

# Worst Case Scenario and Stakeholder Group Decision: A 5-6 Meter Sea Level Rise in the Rhone Delta, France

Marc Poumadère <sup>a,b</sup>, Claire Mays <sup>a</sup>, Gabriela Pfeifle <sup>a,b</sup>, with Athanasios T. Vafeidis <sup>c,d</sup>

<sup>a</sup> Institut Symlog, 262 rue Saint-Jacques, 75005 Paris, France

(Address correspondence to: [poumadere@wanadoo.fr](mailto:poumadere@wanadoo.fr))

<sup>b</sup> Ecole normale supérieure, Cachan, France

<sup>c</sup> Middlesex University, London, UK

<sup>d</sup> University of Aegean, Mytilene, Greece

## Working Paper FNU76

1	Introduction .....	2
2	Scenario development for the French case study .....	4
2.1	The Rhone delta context .....	4
2.2	The 5-6 m SLR scenario in Camargue .....	6
2.3	The socioeconomic and local impact scenarios (SES) .....	7
2.4	Interviews of experts and stakeholders .....	8
2.5	The scenario workshop .....	9
3	Workshop results .....	10
3.1	Social values and group process .....	10
3.2	Content analysis of the workshop proceedings .....	12
3.3	Recommendations generated by participants .....	15
4	Conclusion .....	19
5	ACKNOWLEDGEMENTS .....	21
6	REFERENCES .....	21

**Figures 1, 2 (maps): See end of file**

## Abstract

Risk policy and public attitudes appear disconnected from research predicting warmer climate partially due to human activity. To step out of this stalled situation, a worst case

scenario of a 5-6m sea level rise (SLR) induced by the collapse of the WAIS and occurring during the period 2030-2130 is constructed and applied to the Rhone delta. Physical and socio-economic scenarios developed with data from the Rhone delta context are developed and submitted to stakeholders for a day-long workshop. Group process analysis shows a high level of trust and cooperation mobilized to face the 5-6m SLR issue, despite potentially diverging interests. Two sets of recommendations stem from the scenario workshop. A conservative "wait and see" option is decided when the risk of the WAIS collapse is announced in 2030. After WAIS collapse generates an effective 1m SLR rise by 2050, decisions are taken for total retreat and rendering of the Rhone delta to its hydrological function. The transposition of these results into present times policy decisions could be considered. The methodology developed here could be applied to other risk objects and situations, and serve for policy exercises and crisis prevention.

### **Key Words**

Sea level rise, France, Camargue, scenario, extreme climate, stakeholder workshop

## **1 INTRODUCTION**

In spite of the stance taken by political figures, general attitudes in France regarding climatic hazards appear to lag behind scientific warnings. The occurrence in Europe of a severe heat wave during the summer of 2003 and the analysis of the related health impact (an excess mortality of some 15000 persons in less than two weeks was observed in France) shows that this climatic risk was strongly socially attenuated despite available scientific information and specific medical guidelines for prevention (Lagadec, 2004; Poumadère et al., submitted).

Research establishes strong links between risk and affect (Slovic et al., 2004). Collective emotion is palpable *after* disasters have occurred and can trigger reactions at all levels of society worldwide, as seen in the case of the Asiatic tsunami of December 2004. Attitudes toward climatic change as a socially embedded issue, and behavioral intentions, however, are subject to the following major difficulty: how to feel any emotion *before* some future event, of which most consequences will be for others? Without such emotional involvement, it appears unlikely that any of the required decisions and actions, considering the needed radical changes in behavior and lifestyle, will occur.

The need today to consider the worst case or extreme scenarios makes us face a grim and potentially dramatic future, full of bad news that many societal actors might rather ignore

or deny. However, such an approach might contribute to better adapting to and/or preventing some of the worse events of the future. To act in order to avoid a disaster requires us to be convinced that it will happen (Dupuy, 2004). To go beyond this apparent paradox, specific methodologies have to be developed.

The study presented here takes place in that general perspective of management of future climate threats, partly due to greenhouse-gas emission, and addresses three main questions:

- Is it possible to develop a decision-making methodology adapted to dealing with such major uncertainties?
- Can it be applied to build a specific case study in France ?
- What new information and learning are produced through the process?

The study considers, through stakeholder participatory methods, an extreme climate scenario applied to the Rhone delta in south-east France on the Mediterranean. The extreme climate scenario used in the project involves the possible collapse of the West Antarctic Ice Sheet (WAIS) and the consequences studied are those of rapid sea level rise. For this purpose, a supplementary sea level rise<sup>1</sup> of 5m is reached in a period of 100 years, in a linear fashion, and starting after the collapse of the WAIS shortly after 2030 (Nicholls et al., submitted, this issue) (See Figure 1.). Although this specific configuration of rate and duration is considered by some to be highly unlikely (Oppenheimer, 2004), it cannot be said to be totally impossible. Furthermore, this scenario has the distinct advantage of presenting the issue in such a way that it can speak here and now to a wide array of direct stakeholders (whom we were to meet during a participatory policy exercise and its preparation) and beyond them, possibly, to the general public.

-- Figure 1 HERE --

Such important variables as social perception of risks and stakeholder decision-making regarding a low probability event with future high consequences are certainly difficult to assess and integrate. Along with uncertainties regarding the physical nature of the potential WAIS collapse and its implications, several levels of uncertainty are to be dealt with in regard to risk management capacities in such a situation (Kasperson et al., submitted, this issue).

---

<sup>1</sup> We state “supplementary” sea level rise because, even in the absence of the extreme Antarctic events hypothesized here, the sea level if continuing its current trend is expected to rise up to about one meter in the 21st century (Church and Gregory, 2001). Thus the reference made to a 5-6 m SLR.

Several participatory techniques can be used to study such decision making, e.g.: Focus groups, Simulation techniques and Policy exercise method, which can be done moving forward in time (classic) or backward (backcasting); see Hizsnyik and Toth (submitted, this issue). For the French case study, we chose to mount a flexible policy exercise or scenario workshop based on the Classic design (moving forward in time), supported by detailed information packages that were presented according to the evolution and branching points of the group's discussion.

We present in this paper the scenario development in the context of the Rhone delta, the scenario workshop process, and the results obtained, in particular the recommendations expressed by the working group.

## **2 SCENARIO DEVELOPMENT FOR THE FRENCH CASE STUDY**

### **2.1 The Rhone delta context**

Each Atlantis workshop in the three case study contexts used the same sea level rise (SLR) scenario: a supplementary SLR of 5 m is reached in a period of 100 years, in a linear fashion, starting after the collapse of the WAIS soon after the year 2030. However, the three case studies dealt with highly contrasted local situations. For The Netherlands, the whole country and its development would be concerned by a +5m sea level rise. With the Thames estuary, a densely populated area expanding from London seaward is threatened. The Rhone delta is primarily a wetland in which some control of sea and river water movements has been set up to support human activities that co-exist with nature reserves.

The Rhone delta or "Grande Camargue" in SE France resembles a 750 km<sup>2</sup> island embraced by the two branches of the Rhone and the Mediterranean Sea. The delta became stabilized only at the end of the 19th century and the ecological characteristics of Camargue are influenced by the successive sedimentations brought in by the flux and reflux of the sea and the Rhone (Heurteaux, 1969). The continuous evolution of the Rhone river's shape and repeated floods have led inhabitants to embank it, starting as early as Antiquity to become total at the end of the 19<sup>th</sup> century (although not invulnerable, the latest breach instance being in December 2003). Thus, about one hundred kilometers of dikes today protect housing and human activity from Rhone river flooding (Allard, 2000).

From the sea, the vulnerability of this delta and coastal zone poses policy issues of protection against higher tides and or other adaptation, such as sea level rise (Paskoff, 2001a;

2001b; 2004); at this point only a modest dike faces the Mediterranean sea, the main threat being perceived as coming from the Rhone river.

Climate in Camargue, of a Mediterranean type, has several specific traits which give the delta its particular character (Picon, 1988). The level of rainfall is quite low (less than 600mm per year), temperature is mild in winter (seldom does it go lower than  $-5^{\circ}\text{C}$ ) and rather high in summer, while the wind factor is strongly accentuated, due to the delta's geographic position at the mouth of the Rhodanian corridor at the Mediterranean. The mistral is the best known of these winds. It is present all year round, often violent, lowering temperatures, increasing evaporation and decreasing atmospheric humidity. It is the climatic factor that most deeply influences landscape, housing and agricultural practices in Camargue.

The Camargue Island, as it is sometimes referred to, is sparsely populated (60 000 inhabitants) and the main city, Arles, situated at the top of the triangle, contains 83% of the population. The Camargue is well known for its regional natural park protecting the biological diversity of the area, and creating conditions for pink flamingo nesting. Other publicly-controlled spaces are the coastal conservatory and forestry reserves. A private biodiversity research foundation owns a significant share of the territory.

