

Imprint

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Abstract

This report aims at identifying potential issues for collaboration related to climate adaptation through application of a tool for assessing macro-regional risks. The tool is intended to assist decision-makers and other stakeholders in the Baltic Sea Region (BSR) in discussions on how climate adaptation related cooperation would benefit most from macro-regional cooperation. It is based on four criteria: 1) confidence, 2) speed (determined by Baltadapt climate modellers), 3) importance of impacts and 4) macro-regional coverage (based on a questionnaire answered by 3-8 stakeholders from each of the nine riparian BSR states). Based on equal weighting of these factors, impacts related to biodiversity/eutrophication of the Baltic Sea, as well as impacts related to agriculture were given the highest rankings, which demonstrates the importance to include these sectors and their interrelationship as an important focus in macro-regional cooperation on climate adaptation in the BSR. Impacts related to biodiversity and agriculture have in common that they are caused by climate change that will occur or already has occurred with a high degree of certainty (e.g., linked to air and water temperatures and rising sea levels), as well as having a very large macro-regional spatial coverage, and being perceived as of high societal and/or environmental concern.

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1 Introduction

This report entitled “The vulnerability assessment concept: a tool for prioritization of the most relevant issues for macro-regional cooperation” aims at identifying potential issues for collaboration related to climate adaptation through application of a tool for assessing macro-regional risks. The tool is intended to assist decision-makers and other stakeholders in the Baltic Sea Region (BSR) in discussions on how climate adaptation related cooperation would benefit most from macro-regional cooperation. It has been produced as part of Baltadapt task 4.5 “Integrated Vulnerability Assessment Concept”. Together with the work to review national, regional or sectoral vulnerability assessments in Baltadapt (reported in Alberth et al 2012) and the guidelines for system vulnerability (reported in Hjerpe et al 2013), these three activities all essential for integrated vulnerability assessment, are now completed.

In order to serve as assistance for dialogues on which issues are relevant for macro-regional cooperation on climate adaptation, a tool for “macro-regional” risk assessment has been developed.

Prioritizing of candidate issues to be focused on in the macro-regional cooperation on climate adaptation in the BSR clearly needs to be based on estimates of potential impacts and adaptive capacities in various parts of the BSR. The proposed tool guides its users through a systematic evaluation of possible impacts, grouped under the change of specific climatic variables, according to two criteria: confidence, speed, determined by Baltadapt climate modellers. When impacts are related to several climatic variables, this is indicated, with reference to the other climate variables to take into consideration. The two other criteria; importance of impacts and macro-regional coverage were estimated based on a questionnaires answered by 3-8 stakeholders from each of the nine BSR states with coast to the Baltic Sea, where macro-regional coverage was determined from the number of countries for which the impact was assigned to be important for their country. Data for the four criteria were loaded into an Excel spreadsheet, were first averages of criteria 3 (importance) was calculated for each country and then the average of the four criteria were calculated for each included impact.

The included impacts, were identified from the Baltadapt Impact Assessment Reports on: marine biodiversity (Dahl et al., 2012), fish stocks and fisheries (Peltonen et al., 2012), infrastructure (Krämer et al., 2012), and tourism (Kule et al. 2013), as well as from the Stakeholder meeting report with regard to agriculture and coastal tourism (Andersson et al., 2013).

The tool was used to systematically rank seventy potential impacts of climate change in the BSR. Thirty-eight of the possible impacts were assigned a combined average exceeding 3.5 for the four criteria (where each of the four criteria can have a value ranging from 0-5). Spider-diagrams illustrating the scores for each of these impacts are presented in this report, grouped under the change in climatic variable it mainly relate to (see Section 3).

We found that the tool provided quite distinct results, in terms of identifying candidate issues for macro-regional collaboration. Before we present our main experiences from using the tool, it is important to note that this particular application of the tool provides a combined picture of climate modelling experts active in the project (responsible for the ranking of “confidence” and “speed) and a limited number (3-8) of stakeholders from each BSR state which were responsible for the ranking of

“importance” and “macro-regional coverage”. The stakeholders consisted of participants in the 2nd Baltadapt Policy forum (held in Stockholm in December 2012), participants in the agriculture and tourism stakeholder dialogues, plus some national climate adaptation experts identified by Baltadapt partners. The selection of stakeholders was thus rather random and cannot, from a scientific point of view, be seen as fully representative of how politicians in the region nor other stakeholders such as businesses, environmental organisations, local and regional governments, or the general public view the severity/potential of the candidate impacts. It should rather be seen as a pilot test of prioritization in a macro-regional context where the spider-diagrams proved to be an efficient tool to swiftly get to the core criterion that limits the overall rating for a particular impact. For instance, some were limited by the climate modelling scientist’s provision of a low confidence that the impact would take place or that it would take place in the near future, others by stakeholder identification of low severity/potential without adaptation (importance), or the fact that high importance to adapt was only identified by a few countries, which means that although important in a national context it might not be an issue to address in a macro-regional context. Often confidence and speed, that is the time horizon before an impact becomes detectable, co-varied. This is unsurprising since we could be quite confident that a change that is already detectable will take place.

We hope that this report will serve as a basis for further discussions with regards to what issues would benefit most from macro-regional collaboration and coordination. We also strongly encourage others to use this tool to get a more robust basis of the rankings and, thus, an even better support material to assist the selection of issues for collaboration.

2 Methodology / Approach

Prioritizing of candidate issues to be focused on in macro-regional cooperation on climate adaptation in the BSR clearly needs to be based on estimates of potential impacts and adaptive capacities (Figure 1) in various parts of the BSR.

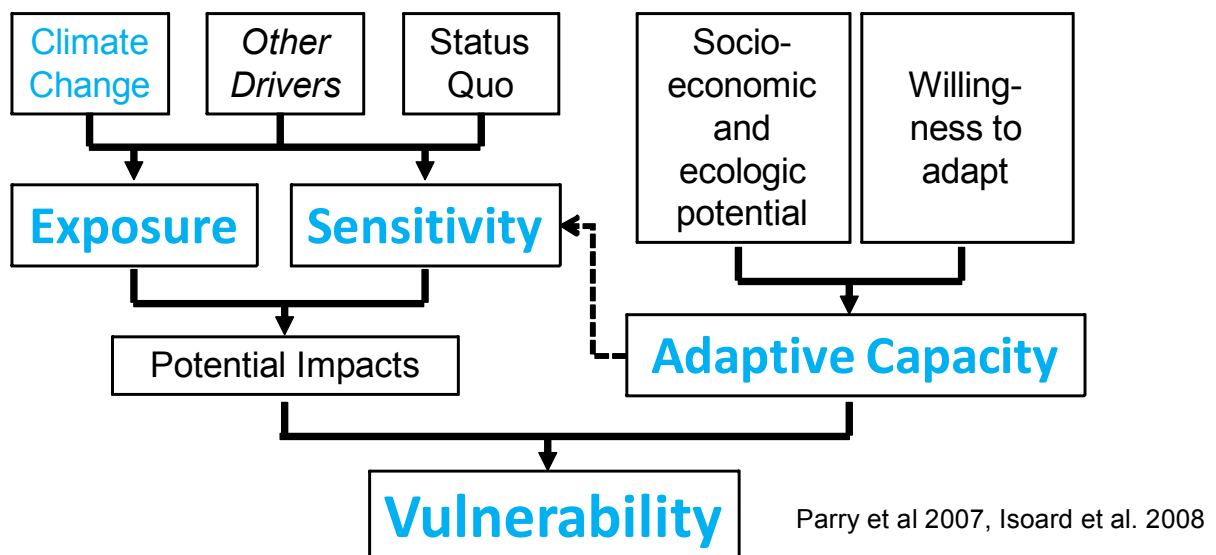


Figure 1: Estimates of vulnerability, based on exposure, sensitivity and adaptive capacity.

The tool for “macro-regional risk assessment” is based on visualisation of macro-regional expert judgements of four relevant criteria for each impact:

1. high confidence that climate change will take place;
2. high speed of climate change;
3. high importance defined as high severity without adaptation or potential with adaptation;
4. high macro-regional coverage defined as high number of states which have identified a high national importance

However, no judgement has been made of the relative importance or weight of each of these four criteria. In forthcoming applications of the tool, we foresee that the users, representing climate modelling experts and various groups of stakeholders could agree on such weightings, where, e.g., importance (severity/potential) could be given a higher ranking (indicating that based on a solidarity principle macro-regional cooperation is needed although only a few states are vulnerable to an impact) or that the speed of change is given a lower ranking (indicating that adaptation also is needed for long-term impacts, e.g. when an action made now will reduce vulnerability also in a long-term perspective). The first two criteria (confidence and speed) are related to the climate exposure of the BSR, whereas the third and fourth criteria (importance and macro-regional coverage in addition to impact are strongly related to the adaptive capacity element of integrated vulnerability. As described above, in this report, the two first criteria (confidence and speed) were based on expert judgements from climate scientists within the Baltadapt project, whereas the two second (importance and macro-regional coverage) were

based on expert judgements from 3–8 stakeholders from each of the nine coastal BSR states. The four criteria are briefly described below.

2.1 Criterion 1: Certainty

For some climate variables, including air temperature and sea level rise, the certainty that they already are or that they will take place is high, whereas for other variables, including wind speed, the certainty is quite low, with contradictory results from different climate change projections (cf Section 4). Even with high confidence, however, adaptive management is needed, since then the actual amplitude of this change might be uncertain.

In the prioritization, “certainty”, refers to the confidence that climate change will take place, ranked on a scale ranging from low, medium to high probability, where also geographical differences of the certainty within the BSR are considered.

The “certainty” criterion was determined by expert judgement of climate change modelling experts participating in the Baltadapt project. Please observe that the “certainty” relates to the confidence that a change of a climate variable (such as air temperature) has or will take place, not to the certainty that this change will cause a specified impact.

2.2 Criterion 2: Time horizon

Some climatic changes are already visible or projected to be significant already in the near future, whereas other will have significant impacts first in a longer time perspective (Figure 2). However, measures in reaction to, for instance, sea level rise (a change that is visible already in the southern parts of the BSR but where exposure in the northern parts is delayed due to land uplift) need long political and administrative planning horizons. This means that changes involving significant inertia need to be on the agenda for political and administrative planning long before these impacts are becoming observable. However, although we might have some time to wait with action to address long term impacts, adaptation to changes that already are occurring or that are foreseen in the near future cannot wait.

