Environmental Essay

Adapting to the Climate of the Future

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MINISTRY OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION AGENCY

Adapting to the Climate of the Future

Environmental Essays no.29, 2004

Contents

Be prepared for climate change

Climate change – what has that got to do with my line of work? This is probably a question most people will ask, when they are told to start adapting – in their daily work – to the changes in the climate which are on their way – and which will also affect Denmark.

Nevertheless – this is exactly what this leaflet tells you to do.

Although there is much uncertainty about the development of the climate and the contribution of human activities to the greenhouse effect, the time has come – according to the recommendations of scientists and other experts – to integrate climate change into the long-term decisions we take in a number of areas.

Previously the Danish Ministry of the Environment was focusing only on the need to reduce emissions of greenhouse gases in order to control the increasing greenhouse effect and the resulting climate change as far as possible. With this leaflet the Ministry wishes to point out that we also have to focus on measures to adapt to the climate change. Adaptation to and prevention of climate change are not a

question of either one or the other – but rather of both.

The leaflet is the Ministry of the Environment's follow-up to the report "Effects of climate change – adaptation in Denmark" published (in Danish: Effekter af klimaændringer – tilpasninger I Danmark") by the Academy of Technical Sciences in September 2003, and the Danish Board of Technology report "New Climate – New Life?" (in Danish: "Nyt klima – nyt liv?") from June 2004. Efforts are required, because – in some areas – hesitation to include available knowledge on climate change in our daily work may prove very expensive for society.

This leaflet does not give ready-to-use answers, but intends to invite decision-makers, business and authorities in Denmark to assess how possible climate changes can be integrated in new projects and in current planning and maintenance activities. Not as a requirement, but as inspiration for considerations at local level on how best to take future climate change into account.

In some areas, planners have already been thinking ahead, for instance in the construction of the Copenhagen Metro, in which climate change was taken into account.

In other areas, the problems have hardly been considered.

This leaflet is mainly targeted on the latter, focusing on selected areas which illustrate what kind of problems may be encountered by regional and local authorities, by consultants, contractors and engineers etc., at management as well as staff level. The point is that environmental and economic benefits can be gained if business and authorities are aware of climate change in due time.

The Ministry of the Environment wishes to put adaptation to climate change on the public agenda, and to increase awareness of the time it takes to introduce new ways of thinking and new procedures, to change rules etc. In other words, climate change can already be integrated in the approach we use in our daily work.

"ADAPTATION TO AND MITIGATION OF CLIMATE CHANGE ARE NOT A QUESTION OF EITHER ONE OR THE OTHER – BUT RATHER OF BOTH".

Efforts on two fronts

”Extensive rainfall over a very short time makes several rivers in France overflow their banks – to the surprise of many people. Meteo France states that within 24 hours 150 mm of rain fell at Marseille, and in some small towns nearby, up to 213 mm of rain fell in the same period. Normally, precipitation in this region reaches 70 mm for the whole season.” This statement appeared on the Danish Meteorological Institute website on 8 December 2003.

It is true that this story is not about Denmark, and that we do not have rivers that big. However, this is not the point. What is important and worth noticing is the expression “to the surprise of many people”. We have to try and prevent that similar weather extremes may also take us by surprise in Denmark.

The global climate is getting warmer. Average global temperatures have increased by approx. 0.6°C during the 20th century, and the last decade (1990-2000) was the warmest since systematic measurements began in the middle of the 19th century. Nature's response takes different forms – trees burst into leaf earlier in spring, animals move from their usual locations, the level of the sea rises.

With the global climate change – the approach of which is internationally recognised – the risk of certain extreme weather events will grow, also in Denmark. We have to accept the fact that the Danish climate is changing.

In Denmark there are already some indications of climate change. In the course of the last 15 years, average winter temperatures have increased by 1.5 to 2 °C and summers have become similarly warmer. In the warmer climate the birch pollen season starts three weeks earlier than 25 years ago (see page 32), and the amounts of pollen of both alder, hazel, birch, and grass are increasing.

