DANISH ENERGY AGENCY

Socio-economic Screening of Climate Change Adaptation

SUMMARY

JUNE 2010

Note:

This is an English version of the summary in the report ‘Samfundsøkonomisk screening af klimatilpasning, juni 2010’. The report is made by the consultancy firm NIRAS for the Danish Energy Agency.

1. SUMMARY AND CONCLUSION

1.1 Overall conclusion

It is highly likely that we will experience changes to our climate in the future, however the magnitude of these changes is uncertain. The changes are expected to entail both costs and benefits for Danish society, yet the overall consequences depend on how we adapt to the changes.

This socio-economic screening deals with the 14 sectors[1]that are described in the government's climate change adaptation strategy, *Danish strategy for adaptation to a changing climate* (the Danish government, 2008).

The screening indicates that coastal protection, buildings, roads/railways and sewerage are especially relevant candidates for more in-depth analyses. Potential damage costs are high in these sectors, and the example calculations indicate that these sectors have the greatest potential for limiting damage costs in a cost-effective manner through adaptation measures. The sectors mentioned are characterised by long-term investments, and this calls for early incorporation of climate change adaption. Within the sector of coastal protection however, it is possible to implement adaptation measures at shorter notice. In addition the most significant consequences in this sector are not expected to occur until after 2050.

It is important that climate change adaptation takes into account the correlations between sectors, so that any synergies between different climate change adaptation measures may be exploited. Spatial planning is very important in ensuring these correlations, and therefore this sector should also be highlighted as central.

An important conclusion of the screening is, that for almost all of the sectors it is assessed that climate change adaptation can take place within the existing regulatory framework.

[1] The government's climate change adaptation strategy mentions only 11 sectors, however this is because buildings, roads/railways and sewers are dealt with as a single sector (buildings and infrastructure), as are agriculture and forestry.

Further analyses are required to identify the specific demands for climate adaptation. The demand for knowledge is assessed to be particularly great for the building sector, because in this sector assets are very large, while the existing knowledge about the socio-economic cost-effectiveness of climate adaptation is rather limited.

Furthermore, the screening shows that there is a general demand for socio-economic analyses at a more concrete level within geographically delimited areas (e.g. at municipal level), because the diversity within and across the different sectors makes it difficult to reach conclusions based on analyses carried out at a very general level. To ensure the best possible adaptation from a socio-economic perspective, a cross-sectoral approach will have to be used, so as far as possible, all relevant sectors and cross-cutting effects are incorporated simultaneously.

Future analyses should ensure optimal overall adaptation including assessing several possible alternative adaptation measures. From a socio-economic perspective, it is not important whether adaptation takes place on an ad hoc basis (autonomously), or requires special initiatives, i.e. as planned adaptation.

It is assessed that there is a need to develop tools to manage the uncertainties linked to adaptation-related decisions. These tools should be application-oriented, so that they can contribute to improving the decision basis for concrete decisions on climate change adaptation measures, both at national and municipal levels.

1.2 Introduction

There is clear scientific evidence that the climate is changing due to greenhouse gas emissions. We cannot escape these changes, but we can limit them, if we reduce our greenhouse gas emissions significantly.

An altered climate will cause both socio-economic benefits and costs for Denmark. Therefore, we need , in several areas, to assess whether and how Denmark can adapt to an altered climate in order to limit damage and enhance benefits.

This screening looks at climate adaptation across the 14 sectors dealt with in the government’s climate change adaptation strategy from 2008. The objective of the screening is to give an overall picture of the magnitude of the climate change impacts and the associated damage costs or benefits, and possible adaption measures at play in the sectors. The screening also relates to whether adaptation can take place within the existing regulatory framework.

Since this is a screening which covers many and very different sectors, each of which would require extensive efforts to cover in depth, the review and analyses of the individual sectors have been kept at a general level. Furthermore, we are dealing with very long time frames, and there is a considerable uncertainty linked with how the climate will change. We cannot say with certainty what will happen to the climate, and with society for that matter, up to 2100. This also explains why this screening focuses on estimates of sizes rather than precise figures.

In several of the sectors dealt with, existing production and production methods are putting the environment under pressure, for example in the form of nitrogen and pesticides, which are having a negative impact on groundwater and surface water. These environmental impacts are already a reality and could be exacerbated by climate change. This makes it particularly difficult to isolate the effect of climate change.