Time horizon (i.e., the speed of change) was defined, by climate change researchers participating in the Baltadapt project, as the time until a significant change of a climate variable can be expected. The scale was ranging from already being observable up to 100 years or more. Please observe that also this criterion refers to the time until a climate variable has been significantly changed, not when a significant impact of a change of a specific climate variable on a specific issue is expected (although these are expected to be well correlated).

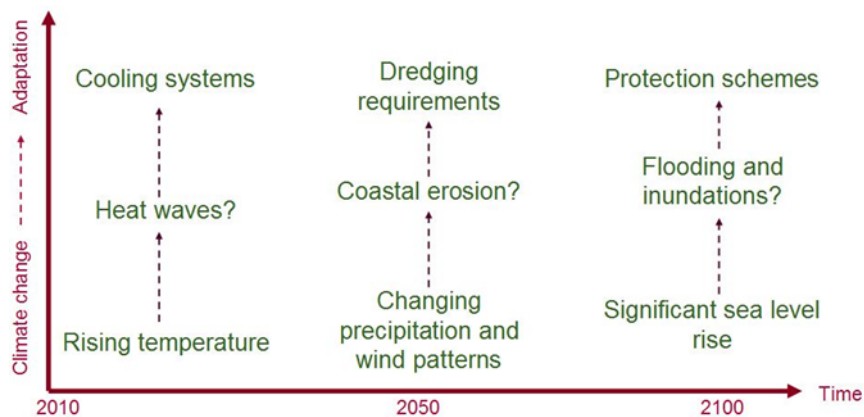


Figure 2: Infrastructure planning to meet changes at different time scales (from Baltadapt Report # 5 “Climate Change Impacts on Infrastructure in the Baltic Sea Region”).

2.3 Criterion 3: Importance

The foreseen importance of adaptation for human welfare and/or ecosystems from a specified impact of climate change is crucial for decisions to take action to adapt. Importance, defined as high severity without adaptation or high potential with adaptation may be evaluated in economic terms or by other criteria. Severity and potential depends on vulnerability, which, in turn, is determined by a combination of impact (determined by exposure and sensitivity), and adaptive capacity (Figure 1).

2.4 Criterion 4: Macro-regional coverage

Although some impacts can be of crucial importance for a specific part of the BSR, to be relevant for cooperation linked to the BSR Climate Adaptation Strategy, they should preferably be of concern for several countries in the BSR. Accordingly, to become a main focus of the strategy, a wide geographical coverage of impacts and vulnerability increases the benefits from cooperation across the region.

Macro-regional coverage was determined from the number of BSR states from which the average expert judgement of national importance of an issue was determined as 3.5, where 3 represents moderate importance and 4 represents high importance.

Due to the limited access to studies related to vulnerability and adaptive capacity within specific sectors for the BSR, the latter two criteria will, until this knowledge gap is filled, have to be based on “expert judgements” from representatives from BSR states. In this report, the importance to take action is thus based on expert judgements from 3-8 stakeholders from each BSR coastal state, who, from their national perspective, ranked the importance to take action related to each issue on a scale ranging from insignificant (1) to very high (5).

3 Visualisation of factors determining the relevance to include an issue in BSR macro-regional cooperation on climate adaptation

A preliminary assessment of impacts to be focused on in macro-regional cooperation on climate adaptation in the BSR, based on the four criteria described above was made.

The list of possible impacts was based on the Baltadapt Impact Assessment Reports:

- Baltadapt Report #3: Climate Change Impacts on Marine Biodiversity and Habitats in the Baltic Sea – and Possible Human Adaptations (Dahl et al., 2012)
- Baltadapt Report #4: Climate Change Impacts on the Baltic Sea Fish Stocks and Fisheries. Review with a Focus on Central Baltic Herring, Sprat and Cod (Peltonen et al., 2012)
- Baltadapt Report #5: Climate Change Impacts on Infrastructure in the Baltic Sea Region (Krämer et al., 2012)
- Baltadapt Report #6: Climate Change Impacts on Coastal Tourism in the Baltic Sea Region (Kule et al., 2013)
- Baltadapt Report #10: Baltadapt Stakeholder Dialogues - Stakeholder Input from the Tourism and Agricultural Sectors to the BSR Climate Adaptation Strategy (Andersson et al., 2013)

A first list of suggested impact to include in the assessment was sent to the authors of these reports for comments and complementation before the final list of possible impacts was decided upon.

The report contains tables of all assessed impacts, with those impacts rated as important to include in macro-regional cooperation (average value of the four criteria >3.5) indicated in bold. The impacts are divided by changes in climatic variables:

- 3.1. Higher annual air temperature (eight out of eight impacts > 3.5),
- 3.2. Warmer summers and more frequent heat waves (none out of three impacts > 3.5),
- 3.3. Increase of high wind speed, storms and high waves in coastal and marine areas (none of the six impacts > 3.5),
- 3.4. Changes in the frequency of freeze and thaw cycles (none out of one impact < 3.5),
- 3.5. Increase of extreme precipitation (none out of two impacts > 3.5),
- 3.6. Increase of river discharge (none out of four impacts > 3.5),
- 3.7. More severe dry spells in summer (none out of four impacts > 3.5),
- 3.8. Rising sea level due to global sea level rise (two out of four impacts > 3.5),
- 3.9. Local, temporal sea level rise due to local wind induced storm surges (none out of two impacts > 3.5),
- 3.10. Warmer water in the Baltic Sea (six out of eleven impacts > 3.5),
- 3.11. Lower salinity in the Baltic Sea (none out of six impacts > 3.5),
- 3.12. Reduced ice cover in the Baltic Sea and along coasts and a shorter season with sea ice (two out of ten impacts > 3.5), and
- 3.13. Lower oxygen concentrations in surface water and increase of anoxic bottom areas (five out of eight impacts > 3.5).

Spider-diagrams showing the ranking according to the four criteria (cf Section 2 above) are provided for all possible impacts, with an average of the four criteria exceeding 3.5. Overall, out of the seventy possible impacts that were evaluated, the combined ranking average exceeded 3.5 for thirty-eight impacts.

The rankings in the spider-diagrams were transferred to numbers ranging from 1 to 5, using the following criteria.

Criterion 1: Certainty

| 1 | 2 | 3 | 4 | 5 |
|-----|----------|---|--|------------------------------|
| Low | Moderate | High in most of region, moderate or low in the rest of the BSR region | High in general, but moderate for extremes | High in the whole BSR region |

Criterion 2: Time horizon

| 1 | 2 | 3 | 4 | 5 |
|--------------|--|-------------|------------|------------|
| 50-100 years | 10-50 years in general, 50-100 years for extremes, or 10-100 years, or 0-100 years | 10-50 years | 0-50 years | 0-20 years |

Criterion 3: Importance

| 1 | 2 | 3 | 4 | 5 |
|--|---|---|---|---|
| The average ranking of "importance" (as a mean of the nine national estimates) was below 1.5 | The average ranking of "importance" (as a mean of the nine national estimates) was 1.5 to 2.5 | The average ranking of "importance" (as a mean of the nine national estimates) was 2.5 to 3.5 | The average ranking of "importance" (as a mean of the nine national estimates) was 3.5 to 4.5 | The average ranking of "importance" (as a mean of the nine national estimates) exceeded 4.5 |

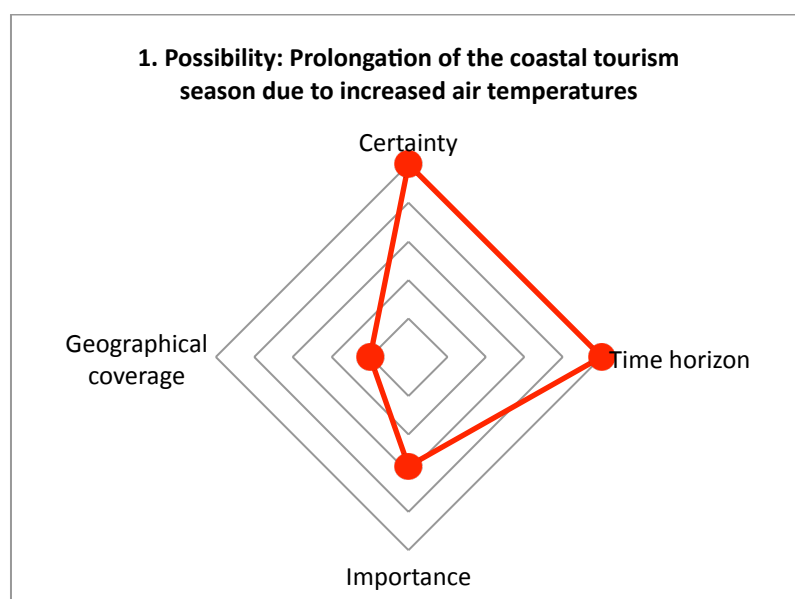
Criterion 4: Macro-regional coverage

| 1 | 2 | 3 | 4 | 5 |
|--|--|--|--|--|
| 0 - 2 states gave an "importance" ranking that on average exceeded 3.5 | 3 - 4 states gave an "importance" ranking that on average exceeded 3.5 | 5 - 6 states gave an "importance" ranking that on average exceeded 3.5 | 7 - 8 states gave an "importance" ranking that on average exceeded 3.5 | 9 states gave an "importance" ranking that on average exceeded 3.5 |

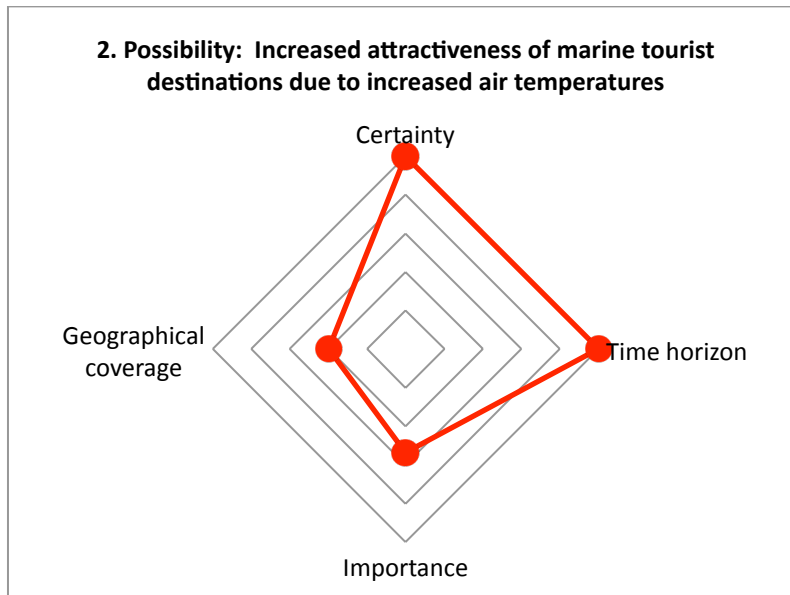
3.1 Higher annual air temperature

| Certainty: HIGH | Time horizon: 0-20 YEARS (that is, the change is already detectable) | Average rating (0-5) | Possible Impacts: |
|---|---|-----------------------------|---|
| Macro-regional coverage: WHOLE REGION | | 3.5 | 1. Prolongation of coastal tourism |
| | | 3.7 | 2. Increased attractiveness of marine tourism destinations |
| | | 3.9 | 3. Potential for higher crop yield |
| | | 4.1 | 4. Possibilities to introduce new agricultural crops |
| | | 4.2 | 5. Possible to take advantage of longer vegetation periods for agricultural production |
| | | 4.8 | 6. Changed geographical distribution may lead to introduction of new pests affecting livestock and plants |
| | | 4.1 | 7. Changed growth and geographical distribution of weeds |
| | | 4.2 | 8. Changes in nutrient loads, for southern parts probably increased phosphorous loads, but might be decrease in northern parts due to less ground frost |

