achieve these goals, viz.

- "data-driven modelling", trying to describe the observed coastal behaviour in mathematical terms without going into the underlying dynamics,

- analysis of the morphodynamic system's inherent instability, i.e. its tendency to form rhythmic morphological patterns,

- "upscaling" from detailed descriptions of waves, currents and sediment transport in interaction with the changing bed topography,

- qualitative modelling, meant to provide convincing information to lay people involved in decision-making processes concerning coastal zone management.

This project has definitely contributed to a broader perspective on coastal modelling and knowledge representation, but it also encountered the practical difficulties of linking up with an ill-defined group of end users.

• *1997 - 2001: COAST3D (MAST III)*
The purpose of the COAST3D project (Soulsby, 1998) was:

- to improve understanding of the physics of coastal sand transport and morphodynamics,
- to remedy the present lack of validation data of sand transport and morphology suitable for testing numerical models of coastal processes,
- to test a representative sample of numerical models for predicting coastal sand transport and morphodynamics against this data, and
- to deliver validated modelling tools, and methodologies for their use, in a form suitable for coastal zone management.

The project objectives were to be achieved by conducting field measurements purpose-designed for numerical model evaluation, with adequate boundary conditions and a dense horizontal array of measurement points, in conditions typical of the European coastline. Previous coastal experiments in Europe and elsewhere had placed their main emphasis on hydrodynamics; an innovative feature of the COAST3D project was that the emphasis throughout was on sand transport and morphodynamics. Another distinctive feature was the focus on non-uniform (3D) coasts, rather than on the relatively well understood (but possibly unrealistic) uniform 2D case. Experiments were performed at two contrasting sites: a quasi-uniform (2.5D) stretch of the Dutch coastline, in which the three-dimensionality is provided by rip channels intersecting a breaker-bar system (see Figure 3.9); and a fully 3D site on the UK coast, featuring a beach and spit adjacent to a tidal inlet and rocky headland. This phased approach allowed both the process information and the performance of the numerical models to be more easily interpreted. Innovative techniques would be used in the experiments. Numerical modellers would work interactively with the experimenters, at the planning, experiment, and evaluation phases. Participants from national regulatory authorities were to ensure that the project was focused on practical tools for coastal zone management. How this fourth objective was to be achieved proved far from trivial. The translation of project results to end users took place at the end of the project, separated from the project's technical activities. This approach did not yield the expected results. As an alternative, a methodology was developed to facilitate the formulation of research questions, explicitly related to practical problems, at the beginning of the project, so as to facilitate the translation of results at the end (Van Koningsveld and Mulder, 2001; Mulder *et al.*, 2001). This methodology is being applied in the current EU FP5 projects SANDPIT and COASTVIEW. The COAST3D efforts are described in more detail in Chapter 4.

In hindsight, the EU RTD-programme, at least as far as coastal research is concerned, seems to go through similar development stages as the Dutch coastal research efforts, initially focussing on fundamental process-scale research (G6-M and G8-M), later focussing on larger temporal and spatial scales, the development of guidelines and the exploitation of results for coastal management (NOURTEC, SAFE, PACE and COAST3D).

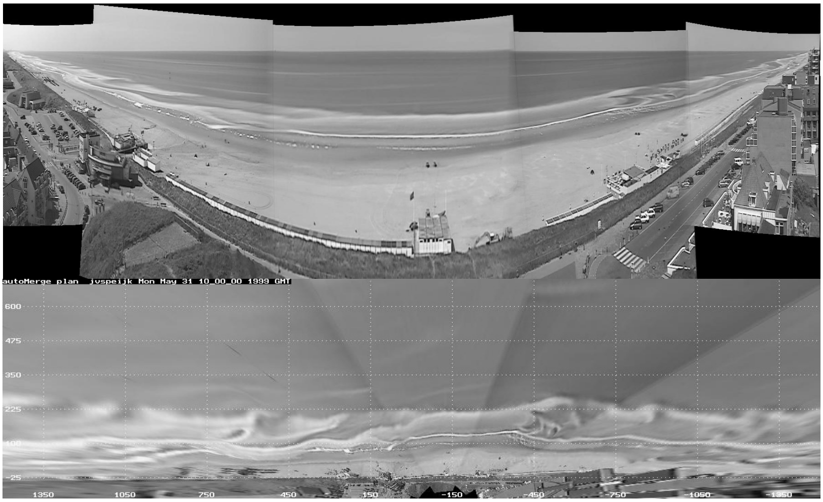


Figure 3.9: *The Argus video technique reveals alongshore non-uniform features on the central part of the Dutch coast which was previously assumed to be alongshore uniform (Source: Rijkswaterstaat)*

3.5.4 Driver 3: National ICES-KIS driven research

In 1994 perceived weaknesses in the knowledge infrastructure triggered the establishment of an Interdepartmental Committee for Economic Structure enhancement (ICES). The working group Knowledge Infrastructure (ICES-KIS) advises the Dutch government on investment strategies for development, expansion, dissemination and exploitation of knowledge in support of the Dutch economy. The ICES-KIS programmes are long-term investments financed from the Dutch natural gas revenues and intended to enhance the knowledge infrastructure as a fundament of the Dutch economy. As such, the aim of the ICES-KIS programmes in general and coastal research in particular is significantly different from that of the Rijkswaterstaat-driven research. Since 1994 two investment rounds have been put into effect (ICES-KIS I (1994-1998) and ICES-KIS II (1998-2002)) and a third round is currently in preparation. Coastal research issues were addressed in the Land Water Environment Information Technology project (LWI, ICES-KIS I), and are being addressed in the ongoing Delft Cluster project (DC, ICES-KIS II).

• *1994 - 1999: LWI (ICES-KIS I)*

The Land Water Environment Information Technology project (LWI) was initiated in a time with the important trends of the upcoming influence of computers and information technology, on the one hand, and the increasing complexity in realisation of large infrastructural projects, on the other. The LWI project aimed to combine the (supposed) benefits of the former in support of the latter. Large infrastructural projects impact the landscape (see Figure 3.10) and meet an ever increasing resistance from different stakeholders. Stakeholder influence is important as it may lead to more widely accepted decisions, as became apparent in the case of the Eastern Scheldt closure. Finding efficient ways to deal with this influence, however, is an important issue, because it can delay, paralyse or otherwise impact the decision process. A long list of expected future projects, like a northern branch of the A4 highway, the problems with the expanding Schiphol airport, the planned Betuwe railway from Rotterdam harbour to the hinterland, the Second Maasvlakte to expand the Rotterdam harbour, the continuous deepening of the Western Scheldt to provide access to Antwerp harbour, etc. justified research into the decision processes related to the realisation of such projects and the role of knowledge in these processes. An integral approach, exchanging information from a range of different perceptions on the issues at stake

Figure 3.10: *The first Maasvlakte as an example of the impact of large scale infrastructure on the landscape (Source: Rijkswaterstaat)*

was (and still is) thought to be a possible solution. ICT based decision support systems were developed that combined knowledge on a variety of disciplines, from coastal engineering and ecology to economy and sociology. The emphasis, however, was placed on the integration of (existing) measurement, modelling, processing and design techniques. In hindsight, it would have been possible to couple complex models in support of strongly simplified decision making processes. The actual support to the infinitely more complex real-life decision making processes proved to be far less effective.

In the perception of the researchers, the project yielded important results on the use of information technology in combining different sources of information and coupling complex models, on the one hand, and in the intensive co-operation with consultants, contractors and end users, on the other hand (LWI, 1998). The expectation that combination of information would produce a high added value proved to be difficult to prove to end users. A lot of the project benefits were based on practical experience that proved hard to transfer. On top of that the time needed to produce a decision support tool was so long that by the time the tool was finished the original question had changed or lost its relevance. As a result, the decision support products were used by consultants and contractors that were involved in the project, rather than the actual decision makers that were less involved. The fact that the LWI products had only a modest impact in decision processes was in the perception of researchers also due to the fact that the decision makers were not ready for (or not yet interested in) the new technologies. In the perception of decision makers involved, the LWI solutions were often focussed too much on the technical aspects of the issues at hand. On top of that, the technical solutions would often be developed in isolation. More benefits were recognised at the level of communication, e.g. in ‘role playing’ and ‘gaming’. These ‘tools’ proved to support the understanding and appreciation of the position of others in the decision process. End users perceived this as a greater contribution to decision making than the technological facilities.

After the LWI project, focus shifted away from decision support towards fundamental knowledge development necessary to deal with the future challenge of large infrastructure projects. The Delft Cluster project initiated under ICES-KIS II united five Delft knowledge institutes, active in the field of civil- and hydraulic engineering, in a knowledge network aimed at advancing and distributing of knowledge in these fields. Although the intended focus was on fundamental research, the involvement of the so-called ‘sector’ makes the Delft Cluster research far from free research. The driving force of the co-financing sector is definitely present, even if the majority of the matching funds is provided by governmental institutions.

• *2000 - present: Delft Cluster (ICES-KIS II)*
The starting point of the ICES-KIS II programme, and hence of Delft Cluster, was pre-competitive research, towards the fundamental end of the spectrum. At the same time, Delft Cluster has a co-financing formula of 40% ICES-funding, 30% partner contribution and 30% matching from the ‘sector’ (government, private consultants and contractors in

civil and hydraulic engineering). Delft Cluster is meant to be an open network, centred around the five main partners, for strengthening knowledge development and dissemination. As far a coastal research is concerned, DC is very much a continuation of previous programmes, or an extension of ongoing ones. The matching requirement leaves little room for free research. One important innovative element in DC is called biogeomorphology, which stands for the integration of physical and ecological aspects of surface water systems. Important changes with respect to previous coastal research programmes are the explicit attention for knowledge management and circulation, and the involvement of the commercial sector, implying that Rijkswaterstaat is no longer in exclusive control of this research (though still a most important player). As a consequence of its structure, DC contributes to the increased complexity of research management. The co-financing requirement by DC and other research financiers leads to a complex clustering of projects, since matching is mostly ‘in kind’, via other projects (which usually don’t match perfectly, neither in funding, nor in time). The multi-partner requirement leads to the involvement of several partners executing a cluster of projects. Hence, research into a certain issue usually involves a number of mutually matched projects, commissioned by different funding agencies and carried out by a significant number of institutes.

Despite this shift from the application-oriented LWI back to the more science-orientated Delft Cluster approach, the discussion on how to translate research findings into useful products for end users in the contributing ‘sector’ continues. This provides yet another illustration of the continuing struggle between application-oriented and science-orientated research. In ICES-KIS III which is currently under development, and discussion on this subject has started, once again. Now that the funding agencies have somewhat relaxed the restriction to fundamental research, there is scope of more user-oriented activities such as demonstration projects and software development.

3.6 Analysis of historical observations

What can be learnt from the above described historic overview of coastal research projects?

Content Analysis of Research Programs

Looking at the content of coastal research projects we can observe two things:

(a) a broadening of the frame of reference in coastal policy and management

(b) a reflection of this broadening in the accompanying research, though with a certain time lag.

Over the years we have seen a shift in strategy, from adaptation, to protection and finally to accommodation, in society’s response to natural challenges. Especially in the last three decades, an increased interest in other aspects than just safety from flooding greatly complicated decision processes. The worldwide trend to treat coastal problems with holistic and integral approaches illustrates that this development is not restricted to the Netherlands. By analysing some national and international coastal research projects over this same time period, we have been able to identify the effect of this increased complexity on the content of these programmes, albeit with a certain time lag. In the Netherlands case, the initial research focus on hydrodynamic and morphodynamic processes was particularly inspired by questions regarding the required strength and stability of planned coastal engineering works to guarantee a certain level of protection from flooding. A focus easily explained from the traditional Dutch emphasis on protection. The broadening of society's frame of reference resulted in different questions for coastal policy makers, triggering the need for a different type of knowledge. This gave rise to a shift from development of fundamental and process scale knowledge towards the development of more holistic and multidisciplinary knowledge, marked by the introduction of disciplines like geography, ecology, economy etc. On top of that the accepted time to go from study to application, in the design of infrastructure or in support of new regulations, had drastically decreased. This gave rise to a still continuing struggle between the development of new knowledge, and the application of existing knowledge.

Process analysis of Research Programs

Independent of the (scientific) content, each research program appears to exhibit the following lifecycle:

- initiation of the program,
- performance of research activities,
- increasing dissatisfaction of research drivers and end users,
- intervention, downsizing, discontinuation or termination of the program.

The historic description of coastal research projects over the last 30 years shows how through time research drivers would become increasingly dissatisfied with the results of their R&D investments. Whenever this dissatisfaction became too large, it would result in intervention in existing programs, i.e. termination or downsizing, and shifts in research focus in newly initiated programs. Initiation of new research projects gave drivers of knowledge development programs the opportunity to reset the project goals to better reflect their altered need for information. The cause of this growing dissatisfaction may be explained from a diverging perception between drivers and researchers on what is relevant research. The seemingly inevitable divergence is due to a difference in pace between coastal policy and management, on the one hand, and coastal research, on the other. Policy makers and managers have to apply existing knowledge while researchers are still of the opinion that the existing knowledge should be developed further to be suitable for application, thus introducing the aforementioned time lag. As a result research drivers feel that the process from knowledge development to practical application takes too long. They perceive the continuous initiation of new projects as a good method to stimulate and focus researchers. Researchers, on the other hand, feel that 'good' research requires time. They perceive the continuous initiation of new knowledge development projects as an inefficient use of resources.

Problem setting

The above described lifecycle found in practice illustrates a gap between drivers and users of knowledge and developers of knowledge. The period of years over which these research programs run is long enough for the consequences of this gap to (eventually) surface. In fact the gap may be the most obvious in long-range research programmes, but its consequences can also be recognised in other types of projects or research projects with a shorter life span. There are many examples available of research reports that remain unused, or even unread, and research outputs that in the perception of researchers provide an answer to the question, but that the end user is unable to use or recognise as a solution to his/her problem. The gap between coastal science and coastal management is often described as a 'knowledge gap' or a 'communication gap' and a commonly suggested way to bridge this gap is through 'improved communication' (e.g. EU, 1999; Capobianco, 1999; RWS, 2001). But what exactly is to be improved? Our analysis shows that the gap may in fact best be characterised as a 'relevance gap' and we should improve the communication on what is 'relevant information', 'relevant knowledge'. Of course, the relevance of information and knowledge is a matter of perception. Not all knowledge that is scientifically relevant (long term), is also practically relevant (short term). Currently, the content of research programmes is mainly driven by researchers aiming for scientific relevance (see Figure 3.11).

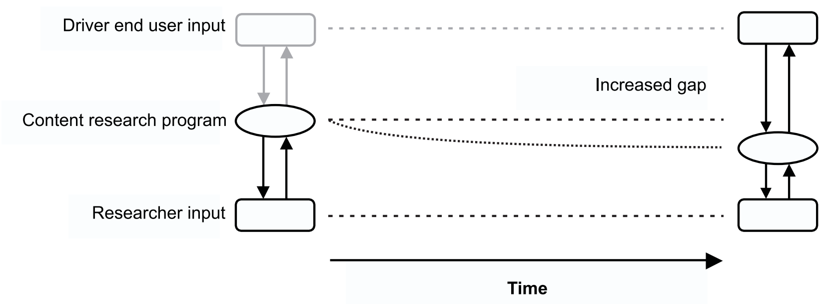


Figure 3.11: *Unbalanced driven research programme*

Suggested solution

Differences in pace between R&D and application trigger an increasing difference in perception of what is relevant. This explains the growing dissatisfaction of research drivers. When the difference in perception becomes too large, this may result in intervention in the program itself or a different focus in following programs. This was the case with the shift from process-scale research (TOW) to larger time and space scales (Coastal Genesis 1) in the 1980's, with the reorientation following the definition studies for Coast*2000, with the shift from the application-oriented LWI program to the more science-oriented DC programme etc.

Mulder *et al.* (2001) notice that, although many research programs are often granted based on practical relevance, only few coastal research projects have actually attempted to translate their findings into management-relevant knowledge or information, and often with limited success. They attribute the difficulty of translating the knowledge to end users to the lack of end user's involvement in driving the content during the programmes. The resulting emphasis on scientifically relevant information makes an ex-post translation of the research results difficult, if not impossible (Figure 3.11). To improve this situation they suggest to establish a more balanced drive throughout the project (Figure 3.12). To make this suggestion operational they present a methodology for the development of a 'frame of reference', e.g. based on the analysis of policy documents and interviews, which helps to identify knowledge gaps that match the need of end users related to a particular problem. End users, as well as researchers, are stimulated throughout the project to indicate their progress in broadening or detailing this frame of reference. As such the method provides handles to design the content and the process of ongoing programs, so as to combine practice-oriented research with curiosity-driven research. The method is currently being tested in several coastal research projects.

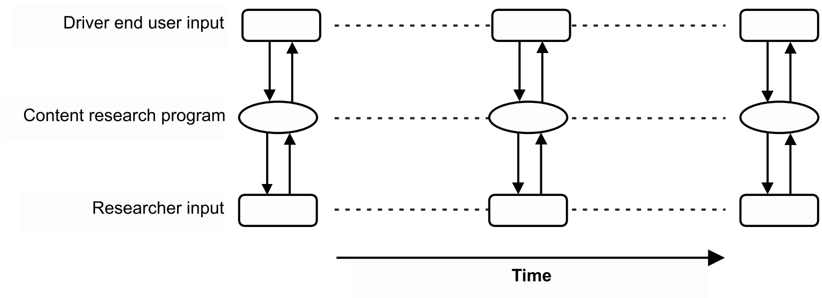


Figure 3.12: *Balanced driven research programme*

The application of the methodology for a balanced drive is a necessary but insufficient condition for success. Obviously willingness to co-operate, an open atmosphere and a flexible attitude are also required to provide a favourable context. Individual personalities, research management and finance regimes can either stimulate or impede the development of such a context.

3.7 Conclusions

Dutch water management has traditionally been influenced by technology and technological innovation. In the early 20th century, large scale flood defence works of unprecedented scale, viz. the 'Afsluitdijk' (1927-1932) and the Delta Works (1958-1986), triggered the introduction of science into watermanagement. An overview of the coastal research projects and Coastal Policy Documents of the last 30 years serves to illustrate the continuing dilemma of technical and scientific innovation versus practical use for coastal management and coastal policy. When left unattended, an increasing gap emerges between what is relevant research from a scientific point of view and what is relevant research from driver/end user point of view. A brief analysis of a number of international European projects supports the conclusion that this dilemma is international in nature and not limited to the Dutch case.

To avoid or postpone the seemingly unavoidable occurrence of a gap in driven research programs, we advocate to balance the end user and researcher inputs throughout the project and suggest to take the information need of the end user as a starting point, rather than the scientific state-of the-art. It is our firm belief that it is in the interest of both coastal management and coastal science to monitor and bridge the ‘relevance gap’ described in this chapter. It is in the interest of the driver and end user, so that he/she can take better informed decisions. It is in the interest of the researcher, so that he/she can secure the necessary research funding and the opportunity to test findings in practical situations. The amount of resources invested in coastal research and the huge interests looked after by coastal managers and coastal policy makers justifies efforts to avoid or at least postpone the aforementioned divergence of perceptions. Active involvement of drivers/end users and researchers in driving the content of ongoing projects, e.g. by frequently confronting research results with developing driver/end user needs, is a promising way of doing this.

Chapter 4

Bridging the relevance gap

4.1 Introduction

Chapter 2 describes why, when and how coastal managers may call upon specialists for system state descriptions, intervention development, impact assessment and reduction of uncertainties. Required specialist knowledge may be gathered through studies or developed in research projects. Chapter 3 shows that the perceptions of coastal managers and coastal scientists, regarding the usefulness and effectiveness of coastal research programs, do not necessarily agree. In fact their respective perceptions seem to diverge invariably over time. As a result coastal managers often feel that it is difficult to apply the results of research or studies to policy formulation and practical management. For a specialist in coastal behaviour, for example, useful information might be a set of equations or a model that better describes bar-behaviour under currents and waves (information about reality). For a coastal manager, it might be a decision recipe for the design of shore nourishments (information for reality). The former may be used to improve the latter. In practice such benefits of specialist knowledge are often not or hardly recognised. As a likely reason for this divergence, a lack of 'driver or end user involvement' is suggested in Chapter 3. To avoid or at least postpone this seemingly unavoidable divergence, balancing the end user and researcher input throughout the project, e.g. by frequently confronting research results with developing driver/end user needs, has been suggested as a promising solution. This chapter describes an effort to make the above-described abstract notion more concrete and operational.

We start with a description of the efforts to extract useful elements for coastal management from the scientific research undertaken in the context of the COAST3D project. From this practical example we draw lessons regarding the difficulties associated with managing 'driven' research and the elements that are crucial in matching specialist research efforts with end user needs. Based on these lessons we suggest a methodology to support a balanced drive of research projects with an end user component.

4.2 Lessons learned from the COAST3D project

4.2.1 Setting the stage

The COAST3D project (Soulsby, 1998), a collaborative project co-funded by the European Commission's MAST-III programme and national sources, has run from October 1997 to March 2001. A consortium of 11 partners from five EU states (UK, Netherlands, France, Spain and Belgium) worked on the project. As mentioned in Sub-section 3.5.3, it had the following objectives:

- to improve understanding of the physics of coastal sand transport and morphodynamics;
- to remedy the present lack of validation data of sand transport and morphology suitable for testing numerical models of coastal processes at two contrasting sites;
- to test a representative sample of numerical models for predicting coastal sand transport and morphodynamics against this data; and
- to deliver validated modelling tools, and methodologies for their use, in a form suitable for coastal zone management.

The COAST3D project explicitly intended to address the translation of end results to end users. From this perspective, the most challenging objective of the COAST3D project has been: 'to deliver validated modelling tools, and methodologies for their use, in a form suitable for coastal management'. A challenging objective in the sense that, although many coastal research programs are often granted based on practical relevance, only a few of these projects have actually attempted to translate the knowledge gained into coastal management guidelines, and often with limited success. The EU demonstration projects on Integrated Coastal Zone Management (EU, 1999), amongst others, have signalled this problem and identified as some of the causes:

- the lack of consideration/contact with potential customers for the research results and an assessment of their needs at an early stage; and
- an unwillingness among academics to consider practical and workable approaches in applying science to 'simple' situations.

Against this background, governmental agencies -end users participating within the COAST3D project- from the onset of COAST3D have continuously stimulated modellers and experimenters to demonstrate the usefulness of their tools for end users. Contrary to the conclusions of EU (1999), this process identified as a basic problem:

- the formulation by coastal managers of questions that unambiguously provoke answers covering the actual information need.

The fact that researchers feel that on the scientific level usually significant progress has been made, has led to a common interpretation that the translation of results is a knowledge management problem. The work in this thesis suggests that at least part of the issue is a research management problem. The opposing views on where to start, suggest that any attempt to deal with this problem is likely to meet opposition. Nonetheless, finding a methodology to handle this problem has become a major challenge for the COAST3D project and the research reported in this thesis.

4.2.2 Concise project description

Except for the project's fourth objective, the COAST3D project was science-driven. Therefore the majority of the project participants were science-oriented institutes (universities and hydraulic laboratories). The project primarily entailed modelling and fieldwork. To facilitate communication and co-ordination the project had established a limited hierarchical structure. The project was controlled by a steering committee under supervision of the project coordinator. Considering the topics to be covered by the project three sub committees were formed: the modellers group, the experimenters group and the CZM tools group. The modellers made up the bulk of the project personnel, followed by the fieldworkers and the end users, respectively.

Scientific objectives
The first three objectives of the project aimed at increasing physical system knowledge and use it to improve the descriptive and predictive capabilities of present models of coastal behaviour.

