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Implications of Sea-Level Rise for Europe's Coasts: An Introduction

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ABSTRACT

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This paper introduces the collection of papers on impacts of sea-level rise on a number of European countries, and presents some overarching conclusions.

INTRODUCTION

As the implications of climate change have become more evident, so has there been an increasing focus on the effects of climate change and responses in Europe and its constituent nations. This includes a strong interest on the coastal implications because of high exposure (*e.g.,* EEA, 2005), as well as climate change in the wider context of coastal management (*e.g.,* EEA, 2006; EUROSION, 2004; NICHOLLS and KLEIN, 2005). In addition, the European Commission is developing a Green Paper on adaptation to be published in 2007, in which coasts are again an important part of the threat and need for action.

This collection of papers represents a small contribution to better understanding of the implications of sea-level rise for Europe's coasts. They result from the SURVAS (Synthesis and Upscaling of sea-level Rise Vulnerability Assessment Studies)[1] EU-funded project, and, in particular, the "Expert Workshop on European Vulnerability and Adaptation to Impacts of Accelerated Sea-Level Rise," held in Hamburg, Germany, 19–21 June 2000 (DE LA VEGA-LEINERT, NICHOLLS, and TOL, 2000). The aim of this workshop was to assess the current state of knowledge on European vulnerability and adaptation to the effects of sea-level rise and to discuss further research needs. As such, these papers provide a useful snapshot of a moving field concerning the status of understanding of the threats of sea-level rise and the level of our preparations for these threats at the beginning of the 21st Century.

Drawing on the 13 national papers contained here and the 24 countries in the Proceedings, it can be seen that the present understanding of sea level varies significantly between European countries. In broad terms, the Black Sea, Mediterranean, Atlantic, North Sea, and Baltic coasts can be meaningfully distinguished in terms of coastal problems and vulnerability needs, and the papers are presented in this sequence. However, these broad regions can hide important, more local, variations. For instance, the Mediterranean deltas appear to be "hotspots" of vulnerability (see SÁNCHEZ-ARCILLA *et al.* , 2008). Hence, local, national, and regional patterns of potential problems are apparent, and these can be related to a combination of physical, social, and cultural factors.

Table 1 summarises the available national effects in Europe in the same format used by NICHOLLS and MIMURA (1998) and considers the implications of the changing risk of flooding and the potential for different types of losses and the adaptation costs to protect the human environment (*i.e.,* ecosystem losses are accepted). It provides data on the potential implications of a 1-m rise in global sea level on five European countries with the sources: Netherlands (NICHOLLS and MIMURA, 1998), Poland (NICHOLLS and MIMURA, 1998), Germany (EBENHOH *et al.,* undated; STERR, 2008), Estonia (KONT *et al.*, 2008), and Turkey (KARACA and NICHOLLS, 2008). It should be noted that monetary effects have not been reduced to a common base year, but given the time span of the relevant studies, this is not a major factor. The Netherlands stands out as having by far the largest potential consequences in both absolute and relative terms. However, Germany and Poland have significant capital assets threatened

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[1] The overall goal of the SURVAS Project was to further our understanding of accelerated sea-level rise (ASLR) and its associated effects (see www.survas.mdx.ac.uk). In addition to the Hamburg workshop, there were major workshops in Cairo (on Africa) (DE LA VEGA-LEINERT *et al.,* 2001), Kobe (on Asia–Pacific) (MIMURA and YOKOKI, 2001), and London (overview) (DE LA VEGA-LEINERT and NICHOLLS, 2001).

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Table 1. *Effects of sea-level rise in selected European countries, assuming the 1990s situation and no adaptation, plus adaptation costs to protect the human population.*

Country (year)	SLR Scenario (m)	Coastal Flood Plain Population		Population Flooded per Year		Capital Value Loss		Land Loss		Wetland Loss	Adaptation Costs	
		No. ($\times 10^3$)	% Total	No. ($\times 10^3$)	% Total	US$ ($\times 10^9$)	% GNP	Area (km^2)	% Total	Area (km^2)	US$ ($\times 10^9$)	% GNP
Netherlands	1.0	10,000	67	3600	24	186	69	2165	6.7	642	12.3	5.5
Germany	1.0	3120	4	257	0.3	410	30	n.a.	n.a.	2400	30	2.2
Poland	0.1	n.a.	n.a.	25	0.1	1.8	2	n.a.	n.a.	n.a.	0.7	2.1
Poland	0.3	n.a.	n.a.	58	0.1	4.7	5	845	0.25	n.a.	1.8	5.4
Poland	1.0	235	0.6	196	0.5	22.0	24	1700	0.5	n.a.	4.8	14.5
Estonia	1.0	47	3	n.a.	n.a.	0.22	3	>580	>1.3	225	n.a.	n.a.
Turkey	1.0	2450	3.7	560	0.8	12	6	n.a.	n.a.	n.a.	20	10

n.a. = Not applicable.