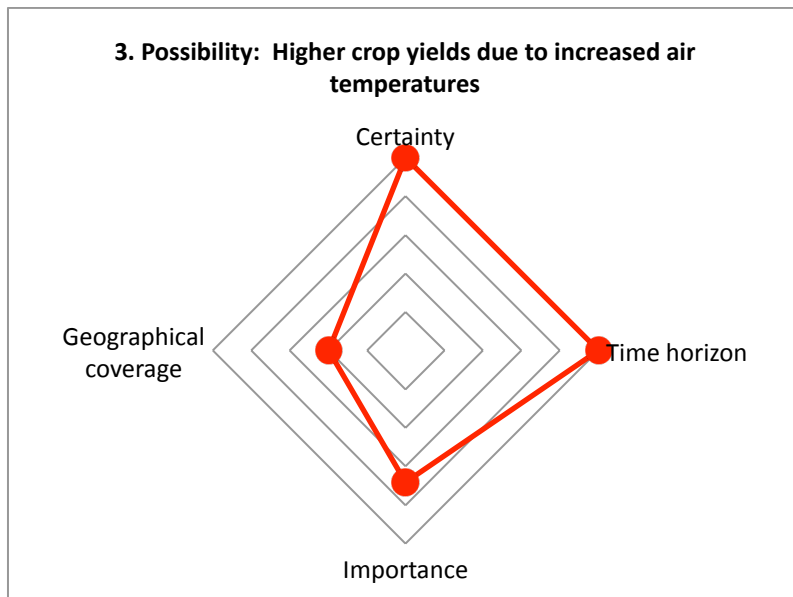
The first spider-diagram shows the climate expert and stakeholder judgments of the four factors determining if the potential for **prolongation of coastal tourism** in the coastal areas of the BSR **due to higher air temperatures** should be considered in macro-regional cooperation. There was agreement that higher temperatures already are detectable and that they will continue to increase, which thus already now provides the potential for prolonged tourist seasons. According to potential with adaptation, however, stakeholders rated the importance of adaptation to the benefits from prolonged seasons as moderate with a low macro-regional coverage.



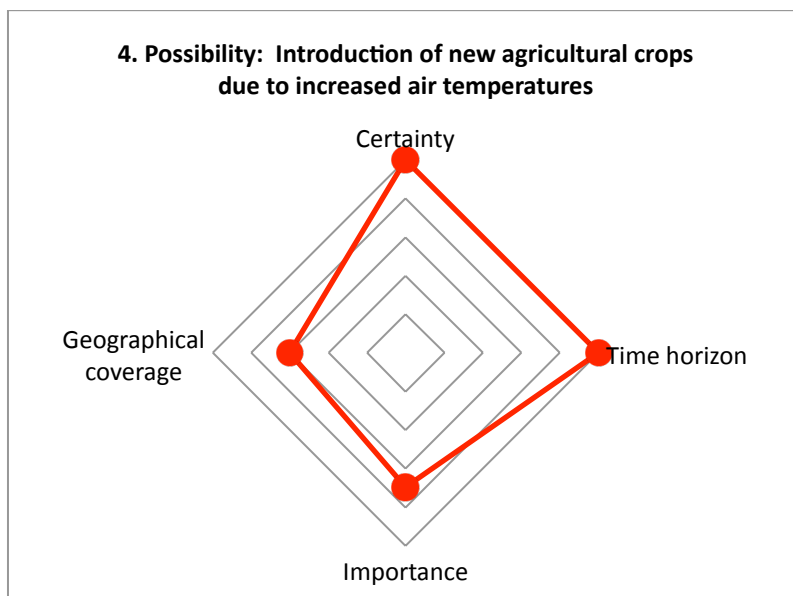
The second spider-diagram shows the climate expert and stakeholder judgments of the four factors determining if the potential for **increased attractiveness of coastal tourism destinations** in the BSR **due to higher air temperatures** should be considered in macro-regional cooperation. There was agreement that higher temperatures already are detectable and that they will continue to increase, which thus already now provides the potential for prolonged tourist seasons. According to potential with adaptation, however, stakeholders rated the importance of adaptation to the benefits from prolonged seasons as well as the macro-regional coverage as moderate.



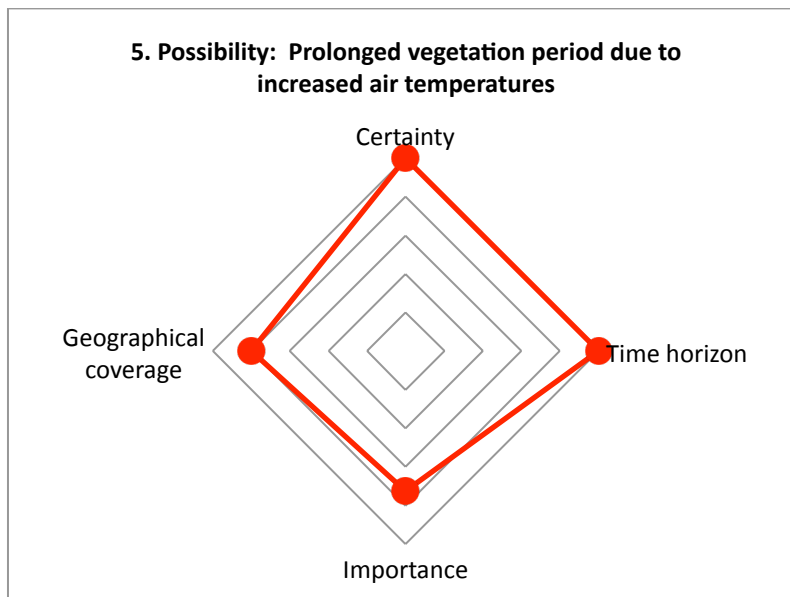
The third spider-diagram shows the climate expert and stakeholder judgments of the four factors determining if the **potential for higher crop yields** in BSR agriculture **due to higher air temperatures** should be considered in macro-regional cooperation. There was agreement that higher temperatures already are detectable and that they will continue to increase, which thus already now provides the potential for higher crop yields (with acknowledgement of that the positive effects of increased temperatures might be substituted by a negative impact if future temperatures increase above optimal temperatures). Stakeholders rated the benefits of impact of adaptation as high, but with a moderate macro-regional coverage. In two of nine countries the possibility of adaptation to increase crop yields was rated as exceeding 3.5 on average (and in two countries the average was exactly 3.5).



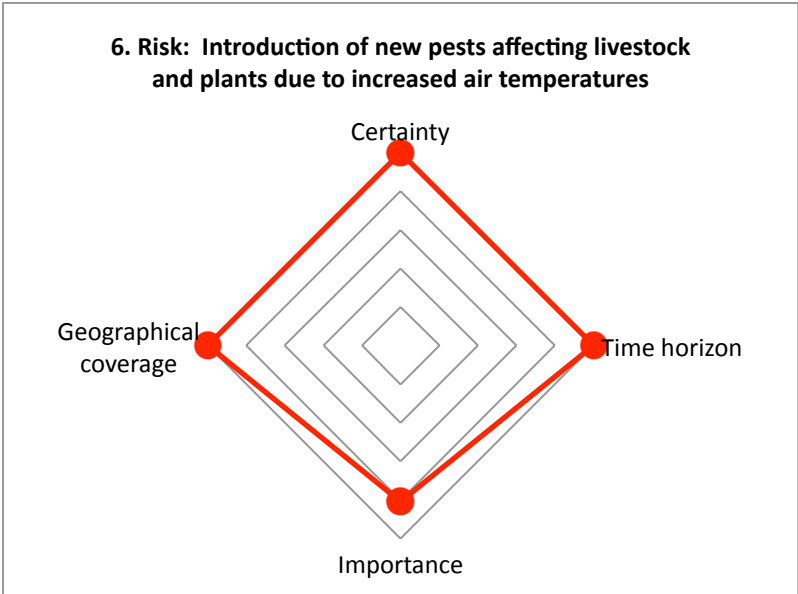
The fourth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining if the potential for **introducing new agricultural crops** in the BSR region **due to higher air temperatures** should be considered in macro-regional cooperation. There was agreement that higher temperatures already are detectable and that they will continue to increase, which thus already now provides the potential to introduce new crops. Stakeholders rated the benefits of introducing new crops as high, but with a fairly low macro-regional coverage. In four of nine countries the importance to adapt to the possibility to of introducing new agricultural crops were rated as exceeding 3.5 on average (and in three countries the average was exactly 3.5).