1.3 Climate change

It is a well-documented fact that we will be experiencing changes in the climate in the decades to come, however the magnitude of these changes is linked to great uncertainty. Attempts are being made to describe these uncertainties by setting up different global climate scenarios. These global scenarios can be scaled down to Danish conditions. In practice it is difficult to distinguish between the different scenarios up to ca. 2050. It is not until after 2050 it will be possible to see the results of future global efforts to mitigate further climate change.

Most of the analyses of the significance of climate change for the various sectors are based on the A2 scenario, which is a medium-high climate scenario, estimating a temperature increase of about 3 degrees by 2100. This screening therefore takes its point of departure in this scenario. There will be a considerable increase in precipitation volumes, especially in winter, and there will be more extreme rain events. The size of the rise in water levels is uncertain, but recent research indicates that levels may rise by up to 1 meter. There will also be more frequent and more powerful storms.

1.4 Method

The Danish climate change adaptation strategy focuses on the importance of timely adaptation to climate change. The strategy emphasises that climate change adaptation as far as possible should take place continuously (autonomously), in that authorities, enterprises and the citizens should react to climate change impacts on their own initiative, in time, and within the existing legislative, financial and technological framework. To the extent that autonomous adaptation does not suffice, politically adopted adaptation measures

will have to be applied, i.e. planned adaptation. The strategy therefore operates with two types of adaptation: autonomous (continuous) adaptation and centrally planned new political decisions. This distinction however raises some methodological issues when carrying out socio-economic analyses.

The objective of the current screening is to identify possible adaptation measures to address the consequences of climate change. When assessing whether an adaptation measure is appropriate from a socio-economic perspective, the costs and the benefits of the measure are assessed against a baseline scenario where the measure has not been implemented. The baseline scenario should therefore describe what society would look like without the relevant adaptation measure. This also means that continuous (autonomous) adaptation in the individual sectors must be included as part of the baseline scenario. However, the Danish government's climate change adaptation strategy does not provide a clear definition of what falls under the concept of 'autonomous adaptation'.

The review of a number of foreign studies reveals that 'autonomous adaptation' is often defined as the adaptation that takes place on market terms (for example conversions to different agricultural crops), or in the form of natural processes (for example altered biodiversity in nature). However, larger public-sector investments in, for example, coastal protection and infrastructure, are defined as planned adaptation.

The Danish climate change adaptation strategy applies a broader interpretation of 'autonomous adaptation' - an interpretation which includes measures that are carried out on a continuous basis by the public sector as a part of the general planning efforts taking place within the sector. For example, continuous changes to road standards and building regulations or increased maintenance due to climate change, due to the fact that these initiatives often are part of the general planning activities within the sector in question.

It may also be relevant to assess whether this adaptation is appropriate from a socio-economic perspective, even though it is considered to belong to the category of autonomous adaptation. The screening therefore concentrates more on whether or not the measure is appropriate, rather than on whether it can be defined as autonomous or planned adaptation. The main point being that from a socio-economic perspective, the distinction between autonomous and centrally planned adaptation is not relevant.

In terms of methods used, the discount rate is likewise a key parameter in a socio-economic analysis which assesses long-term consequences, especially if there is a large time span between costs for adaptation and benefits in the form

of avoided damage costs. Generally speaking, the higher the discount rate, the less the future effects will weigh. This screening is based on the recommendations of the Ministry of Finance,[2] supplemented with calculations in which the results are shown without having been discounted, in order to show the sensitivity to the discount rate.

1.5 Grouping of sectors

To create an overview of the 14 very different sectors dealt with in the screening, the sectors have been divided into four groups. Each of the groups has a number of common characteristics outlined below.