Water management in Camargue with the natural constraints of climate, flat relief and salinity produce a complex hydrological system whose functioning is difficult to model (Dervieux et al., 2002). An intricate network of irrigation and draining has been developed, downstream from the pumping systems in the Rhone to support fresh water agriculture (rice farming) and livestock farming (bulls and the famous white horses). Extensive land holdings, rather than intensive farming, characterize the Camargue socio-economic system.

The rich wildlife favors hunting, and fishing is important as well. Salt marshes in the vicinity of Salin de Giraud both produce a well-identified culinary specialty and support some chemical industry. On the isolated beachfront of Beauduc, a fair-weather village is composed of unauthorized cabins and caravans. Traditionally used as a refuge by sailing fishermen, Beauduc was settled by summering workers and their families from nearby Salin, then by various others. This situation is the subject of an ongoing local debate, as some desire the removal of an insalubrious slum while others see the settlement as an expression of collective freedom.

The Camargue is a popular nature-oriented tourist destination and important pilgrimage site; 8000 Gypsies fete their patron saint each May in the seaside village of Saintes-Maries-de-la-Mer (2500 inhabitants), which receives in all several hundred thousand visitors each year.

The hydrological and climatic conditions of the Camargue accommodate varied human practices, some complementary and some in opposition, but they all are closely related to the local environment and give the Camargue a sense of identity shared by those who live between the two arms of the Rhone (Claeys-Mekdade et al., 2002). These elements were taken into account to develop the sea level rise and socioeconomic scenarios.

## 2.2 The 5-6 m SLR scenario in Camargue

The French policy exercise was prepared by applying the SLR scenario to the Camargue topography, producing maps of land mass to be lost at different points in the progression inland of the tide line (Nicholls et al., 2003). Figure 2 shows the final 5 meter submersion of Grande Camargue in 2130.

---Figure 2 here---

The sea level rise scenario adapted to the Camargue aims at helping stakeholders to grasp this unusual situation. It is divided in five parts, each corresponding to a time period chosen by the research team during the project preparation.

The first part, SLR 2004, summarizes the present situation concerning, on one hand, the possibility of WAIS collapse and its ensuing potential consequences and, on the other hand, observations relating to the SLR in the Camargue and in Marseille (the largest city on the French Mediterranean coast). The following parts of the SLR scenario correspond to extreme projections of present data, but are plausible.

In 2030 (SLR scenario 2030), the extreme scenario of SLR (5 m in 100 years, linear rate) is judged at this point of time to have a probability of 20%. In 2050, the collapse has already occurred and the process it has set into motion is considered engaged and irreversible. A supplementary rise of 1 m is observed and the probability that it continues in a linear manner is revised upward to 80% in the SLR scenario of 2050.

A snapshot in 2080 shows that the SLR has indeed continued in linear fashion. The final SLR scenario (2130) describes the impact of a + 5 m SLR over the Camargue, recognizing this is just one small region affected in a global context.

These SLR scenarios were prepared to support the stakeholder scenario workshop, which simulated deliberations situated at the corresponding points in time. At the opening of the workshop (present-day 2004), the risk of a WAIS collapse is announced but not quantified. Stakeholders are then asked to imagine they are in 2030. In 2030, the WAIS

collapse risk (with its potential consequence of linear SLR totaling 5-6m over one century) is assessed at 20%. Participants must reflect on a management strategy to adopt in the face of this uncertain event. In 2050, they learn the actual collapse did indeed occur and the Rhone Delta has already experienced a 1-meter SLR, with continuation assessed at 80%. After their deliberations and new strategic recommendations, participants are shown the snapshot of the situation in 2080 as the sea has continued to mount. In a final phase of the workshop, they discover the shape of the Camargue and its socioeconomic situation after the sea has indeed risen to +6 meters total in 2130.

### 2.3 The socioeconomic and local impact scenarios (SES)

Another aspect of our preparation for the workshop was to produce socioeconomic scenarios (SES) following the same time scale (Pfeifle, Mays & Poumadère, 2004). First an inventory of the Camargue (SES 2004) took into account current data related to population, economic background, and perspectives for development and legal context. Simple extrapolations were then made to project future situations in 2030, 2050, and 2130<sup>2</sup>.

The population growth rate, for instance, was obtained through the synthesis of several indicators<sup>3</sup>. The future economic development integrated both the present growth trends and existing planning projects. Through desk research and interviews<sup>4</sup>, detailed socio-economic accounts were developed reflecting the different major management options that could be chosen when adapting to the potential impacts of the SLR, ranging between "abandon" the area to "fully protect from the rise of the sea", with various hybrid options in between. Obviously, different stakeholder choices would open different development pathways, thereby influencing different future options. For instance, the protection option, i.e., the choice to erect dikes to protect existing land and activities, would allow the use of land under sea level (with some additional problems like growing soil salinisation) but would create additional risks (vulnerability of existing or new installations placed behind dikes if these should be overwhelmed). Alternatively, to allow the mounting sea to ingress unhindered upon the land would imply abandoning areas that currently support residential and economic

---

<sup>2</sup> Materials were developed as well for 2080 but because of time limitations were submitted only in snapshot form to participants in the one-day workshop. The present discussion will leave aside the 2080 information.

<sup>3</sup> Various online-sources were used (e.g. [www.insee.fr](http://www.insee.fr), [www.oecd.org](http://www.oecd.org), [www.observateurocde.org](http://www.observateurocde.org)), as well as several paper documents (Le Bilan du Monde Edition 2004, Programme de l'OCDE sur l'avenir, Blanchet & Lerais 2002, Brutel 2002, Brutel & Omalek 2003, Desesquelles & Richet-Mastain 2004, Nauze-Fichet, Lerais & Lhermitte 2003).

<sup>4</sup> An interview with Prof. Roland Paskoff (Conservatoire du Littoral) was particularly useful for conceptualizing the different development pathways that might be followed.

activities: thus subsequent management decisions would principally concern population retreat inland. Each of these options presents advantages and costs to weigh in taking a decision.

Considering that it is impossible to predict precisely which of these choices and decisions would be taken by real-life stakeholders and experts participating in the workshop, we chose to develop socioeconomic scenarios (SES) to accommodate two extreme possibilities: the protection option and the retreat option. Thus, while the SES 2030 is a reasonable linear projection of the situation actually observed in 2004, the SES 2050 was generated in two different versions: one to be presented to workshop participants if they chose (in 2030) to favor the protection option, and another for use in case of choice of the retreat option. Three SES 2130 versions were generated: full protection (reflecting a choice to protect in both 2030 and again in 2050), partial protection (modest retreat in 2030 and protection in 2050 after experiencing a SLR of +1 m compared to normal expected ingress from today's coastline), full retreat (as of 2030, or only after 2050: the 2130 socioeconomic consequences for the abandoned area are the same in both cases).

## 2.4 Interviews of experts and stakeholders

These socioeconomic and local impact scenarios were informed by 30 formal individual interviews with experts (geology, hydrology, geography, sociology), professionals (land use planning, risk analysis, public health, insurance, journalism), and local stakeholders (industry, elected bodies and management support, farmers, hunters, clergy).

After consenting to set a date for an interview, each person received a summary of the research project, an introduction to the climate change, WAIS collapse and potential SLR issues, and a pre-questionnaire indicating the points to be covered in the interview. The actual semi-directive interviews then allowed participants to freely express their point of view and bring in new or unanticipated points or information. The interviews in sum allowed the following broad areas to be explored in regard to the idea of rapid SLR: similarity with existing or known situations<sup>5</sup>, response options, involved and concerned stakeholders, local identity and specificities in historical, cultural, economic, technical and political terms. Overall, the interviews made valuable contributions to the development of the SES including

---

<sup>5</sup> Interviews took place just a few weeks after the occurrence in Dec. 2003 of major flooding from an overflow of the Rhone river, seriously affecting Arles and other parts of the Camargue. Local sensitivity to flood risk and management experience certainly exist in Camargue, although the proposed SLR scenario introduces specific differences: the threat comes from the sea rather than from the river, and once engaged the SLR is irreversible.



insight into the different management options that might be favored and contextual costs and advantages of each one.

## 2.5 The scenario workshop

A representative subset of 12 interviewees (see Table 1) were then recruited to participate in the day-long scenario workshop. The stakeholder participants were asked to call upon their professional expertise and personal knowledge to elaborate a common response strategy in the face of a (hypothetical) uncertain future situation.

