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KRIM: CLIMATE CHANGE, COASTAL PROTECTION AND RISK MANAGEMENT IN NORTH-WEST GERMANY

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1 Summary

The interdisciplinary KRIM project has generated orientation and policy-relevant knowledge for the future task of risk management in coastal protection efforts under conditions of climate change. KRIM included seven subprojects from the social sciences and natural sciences. A Decision Support System is under development. The central findings here are that the adaptation to climate change currently needed can be achieved using established strategies and structures, provided that the accelerated rate of rise in mean sea level is accepted as a "new parameter" by the political and administrative systems involved. In order to support this acceptance, the discussions on climate change and the risk of storm tides, debates which have largely been pursued separate one from the other, will have to be brought together. This process has already begun but needs to be further intensified. In order to prepare for medium- and long-term adjustment to climate change, the discussion already started on the further development of the coastline protection strategy will have to be continued and expanded, ultimately to culminate in integrated risk management; financing will have to be guaranteed for the research required in this context.

2 Aim of the research in the framework of DEKLIM

Due to their far-reaching impact on natural and socio-economic systems, climate change and climate variability present major global challenges. In view of the potential risks caused by climate change, climate impact research has become increasingly important. Against this background, the goal of the German climate impact research program, DEKLIM C, is to study the consequences of climate change and climate variability in selected ecological and socio-economic systems in order to better understand the factors that determine their vulnerability. The climate impact research program aims to produce policy-relevant knowledge that will help to improve the capacity of societies to cope with the effects of climate change. Moreover, DEKLIM C places emphasis on intensive co-operation and communication with stakeholders, potential users of the research results, and the public at large.

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Since climate impact research has to deal with complex interactions between physical, ecological, socio-economic and political systems, the KRIM research group is characterised by interdisciplinary research co-operation between social and natural scientists.

Based on some previous work (Schuchardt and Schirmer 2001, 2002a; 2003) the KRIM project aims at providing know-how for society's future task of "risk management in coastal protection under climate change conditions", giving special attention not only to the natural sciences, engineering and economics, but also to the processes of perception, communication, interpretation, organisation and funding. Conflict potentials, decision-making structures and possible solutions are analysed.

The objectives of KRIM are

- to analyse the consequences of an accelerated rise in sea level and intensified extreme incidents for different natural and social settings within the North Sea coastal region,
- to examine individual and societal perception and communication of the possible consequences of a sea level rise and the rising risk of dike failure as well as to analyse the implicit conflict potentials, the decision-making structures and the possible solutions, and
- to develop on this basis a Decision Support System (DSS) for coastal protection management as a methodological instrument for integrative analysis and as a tool to support public discourse on the handling of the impacts of climate change on coastal regions.

The study area is the Weser-Jade region in Northern Germany, including the Lower Weser estuary, the Jade-Bay, the Wadden Sea, the marshes, the barrier island Wangerooge, the cities of Bremen, Bremerhaven and Wilhelmshaven and some smaller cities and towns.

3 Structure of the project and approach

The task defined for the KRIM project requires an analysis of functional interrelationships between natural and social systems. Based on the realisation that society perceives the state of its environment through a filtering process for perception and communication (Becker et al., 1998) and that an activation of its instruments is the result of complex opinion-forming processes, several disciplines are involved as subprojects (SP) in the KRIM project (subproject leaders in brackets):

- SP "Climate Change and Hydrodynamics and Morphology" (Iris Grabemann; Dieter P. Eppel, GKSS Research Centre);
- SP "Climate Change and Coastal Protection" (Claus Zimmermann, Franzius Institute, University of Hannover);
- SP "Climate Change and Ecology in the Coastal Region" (Michael Schirmer, University of Bremen);
- SP "Climate Change, Political-Administrative Regulation and Coastal Protection (PAS)" (Hellmuth Lange, University of Bremen);
- SP "Regional Economic Risk and Response Analysis of Climate Change Impacts" (Wolfram Elsner, University of Bremen),
- SP "Climate Change in the Public Sphere" (Hans Peter Peters, Jülich Research Centre),
- SP "Integrative Analysis and Decision Support System" (Michael Schirmer, University of Bremen, and Bastian Schuchardt, BioConsult).