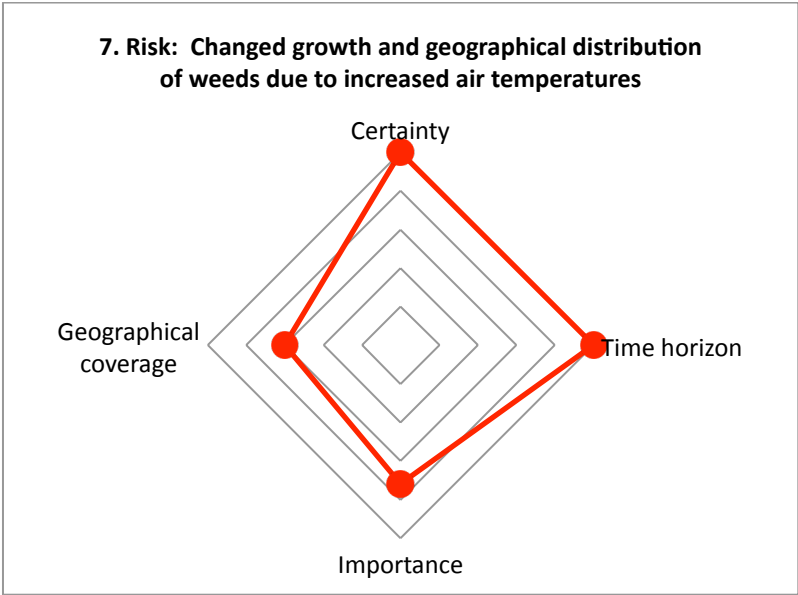
The fifth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining if the possibility to take advantage of a **prolonged period for agricultural production** in the BSR region **due to higher air temperatures** should be considered in macro-regional cooperation. There was agreement that higher temperatures already are detectable and that they will continue to increase, which thus already now provides the potential to introduce new crops. Stakeholders rated the importance of this impact as high. Stakeholders also attributed high macro-regional coverage to the impact of adaptation to prolonged vegetation periods, in seven of nine countries the severity of introduction of new pests were rated as exceeding 3.5 on average.



The sixth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining if the risk that new **pests will affect agricultural livestock and plants** in the BSR region **due to higher air temperatures** should be considered in macro-regional cooperation. There was agreement that higher temperatures already are detectable and that they will continue to increase, which thus already calls for adaptation to avoid new pests. Stakeholders rated the severity of this impact as high that is they believed that without adaptation this would have a significant effect on agricultural activities in the BSR region. Stakeholders also attributed high macro-regional coverage to the impact introduction of new pests, in eight of nine countries the severity of introduction of new pests were rated as exceeding 3.5 on average (and in the ninth country the average was exactly 3.5).

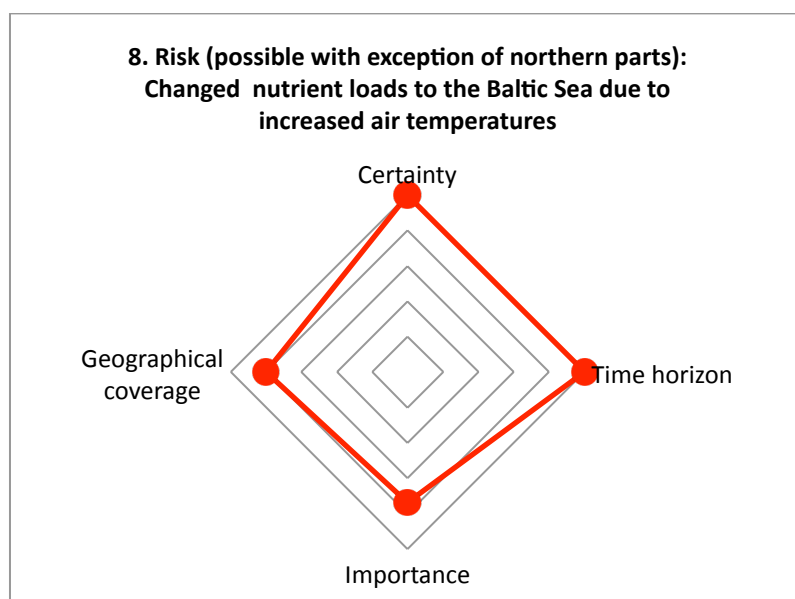


The seventh spider-diagram shows the climate expert and stakeholder judgments of the four factors determining if risks related to increased **growth and geographical distribution of weeds due to higher air temperatures** should be considered in macro-regional cooperation. There was agreement that higher temperatures already are detectable and that they will continue to increase, which thus already now provides a risk related to increased growth and changed geographical distribution of weeds. Stakeholders rated the severity of this impact as high that is they believed that without adaptation this will have a significant effect on agricultural activities in the BSR region. However, stakeholders attributed a moderate macro-regional coverage to the impact, in four of nine countries the severity of accelerated growth and changed distribution of weeds were rated as exceeding 3.5 on average (and in two countries the average was exactly 3.5).



The eight spider-diagram shows the climate expert and stakeholder judgments of the four factors determining if risks (and possibilities in the northern parts due to less ground frost) related to **changed**

nutrient loads from the drainage basin to the Baltic Sea **due to higher air temperatures** should be considered in macro-regional cooperation. There was agreement that higher temperatures already are detectable and that they will continue to increase, which thus already now provides a risk related to increased phosphorus loads from the basin. Stakeholders rated the severity of this impact as high that is they believed that without adaptation (i.e. remedies in the drainage basin aiming to reduce the loads) this will have a significant effect on the nutrient load to the Baltic Sea. Stakeholders attributed a moderate macro-regional coverage of changed nutrient loads from the drainage basin, in five of nine countries the severity of higher nutrient loads from the drainage basin were rated as exceeding 3.5 on average (and in one country the average was exactly 3.5).



3.2 Warmer summers and more frequent heat waves

| Certainty: | Time horizon: | Average rating (0-5) | Possible impacts |
|--|--|-----------------------------|---|
| HIGH for warmer summers, MODERATE for more frequent heat waves | Warmer summers: 10-50 years | 2.8 | More need for cooling/ventilation systems and refrigeration in ports (stored goods) |
| Macro-regional coverage: WHOLE REGION | More frequent heat waves: 50-100 years | 3.1 | More need to ensure cooling of buildings and public traffic systems |
| | | 3.2 | More health problems |

None of the three included possible impacts of warmer summers and more frequent heat waves were, on average, exceeding 3.5 and spider diagrams have, consequently, not been included in this report. They are available from the authors upon request.

3.3 Increase of high wind speed, storms and high waves in coastal and marine areas

| Certainty: | Time horizon: | Average rating (0-5) | Possible impacts: |
|---|----------------------|-----------------------------|---|
| LOW | 50-100 years | 1.8 | Rougher conditions for maritime traffic, increased risks for shipping accidents |
| Macro-regional coverage: Models are neither agreeing on the direction of change nor on where the changes will occur. Some models indicate an increase in extremes over the Baltic Sea, others do not. | | 2.9 | Increased risk of damage to port infrastructure, equipment and cargo |
| | | 2.4 | More coastal erosion, but also sand accumulation elsewhere |
| | | 1.4 | Power outages, impacts on manoeuvring and loading of ships in times of storm surges |
| | | 1.4 | Damage to fishing vessels and gears and breaks in fishing |
| | | 1.4 | Danger to the crews of fishing vessels |

None of the six included possible impacts of increasing wind speed, storms and high waves were, on average, exceeding 3.5 and spider diagrams have, consequently, not been included in this report. They are available from the authors upon request.

3.4 Changes in the frequency of freeze and thaw cycles

| Certainty: | Time horizon: | Average rating (0-5) | Possible Impact |
|--|----------------------|-----------------------------|--|
| HIGH | 10-50 years | 2.9 | Changed risk of damage to port infrastructure, equipment and cargo |
| Macro-regional coverage: Decrease in the southern area (no ice) and increase in the northern part of the region. | | | |

The possible impact of changes in the frequency of freeze and thaw cycles, that is changed risk if damage to port infrastructure, equipment and cargo was, on average, not exceeding 3.5 and consequently, no spider diagrams have been included in this report. They are available from the authors upon request.

3.5 Increase of extreme precipitation

| Certainty: MODERATE | Time horizon: 10-100 years | Average rating (0-5) | Possible impact: |
|---|--------------------------------------|-----------------------------|---|
| Macro-regional coverage: WHOLE REGION | | 3.3 | More flash floods affecting e.g., urban areas, agricultural land, ports and tourism |
| | | 3.3 | Nutrient losses in times of high rainfall intensities/floods will increase eutrophication |

None of the six included possible impacts of increasing of extreme precipitation were, on average, exceeding 3.5 and spider diagrams have, consequently, not been included in this report. They are available from the authors upon request.

3.6 Increase of river discharge

| Certainty: MODERATE | Time horizon: 10-100 years | Average rating (0-5) | Possible impact: |
|---|--------------------------------------|-----------------------------|---|
| Macro-regional coverage: Increases largest in the north and especially winter Summer discharge may decrease, especially in the south | | 3.0 | More flooding at river mouths, rise of groundwater level might cause damage to infrastructure constructions |
| | | 2.0 | More downstream sedimentation |
| | | 2.6 | Increased discharge is a factor that probably will increase nutrient transport to the sea |
| | | 2.2 | Lack of riverine water for irrigation and other water consumption |

None of the four included possible impacts of increasing river discharge were, on average, exceeding 3.5 and spider diagrams have, consequently, not been included in this report. They are available from the authors upon request.

3.7 More severe dry spells in summer

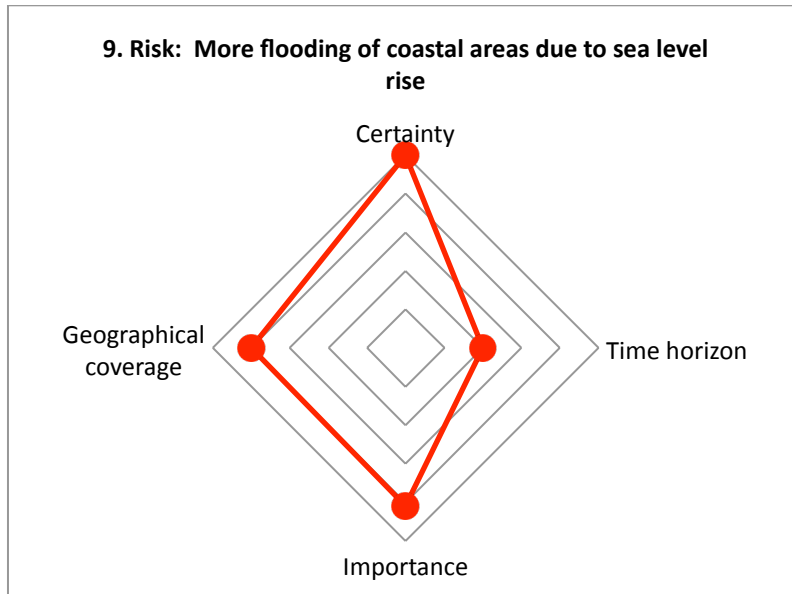
| Certainty: LOW in most of the region, MODERATE in southern parts | Time horizon: 10-100 years | Average rating (0-5) | Possible impact: |
|--|--------------------------------------|-----------------------------|---|
| Macro-regional coverage: Most likely in the southern parts of the BSR region | | 2.2 | Difficult to safeguard summer water supply |
| | | 2.1 | Drought damage to vegetation used for coastal protection |
| | | 2.9 | Increased risk of forest fires |
| | | 2.2 | More attractive for tourists (if not indirect negative impacts occur) |

None of the four included possible impacts of more severe dry spells in summer were, on average, exceeding 3.5 and spider diagrams have, consequently, not been included in this report. They are available from the authors upon request.