For this purpose four field experiments were successfully conducted, resulting in large amounts of high quality data on water-levels, currents, waves, sediment transport and bathymetric changes. The first two experiments took place at Egmond on a quasi-2D sandy stretch of the Dutch coast, with pilot and main experiments in spring and autumn 1998, respectively. The second two experiments took place at Teignmouth on the south coast of England in spring and autumn 1999, where a rocky headland and a river mouth give rise to a strongly three-dimensional morphology, dominated by sand and shingle sediments. Analysis of the data provided new understanding of coastal physical processes, assumed to be valuable for coastal management, both directly and indirectly through the improvement of hydrodynamic and morphodynamic numerical models.

The field measurements were specifically designed to support testing, evaluation and further development of (numerical) hydrodynamic and morphodynamic models. For this purpose fieldworkers aimed to supply the modellers with adequate boundary conditions and a dense horizontal array of measurement points. To coordinate efforts, modellers and the experimenters worked in close interaction at the planning, experiment, and evaluation phases of the project.

In hindsight the project was, and in fact continues to be, successful in obtaining its scientific objectives.

Practical objectives
Section 2.4 has shown how models can be considered to be tools for CZM. Field measurements and monitoring, in their own right, represent basic tools for CZM in many practical cases. The comparison of the models with collected data is an important step forward in achieving greater confidence in their use for practical CZM problems. As a secondary product, the project's fourth objective of delivering suitable information for coastal management, was to be obtained through the development of guidelines for the use of the scientific products as CZM problem solving tools. The development of these guidelines was the responsibility of the CZM tools group. Main participants in the CZM tools group were Rijkswaterstaat, from the Netherlands, and the Environment Agency, from the United Kingdom. The guidelines were to meet a *specific* and a more *general* objective. The specific objective was:

- to enable the coastal zone manager to make optimal use of the research results and available tools of the project COAST3D,

the more general one was:

- to contribute to bridging the existing gap between coastal science and coastal management.

The guidelines were primarily targeted at coastal managers at the level of regional engineers within a national authority. At the same time the contribution of COAST3D research groups to the production of the guidelines was to promote their involvement in application oriented research and stimulate awareness of their role in it. Therefore, a secondary target group consisted of coastal researchers, their managers and funders, and universities. Within the range of potential CZM tools, COAST3D focussed on its "core business", i.e technical design tools.

The original plan regarding the 'guideline development' issue was to wait for the final results to be presented at the end of the project. The CZM tools group would then gather all scientific information developed in the project and translate it into useful information for end users. No concrete practical problem to which the researchers could contribute had been formulated, however, and there was no clearly identified client for the planned guidelines. As a result there was hardly any pressure on researchers to actively consider the interests of the CZM tools group *during* the project. To make sure that the fourth project objective would not be forgotten, the CZM tools group continuously tried to stimulate the researchers to consider the needs of the end user. In practice, however, the lack of a concrete approach how to do so, made these efforts fruitless. A method was developed for this purpose. In the next section some of the efforts of the CZM tools group to that effect are described.

4.2.3 The efforts of the CZM tools group

During the COAST3D project it became clear to the members of the CZM tools group, that the formulation of guidelines for the use of COAST3D project results as CZM problem solving tools, would be a tough problem. As a matter of fact, as more time went by, the eventual translation seemed to become ever more problematic. Something had to be done to change the originally intended knowledge management type approach of "*translation* of scientific results at the *end* of the project" to a research management type approach focusing on "the *production* of relevant practical results *during* the project". The question was how to do this in a constructive manner. An approach had to be developed that would enable the CZM tools group to focus the efforts of researchers on the development of practically useful results *during* the project.

The first activity of the CZM tools group regarding this matter consisted of an effort to increase awareness of the issue by presenting a general approach to coastal management problems and the role of fieldwork and modelling therein. The science-oriented participants, however, felt this approach was far too general and they felt unable to apply this framework. More concrete questions had to be posed.

In a next attempt, an inquiry to obtain information from the project participants had been shaped in the form of practical cases for the areas of Egmond and Teignmouth. The questions in these cases were deliberately chosen to be very specific and at several levels of aggregation (Mulder and Van Koningsveld, 2000b). The new *problem driven* approach suggested by the CZM tools group was not appreciated much, as can be read in a rather critical review of the approach by project coordinator (Soulsby, 2000):

> "… The general framework being proposed would be very appropriate to a project on national or international coastal policy, and forms a very worthwhile PhD project. But I am not convinced that it is an appropriate output of the COAST3D project - it does not draw sufficiently on the content of the rest of the project. … I am concerned here that the proposed approach is being driven by the needs of MvK's PhD thesis rather than the needs of the COAST3D project. …".

Nonetheless this review contained a number of very interesting comments related to generalist-specialist interaction in general and differences in perception, regarding what would be relevant information for coastal managers in particular (see Chapter 2 and Chapter 3). Parts of the review are quoted below:

From Soulsby's review: "…

> **CZM TOOLS -**
> **RESPONSE TO JAN MULDER'S NOTE DATED 25 FEB**
>
> …
>
> I agree with many of the points that Jan makes in his email and attachment, but not with all of them. Specifically:

• **Modification of concept**
I agree that there is a big gap between what CZ managers need, and what researchers (COAST3D or other) can provide, which is partly a communications problem. It is certainly true that the researcher does not find it easy to present his results in a way that contributes to CZM, and also that CZ managers have difficulty defining what they want. I think this is partly why we are progressing in a rather uncertain manner towards the CZM Tools product in COAST3D, and I have seen the same difficulty in other projects (CAMELOT, Estuaries Research Programme).

I agree that it is important to pose specific questions to the participants, but I am not sure they will be able or willing to answer the very problem-specific but research-general questions posed . . .

. . .

• **Objectives**
The COAST3D project certainly was conceived to improve generic techniques, and this does lead to some problems of translating results to site-specific problems. But there is a danger that if we concentrate heavily on site-specific problems then we lose the benefits of the generic approach, and (importantly) it could be seen as providing nationally-orientated outputs which would be criticised in the final scientific review of the project.

• **Road to travel**
I like the idea of describing the situation before COAST3D, and then the contributions made by the project.

• **Contribution participants / concrete assignment**
Some clearly defined tasks for the participants are very desirable. But who should answer them - every participant, contact person per institute, leaders of tasks/subtasks? This needs to be clear, otherwise everyone will expect someone else to answer.

. . .

• **Appendix B**
This sounds much too esoteric and abstruse for the COAST3D project, ... It mainly describes how national policy is handled, and is very specific to the Dutch national case, in particular the “recipes”, which follow from Dutch legislation. Remember that the CZM Tools Group decided that the primary target reader of our CZM Tools report should be the Regional Engineer, with a secondary target of the research community - I don’t think either of these types of reader would derive much benefit to how they operate from this appendix.

. . .

“SO WHAT IS COAST3D LIKELY TO ACHIEVE?”, I HEAR YOU ASK.

I think the questions posed by the CZM Tools Group to the other participants should be devised in such a way that the participants can give meaningful answers, based strongly on the work they have done in the project. The sorts of answers that I could imagine participants giving (once their work is completed) are:

1. Related to innovative measurement techniques
"My research using X-band radar has produced a new remote-sensing technique for underwater bathymetry. It can only be used when waves larger than *x* m. are present, and it can operate out to depths of *y* m. It can be used during storms, when other techniques are not usable. It is accurate to +/- *z* m."

Similar answers could be given for WESP surveys, ARGUS, GPS on Quadbikes, etc., for ABS, SLOTS and the CRIS instruments for sediment transport, and for the various wave-measurement systems.

2. Related to process understanding
"My research on swash-zone processes has produced a better understanding of the relative magnitudes of swash and surf-zone sediment transport rates. It has provided a formula for sediment transport rates that can be incorporated into Coastal Profile and Coastal Area numerical models to enable them to make predictions of morphological change above the still-water line. It is believed to be accurate to +/- *x*%, for grainsizes in the range *y* to *z* mm."

Similar answers could be given for Low-frequency Wave contributions, wave propagation over dissected bars, wave reflection from beaches of different slopes, jet formation from river mouths, sandwave migration, etc.

3. Results related to modelling
"My research using a Coastal Profile Model has shown that such models are not able to make detailed predictions of bar and beach development on individual profile lines in areas such as Egmond where the beach is strongly 3-dimensional with rip channels and dissected bars. However, if the model is run for a long-shore averaged bathymetry, the CPM is able to make predictions of bar and beach development that lie within one standard deviation of the mean observed development, where both mean and s.d. are calculated from a set of profiles spaced 50m apart. We expect that such models run in this way will provide useful predictors of the response of a beach to natural storm and tide events, and to the effectiveness of stabilisation methods such as re-nourishment."

Similar answers could be given for Coastal Area Models, including reliability of wave propagation models in complex bathymetries, effectiveness of tidal models in reproducing eddies off headlands, conclusions drawn about techniques for making long-term predictions of sandbank migration, etc. Such models can be used to test schemes for maintenance of navigation channels and dredging requirements, flood defence in complex areas, positioning of outfalls, effectiveness of seawalls and their interaction with beaches, etc.

I feel that we are more likely to draw out all the value from the project if we ask questions that require answers like the above (possibly giving the participants these answers as models). And that we also should keep the set of site-specific problems as wide as possible, rather than concentrating on only one or two aspects.

Richard Soulsby 2 March 2000"

Needless to say the proposed problem driven approach never made it past the steering group. A major concern was that not all participants would be able to contribute directly to the suggested cases. The steering group was worried that the questions posed would not bring out the 'true value' of the essentially science driven COAST3D project. The answers suggested in Soulsby's review were useful in the *perception* of researchers, as it would enable them to display what they had achieved - *'what was done how?'*. For end users such answers would only be interesting after it would be clear why they would need certain system information, e.g. measurement data, process understanding and model results, in the first place. Thus, in the *perception* of the end users, these answers alone would not be very useful, as they would fail to provide solutions to one of their main problems - *'when to do what?'*.

A more generic approach needed to be devised, capable of satisfying both needs. In a third attempt, the tools group's efforts were directed at formulating a generic problem for all coastal managers of comparable stretches of coast (cf. Mulder and Van Koningsveld, 2000a). The rationale behind this effort was that, dealing with coastal systems in a rational and sustainable manner, all coastal managers are basically interested in describing the state of the system under their control. Based on a comparison of this system state description with a desired or reference state the manager can decide on the need for intervention. To understand and evaluate the impact of alternative interventions the coastal manager also needs to understand the internal working of the system. So beside a useful system state description, the coastal manager also needs knowledge on the systems behavior. In a questionnaire the partners were confronted with an *imaginary* coastal manager that had just accepted a new job somewhere on a European stretch of coast. It was stated that this manager knew nothing of the area under his control and the first item on his list would be to get a description of the state of his coastal system. All partners were asked to help this imaginary coastal manager to deal with his tasks and problems. The questionnaire requested to make concrete suggestions, including a description of the way they had described the system at Egmond and Teignmouth and the tools they had used in the process. The questions were accompanied by example answers, at different space and time scales, as suggested in Soulsby's review. The results of the inquiry (9 questionnaires sent out in total - one to each participating institute - return rate 100%) was that all but one exclusively returned information on 'what was done how?'. The CZM tools groups had expected the included background information to lead to more information on 'when to do what?', a nuance illustrating the different perspectives of specialists and generalists! The example answers in Soulsby's review did include references to the use of models to test e.g. effectiveness of re-nourishment, maintenance schemes for navigation channels, coastal defence schemes etc. In practice no such references to practical applications were made, at all, in the answers to the questionnaire. The one that did, was filled out by Soulsby himself. As a matter of fact, it proved virtually impossible for the CZM tools group to formulate questions that *would* result in this type of answers. For the short term, some benefits of the questionnaire results were to be found in the fact that more clarity had been obtained on why some of the specialist answers where perceived to be of limited use to end users. Discussions on how to produce more productive results, however, were perceived to be far too abstract.

To get more information from the partners on 'when to do what?' the original case approach came back into focus. The observation that it was hard to formulate questions that would result in the desired type of information triggered the notion that, instead of asking ‘open’ questions, it would be more productive to confront researchers with a ‘closed’ suggestion for a practical approach and ask them to improve it based on their expert knowledge (Van Koningsveld and Mulder, 2000). To facilitate the specialist’s contribution, the suggested practical approach should explicitly include the management hypotheses on which this approach was based; hence the name ‘hypothesis network’-approach. To prevent specialists from hiding behind unfinished models and research, they would be challenged to apply their current state-of-art models and knowledge in so-called ‘pilot applications’.

In a fourth attempt, a new case was developed, with the objective to draw information from the project on how to decide on the ideal mix between modelling and fieldwork given a nourishment problem - information on ‘when to do what?’. This subject was so directly related to the essence of the COAST3D project that it would be impossible for the researchers to claim that they could not comment. A lot of energy was invested in interaction early in this new (sub)project to make sure everybody understood the objectives and supported the initiative. A special CZM workshop involving representatives of all partners was designed specifically for this purpose. At the end of this workshop two pilot applications, designed with great level of detail and aimed at providing specific information on the mix between modelling and fieldwork, had been formulated and agreed upon by the researchers. As a result, the CZM tools and guidelines were now on the project agenda and integrated in the modelling and analysis of fieldwork that remained to be done. This was celebrated by the CZM tools group as an important step towards producing useful guidelines, as the perceptions regarding what was needed and what was going to be developed eventually seemed to match.

Unfortunately, by this time, the COAST3D project entered its final stage and all project participants had to focus on producing the contractually required scientific deliverables that were included in the Technical Annex rather than on addressing the additional elements that had been introduced during the project by the CZM tools group. As a result, only one institute was able to address the agreed case in the end. A more detailed description of this attempt is given by Walstra and Van Koningsveld (2001). Thus, despite all the efforts, gathering the results and interpreting them into useful guidelines still proved to be a ‘mission impossible’ at the end of the project. Although the CZM tools group had not received the information they had hoped for, at least the confidence of end users in the possibility of getting useful input from a project like this had increased. On top of that, a clearer view of what would be perceived as useful results had been achieved.

4.2.4 Evaluation of the guideline specification objective

Researchers, throughout the COAST3D project, were focussed on the development of scientific knowledge. The CZM tools group was expected to facilitate the collection, aggregation, translation and ultimately the transfer of the knowledge developed during the project to end users, at the end of the project. Towards the end of the project, however, the CZM tools group found it hard, if not impossible -apart from crude generalisations- to describe which practical problems could benefit in which way from the knowledge developed in the COAST3D project.

The conclusion was reached that the science-driven knowledge development effort had resulted in a vast amount of knowledge of which the relevance to end users was almost impossible to determine. At the final workshop of the project a metaphor was used describing the project to yield a ‘fireworks of end results’ from which the end users were to ‘catch’ the relevant results. Although the CZM tools group was sure that such relevant results must have been present, they were obscured from the end users by the splendor of the fireworks. It was concluded that in order to produce ‘end user’ results, research would have to be managed in a different, more problem driven, way, where end users and researcher would actively work together, looking for opportunities to improve coastal management practices. The previous chapter suggests that this problem is not limited to the COAST3D project, but more general in nature.

In hindsight the problems encountered during the process of guideline specification may indeed be characterised as symptoms, as intended in Lemma 2.5, of a gap between the researchers and the end users in the COAST3D project. The above-described process provides a clear illustration of how this gap was caused by the mechanism indicated in Hypothesis 2.1. The difference in perception in this case is the difference between the problem-driven focus of the end users and the science-driven focus of the researchers. This difference had existed implicitly throughout the project. The efforts of the CZM tools group helped to make it explicit, albeit only towards the very end of the project. As such the efforts of the CZM tools group resulted in an excellent illustration of generalist-specialist miscommunication. It should be emphasised, however, that the COAST3D project has been *scientifically* successful. The problems and miscommunications described here specifically relate to the project’s fourth objective, viz. to deliver validated modelling tools and methodologies for their use in a form suitable to coastal zone management. And even though not all the goals of the CZM tools group had been achieved, the efforts and discussions during the project have greatly enhanced our insights in this matter.

Bridging the above-described ‘gap’ proved to be a non-trivial problem, that indeed gave rise to many difficulties and frustrations. The continuous miscommunication is illustrated by typical researcher’s complaints like: “Why don’t you ask us more specific questions? Then we will be able to apply our models!” and typical end user’s reply’s like: “I do not need your models, I need solutions for my problems!”. The above statements indicate two important lessons that were to be learned from the COAST3D guidelines experience. Participants to end-user oriented or ‘driven’ research projects should carefully consider them as important elements in the process:

1. the explicit link between research results and practical applications; and

2. the communication between end users and researchers.

Considering ICM problems as a starting point, it is not enough to develop recommended procedures on HOW to use numerical models in coastal practice, it is just as important to specify WHEN, WHAT type of model (or measurement- and analysis method) is needed (i.e. for what type of problem). Therefore, guidelines for using available tools -as an example of the explicit link between research results and practical problems- should answer, in a *problem driven* manner, the following basic questions:

- WHEN to use, WHAT tools, and HOW to use these.

These three elements indicate the relevance of knowledge to problems and together provide the arguments WHY a coastal manager, dealing with a specific problem, could benefit from the application of specialist knowledge.

Answering the WHEN question first of all, requires an analysis of the ICM problem(s) resulting in a specification of the information need. Part of this process is the definition of the problem and of the general objective and an analysis of its context and of its dimensions (see Sub-section 4.3.1 and 4.3.2).

Then, the answer to the question WHAT tools to use requires an information strategy (see Sub-section 4.3.2). Such a strategy depends on:

- the availability of data and tools and possibilities for monitoring and measurements;

- availability and (more important) the validity of numerical models, considering the spatial and temporal scales of interest; and of course

- the optimum combination of tools in terms of accuracy, time, effort and cost.

Finally, the question HOW to use the tools may lead to guidelines for each individual tool. Examples are:

- statistical analysis techniques (minimum data demands etc.);

- monitoring and measurement schemes (parameters, instrumentation, frequency and spatial distribution, accuracy etc.); and

- methodology and procedures for applying individual numerical models.

In the COAST3D case this last type of information seemed to be the easiest to produce (see Appendix 1 and 2 in Mulder *et al.*, 2001). The next section presents a generic methodological approach aimed at explicitly obtaining the above described requirements for useful ICM guidelines.

4.3 A methodological approach to driven research

Now that we have a better idea of the difficulties associated with ‘matching specialist knowledge with end user needs’ in driven research situations, we attempt to develop a methodology that can help in dealing with this type of problem. The analysis in Chapter 3 and the COAST3D experience show that a key element in the miscommunication between specialists and end users in the context of driven research projects, is the lack of an explicit common conceptual frame of reference regarding the problem at hand and the information needed to deal with it. Although coastal managers may have a clear opinion on why they do or don’t need certain specific information (*intent*), a vision of the required *content* and *form* is usually much more vague. Because the requirements for an end product are not known accurately beforehand, specialists contracted to deliver the results find room for interpretation. On the one hand, this flexibility supports the innovative process. On the other hand, it involves the risk that perceptions diverge, causing results to mismatch the end user’s needs in terms of content, form and ultimately intent. In the COAST3D project, for example, it was observed that specialists, when given flexibility, are inclined to give (technical) information on ‘what was done how?’. It proved much harder to get (cognitive) information on ‘when to do what?’.

In the remainder of this chapter we develop a methodology to support efforts to rationalise the use of specialist knowledge in coast related decision processes. The methodology aims to make the essential (technical) components of a decision making process explicit.

4.3.1 The ‘ideal’ frame of reference

Framework for analysis

As stated before, dealing with coastal problems, coastal managers continually need information related to the system under their control. A discrepancy between the actual and desired state of the coastal system, surpassing some predefined threshold, defines a ICM problem. The general objective of ICM is to prevent and mitigate these problems. Although decision making may in practice be not or only marginally based on rational (physical) arguments, we believe that decision processes involving specialist knowledge ***ideally*** should be as rational and transparent as possible.

Rational and transparent decision making requires sound and well-founded argumentation. Specialists may support coastal management by providing information needed for this argumentation. They may describe the system, explain occurring phenomena, reduce uncertainties in predictions of these phenomena etc. We believe that specialist knowledge ***can*** be used to increase the rationality and transparency of decision processes.

Coastal management processes involve a complex of information. We have seen that perceptions on what information is relevant may vary considerably, depending on a given point of view. For a specialist in coastal behaviour, relevant information might be a set of equations or a model describing bar behaviour under the influence of waves and currents, whereas for a coastal manager it might be a decision recipe for designing shoreface nourishments. Despite the difference in perception, the link between both viewpoints is obvious: knowledge from the former may be used for improvements of the latter. In practice however, potential benefits from specialist knowledge for coastal management are often difficult to recognise. The previous example is illustrative for the presence of a 'gap' between the problem-driven requirements of CZ managers and the science-driven goals of researchers.

A way to identify and overcome these differences is by communication on what is 'relevant knowledge'. To identify problems in the communication process we need some sort of reference with which the current method of communication may be compared. For this purpose we introduce into the framework for analysis presented in Section 2.6, the concept of an 'ideal' frame of reference to describe the process of problem solving and decision making and provide handles on roles, responsibilities and the function of knowledge in an 'ideal' situation.

Starting point

The framework for analysis from Section 2.6, described coastal management as a chain of interdependent problem solvers. Within this 'problem solving chain', feelings rather than facts often trigger coastal management initiatives. Whether or not some situation actually presents a problem can only be objectively evaluated against some (explicit) frame of reference. Initial analysis is required to further define the actual problem and an approach towards this problem. Values and interests, at stake in coastal management projects, are guiding for our 'ideal' frame of reference (see Figure 4.1). In the 'problem solving chain', determination of ***values*** and ***interests*** through some form of public debate, is the responsibility of politics. To enable objective evaluation of these values and interests they need to be defined more clearly. For this purpose abstract policy may be detailed by one or more themes that may be divided into aspects that may in turn be subdivided into sub-aspects etc. The words 'theme', 'aspect' and 'sub aspect' in themselves have no formally defined

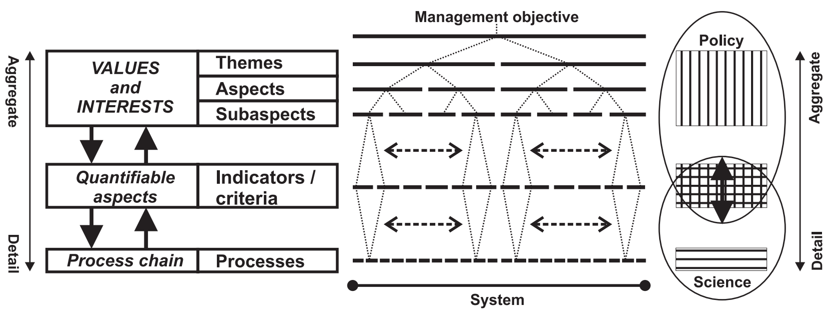


Figure 4.1: *'Ideal' frame of reference.*

meaning but are only meant to indicate that one is a detailing of the other. As such they should be related. Experts can play an important role in the detailing process by providing sound argumentation.

One example of values is related to large scale sand mining: the theme ‘Ecosystem North Sea’, can be divided into aspects like benthos, fish, and birds. Each aspect can be subdivided into different species, aspects of species and aspects of aspects of species etc. In the ‘ideal’ case the detailing process stops at a quantifiable level of detail that enables rational deliberation of values and interests at the higher level of aggregation. For researchers this means that models should be as complicated as necessary, but as simple as possible (cf. De Vriend, 1998, 2002).

> *The process of defining quantifiable aspects is a typical arena where coastal science and coastal management meet.*
> *Choosing between quantifiable aspects is a responsibility of politics.*
> *Suggesting practical quantifiable aspects is a responsibility of science.*

Impact assessment

For measurability of intervention impacts on the system (e.g. large scale sand mining), the detailing process should ‘ideally’ be aimed at deriving one or more quantifiable aspects, commonly referred to as indicators or criteria. Systematic identification of such quantifiable aspects requires system knowledge and insight into the ‘cause effect’ chain expressed in terms of governing processes. The interaction between decision makers and researchers regarding the definition and selection of suitable quantifiable aspects involves a lot of discussion. Some commonly accepted methods, structuring this discussion are available, i.a. the PSIR and the DPSIR approach (OECD, 1994). The construct of values and interests, quantifiable aspects and the supporting ‘cause-effect’ chain can be visualised, e.g. in impact matrices and conceptual models (see also Chapter 2).