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KRIM climate change scenario for 2050:

Using results compiled by the IPCC and in a downscaling study by the GKSS, the joint scenario includes (partly seasonally differentiated): rise of mean sea level: +55 cm; increase of tidal range: +25 cm (HT +65 cm; LT +40 cm); extreme storm-surge: +200 cm; air temperature: +2.8°C; precipitation: +10%; wind velocity: +7% (Dec–Feb). This scenario forms the common basis for assessing the consequences of climate change.

Integrative risk concept:

The concept of risk is used in engineering and the natural sciences as well as in the social sciences. It is theoretically applicable for all disciplines involved in KRIM and represents a tool for integration within KRIM. Based on the different disciplinary definitions, a joint definition taking into account the various aspects has been formulated:

Risk is a mental construct to characterise hazards more precisely. It does not have a direct counterpart in reality and can be constructed only within a specific context. Intuition can be the prime mechanism (public domain) along with scientific methods. The process is centred on the apprehensions of damage based on danger, the quality and quantity of which can be influenced by societal and/or individual decisions and which require acting under conditions of uncertainty.

In the perspective of the technical, natural and economic sciences the two central categories of risk are the extent of damage and the probability of occurrence. Damage may be defined in different ways by different disciplines. In the perspective of the social sciences the risk concept also includes the aspects of risk experience, risk perception and risk communication. All of these aspects have to be included in modern risk management.

The main part of the work was to identify scientific, political-administrative and public risk constructs and to examine the relationships between these three risk constructs. The scientific risk construct has been generated by implementing new scientific approaches which are not in use in the existing scientific risk construct, whereas the existing political-administrative and the public risk constructs have been analysed using various techniques found in the social sciences.

4 Results

Although integrative analysis and the construction of the Decision Support System have not yet been finalised, the following results can be formulated as the main findings:

Scientific risk construct:

We have generated a scientific risk construct in the KRIM project. Among other features, it

- makes uses of scenarios drawn from climate research,
- calculates the probability of occurrence for damage incidents (probabilistics),
- analyses the potential damage in the event of inundation,
- employs an expanded concept of "damage" which, in addition to losses in capital goods and fixed assets, also takes account of reductions in value addition and ecological damage, and
- enables the use of cost-benefit analyses as decision-making criteria.

A construct of risk of this type has to date had no counterpart in the political-administrative system. Decisions in regard to coastal protection in north-western Germany are reached on another basis. In addition to a multitude of individual results (Grabemann et al. 2004; Mai et al., 2004; Schirmer et al., 2004; Elsner et al. 2004), which are discussed in the publications

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prepared by the subprojects, the following results represent the key findings of the integrative analysis for the superordinate questions:

- An accelerated rise in mean sea level diminishes the present safety level along the coast and requires suitable adaptive efforts in the field of coastal protection.
- The accelerating rise in mean sea level is the central parameter in climate change for the German North Sea coast; its vulnerability as regards changes in other parameters is relatively modest.
- Even where the probability of failure is kept constant by strengthening the dikes, an elevated sea level implies an increase in the potential damage level, since water inflow would be greater.
- The damage potentials following dike failure differ widely, depending on where the failure occurs. The potential is fairly small in some zones in the larger region being examined. This is also true when an extended damage concept is applied, i.e. a concept which considers not only the direct damage (property damage) but also ecological damage and reductions in economic output.
- These differences in damage according to the areas affected (a phenomenon which exists even without climate change) are not taken into account in the practices currently applied when dimensioning coastal protection facilities in the region under study. The rule is: "equal safety for everyone" or "equal safety against failure at all points".
- Natural adaptation processes which reduce the probability of dike failure would include a concomitant rise in the tidelands and at the foreshore. At present one cannot say with certainty whether this will happen, but it is likely. Projects to support this effect would include intensified construction of reclamation fields to stabilise the foreshore and stopping any removal of material from the tidal flats and the foreshore. Additional research is required here, however.
- Risk analysis as developed in the KRIM project (using an extended damage concept) represents a process with which to generate a rational decision-making basis for the dimensioning of the coastal protection facilities; methodically it is well suited for linking with the scenarios used in climate research, with the implied uncertainties. It makes no difference whether the "equal safety for everyone" philosophy is retained or cost-benefit considerations lead to dimensioning which differs according to the zone affected.
- There are various strategies available with which an adaptation of the coastal protection system to account for accelerated rise in sea level can be effected. One of these is a redoubling of efforts, following the existing dike line and selecting those locations with the most favourable cost-benefit ratio (and with the widest acceptance, as will be discussed below).
- The erection or activation of a second dike line and the construction of additional flood barriers in certain locations can make sense as a long-term augmentation and to limit the potential for damage.
- The financial requirements for coastal protection will increase in the future with an accelerated rise in sea level.
- Statements as to the probability of an incident and as to the damage to be expected are subject to relatively large uncertainties; this has to be taken into account when using the results.

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- In the very long term view (more than 200 years) the extent to which the rise in sea level can be counteracted in the region may reach its limits, depending on the further progress of climate change.

Public risk construct:

Communication of risks due to climate change and storm tides in the media and the estimates held by the public at large make up what we refer to as the "public risk construct". Such constructs cannot be generally understood as popularised versions of the corresponding scientific risk constructs; the system of communications with the public colours meaning and significance according to its own set of rules. On the subjects of climate change and storm tide risk there are two clearly separate discussions among the public and in the media. There has hardly been any overlapping (at least at the time the survey was conducted). In addition to a multitude of individual findings (Peters and Heinrichs, 2004) which were depicted in the subproject publications, the following are among the important results in the outcome of the integrative analysis for the superordinate questions:

- The discussion on climate change clearly shows the influence of science and the scientific risk construct. Both the media and the general public have adopted the majority position among climate researchers and are assuming that global climate change is taking place and that this is (also) due to anthropogenic influence. This change is associated with serious risks. There is no indication of externalisation of responsibility but there is great readiness to undertake action (at least as expressed verbally).
- The media and the public focus almost exclusively on mitigation in order to counter the risks associated with climate change and thus concentrate on avoiding climate change; adaptation plays almost no part at all in the debate (at the time of the survey).
- Quite striking is the high degree of confidence which the media and the populace placed in science as regards finding the "truth" and diagnosing problems.
- Public discussion on the risks associated with storm tides is in many cases influenced by the regional operatives in coastal protection. Science does not play any significant role here. The regional political and administrative institutions responsible for coastal protection are far more present in media discussion than are the primary scientific sources.
- There is consensus that a storm tide risk does exist, but there is also agreement that this risk is currently being reduced to an acceptable level by coastal protection projects. The public and political-administrative risk constructs for the storm tide risks are not identical at the regional level but are largely compatible. This is also made clear by the high degree of trust which coastal protection (as part of the political-administrative system) enjoys in the three areas studied – Bremen, Wilhelmshaven and Wangerland.
- These two discussions have hardly been linked at all as yet, either in the media or in public awareness. Although climate change is seen as being unavoidable and as an "endangerment", there is hardly any concern about the increase in storm tide risks as a result of climate change.
- The public assumes that coastal protection will be able to master the challenges resulting from climate change by applying established strategies.
- It is obvious that above all coastal protection measures which continue the current strategy will (and would be) accepted.

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- The great degree of trust enjoyed by coastal protection presents both an opportunity and a problem. It offers coastal protection on the one hand the chance to gain support in overcoming external resistance. On the other hand it also implies a considerable amount of obstinacy when changes imposed from the outside are to be implemented.