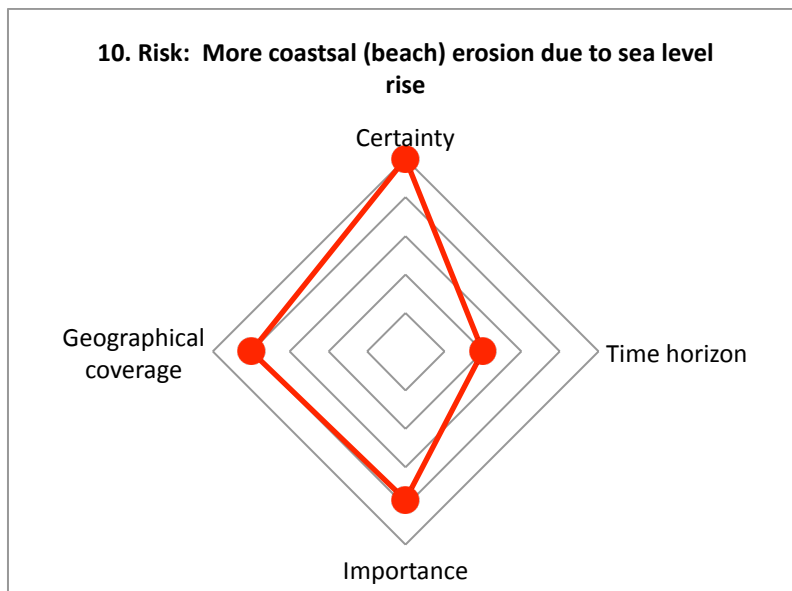
3.8 Rising sea level due to global sea level rise

| Certainty: | Time horizon: | Average rating (0-5) | Possible impact: |
|--|--|-----------------------------|--|
| HIGH | 0-100 years or more | 3.8 | 9. More flooding of coastal areas |
| Macro-regional coverage: | (already detectable in southern parts) | 3.5 | 10. More coastal (beach) erosion |
| The northern areas will not see a strong increase in sea level in the nearest century due to compensation by land uplift. In the south, the sea is already rising. | | 3.4 | Ecosystem losses in coastal areas |
| | | 3.1 | Saline intrusion into coastal groundwater aquifers |

The ninth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk of **more flooding of coastal areas due to the impact of global sea level rise** should be considered in macro-regional cooperation. There was agreement that the sea already is rising in the southern parts, whereas the northern areas not will see a strong increase the nearest century due to compensation by land uplift. Stakeholders rated the importance of this impact as high. Stakeholder rated the importance of adaptation as high. They also attributed a very high macro-regional coverage to this impact; in eight of nine countries the importance to adapt to the risk of more flooding in coastal areas due to global sea level rise was rated as exceeding 3.5 on average.



The tenth spider diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk of **more coastal (beach) erosion in coastal areas due to the impact of global sea level rise** should be considered in macro-regional cooperation. There was agreement that the sea already is rising in the southern parts, whereas the northern areas not will see a strong increase the nearest century due to compensation by land uplift. Stakeholders rated the importance to adapt to this impact as high, but with a moderate macro-regional coverage. In six of nine countries the severity of more coastal (beach) erosion were rated as exceeding 3.5 on average (and in one country severity was rated exactly 3.5).



3.9 Local, temporal sea level rise due to local wind-induced storm surges

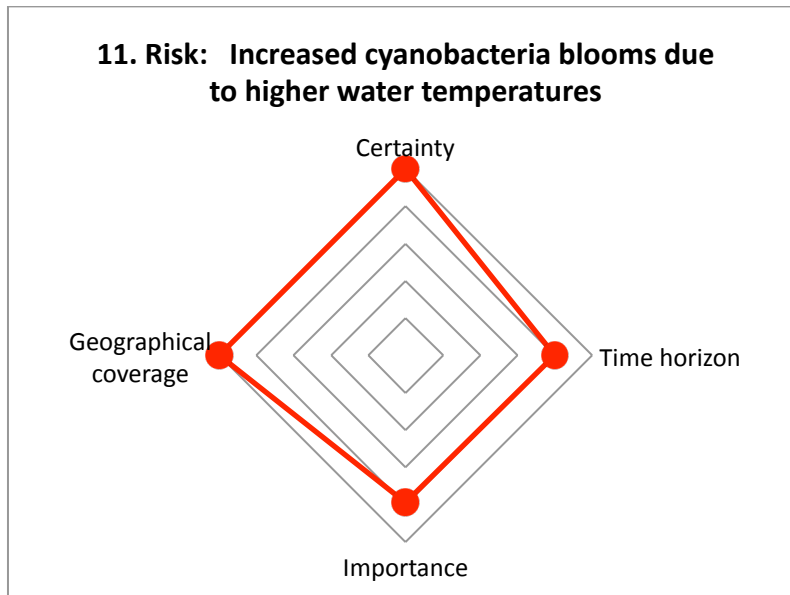
| Certainty: LOW | Time horizon: 50-100 years | Average rating (0-5) | Possible impact: |
|--|--------------------------------------|-----------------------------|---|
| Macro-regional coverage: LOW | | 2.6 | Higher possibility for ships to enter ports without excavating the water-ways |
| | | 2.1 | Damage of buildings, and infrastructure from storm surges |

None of the two possible impacts of local, temporal sea level rise due to local wind-induced storm surges were, on average, exceeding 3.5 and consequently, no spider-diagrams have been included in this report. They are available from the authors upon request.

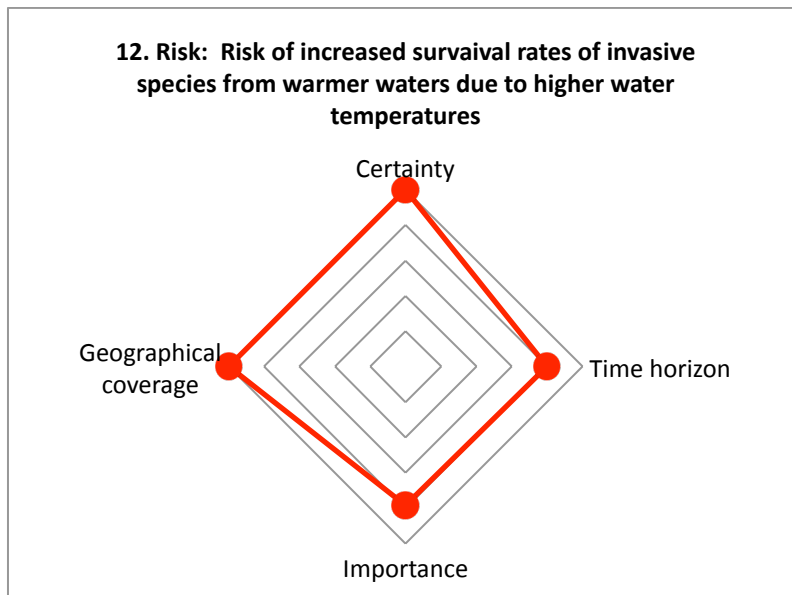
3.10 Warmer water in the Baltic Sea

| Certainty: HIGH | Time horizon: 0-50 years (already detectable) | Average rating (0-5) | Possible impact: |
|---|--|-----------------------------|---|
| Macro-regional coverage: WHOLE REGION | | 4.5 | 11. Increased cyanobacteria blooms |
| | | 3.1 | Ships cannot carry the same load due to decrease of buoyancy |
| | | 4.5 | 12. Risk of higher survival rates of invasive species from warmer seas (transported with e.g. ballast water) |
| | | 3.2 | Risk of more organisms attacking maritime constructions and ships/boats |
| | | 3.6 | 13. More days with suitable temperatures for swimming and water sport |
| | | 3.8 | 14. Higher health risks connected to swimming and water sport (more cyanoblooms, jelly fish, germs and amoebas in the water) |
| | | 3.9 | 15. Fish production and values of catches will change |
| | | 3.2 | Prolonged warm water season impede fishing |
| | | 3.9 | 16. Species such as salmon, trout and whitefish will disappear |
| | | 3.2 | Poor reproduction and low abundance of marine fish |
| 3.2 | Changes in food webs inducing poor growth rates of marine fish | | |

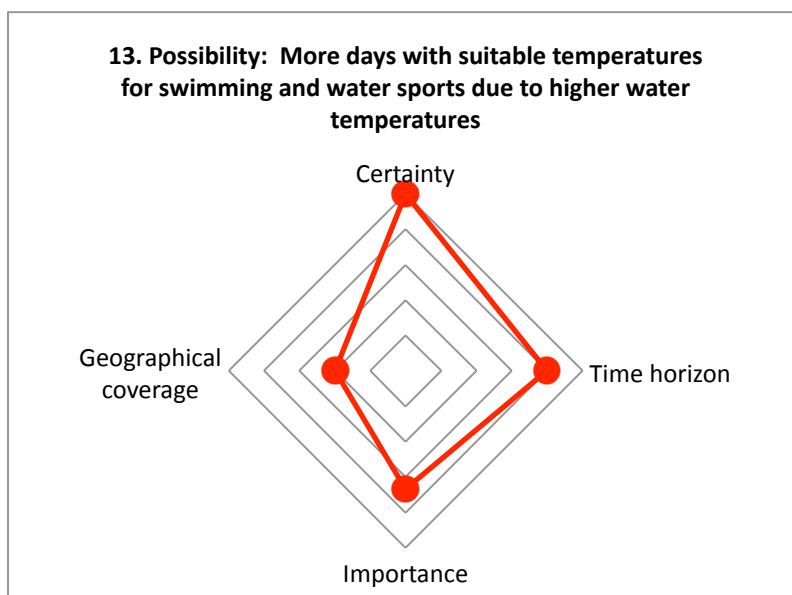
The eleventh spider diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk of **increased cyanobacteria blooms due to higher water temperatures** should be considered in macro-regional cooperation. Climate modellers agree on a very high certainty, and increased water temperatures are already detectable at some locations. Stakeholders rated the importance to act on this risk (e.g. by reduced nutrient loads to the sea). The macro-regional coverage is very high; In seven of nine countries the severity of more cyanobacteria blooms were rated as exceeding 3.5 on average (and in one country severity was rated exactly 3.5).