**Table 1: Stakeholder participants in the scenario workshop**

<b>Stakeholder Category</b>	<b>Workshop Participant</b>
LOCAL GOVERNMENT	Arles Municipal Councilman
LOCAL TECHNICAL SUPPORT SERVICES	General Secretary, Grande Motte Town Hall Arles Chamber of Commerce & Industry Arles City Geographer
HIGH LOCAL EXPERTISE	Regional Natural Park Director Research Director Private Biodiversity Foundation Parish Priest, Stes-Maries-de-la-Mer
STATE/REGIONAL TECHNICAL EXPERTISE	Regional Directorate of the Environment Coastal Defence Analyst Regional Public Health Observatory Epidemiologist National Geological Survey Hydrologist
INDUSTRY	Chemical Manufacturing Site Director
ECOLOGY	Nat. Assoc. of Ecologically Responsible Hunters Militant

On the day of the workshop, held locally, this group was treated as a Camargue Consultative Committee mandated in 2030 and in 2050 by the European Commission to examine SLR risk and provide recommendations in any field of action they felt appropriate. The alternative SES scenarios were held in reserve, to be brought out as appropriate as the participants made strategic and practical decisions to adapt to the different states of WAIS risk knowledge at each time juncture in the workshop. Along with the various scenarios, maps too provided a basis for group discussion and decision. For instance, participants examined with interest maps showing what the Camargue would look like after 30 or one hundred years if the sea rose without protection. To add to the realism of the Committee setting, we also generated newspaper articles<sup>6</sup> dated between 2004 and 2030, and between 2031 and 2050, describing local developments, climate change findings and SLR impacts.

---

<sup>6</sup> With the help of a professional journalist, Ulysse Badorc.

As suggested above in the discussion of the SLR and socioeconomic scenarios, the day-long workshop unfolded in several stages. Upon arrival, the participants' knowledge was refreshed with a short PowerPoint review of the current 2004 inventory of the Camargue and the non quantified scenario of WAIS potential collapse. In the second stage, participants were asked to jump to the year 2030, when they learned through a PowerPoint presentation and written documents that rapid SLR after a WAIS collapse was assessed at 20% probability, and reviewed the 2030 SES. They discussed and analyzed these materials and together developed a strategy for the next 20 years, choosing a "wait and see" partial protection option (i.e., maintaining existent protection).

Stage 3 followed the same pattern: discussions were supported by the SLR 2050 (WAIS collapsed, +1m SLR, further rapid linear rise seen to be 80% likely) and SES 2050 (in the appropriate version as dictated by the option chosen in 2030). Participants analyzed the effects of the 2030 decisions and "corrected course", setting strategy for the next 30 years. At that time, they favored officially organized retreat. In the final part of the day, participants saw a presentation of the 2080 socioeconomic outcomes of their strategic choices. The hypothetical state of the world in 2130 served as a final debriefing and closed the workshop.

### **3 WORKSHOP RESULTS**

#### **3.1 Social values and group process**

Secular wisdom and current practice hold that the group format is best suited to make decisions. Among other advantages, diversity of point of views, cumulative knowledge and experience, and potential for tempering of extremisms come to mind. However, research has questioned this assumption. Stoner (1961) observes that group decisions are riskier than decisions made previously on an individual basis. Many further studies have borne on this risky shift effect, showing that it can be encountered in many situations of social interaction; in some cases, group decisions are more cautious than individual ones. Moscovici and Zavalloni (1969) establish that risky or cautious shifts are the variants of a wider phenomenon: attitude polarization induced by the group. Such polarization is said to occur when the initial individual opinion of a group member is made more extreme following group discussion. Other conditions, such as uniformity of views, secrecy, biased leadership and decisional stress can produce "groupthink" (Janis, 1982) and lead to fiasco decisions.

One can hypothesize that affect and social values are strongly solicited by the scenario methodology. As had already been the case during interviews, persons are confronted with disastrous news and illustrative materials relating to the place where they live, have their family and friends, jobs. In addition, the workshop creates a most unusual situation in which these bad news and materials have to be discussed and lead to group decision. Values are likely to be called upon in both the positions adopted in response to the climate risk decisions, and, in the real-time interactions between persons whose expertise, social roles and economic interests are different.

In order to capture information about the values influencing these levels, an individual social values questionnaire (Bales, 1979; 2001) was constructed for the workshop context. It is structured around 3 bipolar dimensions of opposed or polarized values, each relating to a specific issue. The “power and influence” dimension is bounded by the opposed values on dominance vs. submission, the “interpersonal and social trust” dimension by those on sociability vs. individualism, and the third dimension “legitimacy of authority and its projects” by those on accepting established authority vs. innovation and creativity. Combinations of these values can be found and 26 value-contents are represented in the questionnaire.

The social values questionnaire was administered before and after the workshop so as to test several hypotheses regarding group interaction in such decision-making situations. The questionnaire asked each participant which values should be called upon to work together in facing a hypothetical and uncertain situation, and furthermore which values would be needed for decision makers to face the extreme events evoked by the Atlantis scenario. After the workshop, the same questionnaire form was used to ask which values had actually been shown throughout the day.

The group activity during the workshop was led by one of the researchers, his attention focused on group process, while he guaranteed to the group that their actual output would be taken as they produced it. The other two researchers acted as resource providers (SLR and socio-economic scenarios materials) and did not participate in the group discussion per se, unless they were called upon when any specific information was needed.

The social values questionnaire provides results in line with the cooperative group process observed. Results from the questionnaire filled out by participants, without conferring, just before the start of the workshop show quasi-unanimity on the need for values which have been identified by research (Bales, 2001) as particularly appropriate for a group analytic-deliberative process: values on active efforts towards common goals, equality and

democratic participation in decisions, responsible collaboration, low search for personal power.

Responses to the second leg of the questionnaire (at the close of the workshop) confirm that the anticipated needed values were indeed observed by participants during the day. Interestingly, each participant judged that the group showed the desirable values to a greater extent than the individual respondent felt he or she had exercised them personally. These perceptions may signify recognition that the group's effective achievements go beyond what each individual member could contribute alone. This result is in line with the strong acculturation<sup>7</sup> that occurred during the workshop, during which the researchers observed that each stakeholder learned from the others and from the materials provided by the team to facilitate reflection and deliberation.

These results complement those of a popular research stream today, bearing on the role of trust and of prior beliefs upon current attitudes towards a risk issue (e.g., Poortinga et al., 2004). We have looked at group interactions with regard to individual prior beliefs and to conditions which favor interpersonal trust (and not trust or distrust in regard to an issue). As more and more risk studies rely methodologically upon the group format, more attention could as well be given to the style of group leadership as many options exist. In our case, we chose process-centered leadership, with very limited content interventions.

As the next two sections will show, with content analysis data and presentation of the group's final recommendations, a rather complete set of issues was considered during the discussions and recommendations appear likely to be close to best decisions to adapt to the scenario conditions.

### 3.2 Content analysis of the workshop proceedings

The workshop proceedings were tape recorded and extensive notes were taken by two members of the research team. The third researcher's attention was entirely devoted to the group process. Proceedings were then transcribed from the notes and the transcription checked by comparing the two sets of notes, and the audio tape when there was disagreement or lack of clarity. (The formal presentations of the SLR and socio-economic scenarios, as well as the instructions given at the opening of each phase of the workshop, were not included in the transcript.)

---

<sup>7</sup> This acculturation mirrored in some ways that which occurred within the European interdisciplinary Atlantis research group where significant cross-learning has occurred – which might be a necessary condition to perform research in the complex and multidimensional area of climate change.

This transcript was then transformed into an Excel file in which each line represents the complete speech of one participant. There are 275 speeches (of which only 14 were uttered by members of the research team). Within the 275 speeches, 51 were uttered during the debriefing (5 by researchers). All 275 speeches were retained for content analysis.

The content analysis was performed by one researcher according to the precepts of grounded theory (Glaser & Strauss, 1967), meaning that analytic categories were created as needed to capture differences and similarities among speeches (rather than imposing pre-defined categories). Each speech could be tagged for several characteristics, indicated in Table 2. (Frequencies do not add up to 275 because each characteristic was not necessarily found in each speech.)

**Table 2: Categories used in the content analysis**

<b>Characteristic (column for tagging speech)</b>	<b>Categories or options available in that column (Frequency)</b>
Type of speech	Concerns or Formulates a Recommendation (73) – Formulates a Question to the group (14) – Concerns Socio-economic data (13) - Addresses Probabilities (10) - Concerns SLR (8) – Request for Map (2) – [Statement of fact not otherwise coded (155)]
Theme predominant in the speech <u>(underlined themes, most frequent, are examined again in Table 3 below)</u>	<u>Population issues (36) - Landuse planning (29) - Use of technology (28) - Calls for formal assessment, measurement, monitoring (19) - Role of and need for public information (18) - Role of institutions (16) - Risk definitions (13) - Risk perception by public and by managers (12)</u> Economic costs (11) – Feedback from other pertinent experience (including Rhone flooding and population displacement/public health issues after the Chernobyl catastrophe) (9) – Elected officials (8) – What is at stake? (7) – Soil salinisation (4) – Tourism (4)
Context evoked in speech	Spoken from 2004 position or concerns 2004 situation (40) – Passage of time, duration implied within SLR scenario (20) - Camargue as a situated place with a history (10) – Crisis (7)

During the construction of the categories used to characterize speeches, a new column for tagging was created whenever needed (i.e., the choice of a given category to characterize a speech never excludes the simultaneous choice of a second or third category). In this way the final set of tags has an empirical and expedient character. For instance, concerning the tag "type of speech", it is not suggested that a person cannot possibly talk about a recommendation and mention probabilities at the same time. Simply, it was observed after the

transcript had been reviewed five times that it was never necessary for the content analyst to tag a single speech as both "*recommendation*" and "*addresses probabilities*".