Political-administrative risk construct:

The political-administrative system (PAS) with its operatives in politics, administration and dike associations, all of which play a fairly large role in the region studied, has organised coastal protection in the area studied in such a way that no inundations have taken place since 1962. The acceptance of coastal protection among the public is remarkably high. One thing which makes a considerable contribution to acceptance is the current "safety philosophy" (Kunz, 2004) adhered to in coastal protection, namely "equal safety for everyone".

In addition to a multitude of individual findings which are depicted in the subproject publications (Lange et al., in prep.), the following results, as the output of the integrative analysis, are of considerable importance for the superordinate questions:

- Acceptance of the methods (e.g. probabilistic risk analysis) and the results of the scientific risk construct is currently relatively low in the political-administrative system. Mention is made of the continuing need for further development of the methods; there is still an overly high degree of uncertainty in regard to the extent and nature of climate change.
- The interrelationships between the discussions on climate change and on storm tide risks are largely perceived by operatives in the political-administrative system, but taking appropriate action is still rejected due to the uncertainties as regards development, these still being too great. "Act only on the basis of sure knowledge" is named as an axiom for action; this is not congruent with the implicitly uncertain results of climate research.
- The operatives in the political-administrative system are putting their faith primarily in continuity in the system and thus assume that they will be able to master the consequences of climate change within the course of "business as usual".
- The coastal protection administration assigns responsibility for risk acceptance to the political sector of the political-administrative system while delegating to administrative coastal research responsibility for the question of risk estimation. Both are seen by the coastal protection administration more or less as external factors to which strategy decisions are delegated.
- For the administrative coastal protection system the primary and decisive question is ensuring and expanding the financial framework.
- At present those who would potentially be affected by dike failure are not directly involved in defining the safety standard. Instead, this is done by the political-administrative system. But those affected also make only a very small contribution to the required funding. The residents of Germany as a whole bear the largest part of the costs.

Interdependencies among the risk constructs

- The three risk constructs clearly influence each other. Proper account will have to be taken of this in any future changes in the coastal protection strategies.

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Consequences for mastering the problem:

- The (present) adaptation to accommodate climate change can also be realised with the established dimensioning procedures, the established coastal protection strategy and the current organisation, assuming the appropriate increase in financial resources.
- To achieve this it is necessary that the accelerated rise in sea level be accepted by the political-administrative system as a "new parameter". To support this, the discussions on climate change and the risk of storm tides (and coastal protection), now being pursued largely separately, will have to be drawn closer together.
- The realisation of the necessary adaptive measures in coastal protection might exacerbate existing problems. Acceptance can be promoted by the merging of the discussions on climate change and coastal protection, as mentioned above.
- Over the long term the current, linear coastal protection concept increases the risk that the potential for damage will become ever greater as the difference between the water level and land elevation behind the dikes widens. The development and establishment of zoned coastal protection (e.g. second lines of dikes) can reduce the risk.
- The implementation of zoned coastal protection should be supported by its being fully considered in land use planning procedures.
- Cost-benefit analyses should be employed as an additional decision-making criterion in the field of coastal protection.
- In the medium and long terms the future challenges resulting from climate change itself and from operating parameters which continue to change (including limited financial resources, fairness in resource distribution, increasing the efficiency of public investments, demographic change) will presumably better be managed if the current coastal protection strategy is further refined to become a risk management system within the framework of an integrated coastal zone management (ICZM) concept.
- In spite of an ongoing need for further development, the probabilistic risk analysis is in principle capable of delivering data relevant for planning purposes in regard to existing and future risks (applying the scenario technique in predicting the latter). There is still need for additional research here, however.
- Any expansion of the current coastal protection strategy should be undertaken step by step and should be accompanied by a frank and open dialogue in order not to endanger the high degree of public acceptance of coastal protection.
- Planning in the future should be considered in regard to its "sensitivity to climate-related phenomena". This is to avoid reducing the adaptive capacity of the region and instead to increase it wherever possible.