The twelfth spider diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk that warmer water in the Baltic Sea will increase the survival rates of invasive species migrating from warmer waters should be considered in macro-regional cooperation. Climate modellers agree on a very high certainty, and increased water temperatures are already detectable at some locations. Stakeholders rated the importance to adapt to this impact as high, and its macro-regional coverage as very high; in eight of nine countries the importance was rated as exceeding 3.5 on average.

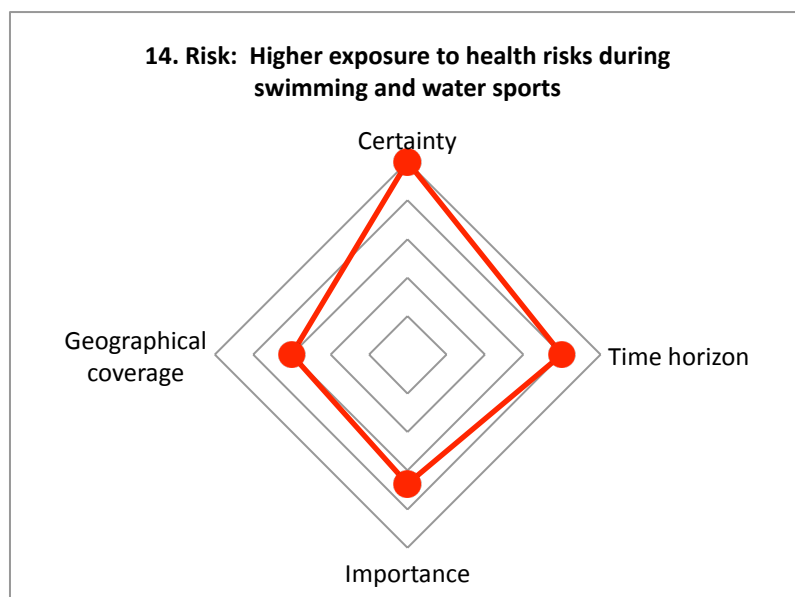


The thirteenth spider diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to take advantage to the potential that warmer water in the Baltic Sea will result in more days with suitable temperatures for swimming and water sports activities should be considered in macro-regional cooperation. Climate modellers agree on a very high certainty, and increased water temperatures are already detectable at some locations. Stakeholders rated the importance to adapt to this impact as well as its macro-regional coverage as moderate. In five of nine states the importance to adapt to this (mainly in the tourism sector) was exceeding 3.5 on average.

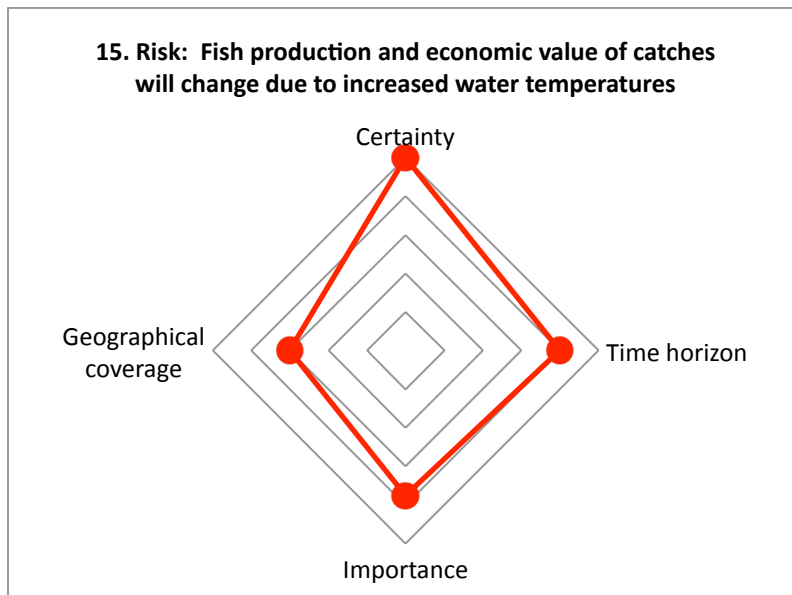


The fourteenth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to take advantage to the risk that warmer water in the Baltic Sea will make more people exposed to health risks during swimming and when doing water sport activities in the Baltic Sea should be considered in macro-regional cooperation These risks could be attributed to more cyanoblooms, jelly fish, germs and amoebas in the water. Climate modellers agree on a very

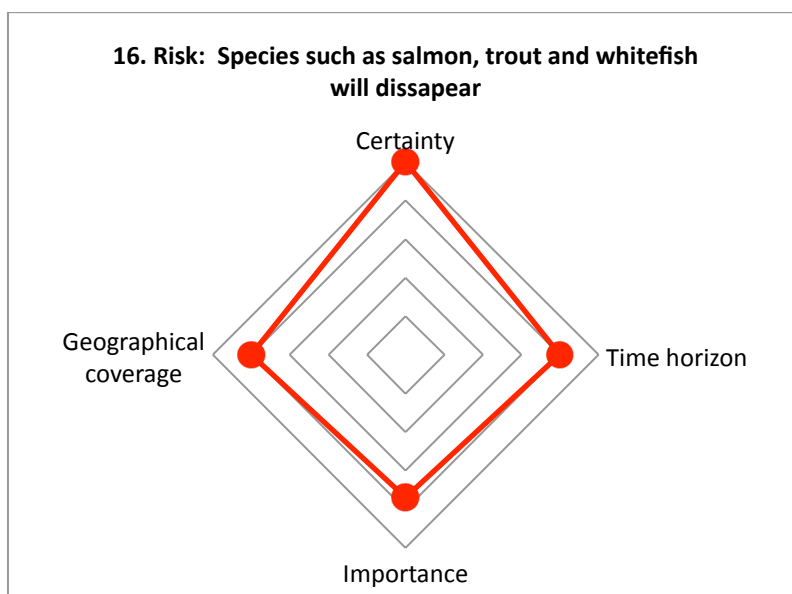
high certainty that water temperatures will increase, with increased water temperatures already detectable at some locations. Stakeholders rated the importance to adapt to this impact as well as its macro-regional coverage as moderate. In five of nine states the importance to adapt to this (mainly in the tourism sector) was exceeding 3.5 on average. Stakeholders rated the importance to adapt to this risk is moderate. Also the macro-regional coverage was moderate; in four of nine countries the severity of increasing exposure to health risks during swimming were rated as exceeding 3.5 on average (and in one country severity was rated exactly 3.5).



The fifteenth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk that warmer water in the Baltic Sea will induce changes in fish production and the economic value of catches should be considered in macro-regional cooperation. Climate modellers agree on a very high certainty that water temperatures will increase, with increased water temperatures already detectable at some locations. Stakeholders rated the importance to adapt to this impact as relatively high that is they believed that this would have a significant effect on fish production and fisheries in the Baltic Sea. However, the estimated macro-regional coverage was moderate; in four of nine states the importance of adapting to possible changes of fish production and values of catches were rated as exceeding 3.5 on average (and in two countries it was rated exactly 3.5).



The sixteenth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk that warmer water in the Baltic Sea will induce changes so that species such as salmon, trout and whitefish will disappear should be considered in macro-regional cooperation. Climate modellers agree on a very high certainty that water temperatures will increase, with increased water temperatures already detectable at some locations. Stakeholders rate the importance to adapt to this impact as relatively high that is they believed that this would have a significant effect on fish production and fisheries in the Baltic Sea. The attributed macro-regional coverage to this impact was high, in six of nine countries the severity of disappearing fish species were rated as exceeding 3.5 on average (and in one countries severity were rated exactly 3.5).



3.11 Lower salinity in the Baltic Sea

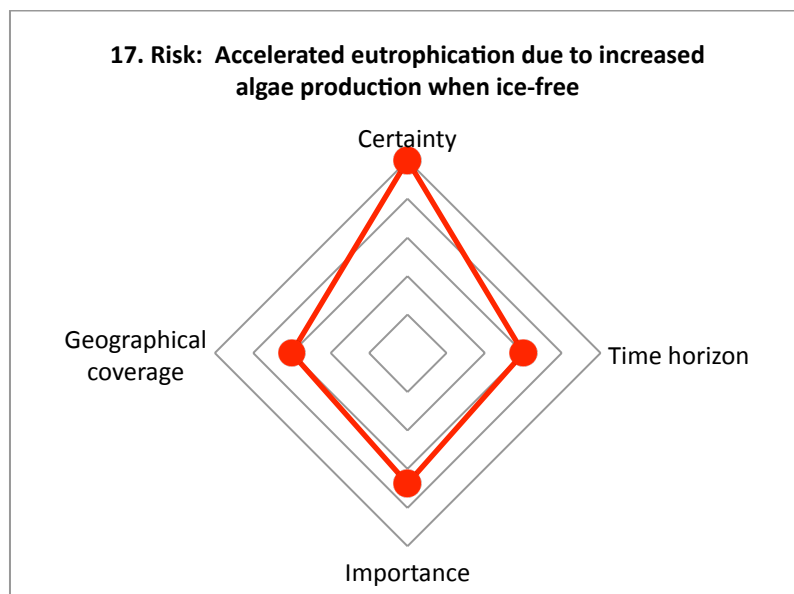
| Certainty: MODERATE | Time horizon: 10-100 years | Average rating (0-5) | Possible impacts: |
|---|---|-----------------------------|--|
| Macro-regional coverage: WHOLE REGION Caused by increased water discharge from the basin, cf 3.6 | | 2.6 | Change of composition of algae belts under the shore from brown/red algae filamentous green algae |
| | | 3.2 | Poor reproduction and low abundance of marine fish |
| | | 3.2 | Changes in food webs inducing poor growth rates of marine fish |
| | | 2.6 | More low-valued fish, e.g., roach, three spined stickleback |
| | | 2.3 | Decreased abundance of species dependent on marine fish and benthic fauna (e.g. guillemot, common eider) |
| | | 2.6 | Decreased distribution of key marine species (such as blue mussels) |

None of the six included possible impacts of decreased salinity were, on average, exceeding 3.5 and spider diagrams have, consequently, not been included in this report. They are available from the authors upon request.