with loss. It is also apparent that large numbers of people will be exposed to flooding by storm surge. Despite its high exposure, adaptation costs are relatively low for the Netherlands and Germany compared with Poland and Turkey. This reflects the size of the national economy and emphasises that, given appropriate preparation, richer countries should adapt to sea-level rise more easily. However, coastal wetlands are also threatened, and these adaptation measures will do nothing to counter this and could even exacerbate these losses, particularly if hard defence options are used. Thus, there is often a conflict between sustaining socio-economic activity and the ecological functioning of the coastal zone in Europe under rising sea levels (NICHOLLS and KLEIN, 2005). These results in Table 1 require an important health warning: they are all based on scenarios of sea-level rise that impact on constant socio-economic conditions (the1990s). Therefore, they could overstate the consequences of sea-level rise relative to other change factors, including other natural system and socio-economic system changes. However, they are useful results if the user bears this important factor in mind, as an indication of relative vulnerability and for testing integrated assessments.

Although many other European countries have quantitative data, it is not in a form suitable to populate Table 1. Also, the importance of sea-level rise in the policy process varies significantly (see also TOL, KLEIN, and NICHOLLS, 2008) according to (i) knowledge about the potential problems and their solutions; (ii) perceptions of vulnerability to sea-level rise and, by implication, to other effects of climate change; and (iii) relative concern about coastal vulnerability compared with other issues, often reflecting the historic experience of coastal problems (*e.g.,* flooding) and expectations about future changes in sea level.

Although the policy process concerning this issue is evolving rapidly as discussed above, in many countries, it will take concerted efforts to improve this status. Presently, concern about sea-level rise is highest around the North Sea basin because of a perception of high vulnerability (STERR, 2008; VAN KONINGSVELD *et al.*, 2008; DE LA VEGA-LEINERT and NICHOLLS, 2008). This is explained by experience of severe sea flooding and loss of life, among other factors. This concern is driving ongoing vulnerability assessment and increasing knowledge, and as a result, adaptation to accelerated sea-level rise is becoming an important aspect of long-term coastal management (*e.g.,* the Thames 2100 Project to upgrade London's flood defences). Elsewhere, there is much less planning for these changes and sometimes no preparation at all. This often reflects a limited understanding of the potential effects that might require a response and a general low priority given to sea-level rise. (Note that the North Sea countries could be some of the least vulnerable in Europe to sea-level rise because of the proactive approach they are taking to this problem.)

The clear message of this research is that sea-level rise and climate change needs to be given a higher priority in coastal management in many European countries. The attention now being given to the issue at the European level is important in this regard and comparative national studies could have an important role in promoting exchange of policy ideas and practise (*e.g.,* RUPP-ARMSTRONG and NICHOLLS, 2007). Useful follow-up activities include:

- improved understanding of the potential physical and social consequences of sea-level rise and climate change for coastal areas (to provide and improve the tools for vulnerability assessment);
- improved impact and vulnerability assessments to assess the magnitude of the problems and the need for responses;
- more discussion on how to increase adaptive capacity, the full range of adaptation options (rather than just considering coastal armouring and sea walls), and optimum timing (proactive or reactive) of implementation;
- more attention to the links between today's coastal problems and future coastal problems as a way to integrate sea-level rise and climate change into coastal management; and
- more investigation into the magnitude of and possible responses to ecosystem degradation and loss between rising seas and hard defences (often termed coastal squeeze): sustaining the human and ecological function of the coastal zone under rising sea levels is a major challenge.

Building on this work, the overview workshop (DE LA VEGA-LEINERT and NICHOLLS, 2001) made the following general recommendations:

- Guided sensitivity analysis of coastal areas to the plausible range of climate change can proceed in parallel with developments in climate and related science. Suitable sce-

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narios of regional sea-level change and changes in storminess should be developed as promptly as possible.

- Place the impact/adaptation needs of sea-level rise in a broader context of dynamic multiple stresses and today's coastal problems, including consideration of other climate change, including extreme events such as storms, and nonclimate environmental, land use, and socio-economic stresses.
- Evaluate the full range of consequences, including the natural system and the socio-economic system and the direct and indirect effects. Indirect effects have often been ignored, but could have significant consequences, such as human health.
- Consider the entire coastal zone, including the subtidal and intertidal impacts (mainly those on fisheries and ecosystems).
- Identify any "flagship" effects on important cultural or natural sites (*e.g.,* Venice, Italy, or the Carmague, France) that are likely to attract widespread public attention and concern.
- Consider adaptation as a process rather than just a set of technical measures.
- Consider the timing of different adaptation measures, identifying particularly those that would be most effective if implemented immediately.
- Evaluate adaptive capacity more fully, including identification of the constraints and barriers to adaptation and how the capacity to adapt could be enhanced.

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