The principal themes introduced and discussed by stakeholder participants are given in Table 3 below. Their relative dominance (rank order of frequency) within the discussion of concrete recommendations is also shown.

**Table 3: Principal themes introduced and discussed by stakeholder participants during the workshop**

<b>Theme contained in participants' speeches</b>	<b>Frequency of occurrence throughout workshop (total n° of speeches =273)</b>	<b>Rank order of frequency within discussion of RECOMMENDATIONS (absolute frequency)</b>
POPULATION issues	<b>36</b>	<b>3 (11)</b>
LAND-USE PLANNING	<b>29</b>	<b>1 (17)</b>
Use of TECHNOLOGY	<b>28</b>	<b>5 (6)</b>
Calls for formal ASSESSMENT, measurement, monitoring	<b>19</b>	<b>2 (13)</b>
Role of and need for public INFORMATION	<b>18</b>	<b>4 (10)</b>
Role of INSTITUTIONS	<b>16</b>	<b>3 (11)</b>
RISK definitions	<b>13</b>	(n.a.)
Risk PERCEPTION by public and by managers	<b>12</b>	(n.a.)

The relative rates of thematic discussion indicate that the stakeholder group is centered on population issues and needs (highest frequency theme throughout workshop) while they rely on land-use legal instruments and formal assessment to construct responses to these needs (these are higher frequency themes within recommendations). Technology, while a center of discussion during the workshop, drops significantly within the recommendations, indicating it is not preferred as a tool for adaptation to rapid sea level rise.

In-depth discussion of these various themes, sometimes confrontational, allowed the group to build up a set of elements facilitating consensual recommendations.

### 3.3 Recommendations generated by participants

The final results of the workshop may be presented as a list of the action strategies and recommendations developed by the participants as they responded to the differing SLR risk scenarios and socioeconomic scenarios across the workshop phases. Table 4 shows the recommendations generated in phase one, situated in the year 2030, while Table 5 shows the recommendations generated in phase two, situated in the year 2050. We report the recommendations in the terms agreed and as written up on a paperboard by the participants (one of the roles chosen by the French Atlantis researchers was to ensure that the group

choices were respected and represented, rather than just substituting interpretations and choices by the volunteer group reporter or by the researchers themselves). The recommendations are listed in the order in which they emerged from discussion, rather than by their importance according to the group. It is interesting to see which strategies and choices emerged early, and which choices, refinements and elaborations these early choices then led to.

**Table 4: Scenario workshop group decisions situated in 2030**

<p><b><u>2030 (before WAIS collapse)</u></b>  <b>The group chooses a "wait and see"/"prepare strategic retreat" option.</b>  <b><i>Recommendations:</i></b></p>
1. Land use planning policy to reflect a "hold off, wait and see" attitude; moratorium on development
2. Create a margin of liberty for the sea: certain zones to be declared uninhabitable; review and alter building zones
3. Elected officials and scientific experts to support and become engaged in public information and participatory mechanisms
4. Cost-benefit analysis to be performed on the "protection" option; study and model possible futures
5. Build protection against Rhone river flooding, in the Camargue and upstream (integrate the top of the river basis; free up river expansion zone)
6. Create a coordinating decision structure
7. Perform an interdisciplinary synthesis of studies and review relevant knowledge
8. Accompany the population in economic, social and psychological terms: create the conditions favorable to possible retreat

The chosen options in phase one (Table 4) convey the desire of the workshop participants to protect the existing Camargue. This does not reflect a backward culturally conservative attitude, but rather is a response to the probability of WAIS collapse and rapid SLR, which at 20% in 2030 is still judged relatively low by the workshop group. They consider that the best adaptation is to make some zoning decisions, reasonably reinforce defenses where recent flood experience proves they will be needed in any case, and integrate scientific knowledge and management structures to prepare better future decisions. The need for cooperation between elected officials and experts is clearly seen in these recommendations, and appears particularly important to manage public information and participation. This is emphasized through the creation of a coordinating structure composed of representatives from government, the public, experts, and other stakeholders.



The majority of the participants agree that a strong “protection” response could be justified only by high economic stakes<sup>8</sup>. As there is no such stake in the area, and because existing economic activities in case of rapid SLR would require disproportionate protective measures, they opt for a vigilant “wait and see” policy that includes prudent preparations for an organized strategic retreat should that become necessary. However, some in the group defend the limited but existing chemical industry, based on transforming the salt produced locally. These stakeholders would rather not totally dismiss the high protection choice; thus the option of performing a cost-benefit analysis is placed among the recommendations. Along the same lines, uncertainty about the future leads to the recommendation of modeling and assessing several possible futures, in order e.g., to better understand the dynamic development of the sea level rise and its ensuing consequences.

Recommendations made in 2030 are thus based upon a thorough knowledge of the existing constraints which already apply in the Rhone delta, regarding in particular land-use planning and preventive/mitigating response to Rhone flooding. The SLR risk from the WAIS collapse is integrated and leads to reinforcing these constraints, such as freeing a zone that could be immersed by the sea. The need for more information (cost-benefit analysis, research review) and better coordination among involved parties is however triggered specifically by the situation suggested by the scenario, as is the planned accompaniment of the population in economic, social and psychological terms.

During the 2050 phase of the workshop discussion, when indeed SLR has commenced, the retreat option is maintained and reinforced (Table 5). The 80% probability that the sea continue to rise in a linear fashion, resulting in +5-6 m by 2130, is judged serious or equated to a quasi-certainty, and is used as an *ex post* justification of the strategic choices made in 2030.

---

<sup>8</sup> Meaning, goods- and employment-producing facilities. Business from tourism, and its possible mass expansion as in nearby Languedoc, are not in the minds of the participants who all seem to have integrated a vision of Camargue as remaining a nature reserve over time.

**Table 5: Scenario workshop group decisions situated in 2050**

<b><u>2050 (after WAIS collapse and effective SLR of +1m)</u></b> <b>The group chooses a "retreat" option</b> <i>Recommendations:</i>
1. Organize retreat: Determine retreat zones Strong laws and decrees of application Set up accompanying measures (economic) Create solidarity fund Organize long-term medical response Create psychological therapeutic units
2. Restore the hydraulic function of the Rhone Delta: Protective spill areas for city of Arles Same for Baux Valley, Bourg Plain
3. Rhone flood reduction program: Continue the action begun in 2030
4. Set up a unitary management organization
5. Develop a culture of "territorial evolution" (acceptance of change by the population...)
6. Prepare for crises (public health, political confidence...)
7. Redistribute local economy into appropriate (less vulnerable) sectors

The option thus retained in 2050 for the coming years is that of an organized strategic retreat (rather than ignoring evolutions that would one day result in the need for an urgent full-scale evacuation). The population is to be relocated in areas to the north not threatened by the consequences of SLR, while respecting the possibility that certain elderly residents, for example, might prefer to wait it out on their ancestral land. There was high confidence that Camargue social identity could survive the transplantation: jokes were made about "New Camargue", and "Saintes-Maries-de-la-Terre" ("of the land") that would replace the existing sister village "of the sea".

Participants did not regard this projected abandonment of areas that today are invested with residences and economic activities, both traditional and modern, as a threat to the integrity of the delta. It is more like a liberation<sup>9</sup>. The Camargue is recognized as a wetland

---

<sup>9</sup> During content analysis, the researchers sought mental images to represent what was conveyed at that level. What came up is the famous scene from the film *Forrest Gump* in which the handicapped boy, responding to urgent advice to "run, Forrest, run!", finds the braces falling from his legs as he runs faster and faster. Another

that already is reclaimed from or shared with the natural elements; its land and water dynamics seem at the same time to be more powerful than human actions and constituent of the delta's own identity. There would be no need to "save" elements (e.g., the pink flamingos) which today are preserved from human activity. A lively part of the discussion bore on what would be the actual coast line after a 5-m SLR, considering the contribution of alluviums from the Rhone, waves impact and sand from the sea that would finally give a new face to Camargue.