From satellite monitoring meteorologists can see that in large parts of Southern Scandinavia, foliation is taking place up to four weeks earlier than it used to. However, Northern Scandinavia is seeing the opposite trend, since spring is generally coming a little later.

Opinions are divided on the extent to

which the global climate change is a result of human activities, and on what we can do to prevent it from happening. No matter what, it still makes sense for decision-makers in regional and local authorities, and for consultants and contractors etc., to start integrating climate change in their plans for the future. There is much to win, and little to lose.

By integrating climate change in planning projects now, Denmark can – with simple means – avoid both unpleasant surprises, unnecessary damage, and large costs.

Contingency and preparedness

First, we should not let ourselves be taken by surprise by extreme weather events – lack of foresight may cause tragedy and extensive costs, and this is exactly what decision-makers and other parties responsible for vital functions in society must relate to. In other words, we should have a contingency system that enables us to manage a range of specific weather situations.

Secondly, we should not be caught unprepared to the fact that the climate will be fundamentally different from what it used to be, affecting both water supply, coastal protection, agriculture, forestry,

fishing, buildings, nature management, infrastructure and public health.

Work on two fronts instead of one

Consciousness of climate change does not at all mean that we give in to the problems it causes. On the one hand, Denmark, being an industrial country, is taking active measures to comply with our international agreements to reduce emissions of greenhouse gases, thus minimising climate change. Denmark takes continuing measures to contribute to international work on climate change under the auspices of the UN Framework Convention on Climate Change, and to fulfil Danish commitments under the Kyoto Protocol of 1997. On the other hand, measures are also needed to adapt society, environment and nature to the new climate situation.

To allow Denmark to adapt to a different climate, the first task is to identify the areas in which decisions are needed in the short term, and the areas where decisions can wait till later. The progress of climate change is relatively slow, according to the climate scenarios calculated by scientists up till now. Therefore, some matters can be dealt with gradually, as they turn up. But continuing monitoring of developments and updated research is needed.

An unusual situation

Areas where decisions could be required in the short term are for instance coastal protection, forestry, sewerage, drainage and building regulations. As far as nature is concerned, choices should also be made, for instance to make sure that we do actually have the possibility of natural adaptation over a large number of years, if this is what we want.

In all these areas we must distinguish between statistical variations and real trends over long time spans – up to a 100 years or more. This is a situation that decision-makers are not used to.

Adaptation may also be a question of incorporating routine responses to possible extreme events, like forest fire and storm surge.

All in all, robust and long-term planning – with relevant safety margins – is preferable. By integrating climate change in work at an early stage, we can save a lot later.

The Danish climate in the future

Compared to other places in the world, it seems that the effects of climate change will be fairly modest in Northern Europe. According to the UN Climate Panel, the IPCC (the Intergovernmental Panel on Climate Change), which counts climate experts from all over the world, temperature increases will probably be twice as big for instance in the Arctic as it is in Northern Europe.

Nevertheless, in Europe as a whole there is a risk of for instance drought, with serious implications for agriculture and severe forest fires, especially in the Mediterranean area.

Although we live in the part of the

Table 1

Climate change in Denmark

Possible climate change in Denmark up to the year 2100, based on an average scenario (according to DMI)

Temperature increase	+ 3-5 °C
Summer precipitation	-10-25 %
Extreme summer precipitation	+ 10-20 %
Winter precipitation	+ 20-40 %
Winter precipitation, snow	- 70-90 %
Sea-level rise	+ 0.5 m
Storm activity	Moderate increase

The figures represent an average scenario for Denmark, which predicts a possible general warming of approx. 3-5°C within a number of decades. Warming is seen mainly for night temperatures, thus reducing the diurnal temperature range, compared to what we are used to. Spring will tend to come earlier, and autumn later. Migratory birds will arrive earlier, forest trees will leaf earlier. Generally, precipitation will increase by 10-20 per cent annually – with less rain in summer, more intense precipitation episodes, and longer periods without precipitation. There is also a tendency towards more storm activity.