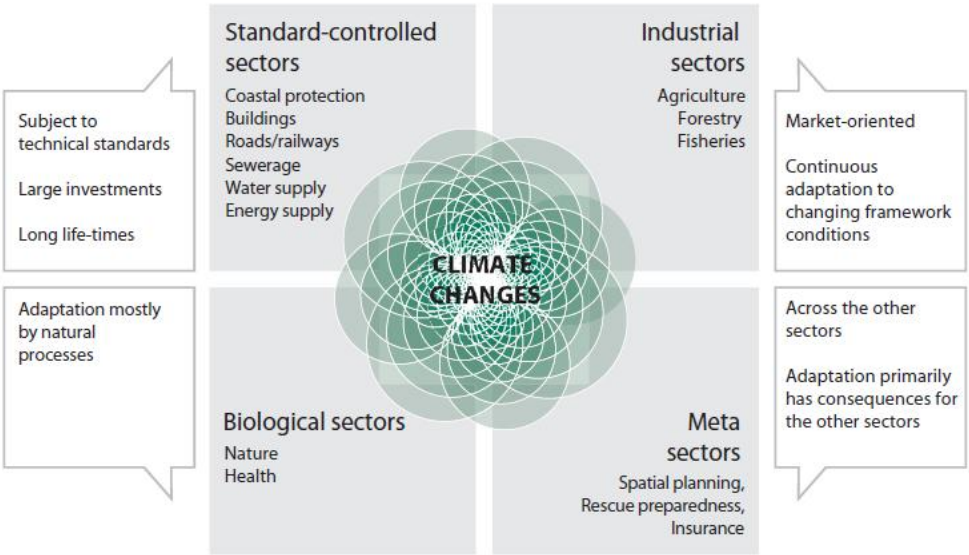

Figure 1: Adaptation in the different sector groups (source: NIRAS)

1.5.1 *Standards-controlled sectors*

The standards-controlled sectors include coastal protection, buildings, roads/railways, sewerage, water supply and energy supply. The standards-controlled sectors are characterised by large capital investments. These are investments with long life spans, that means that climate change adaptation must be incorporated at an early stage (enhanced coastal protection, however, can be realised relatively fast). The standards-controlled sectors are moreover sectors in

[2] The most recent recommendations from the Ministry of Finance say 5 percent. These recommendations are used e.g. in the work on a climate strategy for non-ETS sectors. However,

which the potential damage costs will be very high, if adequate adaptation is not carried out. In these sectors, climate change almost only gives rise to costs and no benefits, and it is in particular damage from extreme events which occasion very high costs.

Adaptation involves the adaption of new construction projects, and maintaining existing buildings and installations, to the new climatic conditions. In the standards-controlled sectors, new construction projects and larger renovations are as a main rule subject to technical requirements that are (already) gradually being adapted to climate change, for example road standards or building regulations requirements.

Among the standards-controlled sectors, costal protection, buildings, roads/railways and sewerage stand out in particular. Within these sectors, the potential damage costs are particularly high, but at the same time these sectors also hold the greatest opportunities for limiting damage costs cost-effectively through adaptation measures.

With regard to water supply, climate change will primarily exacerbate the general pressure on water resources, and this must be taken into account. The energy supply sector is currently under great change, which makes it easier to adapt this sector on a continuous basis.

Table 1 shows the most important climate impacts and measures for these sectors in summary form.

the Ministry of Finance has not yet published a revised socio-economic guidance with the newest recommendations.