According to the post-workshop debriefing, the use of an extreme scenario and the role-playing method allowed stakeholder participants to project themselves into the future in an unaccustomed way. Liberated from usual constraints, they expressed themselves more freely and reasoned more creatively. In strong cooperation, which did not exclude argumentation and confrontation, they each contributed their particular expertise and knowledge to build a strategy (reflected in the concrete recommendations) which at first sight may appear unexpected but which has high internal consistency.

Participants made full use of the scenario material developed for the workshop which, combined with their extensive knowledge of the existing Rhone delta characteristics, fostered highly realistic and adaptive recommendations which readily could be transformed into actual decisions – should it be needed.

Future comparative research could investigate similarities and differences between this case study and the case studies conducted in the contexts of the Thames estuary (Lonsdale et al., submitted, this issue) and of the Netherlands (Olsthoorn et al., submitted, this issue), each bearing upon the impacts of a 5-6 m SLR (Tol et al., submitted).

## **4 CONCLUSION**

As a risk issue, climate change confronts us with several levels of uncertainty. Observed climatic variations over time combined with anthropogenic impact appear difficult to separate and assess with precision, thus rendering problematic a consensus on the likelihood, magnitude and consequences of climate change. Yet public policy ought to be mobilized in case human and natural systems are threatened. Conversely, societal factors dealing with adaptation and/or reduction of activities associated with greenhouse gas production, which

---

image is that of the whale bone and laced corset, imposed upon women's bodies in the 19<sup>th</sup> century, when Camargue was corseted as well with irrigation, drainage and embankments.

suppose radical changes in behavior and lifestyle, are at the core of prevention. The risk of potential disasters and crises is high, resulting from inaction on any of the interdependent dimensions of climate change. This study has shown that it is possible to step out from the gridlock between research predictions and policy inaction combined with passive public attitudes.

The methodological unfolding of this study revealed several interesting points. Interviews brought out persons' variable capacity to project oneself into the uncertain future and consider decision making under hypothetical conditions. The extreme scenario of 5-6m SLR in one hundred years was very often rejected as far-fetched. More salient for interviewees often was the recent severe flooding experienced in December 2003, in which the Rhone river, and not the sea, constituted the menace. In contrast, the workshop group when assembled plunged very seriously into the simulation, assimilating the materials provided and rarely stepping out of role to question the credibility of the scenarios or the decision-making context. The workshop setting and the materials stimulated cross-fertilization among the heterogeneous group members. The group appeared united in the goal of developing the best possible responses to the risk situation, and group recommendations were well-discussed before an agreement was reached. In a sense, the workshop group mirrored the experience of the Atlantis research group itself, composed of individuals from varied disciplines who adapted to conduct a common project.

The recommendations produced by the group in 2030 with the announced risk of the WAIS collapse are in many respects an extension of present risk management in the Rhone delta, with additional measures to take into account the magnitude of the new threat. Recommendations made in 2050, when a 1m SLR has followed the effective WAIS collapse, take full measure of the situation. The option retained is total retreat and rendering of the Rhone delta to its hydrological freedom, and recommendations phase these actions in precise steps. The strong protection option was never a favorite, but was not totally dismissed in that a cost-benefit study of this option was advised in 2030. On the whole, the recommendations are quite precise, thorough, and workable; they rest upon an extensive knowledge of the context thanks to the variety of workshop members. In other words, should a significant SLR be at stake some day in the Rhone delta, the workshop group recommendations provide many if not all elements to consider.

These results favor such a methodology for long term issues of sustainability and crisis prevention, where uncertainty is especially high and has very diverse sources. The combination of scientific construction of scenario material (including maps and descriptive

states of the future) together with a participatory group approach appears productive. Group process and social values analysis make apparent the trust and cooperation tendencies chosen by group members to deal with this situation, in spite of their diversity and differences in their assessment of the threat and its potential impacts.

One active factor might lie in the realism of the scenarios, apt to trigger the emotional involvement apparently lacking in other research renderings of climate change issues. Future research could then be two-fold. It could involve the application of such methodology to develop case studies and decision-making in contexts unrelated to climate change. Alternatively, scenario workshops bearing on climate change could be conducted with various groups, policy and decision makers as well as members of the general public when at stake will be to consider radical changes of behavior and lifestyles.

## 5 ACKNOWLEDGEMENTS

Thanks are offered to the stakeholders and experts who participated wholeheartedly in the interviews and scenario workshop. Work presented in this article was partially supported by the Atlantis Project, funded by the EC-DG Research (EVK-CT-2002-000138).

## 6 REFERENCES

- Allard, P. (2000) *Eléments pour une problématique de l'histoire du risque. Du risque accepté au risque maîtrisé. Représentations et gestion du risque d'inondation en Camargue, XVIIIe-XIXe siècles*. Unpublished doctoral dissertation, University of Méditerranée-Aix-1, France.
- Bales R.F., Williamson S.A. & Cohen S.P., (1979) *A system for the multiple level observation of groups*, Free Press, Westport CT.
- Bales R.F., (2001) *Social interaction systems: Theory and measurement*, Transaction, Piscataway NJ.
- Blanchet, D., Lerais, F. (2002) Projections de population à l'horizon 2050 : présentation générale, *Economie et Statistiques*, n°335-356, INSEE, Paris.
- Brutel, C. (2002) La population de la France métropolitaine en 2050 : un vieillissement inéluctable, *Economie et Statistique*, n°335-356, INSEE, Paris.
- Brutel, C., Omalek, L. (2003) Projections démographiques pour la France, ses régions et ses départements (horizon 2030/2050), *Résultats Société*, n°16, INSEE, Paris.

- Church, J.A. and Gregory, J.M. (2001) Changes in Sea Level. In: Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J. and Xiaosu, D. (eds.) *Climate Change 2001. The Scientific Basis*. Cambridge University Press, Cambridge, pp.639-693.
- Claeys-Mekdade, C., Corsand L. M., Nicolas, L., Schleyer-Lindemann A. (2002) Etre ou ne pas être entre les deux bras du Rhône: identité(s) camarguaise(s) aujourd'hui. *Faire Savoirs*, n°2, Amares, Marseille.
- Clessi, C. (ed.) (2004) Le Bilan du Monde Edition 2004, *Le Monde Hors-série Dossiers et Documents*, Paris.
- Downing, T., Lonsdale, K., Nicholls, R., Willows, R., Hall, J., Dawson, R. (submitted, this issue) Atlantis project: the case study of a possible 5-6 m sea level rise in the Thames estuary.
- Dervieux A., Franchesquin N. (2002) Petite chronique de l'eau: modèle et écologie. *Faire Savoirs*, n°2, Amares, Marseille.
- Desesquelles, A., Richet-Mastain, L. (2004) Bilan démographique 2003, *INSEE Première*, n°948, INSEE, Paris.
- Dupuy, J.-P. (2004) *Pour un catastrophisme éclairé*. Seuil, Paris.
- Glaser, B.G. & Strauss A.L. (1967) *The discovery of grounded theory: Strategies for qualitative research*. Aldine, Chicago.
- Heurteaux P.(1969) *Recherches sur les rapports des eaux souterraines avec les eaux de surface, les sols halomorphes et la végétation en Camargue*. Unpublished doctoral dissertation, Montpellier University, France.
- Hizsnyik, E., Toth, F.L., (submitted, this issue) Managing the inconceivable: Participatory assessments of impacts and responses to extreme climate
- Janis, I. (1989) *Crucial decisions: Leadership in policymaking and crisis management*. New York, Free Press.
- Kasperson, R.K., Bohn, M.T., Goble, R. (submitted, this issue) Assessing the risks of a future rapid large sea level rise: a review.
- Lagadec, P., 2004 Understanding the French 2003 heat wave experience: beyond the heat, a multi-layered challenge. *Journal of Contingencies and Crisis Management*. **12**(4), 160-169.
- Moscovici, S., & Zavalloni, M., (1969) The group as a polarizer of attitudes. *Journal of Personality and Social Psychology*. **12**, 125-135.