Effect scoring

The evaluation of impacts, expressed in terms of changes in the predefined quantifiable aspects, requires the execution of four steps (see Figure 4.2):

Order	Steps	Hierarchy
1	Establishing **reliability/certainty** of predicted effects. Determined by knowledge of the ‘cause effect’ chain and the choices of methods (models, assumptions).	4
2	Establishing **significance** of effects. Determined by knowledge of natural variation in the system.	3
3	Establishing **distinction** between different feasible alternatives for intervention.	2
4	Establishing **relevance** of potential effects, confronted with a desired reference state through some predetermined testing procedure.	1

Figure 4.2: *Problem solving steps*

The first two steps could be completed bottom-up (or system driven) based on existing knowledge of the relevant processes. The primary responsibility for the statements in these steps lies with the scientific community (see Figure 4.3).

To complete the last two steps, a top-down (values and interests or problem driven) definition beforehand is needed of:

a) a ***reference state***, (meaning a description of the desired state per (sub)aspect. This description should exist of a set of quantified indicators representing the benchmark situation);

b) a ***benchmarking procedure*** (viz. determination of the margins between which the indicators may fluctuate before intervention is required); and

c) potential intervention ***alternatives***.

The primary responsibility for the choices in these steps lies with the political community (see Figure 4.3).

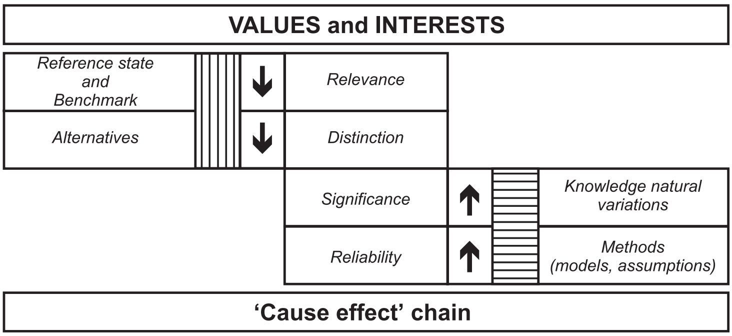


Figure 4.3: *Impact assessment steps*

The *order* (in the sense of what comes first) of the steps for CZM problem solving is usually bottom-up. The *hierarchy* (in the sense of what determines what) of these steps is top down (see Figure 4.2). When explicitly defined, these elements together constitute a framework for rational and transparent decision making that both decision makers and experts can refer to in the interactions in the 'problem solving chain'. As such this *'frame of reference'* provides an important communication tool.

'Ideal' versus real

All ingredients of above 'frame of reference' being present, the conditions are set for a systematic, objective and reproducible impact evaluation: an 'ideal' situation. In reality this is rarely the case. At the political level there is often little agreement on the system's reference states. In cases where there is agreement on these states, they are mostly not (yet) quantifiable. This is often caused by a lack of system knowledge among policy makers and managers. This provides triggers for the political community to engage the scientific community. On a scientific level also ample knowledge gaps exist, which inhibit quantification. Even the first step of evaluation often proves problematic: quantitative expressions of model output accuracy are often not available. Another complicating factor in an integral evaluation of impacts is the difference in state-of-the-art of different aspects and different elements of the 'cause effect' chain. Within the current context, frames of reference given a policy or management objective are therefore rarely in their 'ideal' state. As a reference the 'ideal' does, however, provide handles for improvement of the use of scientific information and a determination of priorities.

A notion that provides an important handle for process improvement is that, in the context of generalist-specialist interaction, attention should be focussed on identification of the ***relevant*** information. Relevance is of course a matter of perception. When matching specialist knowledge to end user needs, relevance to the end user is of paramount importance.

> *What information is **relevant** to the end user depends on the coastal zone management issue at hand.*
> *What information is **needed** by the end user depends on the state of his knowledge.*
> *What **effort** is needed to gather that information depends on the availability of knowledge and resources.*

Combining these three elements and including the specialist's state of knowledge, we can modify Figure 2.5 to include the following knowledge transfer situations (see Fig. 4.4).

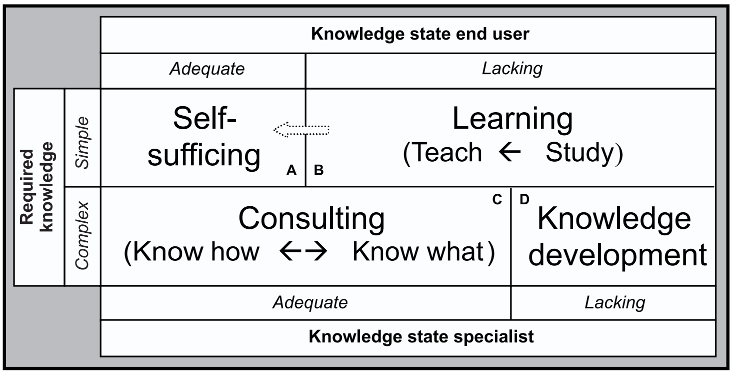


Figure 4.4: *Knowledge transfer situations.*

Just as in Chapter 2 we briefly discuss the diagram from the perception of the end users. Situation A then symbolises a 'simple' case where the decision maker's state of knowledge is adequate to deal with the problem independently. According to Lemma 2.3 the ‘gap’ will not present problems in this knowledge transfer situation because communication with experts is not necessary in this case. Advisors/specialists are only present in the background as developers of knowledge or authors of reports, books and articles.

Situation B represents a ‘simple’ problem combined with a lacking knowledge state of the decision maker. Maybe the decision maker is new on the job and not yet fully trained. In this case, the transfer of existing knowledge could be enough to alter the state of knowledge to adequate and basically create a type A situation. In simple situations where the specialist’s state of knowledge is also lacking a study may need to be commissioned first to gather the required information.

When the problem is more complex, again two situations may be distinguished. In situation C, the state of knowledge of the decision maker is lacking, whereas the specialist’s state of knowledge is adequate. The required information may not be transferred easily, due to the complexity of the problem. To use the available, albeit tacit knowledge, specialists may be involved early in the process. Either to share their ‘know how’, thus enabling the end user to solve his problem, or to help him by solving the problem.

Only when the state of knowledge of the specialist is also lacking, it may be necessary to develop new knowledge (situation D). Another option could of course be to find a different, more experienced specialist whose state of knowledge *is* adequate (situation C). The same goes for the decision maker of course.

4.3.2 Problem driven analysis of ICM information need

Good practice in dealing with knowledge development and transfer in support of CZM decision making is:

- First, identify the end users state of knowledge regarding the issue at hand.
- Next, aim the information to be supplied at improving (altering, broadening or detailing) the end user’s state of knowledge, rather than reporting the improved scientific state of art.
- Finally, design the knowledge transfer process to match the ‘knowledge transfer situation’.

It is easy to understand how the suggested frame of reference should work in this context for a clear and well-defined problem. It is less clear, however, how to proceed when only the intent of required information is (vaguely) known.

The image of the ‘ideal frame of reference’ is generic in the sense that applies to all ICM issues and related combinations of values and interests. In this section the generic image is made somewhat more concrete, with a procedure for systematic derivation of a concrete information need from a specific, though as yet abstract ICM issue.

The proposed procedure is based on the rationale that ICM issues exist over a wide range of time- and space scales (see Figure 4.5). Each issue is closely related to values, interests and user functions. The quality of user functions can be evaluated at different time and space scales and is influenced by coastal behaviour on corresponding scales, with larger scales as boundary conditions and smaller scales as noise. An issue like, for instance, swimmer safety is primarily affected by short term and local processes (e.g. the strength of wind-driven, tidal and rip currents). Addressing an issue like long term coastal defence, processes like (accelerated) sea level rise and climate change naturally become important. As such the scale dimensions of a specific ICM issue indicate which scales of coastal behaviour are relevant.

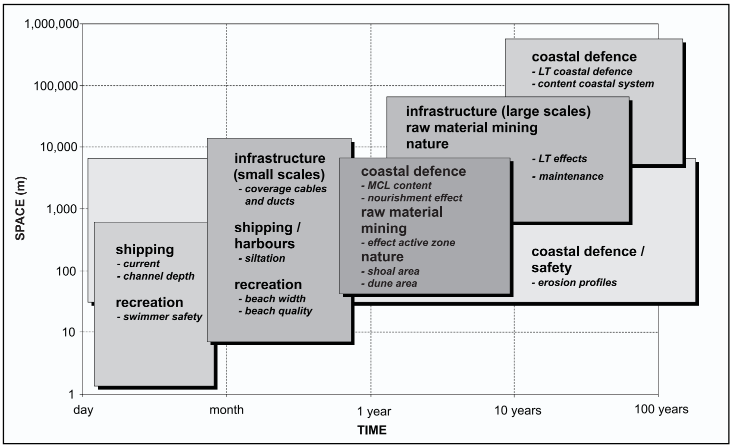


Figure 4.5: *Range of ICM issues.*

Method for systematic analysis of ICM information need
Phase I: desired state of knowledge
As stated before, feelings rather than facts often trigger coastal management initiatives. When the state of some user function, value or interest in the coastal zone is or seems to be at risk, a ***strategic management objective*** regarding that issue is to be formulated. Subsequent specification of the problem (present vs. desired system state and the related tolerance margin) provides important clues on the system knowledge required. Starting point in the analysis of the ICM information need may be any coastal management issue. Each issue is related to the quality of one or more user functions at one or more time scales (see Fig. 4.5). The quality of each of these functions is influenced by interactions between socio-economic, administrative and physical factors (cf. Chapter 2). This first phase involves an inventory of values and interests at stake, followed by the definition of the desired state of the relevant themes.

Phase II: current state of knowledge (regarding problem context)
In order to put the coastal management issues and related values and interests in the proper perspective, it is essential to define the wider context of the problem. By context we mean the external dimensions or boundary conditions of the problem, in other words factors that cannot be influenced. It concerns different aspects of:

- the socio-economic context (present economical functions, social acceptance);
- the administrative context (legal, political, strategic aspects);
- the physical context (environmental and technical conditions).

Dynamic aspects of the context may be included in the form of scenarios. Contextual aspects may be the reason why certain interests, e.g. property development, cannot be honoured at a certain location. A coastal defence strip, for instance, reserved for the long term collective interest of flood defence, may well outweigh short term individual interests for property development in this area. Experts in coastal behaviour may support the coastal management process by illustrating the rational argumentation behind this decision.

Phase III: current state of knowledge (regarding problem content)
When the context (‘what cannot be influenced’) is known, it is possible to oversee the solution domain and fruitfully specify the relevant internal dimensions related to the CZM issue (‘what can be influenced’ and should be resolved to deal with the problem). The ‘ideal’ frame of reference suggests that ‘ideally’ specification of the internal dimensions of the CZM issue should result in quantification of the strategic objective and the potential solution. For this purpose, the often qualitative strategic objective from Phase I, should be transformed into a specific (and preferably) quantifiable ***operational objective***.

As a first step, the operational objective should be expressed in terms of the internal system elements, again with respect to:

- socio-economic aspects; e.g. relevant user functions (safety, navigation, recreation, nature etc.);
- administrative aspects; e.g. management strategies at different levels of administration;
- physical aspects; e.g. different physical parameters (dune width/height, coastline position, beach width, channel dimension/position, area of shoals, coastal structures, wave height/length/direction, current velocities/directions, sediment characteristics, etc.).

and to:

- relevant time and space scales.

Quantifying the operational objective, a coherent set of design parameters, a combination of quantifiable aspects/coastal state indicators and cause-effect hypotheses, is needed to objectively represent the state of the system. Frequent interaction with stakeholders is necessary to ensure their support for the selected indicators and hypotheses. Without this support the operational design parameters are useless as arguments in the decision process. The decision which indicator(s) and hypotheses are fit to be design parameter(s), given a certain problem, is one of the most difficult considerations for coastal managers.

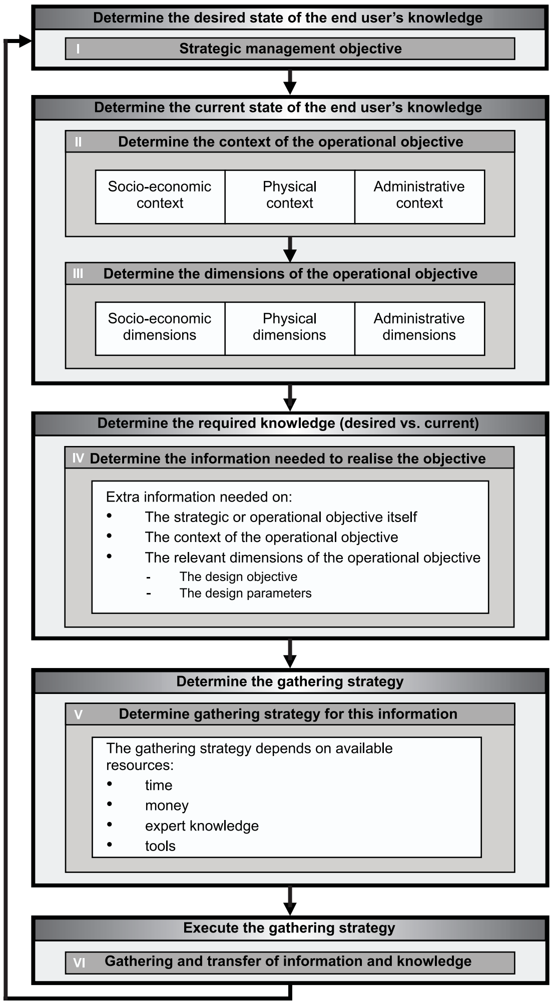


Figure 4.6: *Iterative definition of the information need (Source: Mulder* et al.*, 2001)*

Specialists can support decision makers by suggesting relevant indicators and hypotheses, on the basis of their knowledge and experience. These quantifiable design parameters - useful for coastal managers to enable objective intervention, useful for specialists as most aggregated projections of their study results- play a crucial role in bridging the gap between coastal research and management.

Phase IV: required knowledge
The effort during Phases II and III reveals the analyser's current state of knowledge related to the CZM issue at hand. In this analyser's state of knowledge different levels of aggregation may be distinguished, ranging from aggregated strategic management objectives to more detailed 'cause effect' processes. Given the complexity of ICM problems, the analyser's overall state of knowledge is almost by definition incomplete. Whether the lack of knowledge should be remedied, by study or research, depends on a confrontation with the required knowledge (cf. Figure 4.4). When confronting the combined result of Phase II and III with that of Phase I, we can identify the residual information needed to deal objectively with the problem at hand. Throughout this process specialists can be involved in analysing the problem and satisfying (parts of) the information need. Important aspect during the (joint) articulation of the information need is the definition of required levels of accuracy and detail; a difficult consideration, the success of which in practice is often closely related to the CZ Manager's state of knowledge. The next phase addresses the development of an information strategy to satisfy the coastal management information need.

CZM Information strategy
Phase V: determine gathering strategy
Once the information need has been defined, the next step is to develop a gathering strategy. In practice it is often not possible to gather all required information. Prioritising is therefore an essential part of every gathering strategy. Choices depend on the availability of resources (time, money, information, tools and experts) and the values and interests at stake. Insight into the extent of required resources may be derived from (expert) considerations on (1) existing tools and methods and (2) on existing experience on effort and cost of actually applying the tools.

Phase VI: execute gathering strategy
Once a decision has been made on a feasible gathering strategy, collection of information may be started. Generally, tools and methods for gathering technical information concern:

- collation of background information;
- monitoring;
- measurements;
- modelling;
- interpretation.

An indication of tools and methods that were developed in the COAST3D project, including guidelines on how to these may be used, can be found in (Mulder *et al.*, 2001).

CZM Information loop
The process of determining the information need and the consequent information gathering strategy encompasses in fact an information loop (see Figure 4.6). Feedback of the results of the information strategy enables a further sharpening of working hypotheses, triggering a new, more detailed information need and a more advanced gathering strategy etc. This iterative process results in a progression towards a more focussed and more detailed state of knowledge of the end user.

Starting from a relatively coarse state of knowledge, e.g. including only crude indications on the ICM operational objectives, the information need by consequence will be global, maybe even ‘ill-defined’, requiring a coarse information strategy involving aggregate information only. An example of assignments aimed at gathering this type of information is the development of a ICM vision. The qualitative, abstract nature of such assignments have frustrated many a specialist. It should be realised from the ‘ideal’ frame of reference, however, that vision development determines what is relevant in the more detailed (modelling) assignments. When the end users state of knowledge is advanced and detailed, e.g. through experience, the consequent information need and gathering strategy may also be defined at a more detailed level. The aggregation level, content and form of the information produced and presented by specialists, ought to be related to the issue at hand and the state of knowledge of the end user, for the results to be useful in the decision process.

4.3.3 Handling the communication process

Due to the scope and complexity of coastal issues, ICM is commonly a multi-party process where communication plays a crucial role. Miscommunication of the type addressed in this thesis seems to be the rule rather than the exception. The concept of the frame of reference and the procedure to make it explicit and determine the information need are important tools in understanding and ultimately addressing the divergence in perception by actors with different roles, at different levels of aggregation, of the problem at hand and the knowledge and information that is needed to deal with it (see Hypothesis 2.1). With these tools it theoretically becomes possible to elicit the frames of reference from two different actors and compare these. This may seem an attractive test to investigate and monitor the gap that exists between two actors in a generalist-specialist setting. A test in the context of the VOP project, reported by Van Koningsveld and Aarninkhof (2001), that was performed for that purpose, however, illustrates potential pitfalls of such an approach.

The VOP project is a long-term agreement between the Dutch National Institute for Marine and Coastal Management (RIKZ) and WL|delft hydraulics, aimed at sustaining the long-term development of generic knowledge on coastal processes. In the context of the VOP framework, yearly workshops are organised to exchange developed knowledge. The RIKZ had expressed concerns that it was hard to apply the specialist information produced in the project (e.g. presentations, reports, models, articles etc.), in dealing with their practical problems, viz. improved technical support of Dutch coastal managers. The aim of the workshop held in Delft, October 2001, was therefore to clarify how problem solving in

Dutch coastal management practice could benefit from the generic knowledge developed in the VOP project.

The setup of the workshop was to first split up RIKZ and WL into two separate groups. Both groups were asked to develop an approach to a predetermined ‘ill-defined’ problem that would soon become a ICM reality, viz. how to deal with the upcoming large scale system nourishments? Each group was expected to present a suggestion on the research that would be necessary to fill the knowledge gaps in their suggested approach. After a period of approximately 90 minutes, the two groups would reconvene and each group had to present their results. The workshop organisation would then identify and select some of the differences between the presented approaches to illustrate how separated groups might suggest different courses of action to deal with the same problem. The case was supposed to provide a clear illustration of why a proper communication regarding content, form and intent was necessary to prevent any (further) divergence of perceptions. The afternoon session would then use this insight to communicate more effectively addressing a more ‘well defined’ problem, viz. alternative approaches to deal with the Dutch policy of coastline management.

It turned out that the selected approach was rather hazardous. In the separate sessions both groups had directed their discussions very much towards the expected needs of the other group; in any circumstance a wise thing to do of course. Unfortunately for this particular workshop it resulted in both groups presenting only very general approaches. RIKZ using terms like “RIKZ should identify the relevant user functions and create an impact matrix that WL should then be attempt to quantify” and WL using terms like “We would look at the relevant user functions presented to us by RIKZ and try to quantify the effects of the system nourishments on these functions”. At this level of aggregation both frames of reference indeed *appeared* to match perfectly. In the discussion that followed some participants even used the results to deny the problem; some in rather a verbally aggressive manner using comments like “You see, there is no problem … we don’t need all this communication … you should not try to put problems into our head!”. Two research managers, representing RIKZ in the organisation committee of the workshop, however, were still strongly convinced that the problem they had hoped to illustrate, viz. not being able to apply the specialist answers in dealing with their problems, did indeed exist in reality. The denial of the problem by some of the workshop participants only added to their frustrations about it.

So despite the best of intentions, the effort to elicit and compare two frames of reference and explain communication problems from the detected differences did not work very well in practice. And even if it had, it would have still left open the question how the situation was to be dealt with. It seems that taking communication problems as a starting point for process improvement does not trigger very productive responses.

As an alternative, we choose a problem-driven approach, eliciting only the frame of reference of the end user or driver of a given research project, to see if it can be used as a target that specialists may direct their attention to. Thus, rather than focussing on the communication *problems*, which does not seem to stimulate productive interaction, we focus on the *challenge* of improving the end user's frame of reference by applying specialist knowledge.

In cases where the ICM problem is 'ill-defined', which seems to be more often the case than not, it is hard, if not impossible, to formulate clear questions on what one ***doesn't*** know; this is one of the lessons learned during the COAST3D project. In such cases it was indeed found to be more productive to state what you ***do*** know. In the context of research programmes this means that it would be better to start the research project with a presentation of practical problems to which the researchers can direct their creative potential. A problem remains how to get the end users and specialists to externalise their mental models of how the system works and should be managed. We found the implementation of pilot cases to be a promising methodology. Considering a specified pilot case appeared to be the only way for specialists to demonstrate how state-of-the-art knowledge can be applied in a practical situations. This has several advantages. The 'snapshot' of what e.g. a model can do, first of all helps modellers to show how a model study should be set up and how the results can be usefully interpreted. Furthermore it circumvents the issue of unfinished research.

The application of knowledge in its current state-of-art will expose the uncertainties in e.g. the model predictions. This helps the modellers to identify strengths and weaknesses in their models and suggest future improvements. Last but certainly not least, it helps the coastal managers to see how the model can improve their understanding of the system (Walstra and Van Koningsveld, 2001). In an ideal situation, a prediction of some of the relevant aspects of a case should be made at the beginning of a study or research project, with the means then available, including estimated (un)certainties. At the end of the project a similar prediction should be made with the hopefully improved means. The achieved reduction of the uncertainties (or possibly their improved estimation) could be a measure of the project's success. On top of that, the pilot case may be a significant, and not to be underestimated, binding and structuring factor within the project (cf. De Vriend and Van Koningsveld, 2001). We expect projects structured around problems to produce 'end user results', whereas projects structured around disciplines rather produce 'scientific results'.

4.4 A template: the 'basic' frame of reference

The generic approach of the 'ideal' frame of reference combined with the procedure to define the information need, may yield a very complex picture that can be difficult to apply in practice, although it has been shown to work (cf. Mulder *et al.*, 2001; Willems, 2002; Wierda, 2003). To make the 'ideal' approach somewhat more applicable in practice, we need a 'basic' frame of reference containing a *limited* set of elements that seem to recur in management situations where physical system behaviour presents a threat to values and interests.

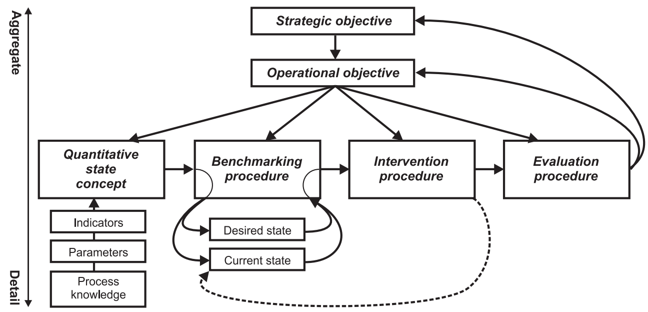


Figure 4.7: *The 'basic' frame of reference*

In line with the reasoning set out in the previous sections, we conclude that in order to make essential (technical) components of ICM decision making processes explicit, a 'basic' frame of reference should include the following elements (see Figure 4.7):

- a strategic objective;
- an operational objective; and
- a decision recipe containing a foursome of elements, viz.:
    1. a quantitative state concept;
    2. a benchmarking procedure;
    3. an intervention procedure; and
    4. an evaluation procedure confronting the operational as well as the strategic objective.