World where the impact of climate change will be less extreme, we should still anticipate that we may be affected, mainly because Denmark is a low-lying country with a coastline of more than 7,000 km, and several hundred small islands. The sea level will rise generally, the annual variations in water levels in watercourses will increase, and the increasing sea level will affect the coastline, which is at risk of retreating. There is also a risk of intrusion of salt in groundwater near the coasts.

To enable us to adapt to the new situation in the best possible way, knowledge on the possible development of the climate in Denmark is essential. We should therefore start integrating the probable climate change in existing practices at state, regional and local levels, and where otherwise relevant.

The DMI is working with climate change

In Denmark climate change is researched primarily at the Danish Meteorological Institute, the DMI. The DMI is monitoring the climate and taking part in international climate research, which constantly tries to assess possible future climate change.

On the basis of international scientific work, the DMI has also calculated how the climate will change in Denmark in the future. The work by DMI has resulted in the establishment of different scenarios, i.e. possible developments of the climate under specific conditions – and, thus, not the same as prognoses.

The data in table 1 are a popular representation of one of the DMI climate sce-

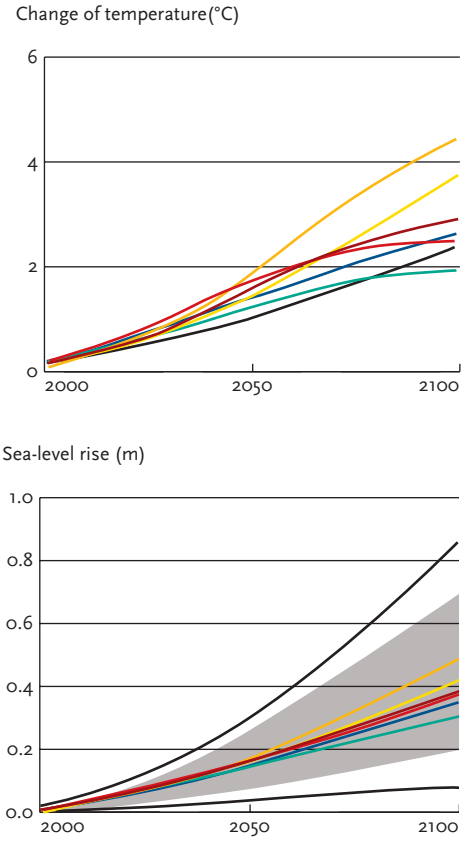


Figure 1
Climate change over the next century
Projections of global temperature rises and water-level rises in scenarios from the UN Climate Panel, the Intergovernmental Panel on Climate Change. The curves represent a number of different scenarios. The extent of changes varies, but the trend is the same.
(According to: IPCC, 2001)

narios for Denmark – at this moment one of the best forecasts of climate change to be expected in response to global warming.

The results from the DMI are based on couplings of large global climate models with the more complex regional models, which are also used for weather forecasts, although in a different form. The global climate models are the same as those used by for instance the UN Climate Panel to make projections of the global climate (see figure 1).

The average scenario presented for Denmark is of course subject to great uncertainty – both as regards the assumptions underlying the calculations, and as regards the calculations proper. Therefore the development might not be exactly as predicted in the scenario. What we can say is that the temperature trends are almost identical, no matter which scenarios for Denmark we are looking at. Variations are primarily a matter of magnitude – or the extent of changes. The uncertainty is greater for precipitation, and for changes in storm activity in particular. The tendency towards less precipitation in the summer and more in the winter, and towards more intense precipitation incidents is, however, generally found also in other

modelling systems than those applied by the DMI.

Ocean currents – a joker

The strong Atlantic Ocean currents, bringing warm water to the North and thus acting like a sort of heater, are very important for the climate in Europe and the Arctic. The most important currents are temperature- and salt-induced currents, but currents may also be wind-driven. The Gulf Stream is part of this system of ocean currents. Most climate model calculations show that total disruption of these currents as a result of global warming is fairly improbable. But according to the calculations, their power will be significantly reduced.