- Nauze-Fichet, E., Lerais, F. & Lhermitte, S. (2003) Les projections de population active 2003-2050, *Résultats Société*, INSEE, Paris.
- Nicholls, R.J., Tol, R.S.J., and Vafeidis, N. (submitted, this issue) Global estimates of the impact of a collapse of the West Antarctic Ice Sheet.
- Nicholls, R.J., Vafeidis, V., Poumadère, M., Mays, C. & Pfeifle, G. (2003) *Rhone delta case study: Possible impacts of a 5-m rise in global sea level*. Atlantis report to the European Commission. Available from Institut Symlog, France.
- Olsthoorn, X., van den Werff, P., (submitted, this issue) Atlantis: the Netherlands under a 5m sea level rise.
- Oppenheimer, M. (2004) Personal communication to the first author, during the international workshop *Perspectives on Dangerous Climate Change*, 28 & 29 June 2004, University of East Anglia, UK.
- Paskoff, R. (ed.) (2001a) Le changement climatique et les espaces côtiers: L'élévation du niveau de la mer: risques et réponses, Actes du colloque d'Arles, 12 et 13 octobre 2000. Mission Interministérielle de l'effet de serre, Paris.
- Paskoff, R. (2001b) *L'élévation du niveau de la mer et les espaces côtiers*. Propos-Institut Oceanographique, Paris.
- Paskoff, R. (2004) Potential Implications of Sea-Level Rise for France. *Journal of Coastal Research*: Vol. 20, No. 2, pp. 424–434.
- Pfeifle, G., Mays, C. & Poumadère, M. (2004) Changement climatique, augmentation du niveau de la mer et (ré)action des parties prenantes: Étude de cas à l'aide d'un scénario catastrophe en Camargue. In H.J. Scarwell, M. Franchomme (eds.) *Contraintes environnementales et gouvernance des territoires*. Editions de l'Aube (Nord), Lille.
- Picon, B. (1988) *L'espace et le temps en Camargue* (2<sup>nd</sup> ed.) Actes Sud, Arles.
- Poortinga, W., & Pidgeon N.F. (2004) Trust, the asymmetry principle, and the role of prior beliefs. *Risk Analysis*, **24**(6), 1475-1486.
- Poumadère, M., Mays, C. & Pfeifle, G. (2003) *Planned vs. de facto risk governance: Lessons from two French cases of risk amplification*. Presentation at the World Congress on Risk, Society for Risk Analysis, Brussels, June 2003. Manuscript available from Institut Symlog, France.
- Poumadère, M., Mays, C., Pfeifle, G. & Vafeidis, N. (2004) *Atlantis project: Case study of a possible 5-6m sea level rise in the Rhone Delta*. Presentation at the Annual Conference

of the Society for Risk Analysis-Europe, Paris, November 2004. Extended abstract available from Institut Symlog, France.

Poumadère, M., Mays C., Le Mer S., & Blong R. (submitted) Dangerous climate here and now: The 2003 heat wave in France. *Risk Analysis*, special issue guest edited by N. Pidgeon & I. Lorenzoni, expected in 2005.

Slovic, P., Finucane, M, L, Peters, E., & MacGregor D. G. (2004) Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk and rationality. *Risk Analysis*, **24**(2), 311-323.

Stoner, J.A.F. (1961) *A comparison of individual and group decision involving risk*. Unpublished Master's thesis, Massachusetts Institute of Technology.

Tol, R.S.J., Bohn, M., Downing, T.E., Guillerminet, M.L., Hisznyi, E., Kaspersen, R., Lonsdale, K., Mays, C., Nicholls, R.J., Olsthoorn, A. A., Pfeifle, G., Poumadère, M., Toth, F.L., Vafeidis, N., van der Werff, P.E., & Yetkiner, I.H. (submitted) Adaptation to five meters of sea level rise. Special Issue from the Society of Risk Analysis-Europe Annual Conference, Paris, 2004; *Journal of Risk Research*.



Figure 1: France in 2130: Submersion after 5-meter supplementary rise in sea level.

*Note: the Rhone delta, subject of our case study, is situated in the lower right hand corner of the country map, situated on the Mediterranean approximately between Montpellier and Marseille.*

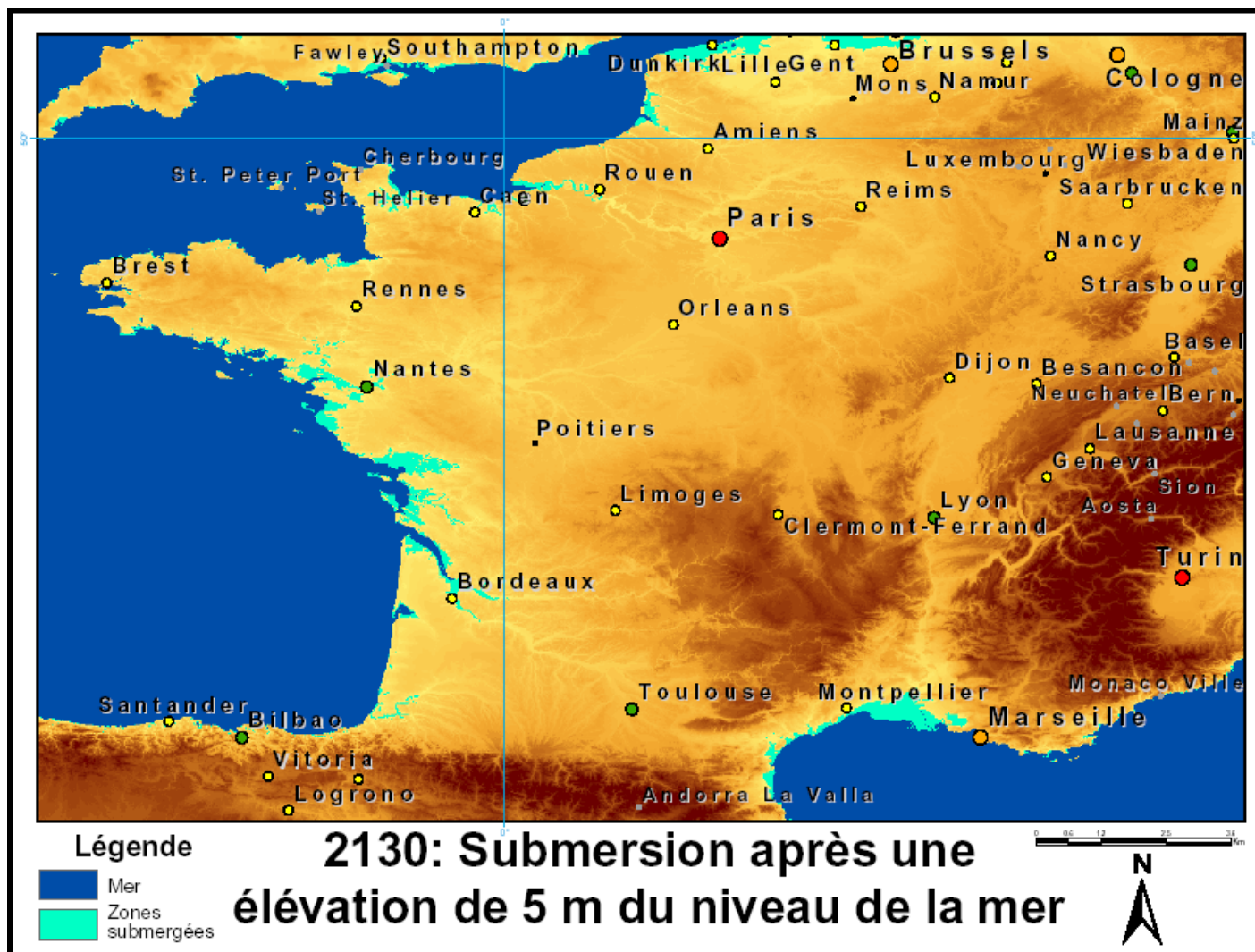
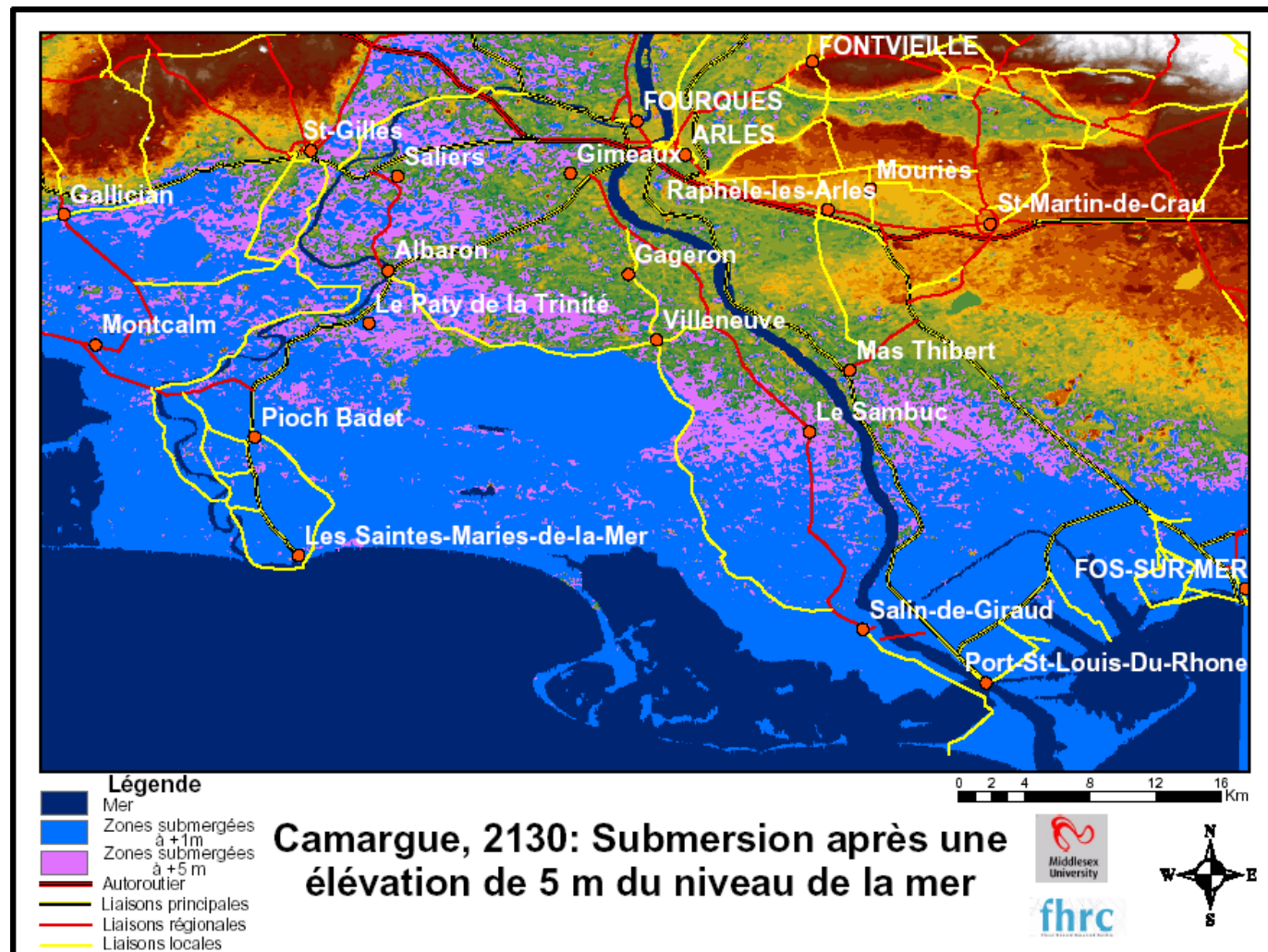