The 'basic' frame of reference, derived in an iterative problem driven manner, provides a useful tool in support of decision making as well as a target for specialist improvement. As such it provides a communication tool supporting efforts to rationalise the use of specialist knowledge in coast related decision processes, as intended in Section 4.3.

4.4.1 Strategic management objective

Strategic objectives provide the long term context for coastal policy and management. They express the vision on the interdependencies of the natural and the socio-economic system and on the role of the human species therein. Strategic objectives tend to vary slowly. Nonetheless they do have a profound impact on the kind of policy and management that is required and acceptable. Again, the historic development of water management in the Netherlands may serve as an example (cf. Van de Ven, 1993; Dubbelman, 1999; Van Koningsveld *et al.*, 2001).

4.4.2 Operational management objective

The operational objective expresses our vision on how to *handle* the interactions between the natural and the socio-economic system. As such it is a concrete implementation of the strategic objective. Operational ICM objectives are in this thesis assumed to be related to the status of values and interests in the coastal zone. As such the operational objective should include an explicit indication regarding the temporal and spatial scales involved. It may take many operational objectives to cover all scales intended in the strategic objective. Simultaneous management of different operational objectives can easily lead to conflicts. What is good for one objective might harm another. What works on the short term could adversely affect the long term. As a result, evaluation of management activities should not be restricted to the operational objective but include a critical review with respect to the strategic objective. Evaluating the interaction between different operational objectives and minimising the amount of conflicts are crucial elements of an integrated approach to coastal management.

4.4.3 Decision recipe

From the strategic and operational objective follows our vision on potential and acceptable human interventions. A fully developed decision recipe for intervention, coherently addresses the following elements:

1. Quantitative state concept
To enable objective and reproducible decision making, a quantitative concept needs to be developed that describes the state of the system or certain aspects thereof in an appropriate form. The appropriate form with respect to usefulness in decision processes is determined by the strategic and operational objective as well as by the next steps in the decision recipe. With respect to practical effectiveness there is a strong link with knowledge of the system's behaviour. A wealth of literature available regarding indicators, indexes, etc. (for a concise literature review cf. Jiménez and Van Koningsveld, 2002).

2. Benchmarking procedure
A benchmarking procedure is necessary, so that we can systematically and objectively determine *when* to intervene in the system. Intervention is required when a discrepancy between the current system state and a desired or reference system state surpasses some predefined threshold. Implicit differences in the desired system state often trigger passionate discussions on what is in the interest of the management objectives and what is not. To facilitate useful discussions, the current as well as the (implicitly) desired state should be made explicit, preferably expressed in terms of the chosen quantitative state concept. This element of the decision recipe often relies on measured or predicted trends in state descriptions, costs and benefits.

3. Intervention procedure
An intervention procedure specifies *how* we should manipulate (part of) the system in order to bring it to a desired state. It specifies not only the type of intervention but also

the method to determine its design. Knowledge of the system, in particular regarding physical processes, plays a crucial role in this element. The design procedure should use the quantitative state concept as one of its primary building blocks. It should at least facilitate significant manipulation of the system's 'current' state, towards its desired state identified in the previous step.

4. Evaluation
The decision recipe and the effects of its application should be evaluated. This evaluation should take place in the development stage of a measure (expected effects), as well as after some period of application (actual effects). First of all, one needs to assess whether or not the operational objective is being sufficiently achieved. If this is not the case, the decision recipe may have to be changed. If the operational objective *is* satisfactorily achieved, it is still necessary to evaluate the management efforts, but now against the wider perspective offered in the strategic objective. This may trigger modifications in the decision recipe but, but it may also result in an adaptation of the current operational objective, or the formulation of a new one.

4.4.4 Iterative method of application: Game, Set & Match

Developing a 'basic' frame of reference that can be used for coastal management and that is based on the best insights in coastal system behaviour obviously requires many iterations, implying a lot of discussion. To prevent too abstract discussions, it is suggested to strive for a fully developed 'basic' frame of reference using the "Game, Set & Match"-principle.

During the 'Game'-phase, some item of the frame of reference is discussed; preferably starting from the strategic objective and working one's way 'down' (cf. Figure 4.4). After some discussion, the actor responsible for defining the coastal management issue, or some mediator, 'Sets' the problem at hand, summarising the previous discussion and making the crucial elements as explicit as possible (state what you ***do*** know). The result is an explicit target for the participants to 'Match' their knowledge to. The 'set' frame of reference may now be altered, broadened or detailed by all participants. With the resulting frame of reference a new 'Game'-phase may be initiated.

In the initiation phase, several iterations may be possible during one meeting or workshop. When, after after a number of iterations, an initial coarse frame of reference has emerged, more time may be needed to actually match new specialist knowledge, as new technologies and algorithms may need to be developed and applied. When at a certain stage the interval between a 'matching'-phase and a new 'game' of discussion becomes too large, it may be useful to apply the concept of pilot applications described in the foregoing, to keep the discussions going.

Working with the 'basic' frame of reference promotes a greater involvement of the end users during research projects and facilitates a regular confrontation of research results with developing end user needs. A successful application of the suggested approach, however, requires an open and constructive attitude of both end users and specialists.

4.4.5 A hypothesis on matching specialist knowledge with end user needs

The above described method is supposed to be useful in rationalising the use of specialist knowledge in coast related decision processes. This is reflected in the following hypothesis:

> **Hypothesis 4.1** *The 'basic frame of reference'-approach stimulates the communication between coastal managers and coastal scientists of different disciplines on what is relevant knowledge, thus preventing or at least postponing the perception divergence mentioned in Hypothesis 2.1 and facilitating useful and effective knowledge transfer to and from the coastal policy and management sector.*

In the next chapter, we start with a brief description of some situations where a frame of reference was *not* used. These examples are mainly intended to re-address the problem dealt with in this thesis. To actually test Hypothesis 4.1, we first analyse some successful cases in Dutch coastal policy and see whether the elements of the 'basic frame of reference'-approach can indeed be identified in these cases. Next, we describe an effort to apply the 'basic frame of reference'-approach in a coastal research project with a clear end user objective. The case examples should give us a clearer idea of whether the approach suggested in this chapter could work in practice and be useful in support of end user oriented knowledge development.

Chapter 5

Practical applications of the ‘basic frame of reference’-approach

To readdress the central problem of this thesis we start with a brief description of three case examples where the matching of research with end user needs has been recognised as a problem. From that starting point on we address the use of the ‘basic frame of reference’ in support of efforts to match specialist knowledge with end user needs, in order to test Hypothesis 4.1.

We start with an analysis of successful technical implementations of Dutch coastal policy to see (1) whether the elements of the ‘basic frame of reference’-approach can be identified in practice and (2) whether an analysis in terms of the ‘basic frame of reference’ provides handles to guide specialist efforts in support of further policy development.

Next we investigate the use of the ‘basic frame of reference’ as a template to stimulate and focus research efforts during end user oriented knowledge development projects. For this purpose we describe a coastal research project with a clear end user objective where the ‘basic frame of reference’-approach is being applied.

Together, the case examples provide us with information on the usefulness of the approach (1) with respect to matching specialist knowledge with end user needs, and (2) regarding its effect on preventing or postponing the divergence in perceptions between specialists and users of specialist knowledge.

5.1 Case examples without a ‘frame of reference’

5.1.1 A European demonstration project on ICM

The first case example, illustrating the problems that may occur in a project when it is unclear how the specialist efforts contribute to the overall problem, concerns the RICAMA project, funded under the LIFE instrument (97/IT/072/PAZ). It was initiated as a part of the EU demonstration programme for Integrated Coastal Zone Management, comprising 35 projects all over Europe. The objective of the RICAMA project was to develop an integrated approach for management of a sizeable coastal area in the ‘Regione Abruzzo’, Italy, bordering the Adriatic Sea.

Tourism, and particularly high-quality tourism, represented the most important development force for the 'Regione Abruzzo'. Coastal erosion was locally perceived to be the most significant threat to maintaining this tourism. The prevalent notion was that coastal defence structures can secure protection. As a result, the entire coastline has been protected by hundreds of (offshore) breakwaters and perched beaches. From past experiences and from the recognised causes of the erosion (a.o. reduced sediment input from rivers), however, it was clear that the erosion could not be sustainably countered with the traditional 'hard protection' technologies. Soft, more environmentally compatible approaches were required. The fact that eminent scientists had previously promoted hard engineering solutions made it difficult for many stakeholders to accept that these structures could even aggravate the erosion problem. Those who derive a living from beach recreation needed to understand that their beaches are not stable and that, without new supplies of sediment, some were bound to disappear.

The intention of the RICAMA project was to set up an ICM framework that could function as a long-term basis for future management of coastal use and development. The project committed itself not only to the development of the framework, but also to its initial practical implementation. Hence, acceptance of the approach by stakeholders was an important issue. In order to achieve an acceptable integrated approach, the scope of this particular project was set wide. The framework was intended for a coastal region with a length of approximately 120 km, along the tract between the Alento and Saline rivers. The scales that the envisaged ICM framework was to address implied the need for analysis at a regional scale. To include all relevant socio-economic and physical aspects, the area of investigation extended a considerable distance inland. For the practical application of the framework, municipalities needed to be involved, which required the eventual framework to resolve (coastal) problems and its causes at a scale fit to be addressed by local authorities, as well.

The project managers decided that full involvement of all stakeholders was not possible at the start. Technical studies conducted in the first phase of the project would be used to provoke local debate with municipal authorities at a later stage. The project had started the studies with a broad and strategic amount of differentiation, in order to achieve its objectives. Specialists from various disciplines were involved, from socio-economics, land-use, coastal morphology and monitoring through to information technology. Several partners from all over Europe entered the project, bringing in expertise on this wide range of subjects. The amount of differentiation made this at least a multi disciplinary project. The integrative aim of the initiative was to find interdisciplinary solutions for the eventual coastal management problems in the 'Regione Abbruzo'. The project was therefore an excellent example of end user oriented knowledge development.

At one of the last workshops, held during two days in September 1999 in L'Aquila, Italy, all partners were invited to present their results. In the perception of the specialists, interesting information had been produced on the physical and socio-economical functioning of the region. One of the partners, for example, presented output of a computer model that was used to investigate flow patterns around the numerous breakwaters that had been constructed along the coastline involved. The model was used as a tool to investigate the hydrodynamic and morphodynamic processes around the breakwaters. The presentation at the workshop included impressive visualisations of the model output, showing the circulations around the breakwater under various conditions. The results were (implicitly) assumed to be relevant in evaluating whether or not the breakwater worked as a coastal defence measure.

The project managers, however, did not recognise this potential and in fact were rather condescending about the results. In their perception, the presentation had no bearing to the project objective. After a while the partners were even accused of having pursued their own interests, instead of focussing on the main target of an integrated approach to coastal management. Needless to say, an unproductive atmosphere had emerged.

After considerable efforts to reconcile the differences of opinion that had emerged, an ad hoc solution, describing a general framework to ICM and indicating the function of the different research efforts therein, resulted in a remarkable change in atmosphere and in the attitude of the project leaders. Making the relation between the specialist efforts and the overall objective explicit seemed to have restored the confidence of the project leaders in a positive end result. Considerable time and energy had been spent, however, repairing the differences in perception. Even though in the end the project leaders were enthusiastic about the end results, one wonders whether the project could have been (much) more successful if an explicit framework would have been introduced earlier in the project and used as a starting point of the analyses.

Judging from the conclusions presented by the EU (1999) regarding information issues in ICZM processes, the above problem of connecting modelling and data collection efforts by specialists to the needs of end users, was recognised in many of the 35 demonstration projects on ICZM. To illustrate this observation a few of the conclusions by the EU (1999) are listed below:

- **Information issues in general (p.12) -** "In view of its importance, the information component of an ICZM initiative should not be left to chance. An explicit strategy is needed for the collection, processing and diffusion of data and information. The strategy should start by an assessment of needs, reflecting the importance of having the correct knowledge base for the specific situation."

- **Identifying and accessing available data (p.12) -** "Data collection is one of the first tasks in an ICZM initiative. However, in an effort to assure that the necessary information is available, too many projects start by setting out to collect all available data about the target area. This "information for information's sake" approach should be avoided as it is often a waste of resources. ICZM initiatives should be issue-led, not data-led."

- **Generating useful data (p.14) -** "On a daily basis large amounts of data are generated … nevertheless, ICZM initiatives often find that the data they require do not exist. Because the data are not generated with the user's needs in mind, they do not necessarily correspond to the desire scale, extent, format, thematic coverage or timeliness. Or while individually the data sets might appear to meet user needs, they are in fact useless because they cannot be combined to create integrated information. These are all symptoms of the gap that exists between data users and providers."

- **Improved communication (p.20) -** “Improved communications between coastal managers and developers of information systems could help bridge the gap between these two communities.”

- **Communication and a common language (p.25) -** “Communication is a two way process. Effective communication can be confounded by administrative secrecy and lack of government transparency. However, communication is also blocked by the use of technical terminology and jargon that means different things to different people. One of the first steps in creating effective communication is therefore the development of a “common language”, which all of the participants understand.”

- **Research and Development to support ICZM (p.59) -** “Research programmes are too often determined on the basis of academic requirements rather than the need to solve practical issues on the ground. As a result it is often difficult to apply the results of research studies to policy formulation and practical management. This criticism applies both to EU funded programmes and to national research. … Mathematical modelling plays an important role in coastal research and is essential for the prediction of the long-term impacts of natural or human forcing. Increased availability of mathematical models greatly benefits many other research tasks and may also directly serve managers and planners. However, mathematical modelling is an area where the gap between researchers and users is particularly evident.”

- **Research proposals (p.60) -** “Research work should be clear about who will be the recipients of their results (NOT just other research workers!!). Research proposals should show how potential users have been brought into the process of identifying research needs. Research proposals should include a clear statement of how the results will be applied to the problem and who will benefit and a clear plan for dissemination of results to both other research and end users; provision for this should be made within the budget proposals.”

These are just a few of the many suggestions that have been derived from the EU demonstration programme on ICZM indicating the relevance of the problem addressed in this thesis. Application of the ‘basic frame of reference’-approach could play an important role in addressing many of these issues.

5.1.2 Delft Cluster and the ‘Sector’

Another example of dissatisfaction regarding end user oriented research is provided by an expression of interest of the so-called ‘wet’ contractors, combined in the VBKO (Vereniging van waterbouwers in Bagger-, Kust en Oeverwerken), to participate in a second tranche of the Delft Cluster research project (see Section 3.5.4).

In a letter, dated January 24^{th} 2002, the VBKO expresses its view on a possible participation in a continued Delft Cluster project (VBKO, 2002). The letter contains some interesting signals of a significant group of potential end users, regarding their (dis)satisfaction with research results. Starting of with a historic perspective on the interaction between contractors and knowledge developers, the VBKO observes that the current status of Dutch water related research has been highly influenced by the Delta project. Furthermore it observes that since then the intensive co-operation has diminished (see also Chapter 3).

The VBKO (2002) claims that the lack of large innovative infrastructural projects comparable with the Delta project, has contributed to a ‘sub-optimal match’ (in Dutch: ‘weinig optimale aansluiting’) between Delft Cluster and the civil engineering sector. This would have led to a scatter of research means, too vague research objectives and an insufficient focus on the interests of this branch of industry. The letter states that a need for knowledge does indeed exist in the contractor community (in Dutch: 'aannemerij') and that it was formulated already in 1998. The VBKO regrets that so far this has not yet been firmly implemented in the Delft Cluster project and states that the lack of useful results has had a negative impact on the relationship between the research community and the contractor community. It is observed that, as a result, it has been hard to involve the sector as a whole in the Delft Cluster program and that an increasing amount of research is being commissioned to foreign institutes. However, the VBKO applauds the fact that for the second phase a greater involvement of the sector in programming and execution of knowledge development projects is planned. To play a role in the second phase of the Delft Cluster the VBKO makes some suggestions, sub-divided into:

- Sector wide knowledge development (in the interest of government, consultants and contractors);
- Collective knowledge development (in the interest of all contractors); and
- Confidential knowledge development (in the interest of one contractor).

Sector wide knowledge development
For the 'sector wide knowledge development', the VBKO refers to the research topics identified by Water-Front, an organisation founded to structure the consultation process between sector, government and knowledge institutes necessary for strategic prioritising of research. The topics identified by Water-Front are:

- Eco-engineering;
- Consequences of climate change;
- Validation of mathematical models; and
- Knowledge management.

It is explicitly stated that funding of this type of research by contractors depends on its relative interest to the collective contractors, the way the research efforts are shaped, the estimated time-to-results and the expected usefulness of the end product.

Collective knowledge development
For 'collective knowledge development', the VBKO states that the main purpose of this type of project is commonly to lower the barrier to come from research to application, e.g. through guidelines or user-friendly computer software. In other words a translation of existing or newly developed knowledge to end users. As a concrete suggestion, the letter first refers to the use of state-of-the-art first-order models by or for contractors and consultants in the acquisition phase of projects. Secondly, it underlines the importance of knowledge diffusion to the 'workfloor'.

VBKO (2002) stresses that it is of crucial importance that every knowledge development project be followed by a translation of the developed knowledge to practice. It is acknowledged that some time is needed for knowledge to 'ripen', which may well exceed the lifetime of the project. The following cycle is suggested:

- Knowledge development;
- 'Ripening' through application in engineering works and pilot-like environments;
- Translation of ripened knowledge to the work floor.

It is suggested that each Delft Cluster project should at least comprise this cycle and the financial arrangements necessary for its implementation. Knowledge development without this translation is not considered to be of interest for business.

Confidential knowledge development
For the 'confidential knowledge development', the VBKO suggest bilateral contact between Delft Cluster and the companies that require that type of research.

The comments listed in VBKO (2002) constitute a clear message from research drivers to research managers to explicitly match research efforts and practical needs. It is clearly stated that such a match is in fact a prerequisite for funding. As such this example again underlines the importance of the topic addressed in this thesis.

Of course one may disagree on how this letter is to be interpreted. A hesitant attitude of the sector in the initiation phase of the Delft Cluster is brought up as an explanation of a lacking match at the end of the project. Many other explanations for the 'sub-optimal' match are conceivable. We believe, however, that the comments in VBKO (2002) provide a clear signal that is closely related to the subject dealt with in this thesis, viz. explicitly matching specialist knowledge with end user needs. The letter illustrates how this match is perceived as sub-optimal, by a significant group of potential funders and users of research. Furthermore, it shows clear a desire to get a better grip on the usefulness and effectiveness of research in the future.

Some have argued that end user oriented research necessarily implies a focus on short-term problems and thus would mean the end of in-depth research. The acknowledgement by the VBKO (2002), however, of a 'ripening'-period and an acceptable time-to-application of up to 10 years, seem to indicate a much more reasonable attitude. The development of state-of-the-art first-order models seems to be a reasonable request that researchers should be able to address. The translation of 'complex' findings into useful knowledge is often too difficult and insufficiently rewarded in the scientific world. As a result it is a challenge that tends to be 'forgotten' when new research projects come along. As such, explicitly including these efforts in research proposals -compare the observations regarding R&D in (EU, 1999)- may indeed be necessary to ensure a proper focus on the generation and dissemination of useful results.

5.1.3 The Flyland project

A third example of a project evaluation, addressing the issue of matching research findings to a decision process, is related to the Flyland project that has been commissioned to investigate the effects of airport island in front of the Dutch coast (RMNO, 2002).

Towards the end of 1999, the Dutch parliament opted for a limited growth of Schiphol Airport at its current location near Amsterdam, instead of relocation to an island off the Dutch North Sea coast. At the same time, a procedure to establish an island airport in the North Sea was terminated. The plan did not get sufficient public support and there were still many uncertainties regarding its feasibility. This, however, did not mean that an airport on an offshore island would be impossible. A multi-year research program called Flyland was commissioned, to investigate the feasibility an airport island, so as to be sufficiently prepared for this difficult issue, if it came up again in the future. Since early 2001, the Flyland program bureau (MARE) has been responsible for driving and coordinating this research program, commissioned by the Ministry of Transport and Public Works, the Ministry of Economic Affairs, the Ministry of Housing, Spatial Planning and Environment and the Aviation Sector (the clients).

Great emphasis has been placed on the ‘embedding’ of the research project. Ideally, at the end of the program in 2006, there should be a broad agreement that the ‘right’ topics have been investigated and that the investigation was done in a proper way. A distinction was made between scientific and societal embedding. Scientific embedding implies results that are authoritative among scientists. Societal embedding implies results that are authoritative among stakeholders. The program bureau MARE is responsible for the societal embedding. The Advisory Council for Research on Spatial Planning, Nature and the Environment (RMNO), advises the clients on a strategic level. As such the RMNO has been involved in, amongst other things, the evaluation of the societal embedding of the Flyland project.

Regarding the societal embedding, MARE was asked to design the research in at least one of the themes according to the ‘joint fact-finding’ approach to knowledge development. This approach aims for continual cooperation between researchers and stakeholders through all phases of the project, from problem definition to the presentation of the end results. The ‘joint fact-finding’ approach is assumed to be crucial in ensuring an effective societal embedding of the research. It requires intensive involvement of the end users, in this case the stakeholders, throughout the process of knowledge development. Chapter 3 has shown that such intensive cooperation is indeed necessary for a balanced drive, matching specialist efforts and end user needs. RMNO (2002) reports that it is not always possible to apply the approach in its pure form, due to (1) an initial disturbance of the balance as a result of previous or ongoing research, and (2) the fact that it is not always possible to identify stakeholders or end users for each (sub)project.

Research in the context of the theme “Marine Ecology & Morphology”, for example, was already in progress when the Flyland project became operational. At the start of this research no stakeholders had been consulted. RMNO (2002) concludes (1) that for this part of the research it was not possible to determine the societal core questions on which this research was based and (2) that the report for this particular theme, at the end of Phase 1, does not reflect any response to the societal input. The fact that the research for this theme had started before Flyland itself, was brought up as a mitigating circumstance. With respect to this theme, the RMNO recommends that in the future Flyland should clearly indicate what is being done with the societal input and which 'joint fact-finding' procedure will be followed during the remainder of the project. For the entire project the RMNO (2002) recommends "(re)formulating the assignment granted to Flyland in such a way that the desired additional research aspects can be included in the programme, and launching the studies called for by the ground-breaking suggestions as soon as possible by engaging external (coalitions of) government bodies. These measures are necessary to prevent a situation where we would eventually know how to build an island airport without being able to take a decision about it.".

This final remark shows that the Flyland project also provides an excellent example of end user oriented research and the problems of matching the knowledge development process to the need of the end users. In fact, the brief description of the recommendations with respect to the Flyland theme "Marine Ecology & Morphology" reveals a situation similar to that encountered in the COAST3D project (see Section 4.2), viz. the challenge of providing end user results in a research project that started off with a science driven approach.

5.1.4 Conclusions

The three problems described above provide a clear indication of a wide-spread desire to get a better grip on matching specialist knowledge with end user needs. It should be stressed, however, that with 'matching results', we do ***not*** mean producing *favourable* results for the financier or driver of the research. It is the rationalisation of the use of specialist knowledge in decision processes that deserves attention.

The examples in the previous section were meant to re-address the core issue of this thesis, viz. the threat of an increasing gap when it is unclear how specialist knowledge be matched with end user needs. In the previous chapter, the 'basic frame of reference'-approach was suggested as a promising methodology in support of efforts to prevent this. The next section illustrates the workings of this 'basic frame of reference' through an evaluation of the Dutch approach to sustainable coastal policy, as globally described in Chapter 3.