You might think that – on the face of it – this would cause temperature decreases in the Arctic and in Northern Europe, as has probably happened so often during the last Ice Age. But – when the climate is warmer, as it is today – sea-ice, clouds and water vapour have a much larger moderating impact on energy balances than they had during the glacial ages. Therefore the impact of weakening sea currents is more than offset, so that the largest temperature rises are actually seen in the Arctic. Also for Northern Europe, calculations indicate rising temperatures even if the heat transport in the Atlantic Ocean is decreasing.

Strandvejen - the coastal road north of Copenhagen
A general sea-level rise will not only increase the risk of storm surge of low-lying land. It will also cause increased coastal erosion and retreating coastlines. In some areas that are protected against erosion today, the beaches may disappear, and the protective measures may be undermined. Pathways along the beach may be more difficult to use.
(Photo: Danish Coastal Authority)

What do they do in other countries?

Several other EU countries are beginning to take account of the changing climate.

For instance the Netherlands, Germany and Austria have prepared action plans relating to storm surge. Greece, Spain and Italy have prepared action plans on drought. Finally, the UK, Belgium, the Netherlands, Germany, Austria, Sweden and Finland have – to a varying degree – integrated the question of adaptation to climate change in their aid to developing countries.

Moreover, the UK has prepared a national strategy for adaptation to the climate of the future.

The strategy forms part of the climate programme adopted by the British Government in November 2000, focussing on measures to reduce greenhouse gas emissions as well as to adapt to a changed climate.

The Department for Environment, Food and Rural Affairs is coordinating climate policy in the UK, cooperating closely with a number of other ministries and agencies involved.

In 1997 the UK Climate Impacts Programme (UKCIP) was established, based at the University of Oxford. UKCIP supports organisations or authorities and other stakeholders responsible for planning and development of infrastructure and contingency. They also help preparing strategies for adaptation in specific areas.

Identification of priority areas

On the basis of UKCIP work and an independent report from Environmental Resources Management (ERM, 2000) the UK climate programme identifies areas where adaptation to a changing climate is particularly important over the next 30 years.

The areas identified so far are: management of water resources, measures against storm surge, impacts on buildings and other infrastructure. Also areas like tourism, biological diversity and planning are being considered.

Examples of adaptation

Planners and technical staff in counties and municipalities, owners of private forests, engineers, architects and physicians – all these experts and many more are involved in work in areas which – in some way or the other – may be affected by future climate change.

The task is now to integrate climate systematically as a parameter in long-term work, in line with other significant parameters that need to be taken into account. However, this is often only possible if politicians, management and top-level executives take the decisions required to allow the issue of climate change to be integrated in the work.

The examples given below show where it will be advisable to start thinking about climate change in daily work. But they do not give the answer to the question: how do we handle the situation in specific cases?

Different options will probably be available to adress both the problems described and other problems that might arise in the wake of climate change – both for nature and for humans. In any case, great benefits can be achieved by taking action now – money can be saved, damage can be avoided, conflicts can be prevented or minimised.

Example 1

Urban areas and the open country

The town Løgstør will no longer be taken by surprise by weather and climate. Situated in Jutland, at the north-western bank of the fjord Limfjorden, Løgstør is one of the towns in Denmark that, for the last 25 years, have faced frequent storm surges and episodes of high sea levels. According to the Løgstør municipal contingency plan, the worst storm surge incidence ever experienced was in 1981. Streets were flooded, and buildings and installations were severely damaged. At that time people were not prepared to deal with such extreme forces of nature.

The storm surge incident at Løgstør triggered the establishment of the contingency plan used today – and the first measures were taken to secure exposed buildings, transmission lines, technical installations and sewers. Large sums have been spent on maintenance and renewal of the waterfront and raising the road along the harbour. Investments are, however, worthwhile – not least in the light of the changed climate in the future.

Several other towns in Denmark that otherwise do not have to deal with these kinds of problem every day may face a similar situation in the future.