3.12 Reduced ice cover in the Baltic Sea and along coasts and a shorter season with sea ice

| Certainty: HIGH | Time horizon: 10-50 years | Average rating (0-5) | Possible impact: |
|---|-------------------------------------|---|---|
| Macro-regional coverage: In southern areas there will very seldom be any ice in the future while in for instance in the Bothnian Bay it will still exist. | | 2.9 | Facilitation of shipping and less danger of ice pressure |
| | | 2.9 | Risk of loss of shipping due to competition from a potentially ice free Barents sea |
| | | 2.9 | Reductions of sailing distances and shipping time |
| | | 2.9 | Less pressure on harbours, coastal protection and other coastal infrastructure |
| | | 2.6 | Decreased possibility for skating and ice-fishing |
| | | 2.6 | Commercial fishing is facilitated |
| | | 3.3 | Changed population of birds and decrease of the ringed seal, with secondary ecosystem impacts |
| | | 3.4 | Increase of vegetation in shallow water |
| | | 3.0 | Decreased risk for anoxia in coastal areas due to improved mixing of water |
| | 3.6 | 17. Accelerated eutrophication due to increased algae production when ice-free | |

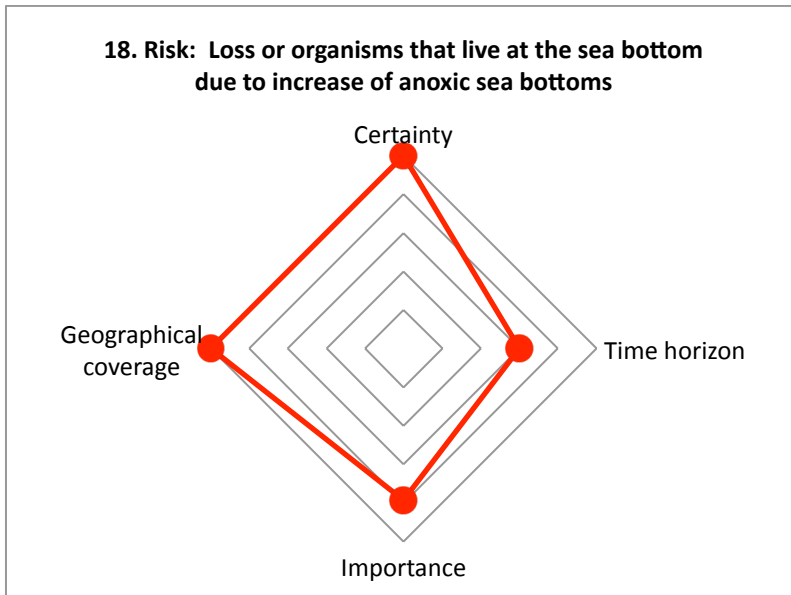
The seventeenth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk that reduced the Baltic Sea ice cover extent and season will accelerate eutrophication due to increased algae production in the ice free season. Climate modellers agree on that ice free conditions will be more common in the near future, with ice occurring very seldom except in the northern parts. Stakeholders rank the need to adapt to this impact as moderately high, with moderate macro-regional coverage. In four of nine countries the importance was rated as exceeding 3.5 on average (and in two countries severity were rated exactly 3.5).



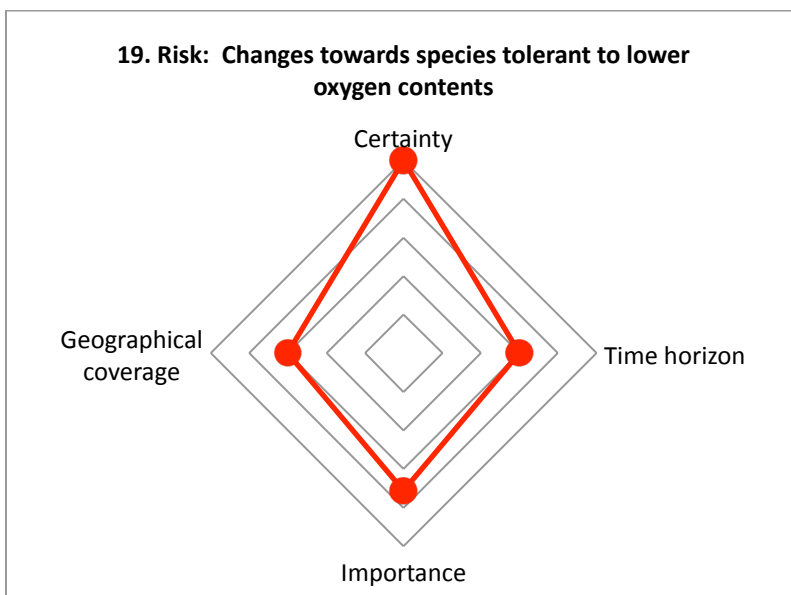
3.13 Lower oxygen concentrations in surface water and increase of anoxic bottom areas

| Certainty: | Speed: | Average rating | Possible impact: |
|---|---|-----------------------|---|
| HIGH | 10-50 years | (0-5) | |
| Macro-regional coverage: WHOLE REGION | Change related to higher air and water temperatures causing lower solubility in the inflowing water and an increased decomposition/oxidation rate of organic matter | 4.2 | 18. Loss of communities of organism that live at the sea bottom |
| | | 3.6 | 19. Changes towards species that are more tolerant to low oxygen concentrations |
| | | 4.2 | 20. Decline of cod which also leads to thin and small herring and sprat |
| | | 3.1 | Low value of fish catches |
| | | 3.4 | Larger variations in catches from marine fish stocks due to increased variations in reproduction. |
| | | 4.0 | 21. Accelerated eutrophication, increased cyano blooms, harmful algae and loss of biodiversity due to release of nutrients from anoxic sediments |
| | | 4.3 | 22. Loss of original marine flora and fauna |
| | | 3.3 | Deterioration of marine habitats and recreational activities due to turbid water |

The eighteenth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk those lower oxygen concentrations in surface water and increase of anoxic bottom areas will induce a loss of habitat for benthic organisms in the Baltic Sea. Climate and environmental modellers agree on that increase of anoxic bottoms due to warming will be initiated in the near future and proceed during the coming decades. Stakeholders rank the importance to adapt to this impact as high, with a relatively high macro-regional coverage. In seven of nine countries the severity of loss of habitat for benthic organisms were rated as exceeding 3.5 on average (and in one country severity was rated exactly 3.5).

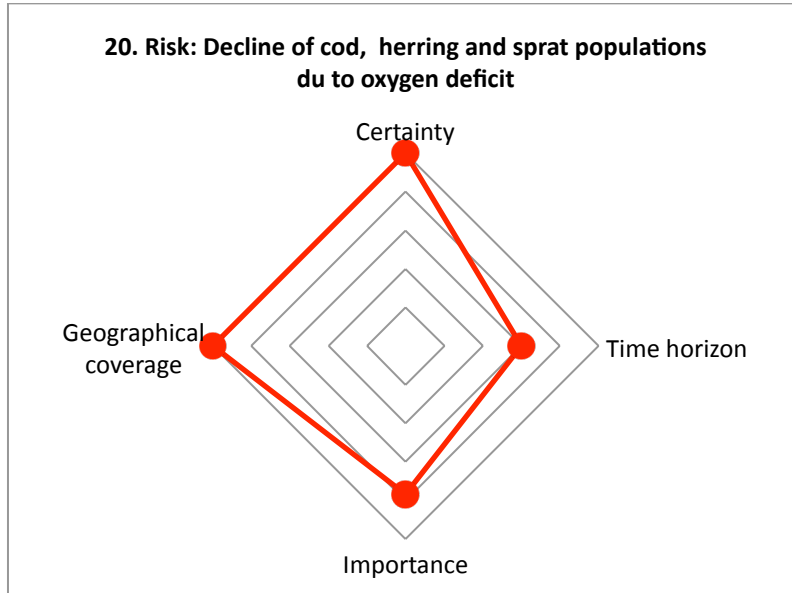


The nineteenth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk that lower oxygen concentrations in surface water and increase of anoxic bottom areas will induce a shift in the Baltic Sea towards species that are tolerant to lower oxygen concentration. Climate and environmental modellers agree on that the impact on oxygen concentrations and anoxic bottoms due to warming will be initiated in the near future and proceed in the coming decades. Stakeholders rated the importance to adapt as moderate. Also the macro-regional coverage was estimated as moderate. In five of nine countries the impact from changes towards species that are tolerant to lower oxygen concentrations were rated as exceeding 3.5 on average (and in two countries severity were rated exactly 3.5).

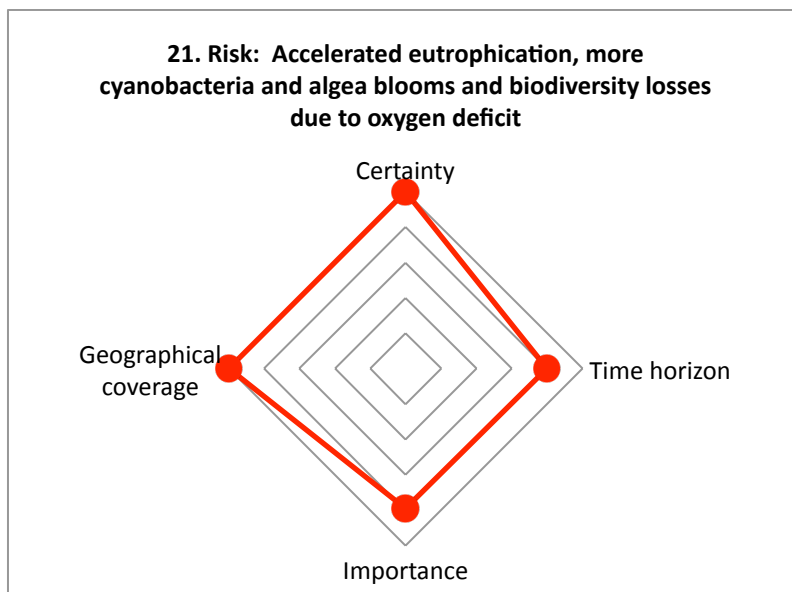


The twentieth spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk that lower oxygen concentrations in surface water and increase of anoxic bottom areas will cause a decline of cod, which also would lead to a decline of

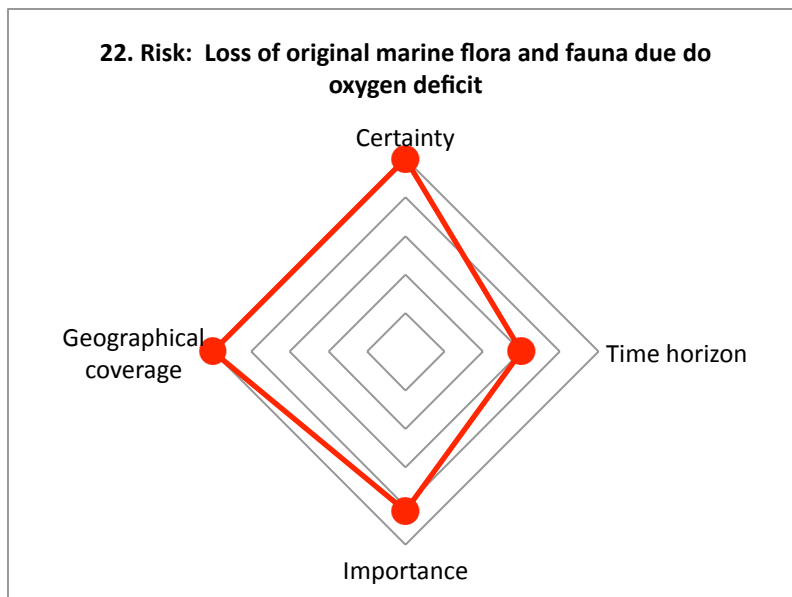
herring and sprat populations in the Baltic Sea. Climate and environmental modellers agree on that the impact on oxygen concentrations and anoxic bottoms due to warming will be initiated in the near future and proceed in the coming decades. Stakeholders estimate a high importance to adapt to this impact. In eight of nine countries the importance of the impact of declining cod, herring and sprat populations were rated as exceeding 3.5 on average.