Figure 2. Grande Camargue in 2130: Submersion after a 5-meter supplementary rise in sea level.



**Working Papers**  
**Research Unit Sustainability and Global Change**  
**Hamburg University and Centre for Marine and Atmospheric Science**

- Guillerminet, M.-L. and R.S.J. Tol (2005), *Decision making under catastrophic risk and learning: the case of the possible collapse of the West Antarctic Ice Sheet*, **FNU-79** (submitted)
- Nicholls, R.J., R.S.J. Tol and A.T. Vafeidis (2005), *Global estimates of the impact of a collapse of the West Antarctic Ice Sheet: An application of FUND*, **FNU-78** (submitted)
- Lonsdale, K., T.E. Downing, R.J. Nicholls, D. Parker, A.T. Vafeidis, R. Dawson and J.W. Hall (2005), *Plausible responses to the threat of rapid sea-level rise for the Thames Estuary*, **FNU-77** (submitted)
- Poumadère, M., C. Mays, G. Pfeifle with A.T. Vafeidis (2005), *Worst Case Scenario and Stakeholder Group Decision: A 5-6 Meter Sea Level Rise in the Rhone Delta, France*, **FNU-76** (submitted)
- Olsthoom, A.A., P.E. van der Werff, L.M. Bouwer and D. Huitema (2005), *Neo-Atlantis: Dutch Responses to Five Meter Sea Level Rise*, **FNU-75** (submitted)
- Toth, F.L. and E. Hizsnyik (2005), *Managing the inconceivable: Participatory assessments of impacts and responses to extreme climate change*, **FNU-74** (submitted)
- Kasperson, R.E. M.T. Bohn and R. Goble (2005), *Assessing the risks of a future rapid large sea level rise: A review*, **FNU-73** (submitted)
- Schleupner, C. (2005), *Evaluation of coastal squeeze and beach reduction and its consequences for the Caribbean island Martinique*, **FNU-72**
- Schleupner, C. (2005), *Spatial Analysis As Tool for Sensitivity Assessment of Sea Level Rise Impacts on Martinique*, **FNU-71**
- Sesabo, J.K. and R.S.J. Tol (2005), *Factor affecting Income Strategies among households in Tanzanian Coastal Villages: Implication for Development-Conservation Initiatives*, **FNU-70** (Submitted)
- Fisher, B.S., G. Jakeman, H.M. Pant, M. Schwoon. and R.S.J. Tol (2005), *CHIMP: A Simple Population Model for Use in Integrated Assessment of Global Environmental Change*, **FNU-69** (submitted)
- Rehdanz, K. and R.S.J. Tol (2005), *A No Cap But Trade Proposal for Greenhouse Gas Emission Reduction Targets for Brazil, China and India*, **FNU-68** (submitted)
- Zhou, Y. and R.S.J. Tol (2005), *Water Use in China's Domestic, Industrial and Agricultural Sectors: An Empirical Analysis*, **FNU-67** (submitted)
- Rehdanz, K. (2005), *Determinants of residential space heating demand in Germany*, **FNU-66** (submitted)
- Ronneberger, K., R.S.J. Tol and U.A. Schneider (2005), *KLUM: A simple model of global agricultural land use as a coupling tool of economy and vegetation*, **FNU-65** (submitted)
- Tol, R.S.J. (2005), *The Benefits of Greenhouse Gas Emission Reduction: An Application of FUND*, **FNU-64** (submitted)
- Röckmann, C., M.A. St.John, F.W. Köster, F.W. and R.S.J. Tol (2005), *Testing the implications of a marine reserve on the population dynamics of Eastern Baltic cod under varying environmental conditions*, **FNU-63** (submitted)
- Letsoalo, A., J. Blignaut, T. de Wet, M. de Wit, S. Hess, R.S.J. Tol and J. van Heerden (2005), *Triple Dividends of Water Consumption Charges in South Africa*, **FNU-62** (submitted)
- Zandersen, M., Termansen, M., Jensen, F.S. (2005), *Benefit Transfer over Time of Ecosystem Values: the Case of Forest Recreation*, **FNU-61** (submitted)
- Rehdanz, K., Jung, M., Tol, R.S.J. and Wetzel, P. (2005), *Ocean Carbon Sinks and International Climate Policy*, **FNU-60** (submitted)
- Schwoon, M. (2005), *Simulating The Adoption of Fuel Cell Vehicles*, **FNU-59** (submitted)
- Bigano, A., J.M. Hamilton and R.S.J. Tol (2005), *The Impact of Climate Change on Domestic and International Tourism: A Simulation Study*, **FNU-58** (submitted)