Table 1: Standards-controlled sectors

Sector	Coastal protection	Buildings	Roads/railways	Sewers	Water supply	Energy supply
Estimated value of installations and facilities today	Ca. DKK 12 billion (Danish coastline, excluding the west coast)	DKK 6,000 billion	Roads: DKK 500-600 billion Railways: DKK 100-200 billion	DKK 100 billion	-	DKK 300-600 billion
Important effects of climate change (without adaptation)	Receding coastline Erosion and flooding of coastal protection installations and harbours	Increased pressure from wind and snow Higher groundwater level - rising damp in homes	Insufficient drainage Flooding of low-lying roads Reduced carrying capacity of bridges, dams etc.	Increased drainage requirements and subsequent risk of flooding	Contamination of wells Flooding of installations Increased water shortages in eastern Denmark	Flooding and storm damage to installations Increased demand for cooling
Sectors impacted	Primarily buildings, but also agriculture, roads/railways, water supply, energy supply and nature	Buildings	Roads/railways	Buildings	Water supply	Energy supply
Adaptation	Increase the height of dikes and reinforce constructions **Establish new dikes** **More beach nourishment activity**	Adapt building regulations **Preventive measures against snow, storm and moisture damage**	**Renovate, enhance capacity and establish drainage systems** Reinforce existing constructions Early warning Adapt road and railway standards	**Enlarge sewer systems and other capacity-enhancing measures, including local drainage solutions**	Relocate wells Relocate or secure installations **Expand protection zones**	Climate and coastal protection of installations Guidelines for cooling
General assessments of damage costs and their relation to adaptation costs	Damage costs are potentially high, but may be minimised through adaptation Preliminary analyses indicate that adaptation costs are low relative to the potential damage costs.	Damage costs are potentially high The extent to which costs can be minimised through adaptation is uncertain (especially for existing buildings) Example calculations indicate that adaptation costs are likewise potentially high (especially for existing buildings), but the proportional relationship to damage costs is uncertain.	Damage costs are potentially high, but may be reduced through adaptation.	Damage costs are potentially high, but may be reduced through adaptation. Adaptation costs are high, but are assessed to be lower than the potential damage costs Example calculations indicate that alternative adaptation measures may be attractive	Damage costs are potentially high but difficult to distinguish from the general pressure on water resources The magnitude of adaptation costs relative to damage costs depends very much on how groundwater resources are valuated	Damage costs are potentially high, but can probably be reduced through adaptation due to conversion of the energy sector (depends on the speed at which the energy system is converted)
Life span and flexibility of investments	Long-term Easy and cheap to change adaptation continuously	Long-term Expensive and difficult to change adaptation continuously	Long-term Whether or not it is easy to change adaptation continuously depends on the relevant adaptation measures	Long-term Expensive and difficult to change adaptation continuously	Long-term Closely related to general regulation	Medium-term Adapted along with the conversion of the energy system
Implementation of measures	In particular after 2050, however there will already be an increased risk in the short term	For new installations, adaptation will already be relevant to implement in the short term Preventive measures could be relevant in the short term	Drainage, cleaning and reinforcement will be relevant in the short term	Relevant within the short term, especially in connection with continuous renovation	Protection against increased contamination will be relevant in the short term, also due to general pressure on water resources	Coastal protection especially after 2050 Guidelines for cooling will be relevant within the short term
Knowledge demand	Demand for further knowledge about concrete water level increases and their consequences	Demand for knowledge about costs of adapting building regulations to climate change, and knowledge about the socio-economic advantages of adaptation.	It is assessed there is need for more knowledge about drainage and reinforcements costs	An assessment is needed of whether a climate factor of 1.3 is socio-economically optimal Concrete assessments of alternative solutions are needed	Demand for more knowledge about concrete needs for further safeguarding water catchment due to changes in agricultural production	Demand for knowledge about the cost-effectiveness of establishing cooling systems in existing buildings

The measures for which the screening has performed example calculations are marked as bold in the table

Implementation of measures
For the standards-controlled sectors in general, it is assessed that climate change adaptation to a great extent can take place within the current regulatory framework. By this is meant that regulations have already been introduced and are being continuously amended to promote adaptation. Below are a number of proposals which can promote the implementation of measures.

- With regard to future demands for coastal protection, greater coordination is required between the individual landowners, the municipality and the government.
- With regard to ensuring incentives to launch preventive measures in the building sector, increased differentiation of insurance policies could be a relevant instrument.
- For the sewerage sector, there may be a need to secure incentives to increase local drainage or other alternatives to enlarging existing sewer systems

1.5.2 *Industrial sectors*
The industrial sectors, agriculture, forestry and fisheries could experience both benefits (this presumably applies to agriculture) and costs as a consequence of climate change. Increased temperatures will generally provide better cultivation and growth conditions and thus greater profits; whereas extreme weather events such as storms may occasion costs, e.g. forest storm damage. Altogether, however, damage costs are assessed to be limited compared with costs in other sectors.

Stakeholders in the industrial sectors are expected to adapt to altered climatic conditions on a continuous basis according to their own financial interests, just as they otherwise adapt to altered framework conditions. In this sector, adaptation measures will consist mainly in ensuring adequate information, so that the players have the best possible knowledge about adaptation opportunities. However, altered climatic conditions could also mean that negative side effects are increased, such as run-off of nutrients and risk of windfalls, and measures may be required to mitigate these.

Implementation of measures
It is assessed that the implementation of measures can take place within the current regulatory framework.

Table 2 shows a summary of climate change impacts and adaptation in the industrial sectors.

Table 2: Market-controlled sectors (The measures for which the screening has performed example calculations are marked as bold in the table).