The twenty-first spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk that lower oxygen concentrations in surface water will accelerate eutrophication and induce more algae and cyanobacteria blooms and biodiversity losses in the Baltic Sea. Climate and environmental modellers agree on that the impact on oxygen concentrations and anoxic bottoms due to warming will be initiated in the near future and proceed in the coming decades. Stakeholders rank this impact as of high importance, and with a high macro-regional coverage. In six of nine countries the severity of accelerated eutrophication were rated as exceeding 3.5 on average (and in two countries severity were rated exactly 3.5).



The twenty-second spider-diagram shows the climate expert and stakeholder judgments of the four factors determining the need to adapt to the risk that lower oxygen concentration in surface water will cause loss of original flora and fauna in the Baltic Sea. Climate and environmental modellers agree on that the impact on oxygen concentrations and anoxic bottoms due to warming will be initiated in the near future and proceed in the coming decades. Stakeholders rank the impact as of high importance, with a very high macro-regional coverage. In seven of nine countries the severity of loss of original flora and fauna were rated as exceeding 3.5 on average (and in one country severity was rated exactly 3.5).



4 Conclusions

Built on the pilot test of the tool for prioritization of the most relevant issues for macro-regional cooperation, based on climate and environmental modellers judgements of certainty and time horizons (reported in Baltadapt Climate Info Bulletins <http://climate-info.baltadapt.eu>) and 3-8 stakeholders from each BSR coastal state the following conclusions were made with regard to possible prioritizations of issues for macro-regional cooperation related to climate adaptation.

In this section, the impacts with the highest ranking for agriculture, eutrophication/biodiversity, tourism and infrastructure are presented.

The identified impacts with high rankings have in common that they are both related to changes of climate variables that already are happening or that, with a high degree of certainty, are predicted to happen in the near future. They also have in common that a significant negative impact for humans and the environment is expected if adaptation does not take place, with a high macro-regional coverage.

The highest rankings were obtained for impacts related to eutrophication/biodiversity and impacts related to agriculture. Since one of the only possible measures to reduce the impacts of climate change on eutrophication (and indirectly on biodiversity) is reduction of nutrient loads from agriculture, a focus on agriculture in macro-regional cooperation could thus be recommended based on the achieved rankings. To make such cooperation attractive for the agricultural sector it is important that environmental concerns are handled together with concerns for adaptation to ensure the prosperity of the agricultural sector.

Below, impacts with a ranking of 3.5 or more are shown for eutrophication/biodiversity and agriculture. Although raised as a concern within the agricultural sector, the increased risk for flooding only received a rating of 3.3 (that is below 3.5). This was due to the fact that the certainty of more extreme precipitation is moderate, with no significant change detected yet (a predicted time span of 10-100 years until a possible change can be expected). Note that for agriculture, both adaptation needs to take advantage to possibilities and too manage risks were identified.

| EUTROPHICATION AND BIODIVERSITY | | | | |
|---|---------------------------|---|---|---|
| Impact | Changing climate variable | Certainty of change of climate variable | Time horizon for change of climate variable | Rating (average of certainty, time horizon, importance and macro-regional coverage) |
| <i>Increased cyanobacteria blooms</i> | Warmer water | High (whole region) | 0-50 years (already detectable) | 4.5 |
| <i>Higher survival rates of invasive species</i> | Warmer water | High (whole region) | 0-50 years (already detectable) | 4.5 |
| <i>Loss of original marine flora and fauna</i> | Oxygen deficits | High (whole region) | 10-50 years | 4.3 |
| <i>Increased phosphorous loads in southern parts, possible decrease in northern parts (less ground frost)</i> | Higher air temperatures | High (whole region) | 0-20 years (already detectable) | 4.2 |
| <i>Increased phosphorous loads in southern parts, possible decrease in northern parts (less ground frost)</i> | Higher air temperatures | High (whole region) | 0-20 years (already detectable) | 4.2 |
| <i>Loss of communities of organism that live at the sea bottom</i> | Oxygen deficits | High (whole region) | 10-50 years | 4.2 |
| <i>Accelerated eutrophication, increased cyanobacteria blooms, harmful algae and loss of biodiversity</i> | Oxygen deficits | High (whole region) | 10-50 years | 4.0 |
| <i>Accelerated eutrophication due to increased algae production when ice-free</i> | Reduced ice cover | High (still occurrence of ice in northern parts, never ice in southern parts) | 10-50 years | 3.6 |
| <i>Changes towards species that are more tolerant to low oxygen concentrations</i> | Oxygen deficits | High (whole region) | 10-50 years | 3.6 |

| AGRICULTURE | | | | |
|--|---------------------------|---|---|---|
| Impact | Changing climate variable | Certainty of change of climate variable | Time horizon for change of climate variable | Rating (average of certainty, time horizon, importance and macro regional coverage) |
| <i>New pests affecting livestock and plants</i> | Higher air temperatures | High (whole region) | 0-20 years (already detectable) | 4.8 |
| <i>Longer vegetation periods for agricultural production</i> | Higher air temperatures | High (whole region) | 0-20 years (already detectable) | 4.2 |
| <i>Possibilities to introduce new agricultural crops</i> | Higher air temperatures | High (whole region) | 0-20 years (already detectable) | 4.1 |
| <i>Changed growth and geographical distribution of weeds</i> | Higher air temperatures | High (whole region) | 0-20 years (already detectable) | 4.1 |
| <i>Potential for higher crop yield</i> | Higher air temperatures | High (whole region) | 0-20 years (already detectable) | 3.9 |

Although a bit more limited than for the agricultural sector, also for the fishery sector, a number of factors with rankings above 3.5 were identified, which might be used as an indicator of relevant issues for macro-regional cooperation.

| FISHERY | | | | |
|--|---------------------------|---|---|---|
| Impact | Changing climate variable | Certainty of change of climate variable | Time horizon for change of climate variable | Rating (average of certainty, time horizon, importance and macro-regional coverage) |
| <i>Decline of cod which also leads to thin and small herring and sprat</i> | Oxygen deficits | High (whole region) | 10-50 years | 4.2 |
| <i>Fish production and values of catches will change</i> | Warmer water | High (whole region) | 0-50 years (already detectable) | 3.9 |
| <i>Species such as salmon, trout and whitefish will disappear</i> | Warmer water | High (whole region) | 0-50 years (already detectable) | 3.9 |

The number of identified impacts with a high macro-regional cooperation ranking (above 3.5) was a bit more limited for tourism, but still there a number of important adaptation to take advantages of possibilities and manage risks were identified. Note that most impacts are opportunities. However, it needs to be noted that the tourism sector might suffer from negative impacts related to eutrophication and reduced biodiversity, as well as from infrastructure impacts caused by the expected flooding and beach erosion due to rising sea levels.

| TOURISM | | | | |
|--|---------------------------|---|---|---|
| Impact | Changing climate variable | Certainty of change of climate variable | Time horizon for change of climate variable | Rating (average of certainty, time horizon, importance and macro-regional coverage) |
| <i>Higher health risks connected to swimming and water sport (cyanoblooms, jelly fish, germs and amoebas in the water)</i> | Warmer water | High (whole region) | 0-50 years (already detectable) | 3.8 |
| <i>Increased attractiveness of marine tourism destinations</i> | Higher air temperatures | High (whole region) | 0-20 years (already detectable) | 3.7 |
| <i>More days with suitable temperatures for swimming and water sport</i> | Warmer water | High (whole region) | 0-50 years (already detectable) | 3.6 |
| <i>Prolongation of coastal tourism</i> | Higher air temperatures | High (whole region) | 0-20 years (already detectable) | 3.5 |

Impacts with a ranking above 3.5 relate to infrastructure where related to rising sea levels; where adaptation to avoid flooding beach erosion of coastal areas where identified as critical to address in the near future in the southern parts of the BSR.

| INFRASTRUCTURE | | | | |
|---------------------------------------|---------------------------|---|---|---|
| Impact | Changing climate variable | Certainty of change of climate variable | Time horizon for change of climate variable | Rating (average of certainty, time horizon, importance and macro-regional coverage) |
| <i>More flooding of coastal areas</i> | Rising sea levels | High (whole region) | 0-100 years (already detectable in southern parts, delay in northern parts due to compensating land lift. | 3.8 |
| <i>More coastal (beach) erosion</i> | Rising sea levels | High (whole region) | 0-100 years (already detectable in southern parts, delay in northern parts due to compensating land lift. | 3.5 |

In summary, the tool was shown to be able to be used to illustrate the prioritization of issues to be dealt with in a macro-regional cooperation. In this specific application, all factors (certainty, time horizon, importance, macro-regional coverage) were given equal weighing, indicating that impacts that are caused already observable change of climate variables, or by change that with a high degree of

certainty are expected to be observed in the near future are prioritized, if they also are perceived as having significant consequences for humans or for the environment and if they are expected to happen in several BSR countries. In other applications, the weighting of the four factors can be made different, if requested by decision makers and other stakeholders that use the tool.

In this application of the tool, impacts related to biodiversity/eutrophication of the Baltic Sea, as well and impacts related to agriculture were given the highest rankings, which demonstrate the importance to include this as one of the main focuses of macro-regional cooperation on climate adaptation in the BSR. These impacts are both due to factors that are linked to climate change that will occur or already has occurred with a high degree of certainty (linked to air and water temperatures and rising sea levels), as well as well as having a very large macro-regional spatial coverage, and being perceived as of high importance.

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