5.2 Case examples with a 'frame of reference'

Policy development is a dynamic and cyclic process characterised by successive stages of development, implementation and evaluation. An illustration of this process is provided, based on an analysis of the history of coastal policy in the Netherlands over the last two decades. Evaluation in 1995 of the coastal policy of Dynamic Preservation, developed during the late 80's and implemented in 1990, led to a redefinition in 2000. The result was the implementation, in 2001, of a sustainable coastal policy in the Netherlands with both a small- and a large scale approach.

The analysis in this section indicates that successful policy development is indeed related to the use of a systematic 'frame of reference'; characteristics are explicit definitions of both *strategic* and *operational* objectives applied in a 4-step decision recipe of (1) a quantitative state concept, (2) a benchmarking procedure, (3) a procedure for CZM measures or interventions and (4) an evaluation procedure. Applications of this frame of reference show its high potential stimulate and focus communication in order to better integrate coastal (engineering) science and coastal policy and management.

5.2.1 North Sea coast of the Netherlands

The Dutch coastline along the SE part of the North Sea (see Figure 5.1) is about 350 km long and commonly divided into three regions, viz. the Delta coast in the south, the Holland coast in the centre and the Wadden coast in the north. The morphology of the Delta coast is dominated by tides. The morphology of the Holland coast between Hoek van Holland and Den Helder is typically a storm-dominated sandy coast. The Wadden coast is characterised by the presence of barrier islands and from a morphological viewpoint somehow comparable to the Delta coast. Some 15% of the coast consists of sea dykes and other manmade sea barriers, 10% consists of beach flats along the tips of the northern Wadden islands and 75% consists of dune areas of varying widths, ranging from less

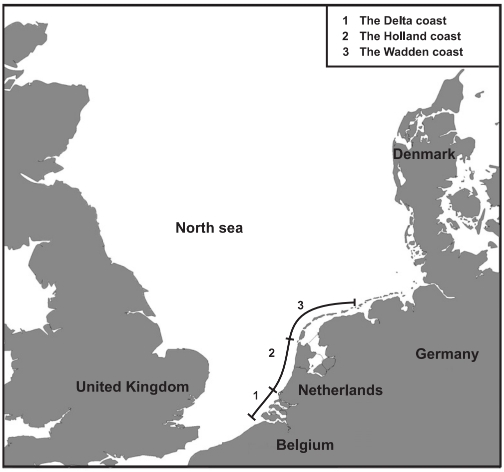


Figure 5.1: *Orientation on the Netherlands*

than 100 meters to several kilometers. The primary function of the coast is to protect the low-lying hinterland from flooding. The sandy coast, however, represents important value to other functions, as well: e.g. ecological value, drinking water supply, recreation, residential and industrial functions. Coastal erosion, dominant along half of the Dutch coast, is endangering these functions.

5.2.2 Coastal policy

Traditionally, coastal policy in the Netherlands concerned safety from flooding (see Chapter 3). After the storm surge disaster of 1953, coastal policy was dominated by the objective to bring all sea defences to a predefined safety level; the so-called delta strength. Implementation took place in the Delta Project. During the 60's, 70's and 80's of the last century, dikes and dunes were strengthened and tidal inlets in SW Netherlands were closed by dams. From the mid 70's the policy perspective of the Delta Project gradually widened. Ecological arguments were included in decision making. As a result, the closure of the Eastern Scheldt tidal inlet in 1986 -climax of the Delta Project-, was decided to be a moveable storm surge barrier. Similarly, during the 80's the scope of coastal policy gradually extended towards other functions. Once the Delta safety levels had been established along the coast, structural coastal erosion problems received increasing attention. The need to maintain structural integrity of the coast in order to ensure sustainability of all coastal functions called for a new coastal policy.

5.2.3 Dynamic preservation of the coastline

In order to stop any further structural recession of the coastline, in 1990 the Dutch Government adopted the national policy of "Dynamic Preservation" (Min V&W, 1990). The ***strategic objectives*** were: *"... to guarantee a sustainable safety level and sustainable preservation of values and functions in the dune area ... "*. The specification of a set of operational aspects promoted an easy implementation. First of all, the specification of a clear ***operational objective***: *"... the coastline will be maintained at its position in the year 1990"*. Furthermore, implementation has been guided by the specification of a ***decision recipe***, defining:

(1) a quantitative concept of the actual state of the system;

(2) procedures for objective benchmarking;

(3) procedures for preferred interventions; and

(4) procedures for evaluation.

The strategic- and operational objectives, together with the decision recipe, constitute what in this thesis is referred to as the basic operational 'frame of reference' for the Dynamic Preservation policy.

1. Quantitative state concept: the Momentary Coastline

The first element of the decision recipe for coastline management is an objective assessment of the state of the system. For this purpose the concept of the Momentary Coastline (MCL) has been developed. To objectively determine this MCL in any given cross-shore profile, a methodology has been developed based on the area (or volume per unit longshore distance) of sand between two horizontal planes (Min V&W, 1991; TAW, 1995a, 2002). This area is to be divided by the difference in height between the upper and lower boundaries. Roughly speaking, the method schematises the coastal profile as a triangle with a certain area that can be determined. The horizontal position of the MCL can be found at the center of the base of this triangle. The upper and lower boundaries are each located at a distance 'H' from the mean low water level (MLWL). This vertical distance 'H', is defined as the vertical difference between the dune foot and the mean low water level (see Figure 5.2) The 'actual' calculation of the MCL is based on data from the Dutch yearly coastal monitoring program (JARKUS), which has been operational since 1963. JARKUS measures coastal depth profiles from the first dune row seawards, through to 800 m offshore, at alongshore intervals of 250 m.

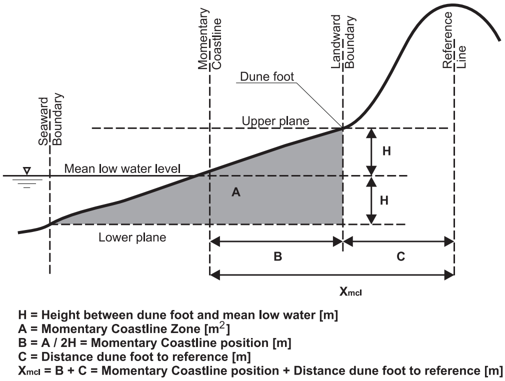


Figure 5.2: *Calculation of Momentary Coastline (MCL) (Source: Min V&W, 1991)*

2. Benchmarking procedure

Next, a benchmarking procedure was developed, with the MCL as the basic quantitative building block.

The Basal Coastline

For problem detection the observed or predicted system state needs to be described and compared with a predefined reference state. The operational objective to maintain the coastline at its 1990 position, implies a reference state related to the 1990 coastline. Therefore the Basal Coastline (BCL) has been defined as the estimated position of the coastline on January 1st of 1990. This estimated position is derived from an extrapolation of the linear trend that can be determined from the positions of the 10 MCL-points in the years 1980 to 1989 (Figure 5.3). The choice for an estimation based on a 10 year linear trend extrapolation, was inspired by the objective to counter structural, rather than incidental erosion.

The Testing Coastline

To provide a crude prediction of the future state of the system, a so-called Testing Coastline (TCL) has been defined. The position of the TCL on January 1st of any given year is determined, in a similar way as the BCL, by linearly extrapolating the trend of coastline positions (MCL) of the ten previous years. Thus the position of the TCL in the year T can be determined by linearly extrapolating the trend in the calculated MCL positions in the years (T-10) until (T-1) (Figure 5.3).

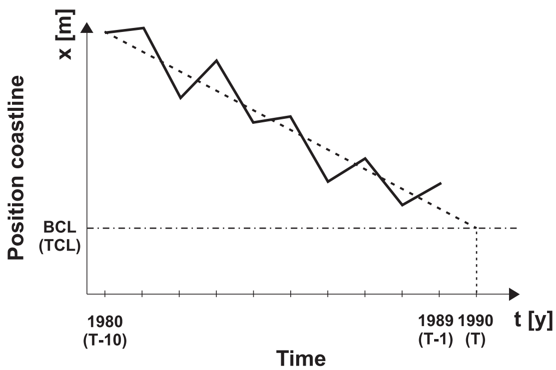


Figure 5.3: *Procedure to define the BCL (resp. TCL)*

The state of the system can now be compared with the reference state, by comparing the TCL position with the BCL position. This comparison provides an indication for the expected coastal state in the year T. A TCL that moves landward of the BCL represents a signal to the responsible coastal authority to consider intervention.

3. Intervention procedure: sand nourishment

The name “Dynamic Preservation”, refers to the preferred approach to achieve the policy objectives. *Dynamic* Preservation implies the goal to make optimal use of natural processes. Consequently, the principal intervention procedure is sand nourishment.

Design procedure

The design procedure for nourishment with a predetermined lifespan is best illustrated by a fictitious example.

Assume that a given coastal stretch suffers from erosion at an average rate of 1 m/year (linear trend determined from 10 MCL positions). The benchmarking procedure reveals that TCL will move landward of the BCL for an alongshore stretch of 1000 m. Then, a basic design of a shore nourishment, with a projected lifespan of 5 years, would be the result of applying the following procedure (see also Figure 5.4).

First of all it is acknowledged that the MCL method only uses a limited part of the upper shoreface to determine the coastline position. Assuming that the MCL trend is representative of the trend for the total active depth of the profile and assuming that the active depth is 20 m, the product of the erosion rate (linear trend determined from 10 MCL positions here symbolised as '$\frac{dX_{mcl}}{dt}$') and the active depth 'D' results in a volume 'V', per unit length of coastline, that erodes annually from each cross-shore transect; in this case (see Figure 5.4a):

$$\frac{dV}{dt} = \frac{dX_{mcl}}{dt} * D = 20\,m^3/m/year \tag{5.1}$$

The product of the annually eroded volume and the projected lifespan 'T_{life}' of the nourishment yields the total expected volume 'V_{tot}' to be eroded during the performance lifetime (see Figure 5.4c):

$$V_{tot} = \frac{dV}{dt} * T_{life} = 20\,m^3/m/year * 5year = 100\,m^3/m \tag{5.2}$$

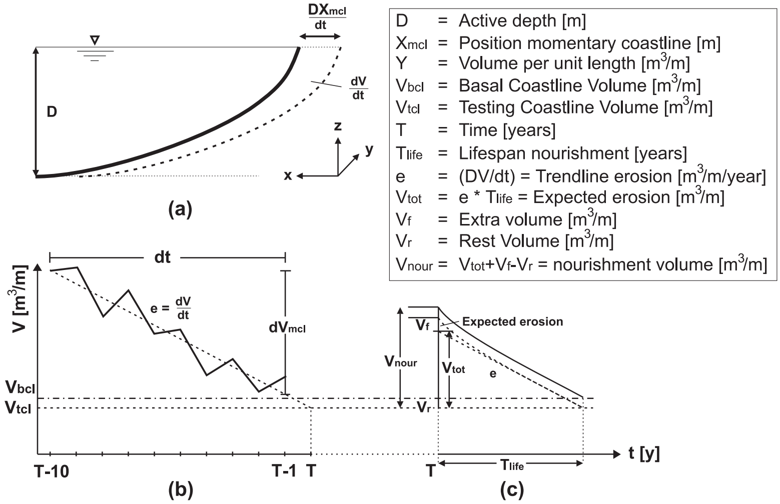


Figure 5.4: *Definition sketch for nourishment design per unit length of coastline (Based on: Roelse, 2002)*

To make sure the intervention is effective, usually a loss-factor 'f' is applied, which accounts for the uncertainties associated with the design procedure as well as the governing natural processes. Roelse (2002) suggests a factor 'f' in the range of 1.1 to 1.5 for beach nourishment. In case of a shoreface nourishment a factor of roughly 2 is applied, to obtain the required nourishment volume 'V_{nour}' (see Figure 5.4c):

$$V_{nour} = V_{tot} * f = 100\,m^3/m * 2 = 200\,m^3/m \tag{5.3}$$

The product of this 'V_{nour}' and the alongshore length of the eroding stretch 'dy' yields the total nourishment volume '$V_{nour.tot}$'.

$$V_{nour.tot} = V_{nour} * dy = 200\,m^3/m * 1000\,m = 200.000\,m^3 \tag{5.4}$$

Figure 5.4c shows that this nourishment volume may be corrected by a volume 'V_r', representing either a reduction in cases of a remaining sand buffer, or an addition in cases where the TCL already surpassed the BCL. The geographical design aspects are determined by specific characteristics of the eroding stretch.

4. Evaluation of policy effectiveness

Periodic evaluation of policy effectiveness is recommended. Min V&W (1990) prescribes a 5 year interval for evaluation. A careful and objective assessment of policy's effectiveness in achieving its objectives, may indicate the need for changes in the 'frame of reference'. How this notion was applied in practice in the case of the Dynamic preservation policy is illustrated in the next Subsection.

5.2.4 Evaluation of dynamic preservation

Since 1990, several evaluations of single nourishment projects (Roelse and Hillen, 1993) and the coastline policy as a whole have been presented (cf. Roelse, 1996, 2002; De Ruig, 1998).

Considering the *operational objective* to preserve the coastline at its 1990 position, a quantitative assessment leads to a clear conclusion: "Dynamic Preservation" has been successful over the period of 1991 - 2000. With a yearly average of 6 Mm^3 of sand nourishments over the last decade, Roelse (2002) states that there is no more coastal retreat and the number of transects exceeding the BCL is decreasing yearly.

With respect to the *strategic objectives*, viz. to guarantee a sustainable safety level and sustainable preservation of values and functions in the dune area, a quantitative evaluation is hampered by the lack of guidelines for benchmarking effectiveness. However, indications are positive.

Increased dune strength - Safety

Roelse (2002) reports over the period 1991 - 2000 first of all an improvement of safety levels. In Dutch coastal policy, safety of dunes is determined with a quantitative state concept referred to as the 'erosion point'. This point represents the extent to which a dune is expected to erode given a certain coastal profile and a set of hydrodynamic boundary conditions (TAW, 1995a). In this evaluation the position of this 'erosion point' relative to objects in the dune area is considered to be a measure for safety; changes in this position a measure for increased or decreased safety. For his evaluation, Roelse (2002) assessed the safety of six known vulnerable objects (3 hotels, 1 resort and 2 boulevards). The calculations were based on a storm surge with an exceedance frequency of the high water level of 1/500 per year; a condition that is also applied when issuing building permits. Figure 5.5 shows the averaged erosion points with respect to the 1990 reference. The trend before 1990 was negative. The shift in 1984 is the result of a nourishment on the island of Texel, near one of the objects. The trend after 1990 is clearly positive.

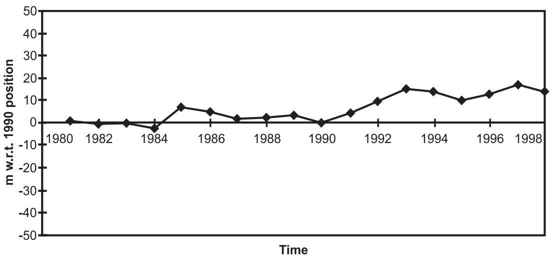


Figure 5.5: *Safety (Source: Roelse, 2002)*

Increased beach width - Recreation

Secondly, Roelse (2002) shows a slight increase of the widths of recreational beaches. To evaluate the development of recreational beach width, Roelse uses as a quantitative state concept, a.o., the 'dry beach width', defined as the distance from the Mean High Water Level (MHWL) to the intersection of the dune front with the NAP +3 m contour (NAP is the Dutch ordnance level). The 'dry beach width' was evaluated for the years 1990 and 1998 at 44 recreation areas along the coast, together making up approximately 30% of the entire length of the coastline (Table 5.1). In 28 of these areas one or more nourishments have been applied in this period. Figure 5.6 shows the results of the *averaged* dry beach widths in 1990 and 1998. In Figure 5.6a the results have been aggregated for all recreation areas in the Netherlands. The averaged width of all 'dry' recreational beaches was found to have increased with approximately 10 m between 1990 and 1998. Figure 5.6b shows that the widest beaches are found along the Wadden coast, with an averaged dry beach width of 180 m. Along the Holland and Delta coast, this width amounts to 50 and 65 m respectively. From the 44 investigated areas, 5 show a decrease in width of more that 10 m (Figure 5.6c). However, none of these areas received nourishment in the period between 1990 and 1998.

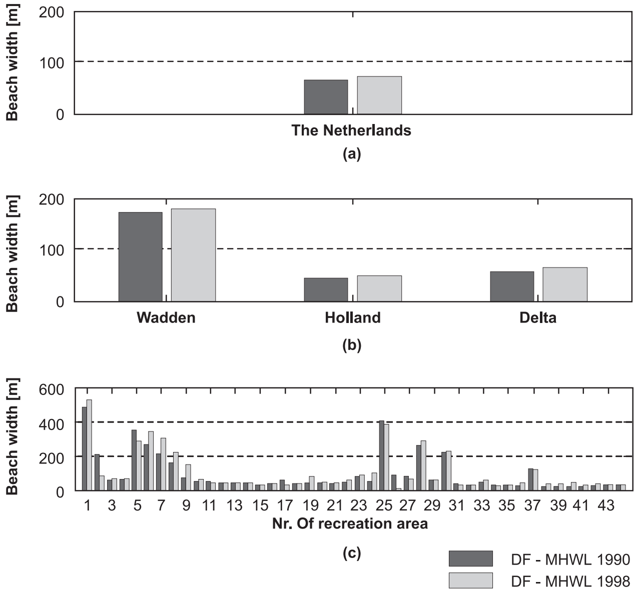


Figure 5.6: *Beach width (Source: Roelse, 2002)*

Recreation area	Nr.
Schiermonnikoog	1
Ameland	2-4
Terschelling	5-9
Vlieland	10
Texel	11
Noord-Holland	12-14
Rijnland	15-18
Delfland	19-24
Voorne	25-27
Goeree	28-32
Schouwen	33-35
Noord-Beveland	36
Walcheren	37-40
Zeeuwsch Vlaanderen	41-44

Table 5.1: *Recreation areas Dutch coast (Source: Roelse, 2002)*

Increase in dune area - Nature

Third, Roelse (2002) reports an increase of the total dune area. To quantify the effects of the nourishment policy on this aspect, Roelse uses the quantitative state concepts 'dune foot position' and 'dune front position'. The seaward delimitation of the dune area is the dune foot, which is marked by the transition of 'flat' beach to the 'steep' dune front. In the field this transition is often hard to identify. Due to natural seasonal sedimentation and erosion processes, the dune foot area is one of the most dynamic areas of the coastal profile. To get consistent time series and to avoid the most intensive dynamics, the 'dune foot position' is chosen relatively high, at a fixed height of NAP +3 m, in the JARKUS profile. The 'dune front position' is chosen at the NAP +6 m contour. Subsequently, the changes in the dune area are expressed in terms of changes in the 'dune foot'- and 'dune front' positions. The chosen method limits the analysis to changes at the seaward end of the dune area. A reasonable assumption, as the landward changes in the dune area have proven to be marginal. Figure 5.7a shows the resulting changes in dune area for the periods 1980-1990 and 1990-1998, based on changes in the 'dune foot'- and 'dune front'

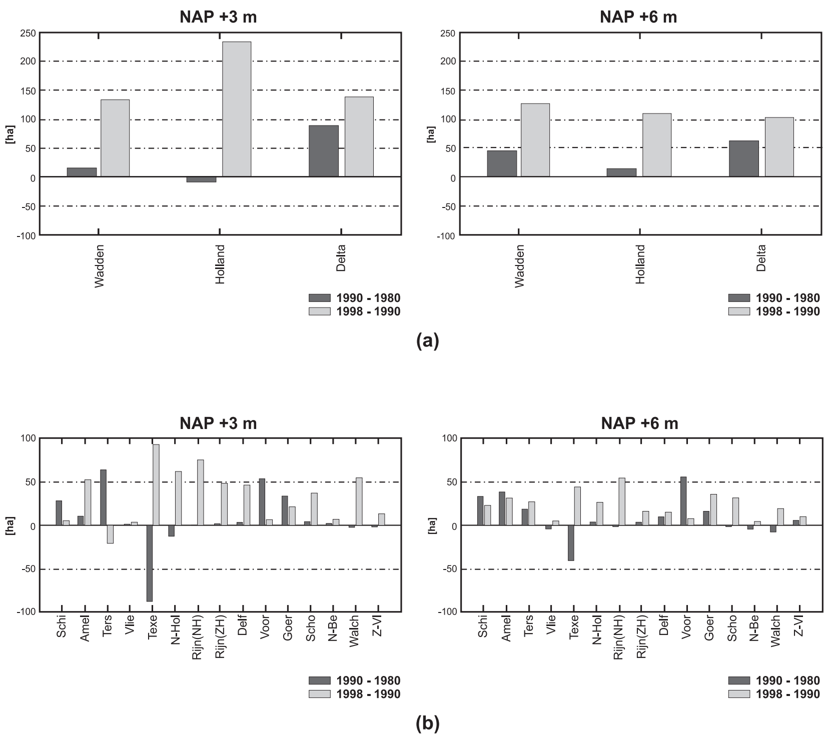


Figure 5.7: *Dune area (Source: Roelse, 2002)*

positions, aggregated for the three coastal regions. All regions show increase in the dune area. The Holland coast shows the greatest response to the coastline policy, especially with respect to the ‘dune foot’. A small decrease over the period 1980-1990 was changed to a gain of dune area of app. 230 ha over the period 1990-1998. Figure 5.7b shows the same changes, but in this case specified for the coastal sections indicated in Table 5.1. Again the figures based on ‘dune foot position’ show the largest changes in dune area, as is to be expected. The island of Texel shows the most remarkable change. A loss of 85 ha in the period 1980-1990 changed to a gain of 95 ha.

Roelse (2002) interprets the evolution of the ‘dry beach width’ and the ‘dune area’ as indications of the evolution of the functions ‘recreation’ and ‘nature’. However, whether the selected indicators are representative for the development of these functions, or all values and functions in the dune area for that matter, is questionable. Such conclusion would require a further specification of the values and functions included in the strategic objective, thus presenting a worthwhile topic to contribute to for specialists supporting decision processes.

The same accounts for the element of the strategic objective dealing with sustainability. Positive indications of the policy effectiveness suggested by Roelse (2002) regard the period 1991 - 2000. Does this imply that Dynamic Preservation is a *sustainable* policy? This question is addressed in the next paragraph.

Sustainability

Discussing sustainability requires making time- and space scales explicit. Typical scales involved in the Dynamic Preservation policy are implied by the currently operational ‘frame of reference’.

The definition of the quantitative state concept MCL involves specific spatial and temporal resolutions. It assumes that the most important changes in the coastal profile within the course of one year, occur between the upper- and lower planes of the definition sketch (Figure 5.2). The depth at which the lower plane intersects the coastal profile is designed to capture the most significant annual changes in the profile. As a result, the typical vertical scale of analysis is 10 to 15 m. The alongshore resolution is determined by the 250 m spacing interval of the yearly monitoring program JARKUS. Consequently, the yearly determination of MCL positions can detect alongshore coastal changes with an order of magnitude of kilometers, while it leaves smaller scale changes, often intra-annual fluctuations, undetected. The benchmarking procedure of BCL and TCL is designed to compensate for structural erosion with a time frame of 10 years. Finally, the nourishment design procedure linearly extrapolates observed changes in the upper part of the profile (BCL-zone) to an assumed active profile reaching to -20 m depth. Nourishments, applied in the context of the BCL methodology, are typically designed with an alongshore scale in the order of kilometers, in a depth interval of +3 to -6 m and average design life span of 5 years.

The BCL methodology as a whole is generally associated with time scales of 1 to 10 years and space scales in the order of 1 to 10 kilometers. The Dynamic Preservation policy has successfully preserved the coast line at the 1990 position during the last decade (Roelse, 2002). Combining this conclusion with the typical scales involved indicates that:

- Dynamic Preservation might be considered *sustainable* at a time scale of 10 years.

However, does this imply it is sustainable at larger time scales, as well?