Many Danish towns are located at fjords or mouths of rivers. In step with the

Table 2

Facts about extreme storm surge

Examples of high waters at inland coasts and in the Wadden Sea, sea rises in centimetres.

Average time between incidents	1 yr	20 yrs	50 yrs	100 yrs
Inland coastlines (Randers)	105	155	168	178
Wadden Sea (Højer Sluice)	288	418	448	469

Source: Danish Coastal Authority, 2002, in the Academy of Technical Sciences' background report, 2003

The table shows the average time between recurrence of the water levels indicated, in current climate conditions, for instance extreme high water of 4.18 m occurs every 20 years at Højer Sluice. With a future sea-level rise of for instance 50 cm, the storm surge will reach 4.68 m every 20 years, if the wind climate does not change. This corresponds to extreme storm surge (4.69 m in the right-hand column), which, today, only occurs once in one hundred years. However, since the wind conditions will also change, the incident that will currently take place once in a hundred years in the Wadden Sea will occur at 5-15 year intervals if the sea level rises 50 cm.

sea-level rise resulting from global climate change, the risk of storm surge etc. will surely affect not only towns at westerly coasts, but, generally, many other towns located near the water.

The rising sea level will affect beach feeding and the construction of dikes, it will cause problems of rising groundwater levels and of salt water intrusion in the groundwater zone in low-lying areas and on small islands.

Regional planning with an extra dimension

Climate change will not only affect many towns located at the sea, but will also influence overall spatial planning in the open country. Therefore a sensible thing for regional planners to do is to consider the consequences of sea-level rise and frequent storms for the use of land in their area, and also to consider how a warmer climate with more precipitation will influence the development in the power plant sector and the capacity of sewage treatment plants.

Facts about the water level in Denmark

- Today: The water level is monitored continuously by the DMI, the Danish Coastal Authority and the Royal Danish Administration of Navigation and Hydrography. In the past century the water level increased by 10-13 cm in south-western Denmark, and fell 1-2 cm at Skagen. Assuming that the water level around Denmark has increased by 15 cm in the last 100 years – corresponding to the global average – an uplift of Danish land must have taken place.
- In the future: Even if the uplift of land continues, it is not sufficient to keep pace with the sea-level rise, which according to the UN Climate Panel's third assessment report 2001 is expected to be in the order of 9-88 cm over the next century.

Regional planners typically take decisions on a number of cases of vital importance to development many years ahead. The latest regional plans cover the period up to 2013, but are revised every four years. Therefore, we might start identifying the areas we wish to preserve, and the areas where possible changes can be accepted, in order not to allocate needless resources to areas which may have to be abandoned in the longer term.

New challenges

By way of example, the anticipated climate change in Denmark may impair the profitability of new buildings at the coasts, unless account is taken of future sea-level rise. The lifetime of buildings is typically a hundred years, and they must therefore be able to withstand new weather, wind and water conditions.

"Today the average time span between water level rises exceeding 150 cm is 100-200 years, but in 2100 they will occur every second year".

Academy of Technical Sciences' report on the Port of Copenhagen

In other areas we may have to reconsider the use of a number of drained fields. Part of the Danish land is elevated seabed, lying low for instance in reclaimed areas. Can these areas be used for agriculture also in the future? Or will the costs of continuing drainage become too big?

The local/regional authorities of the future might also have to view nature management in the light of new climate conditions. In a changed climate, some conflicts of interests may stand out more clearly and present new challenges. But by including available knowledge on climate trends, it will be easier for us to make the right choices in due time.

Development of harbour areas for new purposes

Imagine the local authorities planning a new prestige construction project in a harbour area that is no longer used for traditional purposes. Everyone is excited, and the project is completed. The problems, however, do not arise until the construction work is finished. Suddenly, after a major storm, we are faced with flooded basements and foundations, realising that this will not be the only episode of this nature.