Sector	Agriculture	Forestry	Fisheries
Production value per year	DKK 70 billion	DKK 1.6 billion	DKK 10 billion
Important effects of climate change	Higher yields Changed cultivation conditions and subsequent changes in choice of crops More diseases and pests and increased run-off of nutrients More water-deficient farm fields	Poorer conditions for Norway spruce More windfalls Forest fires	Greater biomass Changes in species composition - possible loss of species Increased ecosystem fluctuations
Damage costs/benefits	Potential benefit in the form of an increase of 16-38% in the value of yields Increased costs of externalities	Presumably less negative value	Neutral to little negative value
Adaptation	**Reduction in nitrogen run-off/leaching** Abandonment of low-lying farm land (including river valleys) Adaptation of pesticides use	Conversion to deciduous forest/close-to-nature forest management	**Release of Baltic Sea cod**
Knowledge demand	There is a need for increased knowledge about the significance of climate change for agricultural production and the derived effects on pesticides use and nitrogen run-off/leaching		Demand for increased knowledge about the significance of the climate on populations/stocks
Timing	Continuous (in step with climate change taking effect)	Long time horizon, and therefore adaptation in the short term	Continuous (as the need arises)

The measures for which the screening has performed example calculations are marked as bold in the table

1.5.3 *Biological sectors*

The biological sectors, nature and health, may experience both benefits and costs as a consequence of climate change. Some of these consequences are non-tradable (non-market values), and the magnitude is therefore difficult to assess compared with the other sectors.

In the biological sectors, both humans and nature will respond and adapt to the changed climate. For example, some plant and animal species will no longer be capable of living in Danish nature, while new species will arrive. Adaptation measures will therefore involve ensuring that ongoing adaptation can take place, e.g. by establishing wildlife corridors. However, adaptation measures can also involve mitigating undesired climate change impacts, e.g. measures against invasive species, or increased demand for preventive medicine, including vaccines against allergies. This adaptation can take place gradually and can therefore be launched when deemed necessary.

Consequently, there is no need for comprehensive efforts here and now. Furthermore, with regard to nature, there is only little that can be done to counteract the effects of climate change. This partially also applies to health, although the potential damage costs, e.g. from more cases of allergies, may be high.

Implementation of measures

It is assessed that the implementation of measures can take place within the current regulatory framework. Costs of establishing wildlife corridors can be reduced if long-term spatial planning is applied which ensures coordination with other measures.

Table 3 shows climate change impacts and measures in summary form.

Table 3: Biological sectors (The measures for which the screening has performed example calculations are marked as bold in the table))

Sector	Nature	Health
Important climate change impacts	Greater biomass Altered species composition - risk of invasive species Changes to and potential loss of habitat types	More incidents of allergies (pollen, mould, house dust mite) More heat-related and fewer cold-related deaths
Damage costs/benefits	Uncertain - nontradable (non-market) effects	Potentially large damage costs
Adaptation	**Establishment of wildlife corridors** Regulations against invasive species	Preventive medicine against allergies, including vaccinations Information campaigns Regulation of undesired plant species
Knowledge demand	There is generally great uncertainty as to impacts on nature	A general demand for increased knowledge about the significance of climate on health
Timing	Continuously according to need	Continuously according to need
The measures for which the screening has performed example calculations are marked as bold in the table		

1.5.4 *Meta-sectors*

The meta-sectors, spatial planning (land use management), rescue preparedness and insurance, are cross-sectoral and could be included as measures to mitigate climate change impacts and associated costs in the other sectors. This could both be to prevent climate change impacts (spatial planning, insurance) and to mitigate impacts (rescue preparedness). No example calculations have been performed for the meta-sectors, since costs and benefits of measures within these sectors fall within the other sectors.

Spatial planning is a very important sector in efforts to adapt to climate change, because, if well planned solutions are implemented, the potential is quite considerable in the form of damage costs avoided in other sectors. However, for the sector itself, the economic consequences are minor in the greater context.

With regard to rescue preparedness, the more and the better climate change adaptation that takes place in other sectors, the less will be the need for extra

rescue response efforts. The potential costs of enhancing rescue preparedness are assessed to be relatively limited compared with the possible damage that can be avoided.

Insurance is generally an important indicator of the price of risk. This also applies to costs linked to extreme weather events. All other things being equal, the consequences of climate change in the insurance industry are greater uncertainty and higher claims.

The demand for differentiation of premiums could increase even more because of climate change, and it is possible that premiums in future will be determined increasingly according to e.g. location (is the risk of basement flooding particularly high or particularly low?), the characteristics and technical structure of the building, the damage history of the building, etc. In general, it must be assumed that if insurance premiums better reflect actual risks, then the individual will have more incentive to adapt to climate change, and thus the number of claims will be reduced as far as possible. From an overall socioeconomic consideration, it therefore makes sense that premiums reflect risks. However, the size and the number of damage events depend not only on the individual's efforts to limit or avoid damage, but also to a great extent on the efforts of public authorities in e.g. the area of sewerage.