Larger time scales must imply larger space scales. Hinton (2000) clearly indicates a time dependency of the depth of closure. Based on an analysis of the JARKUS database covering the Dutch coast to a depth of -8 to -12 m, a continuous closure depth could not be established in the data applying a time frame of 32 years. Thus, considering a time frame of 30 - 50 years a closure depth of -20 m seems a (safe and) justified assumption for the Dutch coastal system. On this basis Mulder (2000) derived a long-term sand balance of the coastal system from available sounding data. Over the period 1965 - 1995 the Dutch coastal system shows a negative sand balance of -4 to -10 Mm^3 per year. Extrapolating the long term trends and including the effect of a sea level rise of 20 cm per century, Mulder (2000) estimated a negative sand balance of -12 to -16 Mm^3 per year for the coming decennia.

Comparing these long term figures with the average yearly nourishment volume of 6 Mm^3 per year according to the BCL approach of Dynamic Preservation during the last decade, led to the following conclusions:

- the present nourishment design procedure does NOT yield representative estimates of sand volume changes in the total coastal system;
- the present policy of Dynamic Preservation is NOT sustainable at larger scale.

The conclusions of this evaluation, as first indicated in (Min V&W, 1996), have led to a redefinition of the Dynamic Preservation policy into a sustainable coastal policy based on a small- and a large scale approach (Min V&W, 2000).

5.2.5 Sustainable coastal policy: a small- and large scale approach

The original *strategic objective* is maintained, viz. "... to guarantee a sustainable safety level and sustainable preservation of values and functions in the dune area ...".

Regarding 30 - 50 years a relevant time scale for a sustainable policy, the matching space scale for coastal policy is considered to be the sandy coastal system from dunes down to a depth of -20 m. Safety levels against flooding, as well as the quality of other values and functions in this sandy coastal system, are depending on the total amount and spatial distribution of the sand. In fact the total amount of sand determines the *potential*, the distribution determines the *actual* status of the various values and functions in the coastal zone.

Considering preservation of the *potential* of various values and functions as the first basic condition for sustainability, a logical *first operational objective* of a redefined sustainable coastal policy is (Mulder, 2000):

1. “Preservation of the total sand volume in the coastal system ...”.

Basically this implies a large-scale approach.

The *actual* status of values and functions in the coastal zone is determined by the actual distribution of sand on smaller time scales. Preservation of values and functions on a time scale of 1 to 10 years, has proven to be quite effective using the BCL approach of Dynamic Preservation (Roelse, 2002). Thus, a logical *second operational objective* of a redefined sustainable coastal policy remains:

2. “... maintaining the coast line at its position in the year 1990”.

This smaller-scale approach, supplemented by the large scale approach, characterises the redefined sustainable coastal policy in the Netherlands, as implemented in 2001 (Min V&W, 2000). From 2001, the Netherlands has raised the total nourishment volume in its coastal system from an average of 6 to an average of 12 Mm^3 per year. The nourishment budget has been raised from 27 to 41 million Euro per year.

Implementation

The operational ‘frame of reference’ developed for the small scale approach of the Dynamic Preservation policy, provides a template for the implementation of the new large scale approach. First of all, a quantitative state concept (Step 1 in the decision recipe) has been defined (Mulder, 2000). Step 2 (Benchmarking), Step 3 (interventions) and Step 4 (evaluation) in the framework remain to be developed. However, there is no discussion on the preferred intervention procedure: sand nourishments.

1. Quantitative state concept: large scale coastal cells

On a time scale of 30 - 50 years, the cross shore space scale is -as indicated before- assumed to range from dunes down to -20 m. The corresponding alongshore space scale is assumed to be several tens of kilometers. An interpretation of long term morphological characteristics (e.g. Wijnberg, 2000) and of tidal inlet systems and navigational channels as sand transport ‘barriers’, led to the definition of nine large-scale coastal cells (Mulder, 2000). The nine cells represent the Dutch coastal system on the time scale of decades (Figure 5.8).

5.2.6 Discussion and conclusions

The historic review of coastal policy in the Netherlands over the last two decades, as presented in this section, illustrates gradual changes in both the policy perspective and in the process of policy development itself.

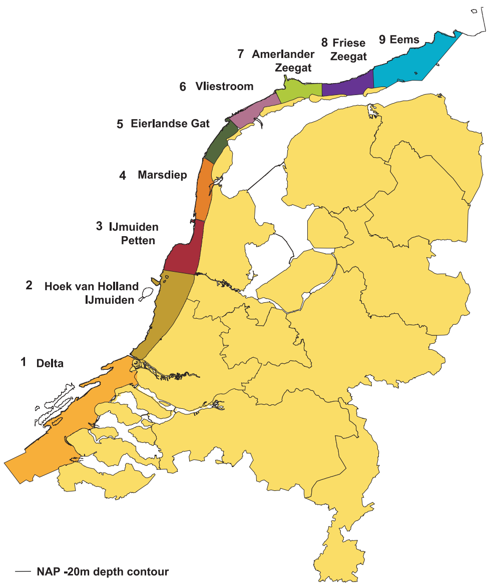


Figure 5.8: *Large-scale coastal cells in the Dutch coastal zone (Source: Mulder, 2000)*

Policy perspective

The dominant focus of coastal policy on safety from flooding -although still number one priority- gradually has been extended to all values and functions in the coastal zone. The strategic objective of Dynamic Preservation (Min V&W, 1990) mentions "... safety level ... and function and values in the dune area ..." and introduced "... sustainable preservation". Implementation from 1990 based on the operational objective "... to maintain the coast line ..." focussed on a relative small scale BCL-approach. Discussions on larger scale effects (e.g. sand losses at larger depths or so-called coastal steepening, and long term developments like sea level rise (Min V&W, 1996)), triggered a (re)consideration of the dimensions of "sustainability". Without changing the strategic objective, the result has been the redefinition of a sustainable coastal policy introducing a supplementary large scale- to the existing small scale approach (Min V&W, 2000). The new policy introduced a second, larger-scale operational objective. Present-day discussions on integrated coastal zone management (Min V&W and Works), 2002), illustrate a further widening of the perspective with a tendency to rephrase the strategic objective of coastal policy exchanging "dune area" by "coastal zone".

Process of policy development

The changes in policy perspective are closely interlinked with the process of policy development. The history of the last two decades illustrates the cyclic pattern of policy development. After the development stage in the 80's (Min V&W, 1990) follows the implementation stage in the early 1990's and an evaluation stage in the late 1990's (Min V&W, 1996). The cycle is renewed in 2001 by implementation of a redefined policy (Min V&W, 2000).

An important factor during all stages of coastal policy development in the Netherlands over the last decade has been the use of an operational frame of reference characterised by a specified decision recipe including a cyclic evaluation of both explicit operational- and strategic objectives.

Its practical use during the implementation stage of coastal policy is illustrated by the successful implementation of the Dynamic Preservation policy since 1990. Analogously, the decision recipe gives strong guidelines for the steps towards a smooth implementation of the new sustainable coastal policy: after the definition of coastal cells as quantitative state concept, it is clear that a benchmarking test and a design procedure for interventions need further elaboration. Necessary studies first revealed a need for additional data. As a result, the large scale coastal cell concept has invoked an extension of the yearly monitoring program of the nearshore zone (JARKUS) with a 5-yearly monitoring of the coastal system down to a depth of -20m. The design of a benchmarking procedure has already triggered a first subject for evaluation. The definition of the large-scale coastal cells, more specifically the cross- and long shore boundaries of the cells, may be considered as explicit management hypotheses asking for scientific scrutiny. Thus, the systematic approach stimulates the transfer of expert knowledge in support of coastal policy.

Like the implementation stage, the 'frame of reference'-approach has proven its use for evaluation- and redefinition- or development stages of the policy. The development of the new sustainable coastal policy is a good illustration. The notion in the frame of reference, of the need to break down strategic objectives into one or more operational objectives (see Figure 5.9), expressed in terms of quantitative state concepts, has resulted in discussions on the dimensions of the sustainability concept, the basis of the new policy. Operational objectives that focus on 'fundamental' aspects of the system, given certain time and space scales, seem to be popular. Managing these operational objectives sets the stage for a favourable development of functions and values that depend on these aspects. For actual realisation of this development, coastal policy and management tend to rely on the system's ability of self-organisation.

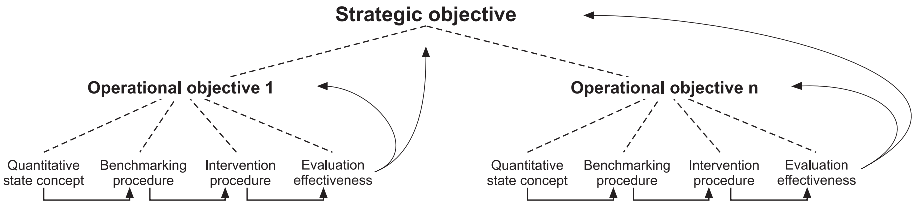


Figure 5.9: *The basic frame of reference as a tool for policy development*

In a similar way the 'frame of reference'-quality indicators and approach may be helpful in further analyses of the strategic objective of the coastal policy; e.g. by specifying scales associated with specific other values and functions in the coastal zone. The BCL- and large scale coastal cell concept, for example, operate at time scales of 1 to 10 and 10 to 100 years respectively. These scales are large compared with the scales of interest for e.g. beach recreational purposes, confronted with seasonal and much more local changes of the coastal system. Thus, for specific recreational interests, the definition of a new operational objective may be required, accompanied by a decision recipe designed at a more suitable scale.

Coastal managers and coastal scientists may work together in all phases of development, implementation and evaluation of policy and management measures. The work in this section illustrates how the 'frame of reference'-approach represents a promising tool to stimulate communication between coastal managers and coastal scientists of different disciplines and to facilitate effective research and technology transfer to the coastal management sector.

5.3 The 'frame of reference' in driven research

In this section we investigate whether applying the 'basic frame of reference'-approach provides handles to stimulate and focus the generalist-specialist interaction required to match research efforts with the information need expressed by end users in end user oriented knowledge development. For this purpose we describe the practical experiences from the international research project COASTVIEW, where the approach has been applied.

5.3.1 The COASTVIEW project

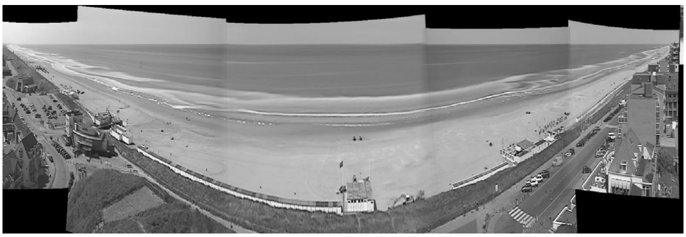
COASTVIEW is a coastal research project sponsored by the European Union under the Fifth Framework (EVK3-CT-2001-00054). It directs its focus to physical problems associated with sedimentary coasts. It is designed to simplify the task of coastal management for which it is necessary to know when a valuable component of the coast is at risk, which processes are responsible, and consequently what appropriate form of intervention (if any) is required in order to sustain or improve the resource. The project hopes to address these issues through the development of video-derived coastal state indicators. For a significant contribution to coastal management the project aims to achieve the following two objectives:

1. To develop resource-related 'coastal state indicators' suitable for describing, in real-time, the morpho- and hydrodynamic state of sedimentary coasts, in support of coastal zone management.

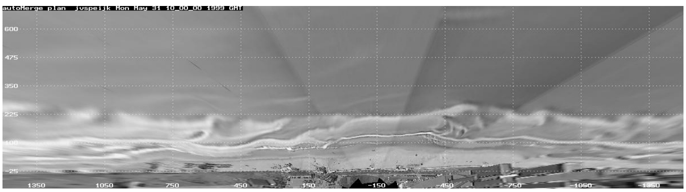
2. To develop and verify video-based monitoring methods and associated analysis techniques for the accurate estimation, monitoring and interpretation of the dynamic significance of these 'coastal state indicators'.

To enable practical implementation of the above-described objectives, research is performed at four morphologically distinct European field sites, viz. a continuous-undefended coastline at Egmond, The Netherlands, a continuous-defended coastline at Lido Di Dante, Italy, a coastal inlet with a single bar or spit at El Puntal, Spain, and a coastal inlet with multiple complex bars at Teignmouth, The United Kingdom. At each of these locations remote video monitoring system or Argus stations are installed. These Argus systems consist of an array of stationary video cameras mounted on an elevated vantage overlooking the coast region of interest (Aarninkhof and Holman, 1999). Through the use of surveyed objects with the cameras field of view (ground control points) the oblique images can be merged (Figure 5.10a) and rectified yielding undistorted plan view of the observed area (Holland *et al.*, 1997) (Figure 5.10b).

The combination of data collected by the Argus cameras and supporting field measurements enables quantitative statements regarding coastal behaviour observed in the video images. In principle all visible features can be detected applying the Argus technique, e.g. shorelines, breaker patterns, wave directions, surface currents, etc. In practice shorelines (Plant and Holman, 1997; Kingston *et al.*, 2000) and bar patterns (Holland *et al.*, 1999; Van Enckevort, 2001) have successfully been detected. Detection of other features like wave directions and surface currents is currently in a much more experimental stage. Combining the detected features with field data and models enables not only qualita-



(a)



(b)

Figure 5.10: *(a) Oblique merged image (b) Rectified undistorted plan view*

tive but also quantitative analysis of morpho- and hydrodynamic phenomena, e.g. the behaviour of inter tidal beach morphology (Aarninkhof *et al.*, 2000), bar behaviour under different morpho- and hydrodynamic conditions (Lipmann and Holman, 1990). The main benefit of the Argus methodology over traditional in-situ measurements is the relatively low-cost, nearly continuous (hourly) synoptic sampling and high spatial resolution, even during storm conditions. The robust nature of the video system also permits long time-series of data that are essential for the identification of trends in coastal evolution.

The rationale behind the COASTVIEW approach is that the information currently available to the coastal manager regarding the physical state of the coast from observations, models and scientific interpretation is often considered to be too complex. As a result it is difficult to use directly, if at all. In order to be of use in decision-making, this complex information needs to be delivered promptly and in a simplified form (see Figure 5.11). The COASTVIEW project chose for reduction of complex information to a limited set of video-derived coastal state indicators (CSIs). The expected benefits from the use of CSIs in the project are twofold:

1. to reduce the complex reality of a coastal system; and

2. to facilitate communications between coastal managers and researchers.

The communication between coastal managers and researchers requires a lot of interaction. The continuous cycle of discussion, depicted in Figure 5.11, may be ‘driven’ by practical problems or technological possibilities. Although (innovative) technology-driven suggestions are obviously welcome in the discussions, the approach adopted in the COASTVIEW project is explicitly problem-driven. This means that the set of CSIs is to be defined systematically based on an inventory of coastal management problems at

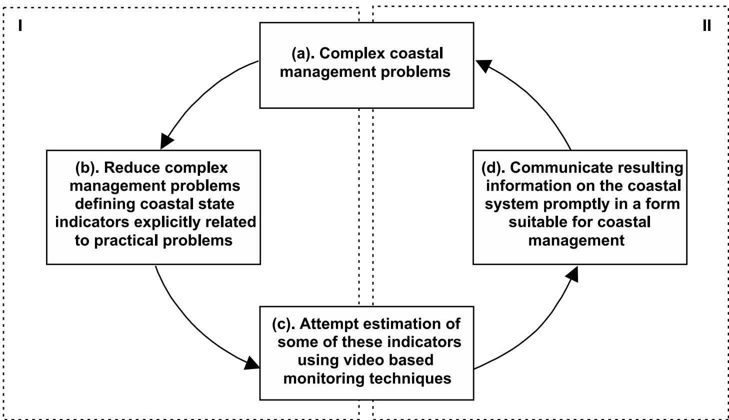


Figure 5.11: *The COASTVIEW approach*

each site (step (a) and (b) in Figure 5.11). The resulting set of CSIs is supposed to represent the reduced information that can be used by coastal managers in dealing with their coastal management problems. After an initial and broad identification of problem related indicators, CSIs that can potentially be quantified using the Argus video technique are selected. Based on this selection a field measurement campaign, customised to each site, is designed to enable ground truth verification of the Argus observations (step (c) in Figure 5.11). The remainder of the project is dedicated to the actual quantification of the CSIs in such a way that the projected end users would perceive them as useful (step (d) in Figure 5.11). To maintain the problem driven approach throughout the project, end users are continually involved to critically review the progress with respect to practical relevance. An interesting aspect of the COASTVIEW project and the main focus of this thesis is the rationalisation of the practical use of specialist knowledge on coastal processes (step (c) in Figure 5.11) to coastal management decision processes (step (a) in Figure 5.11).

This rationalisation is particularly important in the early phases of end user oriented research when important decisions regarding the focus of the project are made. Discussing this topic, we start with a description of the communication process that has been initiated to proceed from coastal problems to CSIs and research questions that can be addressed by the COASTVIEW researchers applying the Argus video technique (Phase I in Figure 5.11). Next we describe some of many problems that surfaced during this communication process and that have impeded effective co-operation, e.g. in the design of the field measurement campaigns. Subsequently, the use is discussed of the ‘frame of reference’-approach in support of rationalising the use of specialist knowledge in decision making. It was introduced to deal with these communication problems. After an illustration of some of the benefits that were acknowledged in the project after the practical application of the approach, we conclude with some suggestions for future end user oriented knowledge development projects.

5.3.2 Process Description: End User - Researcher Negotiation

To stimulate the interaction between end users and researchers, a total of seven formal meetings and workshops, including the final workshop, have been planned during the three-year course of the COASTVIEW project. In preparation for these plenary workshops less formal local meetings take place. The purpose of these workshops and meetings is to enhance cooperation between partners, coordinate the efforts of the different partners and monitor the overall progress of the research. During the first year of the project the meetings and workshops have mainly focussed on the development of CSIs (Phase I in Figure 5.11). As an example the kick-off workshop was designed around a joint definition of CSIs, reflecting the problem driven approach of the project. This Coastal State Indicator Workshop, held in Egmond (NL) in May 2002, provided a rare and exceptionally valuable opportunity for coastal managers and coastal scientists to discuss the main coastal management issues at the different sites. The aim was to get a clearer understanding of manager’s and scientist’s respective approaches to coastal problems and through that process of dialogue to choose a set of appropriate CSIs, based on user needs.

Because it was acknowledged that the first step in the process had to be a clear statement of user needs, the kick-off workshop was carefully structured to ensure that the user input remained foremost; the scientific drivers of COASTVIEW should come only after the user-defined CSIs had been identified. The primary purpose of the kick-off Workshop was to achieve this first step. The envisaged realisation process consisted of three-step approach (see Figure 5.12).

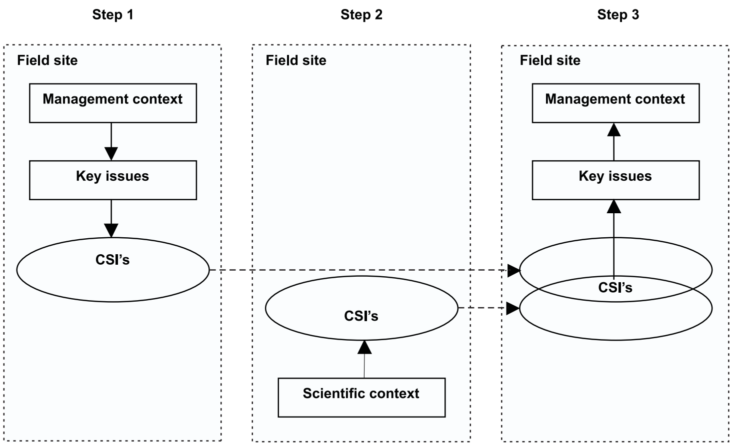


Figure 5.12: *The three-step approach designed for the COASTVIEW Coastal State Indicator workshop*

At the workshop each participating field site was first to present its problem driven coastal management issues and identify a set of relevant CSIs from this perspective (see Figure 5.12 - Step 1). Next the researchers were to present their process based view of the system and identify a set of CSIs interesting and feasible from a scientific perspective (see Figure 5.12 - Step 2). The third and final step was to take both sets and through a process of negotiation integrate them into a single approach (see Figure 5.12 - Step 3). This would, however, prove to be easier said then done.

Step 1: A problem driven selection of CSIs

Identification of a management context
The starting point of the three-step approach is a recognition that management issues arise from distinct management contexts. Many coastal management contexts may be identified. Within the COASTVIEW project, four management contexts have been selected:

- Coastal Protection
- Recreation

- Navigation
- Eco-system protection

The information needs of managers dealing with problems within these different contexts are not necessarily independent. For example, beach width is relevant for coastal protection as well as for recreation. However the management questions to be answered and the priority given to any particular source of information will tend to be different in each of these contexts. The decision was made therefore to treat each of the contexts separately, and only seek for common CSIs at the end of the process.

Identification of related key issues
From each context a series of key issues arises. During the Workshop it seemed that the clearest way to proceed was to define these issues was as questions which managers or policy makers need to be asking about their sites. In Table 5.2, a summary is presented of the questions raised and thus, by implication, the key issues which CSIs ought to address if they are to be of use to coastal managers.

Obviously the list in Table 5.2 is not exhaustive, and each site is likely to prioritise the issues differently. However the list does include many of the issues which were identified as being generic, in the sense that they are likely to be of importance across a range of different sites and conditions.

Selection of appropriate CSIs
Once the key issues have been identified, the search for appropriate CSIs is constrained by the need to find those which:

1. will help the coastal manager address a particular associated question; and
2. will be in a form which the manager will recognise as directly related to the question and suitable to use.

Step 2: A system driven selection of CSIs

In the second step each field site is to be described from a science point of view. The resulting presentations discussed the hydro- and morphodynamic characteristics of each site that were interesting from a scientific point of view. From these scientifically derived characteristics a set of CSIs could be identified that was considered relevant from a scientific point of view. These video derived parameters provide useful descriptors or predictors of the coastal system.

Additionally, the development of new technology like video often presents new opportunities for monitoring and prediction which coastal managers may be currently unaware of. This step therefore provides an important opportunity to test new CSIs in a coastal management context.

Management Context	Key Issues
Coastal Protection	CP1: Are coastal defences (including the natural beach) adequate for the range of conditions expected? CP2: What is the probability of defences being breached? CP3: What infrastructure is at risk from flooding? CP4: What is the optimum replenishment scheme for my beach? CP5: Is dredging adversely impacting my beach, and can I suggest better alternative procedures? CP6: Can I predict beach behaviour if I know something about the offshore bars? CP7: How can I optimise coastal defence in the long term?
Recreation	R1: Are beach users safe? R2: How do I identify/predict risks to bathers? R3: When do I need to worry about a decreasing width of my beach? R4: Can I anticipate the occurrence of algal blooms or seaweed 'attacks', and can I do anything to alleviate the problem? R5: What is the current usage of the beach? Where do people go (duration/location)?
Navigation	N1: Where is the navigation channel? N2: How is it likely to evolve? N3: What is the configuration of dangerous banks? N4: How can dredging be optimised (where, how much, how often, where should spoil go)?
Ecosystem Protection	EP1: Is the state of dune vegetation a cause for concern? EP2: How can the effects of pollutants be mitigated effectively? EP3: How can problems for ecosystems be anticipated and avoided or minimised?

Table 5.2: *Questions resulting from the coastal state indicator workshop*

Step 3: Final selection of CSIs

After the problem-driven and the science-driven suggestions for CSIs the next step was supposed to be a matter of selection. In line with the problem driven approach, coastal managers were asked to prioritise the CSIs that they thought were most important. This would form the basis of the selection procedure. The priority list consisted of both site-specific and generic CSIs.

The selection of a provisional set of CSIs (see Table 5.3) would form the initial focus of the project. However it was recognised that this would only be the first step in the process. It was recognition that it would also be necessary to define acceptable resolution (spatial & temporal) and accuracy of CSIs as well as critical threshold values. The ground truth data and fieldwork form an important part of this process.