Integrated risk management

Although (present) adaptation to the consequences of climate change could also be achieved with the current coastal protection strategy, that strategy should, for the reasons elucidated above, be transformed to become an integrated risk management concept over the medium to long term. This change could be managed in several different ways. The central difference to current strategy is the determination and consideration of risk as a product of probability of occurrence and potential damage. An approach such as this is already being used in Great Britain, the Netherlands and other countries and has also been proposed in Germany (Kunz, 2004 i.a.). Before introducing probabilistic risk analysis it will be necessary, in addition to

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discussing methods, to address the following questions above all:

1. Should this incorporate a change in paradigm from the current "equal safety" to "equal risk"?
2. Is this to be associated with a change from linear to zoned coastline protection? (Also possible without probabilistic risk assessment.)
3. Should this be joined with open communications regarding the residual risk and/or the "accepted risk level"?
4. Should cost-benefit considerations then also be included in the determination of the "accepted risk"? (This is indeed an implied component in the strategy at present, but it is not mentioned so openly.)

The confidence which the public places in current coastal protection practices and in that part of the (regional) political-administrative system which is responsible for coastal protection is extraordinarily high. A change in the strategy should be undertaken gradually and should be flanked by open dialog so as to not endanger this confidence.

Decision Support System:

In the DSS a structured approach towards consequences of an accelerated sea level rise with its possible effects on coastal protection management is combined with advanced information technology. The result is an instrument that facilitates the processing, analysis and (graphical) presentation of information and which acts as a knowledge base. The DSS, which is still under development, is a computer-based instrument integrating knowledge from many different but interrelated disciplines (e.g.: hydrodynamics, ecology, economics, risk management, social sciences etc.). Especially the integral representation of knowledge about both physical and social processes makes a decision support system useful for both integrative scientific analysis and participative policy-making processes.

Prime focus in the development of the Decision Support System is on the integration of knowledge, models and data from the various disciplines involved in the KRIM-project (Schuchardt and Schirmer, 2002). The KRIM-DSS is being developed on the basis of an application framework for integrated Zonal Decision Support Systems (Hahn and Engelen, 2000) and has stimulated the interdisciplinary research process.

5 Conclusions and recommendations

The interdisciplinary research project KRIM has shown that the adaptation capacity of the region is estimated to be high, but that there is an obvious need for action regarding the coastal protection system.

- The (current) adaptation to climate change can also be accomplished using the conventional dimensioning techniques, the established coastal protection strategy and the existing organisation, provided that the accelerating rise in sea level is accepted by the political-administrative system as a "new parameter" and that sufficient financial resources are earmarked for the purpose.
- In order to support this, the discussions on climate change and on the risk of storm tides, conducted largely separately in the past, should be related more closely one to the other. This process has already begun but should be further promoted and intensified.
- In order to prepare for medium- to long-term accommodation to climate change, the discussion on further development of coastal protection strategy should be continued and moved in the direction of an integrated risk management concept. Funding will have to be provided for the research which is still required.

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6 Policy relevance and application

The KRIM project generates networked orientation and know-how needed to take action to respond to the impacts of climate change in the coastal region of the German Bight. In addition to classical research into the impact of climate on both the natural and cultivated areas in the countryside, the effects on the socio-economic system are also analysed. Society's perception and reaction patterns in response to changing risk under conditions of uncertainty are depicted on the basis of models and, in a decision support system, are correlated with the effects of possible preventive and remedial measures. The main issue of relevance to policy-making is "how to deal with the risk". The integrated natural and social science analysis of the sensitivity of the natural and social structures to climate and the analysis of the options for preventive risk and coastal protection management supply findings on the resilience of the natural and social structures. This analysis also provides insights into those groups within society which are involved in risk management and the coastal protection management process; it also sheds light on the interactions among those groups (governance).

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