- Bosello, F., R. Roson and R.S.J. Tol (2004), *Economy-wide estimates of the implications of climate change: Human health*, **FNU-57** (submitted, *Ecological Economics*)
- Hamilton, J.M. and M.A. Lau (2004) *The role of climate information in tourist destination choice decision-making*, **FNU-56** (forthcoming, Gössling, S. and C.M. Hall (eds.), *Tourism and Global Environmental Change*. London: Routledge)
- Bigano, A., J.M. Hamilton and R.S.J. Tol (2004), *The impact of climate on holiday destination choice*, **FNU-55** (submitted, *Climatic Change*)
- Bigano, A., J.M. Hamilton, M. Lau, R.S.J. Tol and Y. Zhou (2004), *A global database of domestic and international tourist numbers at national and subnational level*, **FNU-54** (submitted)
- Susandi, A. and R.S.J. Tol (2004), *Impact of international emission reduction on energy and forestry sector of Indonesia*, **FNU-53** (submitted)
- Hamilton, J.M. and R.S.J. Tol (2004), *The Impact of Climate Change on Tourism and Recreation*, **FNU-52** (forthcoming, Schlesinger et al. (eds.), Cambridge University Press)
- Schneider, U.A. (2004), *Land Use Decision Modelling with Soil Status Dependent Emission Rates*, **FNU-51** (submitted)
- Link, P.M., U.A. Schneider and R.S.J. Tol (2004), *Economic impacts of changes in fish population dynamics: the role of the fishermen's harvesting strategies*, **FNU-50** (submitted)
- Berritella, M., A. Bigano, R. Roson and R.S.J. Tol (2004), *A General Equilibrium Analysis of Climate Change Impacts on Tourism*, **FNU-49** (submitted, *Tourism Management*)
- Tol, R.S.J. (2004), *The Double Trade-Off between Adaptation and Mitigation for Sea Level Rise: An Application of FUND*, **FNU-48** (submitted, *Mitigation and Adaptation Strategies for Global Change*)
- Erdil, Erkan and Yetkiner, I. Hakan (2004), *A Panel Data Approach for Income-Health Causality*, **FNU-47**
- Tol, R.S.J. (2004), *Multi-Gas Emission Reduction for Climate Change Policy: An Application of FUND*, **FNU-46** (forthcoming, *Energy Journal*)
- Tol, R.S.J. (2004), *Exchange Rates and Climate Change: An Application of FUND*, **FNU-45** (submitted, *Climatic Change*)
- Gaitan, B., Tol, R.S.J., and Yetkiner, I. Hakan (2004), *The Hotelling's Rule Revisited in a Dynamic General Equilibrium Model*, **FNU-44** (submitted)
- Rehdanz, K. and Tol, R.S.J. (2004), *On Multi-Period Allocation of Tradable Emission Permits*, **FNU-43** (submitted)
- Link, P.M. and Tol, R.S.J. (2004), *Possible Economic Impacts of a Shutdown of the Thermohaline Circulation: An Application of FUND*, **FNU-42** (*Portuguese Economic Journal*, **3**, 99-114)
- Zhou, Y. and Tol, R.S.J. (2004), *Evaluating the costs of desalination and water transport*, **FNU-41** (forthcoming, *Water Resources Research*)
- Lau, M. (2004), *Küstenzonenmanagement in der Volksrepublik China und Anpassungsstrategien an den Meeresspiegelanstieg*, **FNU-40** (submitted, *Coastline Reports*)
- Rehdanz, K. and Maddison, D. (2004), *The Amenity Value of Climate to German Households*, **FNU-39** (submitted)
- Bosello, F., Lazzarin, M., Roson, R. and Tol, R.S.J. (2004), *Economy-wide Estimates of the Implications of Climate Change: Sea Level Rise*, **FNU-38** (submitted, *Environmental and Resource Economics*)
- Schwoon, M. and Tol, R.S.J. (2004), *Optimal CO<sub>2</sub>-abatement with socio-economic inertia and induced technological change*, **FNU-37** (submitted, *Energy Journal*)
- Hamilton, J.M., Maddison, D.J. and Tol, R.S.J. (2004), *The Effects of Climate Change on International Tourism*, **FNU-36** (forthcoming, *Climate Research*)
- Hansen, O. and R.S.J. Tol (2003), *A Refined Inglehart Index of Materialism and Postmaterialism*, **FNU-35** (submitted)
- Heinzow, T. and R.S.J. Tol (2003), *Prediction of Crop Yields across four Climate Zones in Germany: An Artificial Neural Network Approach*, **FNU-34** (submitted, *Climate Research*)

- Tol, R.S.J. (2003), *Adaptation and Mitigation: Trade-offs in Substance and Methods*, **FNU-33** (submitted, *Environmental Science and Policy*)
- Tol, R.S.J. and T. Heinjow (2003), *Estimates of the External and Sustainability Costs of Climate Change*, **FNU-32** (submitted)
- Hamilton, J.M., Maddison, D.J. and Tol, R.S.J. (2003), *Climate change and international tourism: a simulation study*, **FNU-31** (forthcoming, *Global Environmental Change*)
- Link, P.M. and R.S.J. Tol (2003), *Economic impacts of changes in population dynamics of fish on the fisheries in the Barents Sea*, **FNU-30** (submitted)
- Link, P.M. (2003), *Auswirkungen populationsdynamischer Veränderungen in Fischbeständen auf die Fischereiwirtschaft in der Barentssee*, **FNU-29** (*Essener Geographische Arbeiten*, **35**, 179-202)
- Lau, M. (2003), *Coastal Zone Management in the People's Republic of China – An Assessment of Structural Impacts on Decision-making Processes*, **FNU-28** (submitted)
- Lau, M. (2003), *Coastal Zone Management in the People's Republic of China – A Unique Approach?*, **FNU-27** (*China Environment Series*, Issue 6, pp. 120-124; <http://www.wilsoncenter.org/topics/pubs/7-commentaries.pdf>)
- Roson, R. and R.S.J. Tol (2003), *An Integrated Assessment Model of Economy-Energy-Climate – The Model Wiagem: A Comment*, **FNU-26** (forthcoming, *Integrated Assessment*)
- Yetkiner, I.H. (2003), *Is There An Indispensable Role For Government During Recovery From An Earthquake? A Theoretical Elaboration*, **FNU-25**
- Yetkiner, I.H. (2003), *A Short Note On The Solution Procedure Of Barro And Sala-i-Martin for Restoring Constancy Conditions*, **FNU-24**
- Schneider, U.A. and B.A. McCarl (2003), *Measuring Abatement Potentials When Multiple Change is Present: The Case of Greenhouse Gas Mitigation in U.S. Agriculture and Forestry*, **FNU-23** (submitted)
- Zhou, Y. and Tol, R.S.J. (2003), *The Implications of Desalination to Water Resources in China - an Economic Perspective*, **FNU-22** (*Desalination*, **163** (4), 225-240)
- Yetkiner, I.H., de Vaal, A., and van Zon, A. (2003), *The Cyclical Advancement of Drastic Technologies*, **FNU-21**
- Rehdanz, K. and Maddison, D. (2003) *Climate and Happiness*, **FNU-20** (*Ecological Economics*, **52** 111-125)
- Tol, R.S.J., (2003), *The Marginal Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties*, **FNU-19** (*Energy Policy*, **33** (16), 2064-2074).
- Lee, H.C., B.A. McCarl, U.A. Schneider, and C.C. Chen (2003), *Leakage and Comparative Advantage Implications of Agricultural Participation in Greenhouse Gas Emission Mitigation*, **FNU-18** (submitted).
- Schneider, U.A. and B.A. McCarl (2003), *Implications of a Carbon Based Energy Tax for U.S. Agriculture*, **FNU-17** (submitted).
- Tol, R.S.J. (2002), *Climate, Development, and Malaria: An Application of FUND*, **FNU-16** (forthcoming, *Climatic Change*).
- Hamilton, J.M. (2003), *Climate and the Destination Choice of German Tourists*, **FNU-15** (revised and submitted).
- Tol, R.S.J. (2002), *Technology Protocols for Climate Change: An Application of FUND*, **FNU-14** (forthcoming, *Climate Policy*).
- Rehdanz, K (2002), *Hedonic Pricing of Climate Change Impacts to Households in Great Britain*, **FNU-13** (forthcoming, *Climatic Change*).
- Tol, R.S.J. (2002), *Emission Abatement Versus Development As Strategies To Reduce Vulnerability To Climate Change: An Application Of FUND*, **FNU-12** (forthcoming, *Environment and Development Economics*).
- Rehdanz, K. and Tol, R.S.J. (2002), *On National and International Trade in Greenhouse Gas Emission Permits*, **FNU-11** (forthcoming, *Ecological Economics*).
- Fankhauser, S. and Tol, R.S.J. (2001), *On Climate Change and Growth*, **FNU-10** (*Resource and Energy Economics*, **27**, 1-17).
- Tol, R.S.J. and Verheyen, R. (2001), *Liability and Compensation for Climate Change Damages – A Legal and Economic Assessment*, **FNU-9** (*Energy Policy*, **32** (9), 1109-1130).
- Yohe, G. and R.S.J. Tol (2001), *Indicators for Social and Economic Coping Capacity – Moving Toward a Working Definition of Adaptive Capacity*, **FNU-8** (*Global Environmental Change*, **12** (1), 25-40).
- Kemfert, C., W. Lise and R.S.J. Tol (2001), *Games of Climate Change with International Trade*, **FNU-7** (*Environmental and Resource Economics*, **28**, 209-232).

Tol, R.S.J., W. Lise, B. Morel and B.C.C. van der Zwaan (2001), *Technology Development and Diffusion and Incentives to Abate Greenhouse Gas Emissions*, **FNU-6** (submitted, *International Environmental Agreements*).

Kemfert, C. and R.S.J. Tol (2001), *Equity, International Trade and Climate Policy*, **FNU-5** (*International Environmental Agreements*, **2**, 23-48).

Tol, R.S.J., Downing T.E., Fankhauser S., Richels R.G. and Smith J.B. (2001), *Progress in Estimating the Marginal Costs of Greenhouse Gas Emissions*, **FNU-4**. (*Pollution Atmosphérique – Numéro Spécial: Combien Vaut l’Air Propre?*, 155-179).

Tol, R.S.J. (2000), *How Large is the Uncertainty about Climate Change?*, **FNU-3** (*Climatic Change*, **56** (3), 265-289).

Tol, R.S.J., S. Fankhauser, R.G. Richels and J.B. Smith (2000), *How Much Damage Will Climate Change Do? Recent Estimates*, **FNU-2** (*World Economics*, **1** (4), 179-206)

Lise, W. and R.S.J. Tol (2000), *Impact of Climate on Tourism Demand*, **FNU-1** (*Climatic Change*, **55** (4), 429-449).