Key Issue	CSI
Beach state	Beach volume (to -4m) Beach elevation Beach width Position of the dune foot Beach contours
Algal bloom/ seaweed	Maps of bloom/seaweed location (to include origin)
Subtidal water depths	Channel location Channel depth Slope of sides of channel
Wave condition	Wave height Wave direction Long-term wave statistics
Nearshore current	Mapping of cells and rip currents
Offshore bars	Bar location Bar height Classification of beach bar morphology
Dune condition	Dune height Dune flora (extent, health) Salt spray measure Overwash
Beach use	Location of users Duration of visits Nature of use Density of users
Shipping activity	Number of passages Location of passages Types of vessels
Dredging activity	Location (including spoil dumps) Frequency
Beach Nourishment	Beach state Mapping of bar evolution in key locations

Table 5.3: *Shows how these grouped CSIs are expected to relate to the key issues listed in Table 5.2*

5.3.3 Process Analysis: Problems In The Communication

During the actual implementation of the above-described approach to developing CSIs suitable for coastal management decision-making and appropriate for research, a number of communication problems surfaced.

Without being exhaustive we discuss some of the recurring problems that seemed to have a significant impact on the effectiveness of the interaction between coastal managers and researchers.

Incompatibility of terminology

The actual application of the three-step method to derive suitable CSIs, although promising at first glance, gave rise to ample discussion. At each of the workshops, the general COASTVIEW workshops as well as more informal preparatory local meetings between end users and researchers, discussions became confused due to implicit differences in interpretation of the word CSI. Coastal managers perceived CSIs as concepts that are directly related to their management problem, e.g. swimmer safety, coastal safety, etc. Coastal scientists perceived CSIs as concepts that reflected the state of parts of the coastal system, e.g. wave height, flow velocity, water levels, shoreline positions, etc. Although the results from Step 1 and Step 2 were both called CSIs they proved to be incompatible. The science driven CSIs resulting from Step 2 were more detailed than those derived in Step 1 applying the problem driven approach. How the CSIs from Step 2 could contribute to those derived in Step 1 remained unclear.

As a short-term solution for this communication problem, the term CSI was split up into two new terms after the first discussion, viz. the Issue Based CSIs (IBCSIs) and the Science CSIs (SCSI). SCSIs were defined as individual parameters or indicators which the scientists recognise as objective measures of the physical state of the environment and which will generally be derivable from existing or planned measurement techniques. IBSCIs would typically depend upon an aggregation of the more basic SCSIs, weighted in a particular manner in order to produce an indicator which would directly inform the manager without the need to address unnecessary detail. The clearest example to emerge from the Workshop was the use by some managers of a measure of beach volume (for example to a sub-tidal depth of 4 m). This example of an IBCSI depends upon a range of directly measurable SCSIs such as beach width, beach height, beach slope, sub-tidal water depth and dune location. Not all IBCSIs will be aggregates, however. For example 'beach width' was identified as an IBSCI but is also a SCSI, being a directly measurable simple scientific measure of beach state.

In line with the problem driven approach of the project the choice was made to focus discussions first and foremost on the identification of relevant IBCSIs and from these derive the SCSIs necessary for quantification. The role of the SCSIs is to respond to the IBCSIs required by managers, and not to constrain the identification of IBCSIs.

Implicitly conflicting project goals - science driven vs. problem driven

Another problem that surfaced during the discussions was the presence of implicitly conflicting project goals between the researchers and the end users involved in the project. During the first two workshops, for example, important discussions regarding what should and should not be measured, monitored, modelled and developed took place. During these discussions scientific interests would sometimes implicitly emerge, e.g. through suggestions to measure a certain physical phenomenon, to investigate a certain technical method or to address a certain issue in the CSI effort. One of the important implications of adopting a problem driven approach, however, is the explicit focus on solving coastal management problems. In the COASTVIEW case this materialised by the project managers stating that scientific interests could be pursued, but only if they could explicitly be linked to a coastal management problem and if an end user could be identified that would be willing to participate as a reviewer. This seemed to many participants, to be a harsh prerequisite. Although one may disagree on whether a science driven or a problem driven approach to knowledge development is to be preferred, it seems clear at least that a choice for either approach has to be made in order to deal with this kind of discussions. Despite the fact that on a project level the choice for a problem driven approach was explicitly made, individual partners did often adopt a science driven perspective participating in the discussions, albeit unconsciously rather than deliberately.

Although the scientists perspectives may often seem oblique to coastal managers whose focus is rightfully coupled closely with coastal management issues, it should be recognised that there is often real management value in emergent scientific ideas. For example, considering the management context of navigation, a coastal manager may be interested in the proximity of a hazardous sandbar to a shipping channel. Immediately managers and scientists can agree that a direct measurement of the proximity of a bar to the channel is important, they may also be able to agree on a threshold value (or indicator standard) below which the channel should be modified or dredging should be invoked. However, a suggestion from scientists that the dynamics of the sandbar system should be monitored in order to provide greater insight and predictability of the temporal evolution of hazardous sandbars may seem to coastal managers to be more esoteric. Potentially a predictive model for sandbar location could be a useful tool to predict at what time in the future sandbars may obstruct shipping and help to put contingency plans in place in advance. However, when asked what CSIs are important, coastal managers can only draw on knowledge of what is currently used and shown to be effective. Managers, from their responsibility to society, are often reluctant to incorporate new tools that are not currently used, not tested and often of much less obviously linked to the issues they wish to address.

Implicitly conflicting levels of ambition - short term practical use vs. long term benefits of innovation

A discussion element that is closely related to the previous one is the question whether the project should focus on short term practical use or on long term benefits of more freely organised innovation. Implicit differences in the ambition levels of the partners gave rise to yet another element hindering the progress of the project. Discussions were repeatedly triggered on whether or not it ought to be the purpose of the project to develop innovations for the short term or the long term benefit of coastal management. This resulted in a continual struggle to direct the project focus to topics closely related to current coastal management practice or to freely explore the potential of the Argus technique to provide the foundation for future coastal management innovations. This proved to be a recurring discussion that seems to surface in many other research projects as well (see Chapter 3). Without expressing a preference to either of the previous suggested foci, it is clear that to overcome this obstacle again a clear decision has to be made. The COASTVIEW project decided that it was first to attempt and address currently expressed problems, before other more ‘innovative’ approaches be addressed. It is necessary to demonstrate to coastal managers the utility of video-derived CSI, since the success or otherwise of the project will be judged on how well this is done. It seems logical therefore to prioritise some of the more immediate and realisable goals in the first instance at least.

Local site interests versus general interests
Another issue that surfaced during the research-planning phase was how to deal with local site interests versus general interests. On one occasion, for example, it turned out that based on the local interests at the Egmond site a CSI had been excluded that would be of interest to one or more of the other partners. The CSI in question was related to the monitoring of beach use. The partners from Spain and Italy, that were interested in this CSI, could not investigate this particular CSI themselves due to characteristics of their local Argus stations. Of course it would be possible for them to develop this CSI based on data from the Egmond location, but this could require e.g. a different sample resolution at the Egmond site. Handling these cross-site differences in interest proved to be rather complex.

The pre-mentioned elements often led the discussions away from the most fundamental problem addressed in the COASTVIEW project, viz. to help the coastal manager make better informed decisions. The problems outlined above clearly identified the need for a framework that could guide the end user-researcher interaction in a somewhat more efficient manner.

5.3.4 The “Frame Of Reference” As A Communication Tool

A promising methodology facilitating the knowledge transfer process from the research to coastal management was found in the “frame of reference”-approach as described in the previous section.

Benefits From A Structured Approach

Section 5.2 illustrates how the “frame of reference”-approach represents a promising tool to stimulate communication between coastal managers and coastal scientists of different disciplines and to facilitate effective research and technology transfer to the coastal management sector. So how may it be of use in end user oriented knowledge development projects like COASTVIEW?

Improved appreciation of the communication process
First of all the “frame of reference”-approach is of great use in the communication process as it acknowledges the interests of both decision-makers and researchers. Decision-makers tend to identify with the strategic- and operational objectives and the decision recipes and like to see these improved with specialist knowledge. Researchers recognise themselves in the quantitative aspects of the decision recipe and acknowledge the use of explicitly indicating where their knowledge may alter, broaden or detail any given “frame of reference”. As a result the different partners have gained an appreciation of how they may contribute to better decision making. Furthermore, working with a “frame of refer-

ence" provides an explicit framework that structures previously confusing terminology. The IBCSIs can be associated with the quantitative state concept, while the SCSIs are the parameters associated with quantification of these IBCSIs.

A better match of specialist knowledge with end user needs
Besides a better understanding of the process, working with the "frame of reference" promotes a more explicit match of specialist knowledge with the information need of the end users. The earlier approach resulted in questions, the answers to which would still be hard to use by coastal management. The questions in Table 1 related to Coastal Protection, for instance, seem almost impossible to answer usefully without at least some form of a "frame of reference" regarding the issue of Coastal Protection. Note that this is something quite different from simply providing any answers at all. Of course most coastal researchers can provide all sorts of answers to these questions. But in doing so they would have to implicitly assume their own "frame of reference", making choices regarding what they consider to be e.g. an adverse effect on the beach or an optimal replenishment scheme. It is, however, the responsibility of coastal management to make such choices and as a result it is quite likely that the "frame of reference" implicitly assumed by the researchers differs from that in the head of the coastal managers. As a consequence it is not hard to imagine how such specialist answers could be hard to 'stomach' by decision-makers.

Guiding the knowledge development process
The "frame of reference" approach is also helpful in guiding the knowledge development process. The earlier focus on CSIs (see Figure 5.13) was necessary to focus the discussions between end users and researchers. At the same time, however, this focus diverted attention away from other potentially valuable contributions of the Argus technique. The focus on CSIs, for example, led to the wish of the Dutch end user representatives to reproduce the quantitative state concept currently used in the Dynamic Preservation policy. The rationale behind this was that the MCL is currently used by coastal managers and quantification of this IBCSI using the Argus technology would prove the use of Argus to coastal managers. The MCL, however, is derived based on bathymetric profile measurements, an aspect of the coastal system that is currently hard to detect using the Argus method, although work regarding this aspect is currently in progress. Using the "frame of reference" it was found that, even though it would be very difficult to exactly reproduce the MCL using ARGUS data, it could still be useful in detecting the trend in the coastline, which essentially forms the basis of the BCL decision recipe. Thus the development of a new Argus based quantitative state concept could still provide a useful tool in Dutch Dynamic Preservation policy. As such the context provided by the 'frame of reference', including the quantitative state concept, seems to promote a more productive focus than the CSIs alone.

Besides a contribution to the current operational objective of coastline maintenance, the COASTVIEW project could also consider developing a new "frame of reference" for a smaller scale operational objective, e.g. related to recreation. The continuous synoptic monitoring of the coast provides higher resolution data than the JARKUS measurements,

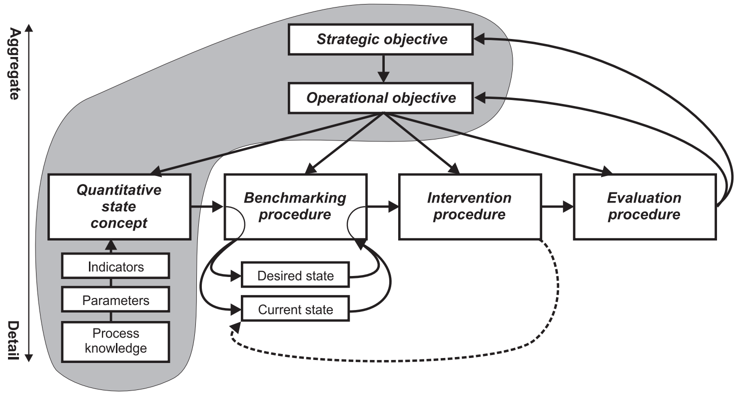


Figure 5.13: *The COASTVIEW focus in the frame of reference approach*

which are taken annually in cross shore rays with a 250 m spacing. The 'frame of reference' for Dynamic Preservation may serve as a template focussing the efforts of researchers.

The first phases of the COASTVIEW project have focused on the shaded area only. It is now (explicitly) acknowledged that during the course of the project attention should be focussed towards completion of the "frame of reference" for a limited selection of operational objectives.

Controlled versus uncontrolled discussions
One of the things associated with end user oriented knowledge development is discussion. It is a 'necessary evil' to come to understanding between the partners. Discussions seem to consume most of the time during the project workshops. This may be perceived as an uneconomical use of valuable time. The question is: Does the application of the "frame of reference"-approach reduce the amount of discussion? It probably does not. But does the amount of discussion need to be reduced? We argue that discussion is good because it is the only way to reach an agreement between the partners. This does not imply, however, that all discussion is productive.

Often, a lot of the discussion is confusion-inspired, due to the use of abstract and confusing terminology and implicit differences in what is the problem at hand and what is the knowledge that needs to be developed to deal with it. It is our opinion that in end user oriented knowledge development projects it is necessary to invest a significant amount of the project time into discussions between project partners. An important challenge remains how these discussions may best be 'controlled' to prevent the waste of valuable time while at the same time remaining focussed on the main goal of these discussions, viz. agreement on what should and should not be investigated.

To prevent the discussions from remaining too abstract the project applies the “Game, Set & Match”-principle to the iterations. During the Game-phase of the workshop approaches from the different field sites are presented. From these approaches some common or useful elements are selected and Set as a proposed standard or method. Finally the group brakes up into sub-groups, trying to Match their local approach to the common approach. To keep a grip on the process it seems that there is a functional limit to group size and a minimum time frame that should be reserved for discussions to produce as concrete results as possible. The individual results are subsequently fed back in a plenary session, thus initiating another iteration.

5.3.5 Discussion and conclusions

Although from the previous section the derivation of elements for the frame of reference, in hindsight, may seem completely straightforward, the process of deriving such a clear view on how to manage a coastal system and how it is to be evaluated, is by no means easy. Even when the strategic and operational objectives have been selected, problems like appropriate spatial and temporal scales, lacking knowledge, required accuracy and useful aggregation of information remain tantalising. One of the strengths of the approach, viz. that different decision recipes are conceivable given a predefined strategic and operational objective, may also become a weakness, as discussion may arise between researchers on which of several potential decision recipes deserves further detailing. End users again may play an important role in prioritising between different suggestions. The ‘frame of reference’ supports this type of discussion and the ‘Game, Set & Match’-approach provides some handles for dealing with the afore mentioned problems in an effective manner.

From the COASTVIEW experience it became evident that in knowledge development projects it is very important to make clear choices on whether the project at hand is exclusively science-driven, or concerns end user oriented knowledge development. If the latter is the case, it is important to choose whether the end user-researcher interaction should be technology or problem driven. We know from personal experience that knowledge developed using a technology driven approach is often hard, if not impossible, to translate to end users. More productive seems the problem driven approach discussed in this section.

Applying a problem driven approach, working towards an explicit ‘frame of reference’ in an iterative Game, Set & Match strategy has proven a promising approach in support of an effective knowledge transfer from coastal research to coastal management. We expect that in the future more research projects will have an explicit focus on end user oriented knowledge development. A recent development, for example, is that part of the Rijkswaterstaat driven research has now been organised in such a way that in order for an R&D investment to be approved, its expected results should earn back the necessary investment within the course of three years. Although it is questionable whether this development will stimulate productive cooperation and yield constructive results, it provides yet another powerful signal that matching specialist knowledge with end user needs is indeed an important topic that deserves acute attention.

Chapter 6

Discussion and recommendations

6.1 The frame of reference applied to itself

For a discussion of the research reported in this thesis we project the basic frame of reference onto itself. Thus attempting to show how the "frame of reference"-approach can be useful in analysing the state of knowledge with respect to a given problem, in this case the problem of matching specialist knowledge with end user needs (see Figure 6.1). In Chapter 2 we started with the development of a hypothesis on a generic mechanism underlying the 'gap' between specialists and users of specialist knowledge. The mechanism suggested in Hypothesis 2.1 was a divergence in the perceptions of specialists and users of specialist knowledge of the problem at hand and the knowledge that is needed to deal with it. A test of this hypothesis against practical experience, in Chapter 3, revealed that this mechanism can indeed be recognised in practice and that from it many problems associated with the 'gap' can be explained. From that perspective we identified as a ***strategic objective***: "to prevent or postpone the seemingly inevitable divergence in perception between specialists and users of specialist knowledge".

In Chapter 4 we developed an operational objective, based on practical experience in the COAST3D project and theoretical analysis, to provide handles on how to deal with this seemingly inevitable divergence in perceptions. As an ***operational objective*** we aimed to: "match specialist knowledge with end user needs *explicitly*".

To facilitate practical implementation we developed a four-step ***decision recipe***, described also in Chapter 4. An investigation into the role of specialist knowledge in decision processes, had revealed the importance of assessing a decision maker's state of knowledge with respect to a given problem. A confrontation of the decision maker's state of knowledge with the problem at hand would enable identification of the necessary information and of the different knowledge transfer situations associated with acquiring it.

To assess the decision maker's state of knowledge, test whether or not it would be adequate to deal with the problem at hand and make this current state explicit in order to enable specialists to match their knowledge to that of the decision maker, we introduced the 'frame of reference'. In our analysis the 'basic' frame of reference is our ***state concept***, albeit a more qualitative than quantitative one as yet.

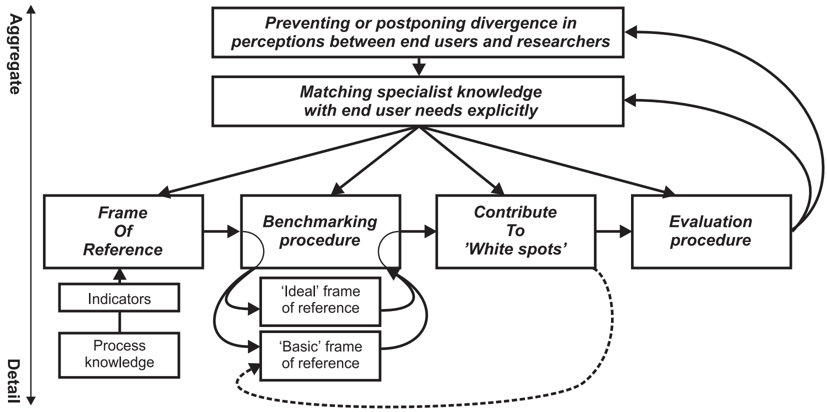


Figure 6.1: *The Frame of reference applied to itself*

Next a benchmarking procedure based on this state concept was needed to assess the information need. As a ***desired state*** of knowledge given a certain problem we introduced the 'ideal' frame of reference. In this 'ideal' situation, an explicit link *has* been made between values and functions in a coastal system and relevant process knowledge through quantitative state concepts, benchmarking, intervention and evaluation procedures. This 'ideal' situation would then enable objective decision making.

To assess the ***current state*** of knowledge we attempt to fill the elements of the 'basic' frame of reference. This can be done through policy analysis, interviews etc. Ideally all elements of the 'basic' frame of reference are filled. A confrontation of the current state with this desired state of knowledge reveals so-called 'white spots'. These 'white spots' provide the targets that specialists may direct their creative potential towards.

To enhance the decision maker's (current) state of knowledge, a 'study', 'consultancy' or 'R&D' project may be initiated. A suggested ***intervention procedure*** in the 'R&D'-context is to use the hypothesis network methodology in combination with pilot projects. The explicit but incomplete 'basic' frame of reference may serve in this case as the statement of what ***is*** known. This way specialists will find it easier to match their knowledge to that of the end user, thus improving his or her state of knowledge.

In the ***evaluation*** phase, one can test to see whether after one iteration the decision maker knows enough to deal with his problem or if a new iteration is still required. In case all elements of the frame of reference have been filled, the effectiveness of the decision recipe should still be tested against the operational objective and the strategic objective. The same holds for this discussion of the "frame of reference"-approach.

In Chapter 5, the “frame of reference”-approach as a whole was first of all used to analyse existing coastal policy to see whether the elements could be recognised in practice and whether ‘white spots’ for further analysis could be identified. This analysis showed that the frame of reference approach could indeed be used in making an explicit link between specialist knowledge and prevailing policy objectives. As such the work in Section 5.2 gives strong positive indications for the method’s effectiveness regarding its *operational objective*, viz. matching specialist knowledge with end user needs *explicitly*.

The work in Section 5.3 illustrates the use of the frame of reference approach as an instrument in driven research situations. Not only does the approach improve the way the information need is identified, it also provides significant support in the communication process associated with end user oriented knowledge development. As such the work in Section 5.3 provides some positive indications with respect to the *strategic objective*, viz. preventing or postponing the diverging perceptions between specialists and end users of specialist knowledge. Unfortunately the time frame of the research reported in this thesis has been too short to make more accurate statements regarding this objective. A longer period of application would be required and maybe the aspects of the strategic objective would need to be more carefully studied before such answers could be provided with a more satisfying degree of certainty.

The above description gives a brief overview of our state of knowledge with respect to the gap between specialists and users of specialist knowledge. In Chapter 1 we stated that, to our knowledge, an adequate framework to address the gap had not yet been developed. Therefore, starting from scratch, the current frame of reference illustrates the progress that has been made in this respect.

6.2 The frame of reference concept

From the above discussion we can see that the “frame of reference”-approach we developed so far is reasonably complete and balanced, in the sense that all elements of the decision recipe have been addressed at a roughly comparable level of detail. Obviously, there are several aspects that require further discussion.

The focus of the frame of reference approach

First of all we need to address the impact of the choice for the problem solving chain and the focus on values and functions in the coastal zone. The concept of the problem solving chain, for instance, has a significant impact on our vision on the role and responsibility of different actors. It seems to suggests, for example, that it is the role of specialists to help generalists deal better with their problems. Although in the context of generalist-specialist interactions this seems to be a fair statement, it probably does not do justice to the entire responsibility of the specialists. Furthermore, we chose to define coastal management problems as discrepancies between the current state of a part of the system and the desired state, surpassing some predefined threshold. This limits the use of the frame of reference to rather specific interaction situations.

Take for instance a citizen of a certain coastal village who wants to build a house somewhere in the coastal zone. The frame of reference approach could assist the municipality in deciding whether or not a building permit would interfere with other values and functions, for instance coastal safety. If a specialist is to be consulted to estimate the effects of this house on e.g. coastal safety, an explicit frame of reference could facilitate communication with the specialist so as to ask questions in such a way that the answers can indeed be used in the process of issuing a permit. The frame of reference is then useful for the communication of arguments from the municipality to the citizen on the physical reasons for denying or awarding the permit. For the citizen who needs to fill in all kinds of paperwork and who has to comply with all sorts of regulations, however, the frame of reference may seem of no or little value. This person would probably be more interested in guidelines or procedures on what regulations he should comply with and what information is required to do that. The transparency of administrative procedures could also be identified as a coastal management problem.

Just like the aforementioned citizen wanting to build a house in a coastal zone might be interested in different information than is presented in the frame of reference, decision makers may be interested in other types of information, as well. A suggestion that has been made on several occasions is that the information need of a decision maker is dominated by considerations with respect to sustainable power and influence, rather than sustainable use and development of the coastal zone. Although we hope that this rather cynical view does not predominate in practice, we completely agree with the fact that other considerations may also trigger an information need. Of course, this leaves the door wide open for other types of decision support.

It is important to realise that the “frame of reference”-approach is primarily aimed at supporting the technical (physical) argumentation of decision processes. It should be understood that other types of information, not explicitly included in the frame of reference, may certainly be of great importance to end users. Furthermore it should be realised that the problem solving chain and the “frame of reference”-approach are not meant to suggest that specialists should always and only be focussed on supporting generalist decision processes. Rather should it be interpreted the other way around: when in a situation some end user has an interest in specialist support, the ideas of the problem solving chain and the “frame of reference”-approach can be applied to effectively deal with the required interaction.