Finally, it may be a matter of ethical / income-distribution-policy considerations, if e.g. some houses cannot be insured or can only be insured at very high insurance premiums.

1.6 Example calculations and further analyses

The screening also includes a series of example calculations. These calculations were performed at a very general level. They serve to illustrate the estimated sizes at play. In general, further analyses will have to be carried out.In this summary, however, focus is on the results of the four sectors that have been deemed most relevant. This does not mean that the need for more knowledge does not apply to the other sectors.

1.6.1 *Coastal protection*

The establishment of new dikes will reduce the risk of flooding. Preliminary analyses indicate that for farmland, it will probably only be cost-effective to invest in protection of the least vulnerable stretches of the coast (which is cheapest) and if flooding occurs so frequently that the soil becomes unsuitable for cultivation.

The potential damage costs are significantly higher for homes and holiday houses, so for these the establishment of dikes will be cost-effective at lower flooding frequencies.

The only measure that can prevent the Danish coastline (excluding the west coast) from receding is active beach nourishment. Beach nourishment projects would also reduce the loss of beaches and thus recreational values. The example shows that beach nourishment is cost-effective from a socio-economic perspective, if the willingness-to-pay to preserve the beaches in question is around DKK 165/year per person in Denmark.

1.6.2 *Buildings*

Example calculations of rising-damp prevention have been performed for both new and existing buildings. These calculations indicate that preventing rising damp in new buildings may be appropriate. For existing buildings, preventive measures are very expensive.

Example calculations have also been performed for the possibility of reinforcing existing buildings against storm and snow damage. The calculations of the specific damage types show that it could be appropriate to secure buildings against storm damage and less appropriate to secure them against snow damage. However, this does not include the cost of screening buildings for whether they are in risk zones for the relevant damage type. The results will be very dependent on the building in question, the damage type and the risk of damage, and it is very difficult to say anything in general about preventive measures for buildings. In practice, what the individual building looks like, and thus the measures to be launched to prevent damage, will differ significantly from building to building.

In conclusion it must be noted that there is required a considerable increase in the amount of knowledge within this important area, which combines the technical analyses of typical damage with cost considerations of preventive measures and the damage itself.

1.6.3 *Roads and railways*

Within the area of roads and railways, more precipitation is the greatest challenge. More frequent and heavier downpours may result in flooding. The increase in precipitation may also lead to traffic delays and thus to socio-economic losses. It takes only few traffic delays before the socio-economic costs are high enough to justify preventive measures. Preventive measures could be in the form of warning systems, better road drainage installations etc.

The best place to intervene depends entirely on the road in question, including traffic volumes and the risk of an event. The same applies to railways.

1.6.4 *Sewerage*

Example calculations have been performed for different alternatives to enlarging sewer systems in an area with separate sewer systems. These calculations show that local infiltration is cheapest by a small margin, closely followed by traditional, new separate sewer systems with a climate factor of 1.3. The alternative solutions, especially the solution with green roofs and open rainwater management, are the most expensive. This calculation does not include the recreational values implied in the alternative solutions. It is difficult to say anything in general about which approach to enhancing the capacity of sewer systems is more appropriate from a socio-economic perspective, since it depends to a great extent on the specific area in question, housing types, existing sewer systems, etc. This applies to costs as well as to benefits.

Preparing more comprehensive socio-economic analyses in the specific case would be very relevant. Such analyses should include all externalities, positive as well as negative, of the different alternatives.

All of the calculations mentioned above were performed at a very general level. It is therefore difficult to draw any solid conclusions from them. There is a general need for more analyses within a delimited geographical area where concrete conditions can be included in the analyses. In this way, there will also be opportunity to optimise possible synergy effects across sectors.

1.7 Correlations between sectors

There is a great extent of overlapping and potential synergies between the different sectors. This applies in particular to those sectors that are deemed to be most significant in relation to climate change adaptation, namely the standards-controlled sectors coasts, buildings, road/railways and sewerage, and their connection to spatial planning.

Especially with regards to managing increased water volumes, there is a need for long-term spatial planning based on hydraulic analyses in order to ensure the best possible foundation for planning. In this way, potential damage costs in other sectors may be reduced significantly, for example, by ensuring that no new buildings are erected in areas prone to flooding, or by incorporating the increased water volumes into the landscape so that they may be used for recreational purposes.