Dealing with aggregation

To reduce the complexity of the more generic approach described in Section 4.3, the ‘basic’ frame of reference was designed to contain a limited set of basic elements recurring in coast-related decision processes. Although in the previous discussion we acknowledged that other elements, not included in the frame of reference, may also be important to end users, practical cases have shown that with respect to the technical argumentation in coast related decision processes, the 'basic' approach as it is now does constitute a useful communication guideline. Nonetheless, some difficulties have not yet been explicitly addressed. One of these difficulties is the subject of aggregation.

In the analysis of the successfully implemented Dutch coastal policy, described in Section 5.2, application of the frame of reference seemed completely straightforward, at least in hindsight. It seems less easy, starting from scratch, with other issues that coastal policy and management need to consider. To illustrate this, we elaborate a fictitious example of dealing with swimmer safety.

Let us assume that we know that swimmer safety is related to waves, currents and tides. A *strategic objective* might be: "to guarantuee swimmer safety at all times". As an *operational objective* we might choose: "to avoid swimming when wave heights are too dangerous, currents are too strong and/or there is a risk of swimmers being cut-off by the tide". Next we we would have to aggregate relevant concepts like wave height, longshore current velocity, rip-currents (location/strength), tidal current velocity, location of hazardous sandbars etc. into one useful *quantitative state concept*. It is in this last step that we encounter aggregation problems.

Using the 'basic' frame of reference approach, we basically have two options. Shall we try and aggregate each of these concepts into a single quantitative state concept? This will be difficult, as they are not very suitable for aggregation. Or do we treat them under different operational objectives, each with its own benchmarks, intervention procedures etc.?

In the latter case the *strategic objective* would remain: "to preserve swimmer safety at all times". But we would have three different *operational objectives*, viz. (1) "to avoid swimming when the waves are too high", (2) "to avoid swimming when the currents are too strong" and (3) "to avoid swimming when there is a risk of being cut-off on a sandbar by the upcoming tide". As an intervention procedure, we may think of a red flag if swimming at a certain location is too dangerous, or a signal to the coast guard alerting them of potential danger to swimmers.

After splitting the complex problem into several clear sub-problems, it will be easier to develop decision recipes for each operational objective. The question remains how to deal with the application of the three resulting frames of reference. Should the three be applied separately, should a selection be made or should the end result still be aggregated into one approach. Discussing how to deal with aggregation, before having obtained a basic insight into the nature of the elements that are to be aggregated, seems not very productive. We feel that the question of dealing with aggregation can be more usefully discussed when the basic characteristics of the separate elements are known. As such, the aggregation problem is a typical arena where specialist knowledge and practical needs may benefit from each other through close interaction. In this interaction it is the responsibility of the specialist to suggest concrete alternatives, while it is the responsibility of the end user to choose which approach best suits his needs.

Concluding, the frame of reference approach does not solve the aggregation problem, but it *does* focus and stimulate the generalist-specialist interaction that is necessary to agree on some approach to the problem. This approach may then be used to focus the research necessary for quantification. If a selection has been made and the developed approach has been applied for several years, the resulting frame of reference for this swimmers example will probably seem just as straightforward as the frame of reference for dynamic preservation in the Dutch case.

Acceptance of change to existing frames of reference

Another element that deserves further attention relates to the acceptance of new coastal management approaches. If some management approach has been applied successfully for a number of years, its success can become a threat for the quality of coastal management. Managers may, for instance, not be eager to change a method that they have been applying for several years. As a result, a manager may decide to no longer participate in the discussions with specialists, necessary for continued improvement.

A potential threat, following routine application of a successful guideline, is that coastal managers may be tempted to apply existing guidelines without further consideration for its effectiveness. Applying a decision procedure without thorough knowledge of the underlying assumptions and considerations can cause a strategy to do more harm than good. An example of such a method may be found e.g. in the Abruzzo region, Italy, where the construction of breakwaters as a coastal management measure was an acceptable solution for many years. Improved insight into the coastal system, among others thanks to projects like RICAMA, have raised the need for a new frame of reference where, instead of hard interventions, soft interventions like nourishment would play a more important role. The learning process that was needed to achieve this framework shift was more difficult than expected (see Subsection 5.1.1). In terms of the “frame of reference”-approach, it would be the task of the researchers to use their insights to try and alter the existing frame of reference into a new one that is more compatible with the present-day characteristics of the system.

Similar examples exist for Dutch coastal policy. For several years it was customary to apply beach nourishments when the benchmarking procedure would call for an intervention. After a few years, shoreface nourishment became the preferred intervention. Especially in the beginning, coastal managers where not very happy with this new approach. They would rather apply a beach nourishment as it has an immediate effect on, for instance, the recreational beach width. At first, the shoreface nourishments were harder to explain to the public. Now, after a few years of application, the shoreface nourishments, sometimes in combination with a beach nourishment, have become more widely accepted. Even to an extent where in some cases coastal managers have asked for a shoreface nourishment rather than a beach nourishment, to the surprise of the specialists involved.

In conclusion, end users and specialist should realise that our vision on the interaction between society and nature in the coastal zone, has been changing for centuries and will continue to do so in the future (see Section 3.2). As a result, approaches that we apply today may no longer be acceptable in the future. To deal with this continued change, coastal policy and management, the public and the scientific community need to maintain communication in order to respond adequately to these changes. It always takes some time to implement a new frame of reference. Especially if it is intended to replace a frame of reference that has been successfully applied for some time. This observation is not something that arises from the application of the frame of reference, rather it has become more apparent than before through the use of the "frame of reference"-approach. The reluctance to accept a new approach, replacing one that has been applied for some time, may also be projected onto the "frame of reference"-approach, itself. When we recommend the implementation of the 'new' frame of reference approach, considerable resistance may be expected. If the benefits of applying the approach can be made sufficiently clear, given time, the approach should find its way to a broader application. This brings us to the next element in the discussion.

The application of the frame of reference approach

How should the approach be applied? - The "frame of reference"-approach should be applied in situations where specialists and users of specialist knowledge interact in the context of problem solving. Some have opposed against the frame of reference's ideal of quantification, arguing that not all things can be quantified, nor would decision-making be made any easier if they could. We very much agree. The ideal of quantification should not be interpreted as an obligation that is set in stone, it should rather be viewed as an 'ideal' goal that helps to focus our attention to making crucial elements of the deliberation process explicit. The desirable amount of explicitness, with total quantification as an extreme, depends on the problem at hand and the decision-maker(s) involved. Furthermore, applying the frame of reference approach, people often feel the need to expand the basic frame of reference, especially during the game phase, e.g. by introducing other layers besides the strategic and the operational ones, by broadening the frame of reference by introducing extra operational objectives and by adjusting the elements comprising the decision recipe. This desire to change the template is a perfectly natural tendency of the discussion process that should be embraced. In the applications so far we have seen that at the end of such discussions usually the outcome can still be usefully projected onto the terms used in the 'basic' frame of reference. This is to be preferred, as it promotes comparability of different frames of reference with respect to a single issue (the process) and with respect to different issues (the approach).

Ultimately, the frame of reference should be used as it was designed, viz. as a tool facilitating the communication between generalists and specialists. Therefore it is not the intention to focus all effort of a research project on contributing directly to the frame of reference. Rather should it be used to focus the discussions regarding what needs to be investigated and what the results are expected to contribute to.

Who should apply it? - Research managers have been the primary target audience for the work in this thesis (see Chapter 1). They are the ones who need to communicate with specialists as well as end users and therefore they are principal actors who could benefit from working with the frame of reference approach. Because the main aim is to stimulate communication between specialists and end users, identified as secondary target groups, these parties should also be actively involved in applying the approach.

A situation in which the specialists work in a science driven manner and the research manager applies the approach in hindsight will probably not be effective, for the same reasons as translation of science driven results to practical needs was not effective in the COAST3D project. If specialists or end users believe that communication with the other party is not their responsibility, no approach will work.

How much time should it take? - The application of the “frame of reference”-approach is something that needs to be learned. Successful application requires well-developed social skills and substantial technical background knowledge. This concerns knowledge of coastal behaviour, as well as knowledge of the problems the end user has to deal with, and of the problems of the end user’s end user (the question behind the question). Once the “frame of reference”-paradigm has been successfully internalised, however, application of the ‘basic’ frame of reference approach need not be very time consuming. Depending on the ambition level of the assignment, the application can take from minutes, involving only a coarse information strategy, up to months, when the information strategy involves measurements and more fundamental research.

6.3 The research approach

Top-down or bottom-up?

The approach to investigating the ‘gap’ between specialists and users of specialist knowledge has deliberately been designed in a *top-down* (or problem driven) manner. Basically we have assumed that a gap was perceived in practice. From that assumption we collected practical experiences and iteratively developed a theoretical framework from which a hypothesis on what caused the gap could be inferred. Next our research was aimed at establishing whether or not the hypothesised cause could be detected in practice. Then after we had developed a sufficient feel for the relevance of the hypothesised cause, we developed a method to mitigate its effects.

A *bottom-up* approach might be to develop a set of criteria and focus on whether or not a gap is indeed perceived in practice. By conducting a certain number of interviews one could use the criteria to construct an objective picture of what elements are indentified in practice in association with the gap, and in which cases the gap is most likely to occur or do damage. The end result would probably yield a lot of suggestions like ‘Yes, communication problems occur in that and that situation’. To make sense of the probable variety of responses, a framework for analysis would then have to be developed to serve as a guideline for the selection of one or more causes eligible for further investigation. We would then still be faced with the question how to address the problems, of course.

At the beginning of this project, the problem of investigating the gap was rather ‘ill-defined’. A benefit of a top-down approach in such cases is that it starts to identify the problem from a conceptual standpoint. The resulting conceptual framework enabled the projected end users to discuss the framework and suggest modifications, based on their practical experience. In numerous discussions and interviews they gave indications on what elements they did and did not recognise in practice. As such, the conceptual framework evolved, through continual reflection with end users, into a framework that many felt addressed the basic problem.

The difficulty of a bottom-up approach is, in the opinion of the author, that it is hard to define a set of criteria that would eventually yield an equally acceptable framework as it has evolved from the top-down approach. In a way this is comparable to the findings in the COAST3D project. When dealing with ‘ill-defined’ problems it is hard, if not impossible, to ask questions, the answer to which provide a solution to the problem identified. In such cases conceptual discussion on what exactly is the problem is more productive.

Working with criteria is easier if the problem is more ‘well-defined’. In such cases it is an excellent way to come to objective scientific conclusions. To apply such an approach if the problem is ‘ill-defined’ seems bound to yield objective scientific answers, the applicability of which in solving the problem remains unclear (compare Lemma 2.5). Furthermore, potential end users usually find it hard to contribute to knowledge development processes of which they cannot see the potential use. As a result, they are often forced to wait until the very end of a project, at which point adjustments are no longer possible. This results in insufficient involvement of end users and an unbalanced drive, which in most cases will impede effective practical application of the end products.

As a result we feel that, although other approaches could have been chosen, the top-down approach adopted for the research presented in this thesis was necessary to effectively go from an ‘ill-defined’ to a more ‘well-defined’ problem. The overview of the results in Section 6.1 provides a sufficiently ‘well-defined’ framework that could effectively focus further scientific scrutiny.

What remains to be addressed

To finalise the discussions with respect to the work presented in this thesis we conclude with a short overview of issues that have not yet been explicitly addressed, but are relevant to the research presented here.

First of all we address our choice to investigate the gap between specialists and end users of specialist knowledge in the context of coastal engineering research projects. Does this mean that the gap does not exist in e.g. advisory or consultancy projects? No, it does not. Rather we feel, in accordance with the conclusions presented by the EU (1999) with respect to R&D in support of ICZM, that mathematical modelling is an area where the gap between researchers and users is particularly evident. With the increased insight into the situations and processes associated with the gap we might more effectively investigate its occurrence in other contexts as well.

A second element is related to the fact that (inter)personal factors have deliberately been excluded in our analysis, that focused on the technical elements of the decision process. It is clear that these social aspects could have a large impact on the effective communication between specialists and end users. Besides the possibility that actors might not see eye to eye, it is well-known from practice that some specialists are better in ‘selling’ their research to end users than others. In the same way, some end users are better than others in asking for specialist assistance. It would be interesting to investigate what causes this. Is this due to social skills, or do these ‘natural talents’ perform well because in generalist-specialist interactions, they automatically match required research with the end user needs (unconsciously skilled)?

A third element that deserves greater attention is the presentation of research results. So far we have not addressed that element, other than suggesting that in communication with end users one ought to attempt to alter, broaden or detail the (implicit) frame of reference of the end user. The work in this thesis mainly focussed on message content. As a communication vehicle we suggested to work with the ‘basic’ frame of reference as it is recognisable to the end users as well as the specialists. Obviously this aspect should be investigated further, to see to what extent message design could increase the effectiveness of the transfer of specialist knowledge.

As a fourth element, we address the fact that in our analysis we have not paid attention to the effect of specialist information on the final decision. The reason for this has been that so many other factors besides matching knowledge are part of this process. As an example, we might look at decision processes in which a number of end users with different interests are involved. In the description of practical cases in Chapter 5, we have mainly focussed on situations where small groups of end users with different interests could be accommodated by introducing matching operational objectives. To come to a final decision, the information related to the different operational objectives should be weighted or possibly even aggregated to come to a final conclusion. Arrow (1951) already showed that, under a few reasonable assumptions, there is no completely satisfactory general procedure for obtaining a group ranking from the individual rankings of the group members. As a result it is not possible to construct a unique group objective from all individual objectives that automatically weights all the separate ones.

The final elements of this discussion are again related to the applicability of the frame of reference approach. How generic is the approach? Can it be applied throughout the problem solving chain? Can it be applied in other disciplines, as well? As stipulated before, the frame of reference approach is focussed on objective decision making with respect to sustainable use and development of coastal zones. For this purpose *all* values and functions ought to be taken into account. Does this imply that the method can only be applied by government authorities? This is a valid question, as for private companies it is mainly their own commercial interests that are paramount. Of course the frame of reference can be applied with only a narrow focus, e.g. limited to short-term success with respect to a favourable operational objective. It is commonly the job of referees, e.g. ratifying government agencies, to identify whether a permit can be issued for a certain activity and if mitigating measures are required, or if a permit should be denied. For this purpose, they should evaluate the planned activity against their own frame of reference that ought to be objective and as complete as possible.

Referring to the interaction types identified in Chapter 2, we feel that generalist-specialist interaction preceding peer-peer interaction, will facilitate communication between comparable levels of aggregation. After discussions on the issue to be dealt with by some end users, acting in e.g. an integrated coastal management project, specialist will get a better idea of the information that is necessary at a higher level of aggregation. This provides them with important handles to match their efforts to that of other specialist in order to better match the end user needs.

6.4 Recommendations for further research

Based on the above discussion we come to the following recommendations for further research. To promote the applicability of the suggested approach we recommend further practical application of the frame of reference to provide answers to the following questions:

- How can the ‘basic’ frame of reference approach be improved in order to further promote the matching of specialist knowledge with end user needs?
- What is the long-term effect of applying the ‘basic’ frame of reference approach on the divergence of perceptions in coastal research projects?
- What is the effect of improvements in the generalist-specialist type interactions on the quality of peer-peer type interactions?
- Can the ‘basic’ frame of reference approach be effectively applied in other project types and other disciplines as well?

Concluding this chapter, we observe that the described approach has triggered discussions on a number of elements that are crucial in the interaction between specialists and users of specialists knowledge and some recommendations for further research. The research reported in this thesis provides us with many useful insights with respect to the gap between specialists and end users of specialist knowledge and suggestions on how to deal with it. In the next chapter we summarise the main conclusions.

Chapter 7

Conclusions

7.1 Conclusions

In this section we summarise the basic conclusions, based on the work presented in this thesis and following the discussions in the previous chapter. We start with the conclusions with respect to the research questions followed by more general conclusions with respect to the overall objective.

7.1.1 The research questions

The aim of this work was to contribute to the insight in the situations and processes that are associated with a 'gap' between specialists and users of specialist knowledge that has been observed in practice and use this insight to develop a methodological approach to match specialist knowledge with end user needs. To achieve this overall objective, four research questions have been formulated in Section 1.4. With respect to these research questions we conclude the following:

1 - Can a generic mechanism be identified that is responsible for (part of) the 'gap' between specialists and users of specialist knowledge?

- A fundamental generic mechanism associated with the difficulties in the interaction between specialists and users of specialist knowledge, is a divergence in perceptions regarding the problem at hand and the knowledge that is needed to deal with it.

- When left unattended this divergence may result in specialist answers that are not (or hard) to use in the end user's problem solving process.

- The emerging 'gap' is attributed to a divergence rather than a difference in perceptions. The time dimension suggests that bridging the gap requires structural efforts, i.e. research management and continuous communication, rather than incidental efforts, i.e. the translation of end results, although the latter may in some cases be possible.

2 - Can the hypothesised mechanism causing the 'gap' be identified from practical experience?

- An analysis of 14 -national as well as international- coastal research projects, confronting their research focus with the 'larger' questions of that time, leads us to conclude that the suggested divergence in perceptions can indeed be recognised in practice.

- The divergence of perceptions as a 'gap' creating mechanism provides a plausible explanation for, minor as well as major, interventions into research programs that we consider, in the long run, to be neither in the interest of the specialists nor of the research drivers and end users.

- The time dimension, indeed is found to play an important role. Shortening the length of research projects has proven to reduce the potential impact of the perception divergence thus diminishing the number of extreme interventions, i.e. project termination or significant shifts in research focus. The fundamental problem, however, remains latently present, recognisable in a continued struggle between the desire to develop new knowledge and to apply existing knowledge.

- It is important to realise that while shortening the project lifetime may prevent the difference in perceptions from becoming too large, it does not address the fundamental mechanism, viz. a continuous divergence of perceptions of the problem at hand and the knowledge that is needed to deal with it.

3 - Can a methodology in support of bridging the 'gap' be developed, focussed on defusing the mechanism mentioned in the previous steps?

- By stimulating and focussing communication between specialists and users of specialist knowledge, with respect to the technical knowledge that is to be developed in a driven research context, the divergence in perceptions might be prevented or at least postponed.

- A methodology has been developed, facilitating an increased end user involvement in knowledge development projects in order to defuse the earlier described mechanism. This so-called 'frame of reference' methodology aims, in a problem driven manner, to make the essential (technical) components of coast related decision processes explicit in order to facilitate effective communication.

- The 'ideal' frame of reference, indicating when a decision can be made based on objective (technical) argumentation, presents a helpful benchmark. The 'basic' frame of reference provides a template in support of discussions towards such objective decision-making. The comparison of the two indicates where 'white spots' in the decision process are located. These 'white spots' may then be prioritised and selected for further study or research.

- The resulting framework contains elements that are useful to both decision makers and specialists. Matching specialist knowledge and end user needs thus becomes a challenge, stimulating the interaction between specialists and users of specialist knowledge.

4 - Does this methodology work in supporting efforts to bridge the 'gap'?

- Based on case analyses we conclude that the 'basic' frame of reference approach can be successfully applied in support of efforts to match specialist knowledge with end user needs.

- The test of the methodology's practical use in analysing existing and successful elements of Dutch coastal policy and identifying 'white spots', yielded positive results. The practical application of the approach in support of end user oriented knowledge development in the context of a coastal research project also yielded positive results.

- Whether or not the method works with respect to preventing or postponing the divergence in perception in the long run is not something we have been able to sufficiently establish during the limited time available for this research project, although the results so far are encouraging.

7.1.2 The overall objective

For the overall conclusion, we place the answers to the separate research questions in a broader context. In Chapter 3 we have seen that, throughout the long history of water management, society's perception of its role in the natural landscape has changed continuously; from adaptation, via defence to accommodation over a period of two thousand years. Throughout that history, technological developments and administrative innovations have traditionally gone hand in hand. Since the beginning of the 20^{th} century, science plays an increasingly important role in these developments, initiated by the large scale efforts to close the Zuiderzee. From that point onward, science and politics worked in close cooperation, with respect to planning and constructing large civil engineering works.

The last thirty years have shown a particularly turbulent change in the relation between coastal science and decision making. Society's frame of reference broadened. Safety from flooding, for example, ceased to be the 'single' dominant management objective in the Dutch case, which culminated in the decision to make the Eastern Scheldt closure a moveable storm surge barrier. Other societal developments gave rise to a significant decrease in the acceptable time from science to application (both in technology and decision making). Thus, on the one hand, the frame of reference used in (political) decision processes has broadened significantly. On the other hand, the scientific community has become increasingly specialised, with sharper divisions into disciplines as well as with increasingly detailed studies. These two factors together have contributed to an increased gap between the interests pursued by science and those pursued by decision makers. This development seems to enhance the importance of the subject addressed in this thesis. In terms of the ideas presented by Stokes (1997) we have found that in the coastal community there is a tendency to focus knowledge development either on ‘inquiry’ or ‘use’ (compare Section 1.2). It would be in the interest of end users as well as specialists, if a work form could be found where the two different perspectives could benefit from each other. The frame of reference philosophy, which focusses on this gap between specialists and users of specialist knowledge, has presented us with a promising way to deal with the above-described developments.

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Much of the work in this chapter is based on research performed in the VOP framework (RKZ-1057) and in Delft Cluster project 03.01.03. It has been reported in (Van Koningsveld *et al.*, 2002a). For the work in Section 4.3 of Chapter 4 I am particularly indebted to dr. Jan Mulder and prof.dr.ir. Marcel Stive. Furthermore I would like to than Dik Rakhorst, Jan Swierstra, Albert Prakken, Karien Luursema, Piet Roelse, Jan van de Graaff, Ruud Spanhoff and Bart Grasmeijer, who allowed me to interview them during several hours. I have learned a great deal from you all.

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Chapter 5
For the case in Section 5.2 the input of dr. Jan Mulder has been greatly appreciated. In a exceptionally productive manner we managed to develop a structure that proved to be an excellent template for other end user oriented knowledge development situations. The work was first published in (Van Koningsveld and Mulder, 2002). An extended version of that work has been submitted to the Journal of Coastal Research. Furthermore I would like to thank drs. Sandra Fraikin, ir. Henk de Kruik, drs. Carola Maas and ing. Jan Swierstra with whom I have worked closely on the second edition of the Leidraad Zandige Kust (TAW, 2002). It has been very enlightening to discuss with you all the elements that a coastal manager would need to know in order to implement Dutch coastal policy.

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Mark, 03-03-2003

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Curriculum Vitae

Mark van Koningsveld werd op 21 augustus 1974 geboren te Gorinchem. Na van 1986 tot 1992 het VWO aan het Corderius College te Amersfoort te hebben doorlopen, startte hij de studie Civiele Technologie en Management aan de Universiteit Twente te Enschede. Op 26 juni 1998 studeerde hij af bij de vakgroep Modelleren van Integrale Civieltechnische Systemen. Onder begeleiding van prof.dr.ir. H.J. de Vriend, prof.dr. C. Hoede, prof.dr. V.N. de Jonge, ir. M.J. Kolkman en dr.ir. J.L. de Kok heeft hij de bruikbaarheid van de theorie van kennisgrafen als hulpmiddel bij conceptuele modellering onderzocht.

Van 1998 tot 2003 was hij als assistent-in-opleiding (AIO) werkzaam bij de sectie Water Engineering and Management van de Universiteit Twente in Enschede, gedetacheerd bij WL|delft hydraulics. Begeleid door prof.dr.ir. H.J. de Vriend, prof.dr.ir. M.J.F. Stive en dr. J.P.M. Mulder verrichtte hij onderzoek naar de aansluiting van specialistische kennis bij de kennisbehoefte van eindgebruikers. Dit onderzoek is beschreven in dit proefschrift.

Vanaf 1 februari 2000 was hij in deeltijd als onderzoeker-adviseur werkzaam bij de afdeling MCM (Marine & Coastal Management) van WL|delft hydraulics in Delft.