Many Danish towns include harbour areas that may be used for new purposes. Often they are attractively situated, and the new building projects are very expensive. Politicians, planners, architects and engineers must therefore include sea-level rise in their long-term planning, in order not to end up with unprofitable buildings and lots of extra costs.

In spring 2003 the Danish Folketing adopted an amendment to the Spatial Planning Act, thus enhancing the scope for changing old harbour areas into new integrated urban areas of houses and housing-compatible industry. The opportunities embedded in this Act underline the need to be very careful when planning the development of exposed harbour areas.

Example 2

Sufficient sewerage

The summer of 2002 was one of the wettest ever seen in Denmark. Many people, in Aalborg for instance, were bothered by sewage retained in the sewer system. After this incident, in 2003, the Aalborg municipality and departments responsible for sewerage distributed an information leaflet advising residents in several hundred properties on how to avoid flooded basements. The leaflet was part of a major project in which the local authorities, in cooperation with the consulting firm NIRAS, the assistance and emergency company Falck, and the facility services company ISS, have recorded data on water-related emergency calls to these firms. Therefore, the municipal authorities had a good overview of incidents of flooded basements in Aalborg.

The aim of this unusual cooperation concept was, however, not only to assist private house owners. A second aim is to be able to incorporate the data in the planning and prioritisation of the redevelopment plans and the sewer renewal plans prepared by the municipality, and make sure that the new systems have sufficient capacity to discharge larger volumes of water than the old facilities.

Increasing precipitation

So far incidents of heavy rain like the one in Aalborg have not been seen very frequently in Denmark. In the last 25-30 years the intensity of precipitation incidents has not increased, but calculations of climate change do in fact foresee increasing intensities. Sewage retained in the sewerage installations, flooded basements, roads and fields may become a problem in the future – unless the individual municipalities take steps now to plan the capacity of sewers for the future, for instance in connection with sewage plans and specific renewal work.

Local authorities should take account not only of increased intensity and frequency of heavy rain, but also consider the possible effects of sea-level rise on the planning of sewer facilities.

The lifetime of sewer systems is typically about one hundred years. Sewers established today must thus, have sufficient capacity for the sea-level rise and the wa-

ter volumes we expect to see within one hundred years.

Backlog of renewal work

The municipalities are currently renewing the existing sewer systems – and therefore now is also the time to take the climate change of the future into account.

It is true that the pressure on the sewer systems has lightened in recent years, due to water savings in private households and in industry, and to some extent also because Danes are tending to move out of urban areas. But the important question is whether the sewer systems can handle the peak loads occurring during heavy rain.

The dimensions of pipes are calculated on the basis of experience with heavy rain during short periods of time (up to 30 minutes), while the requirements for retention basins are based on longer precipitation periods (more than 30 minutes). Work to Increase the capacity of retention basins in densely built-up areas is very expensive, and it would therefore be most appropriate to establish the capacity required in the future in connection with current repair work and with the construction of new plants.

Example 3

The decline of Norway spruce

Owners of forests still remember the storm in 1999, which did so much damage to their forests and to their economy. Most damage was done to spruce plantations. A large proportion of Danish forests consists of mono-cultures – mostly Norway spruce, which is neither particularly capable of withstanding storms, nor of facing the overall effects of climate change.

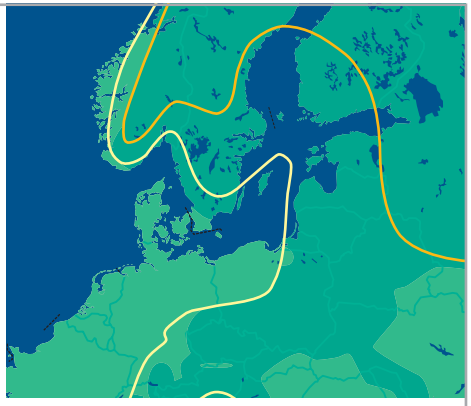


Figure 2
The distribution of Norway spruce
Norway spruce needs cold winters, and its natural distribution generally follows the January temperature limit of minus 2 °C. If the temperature rises for instance 4 °C, the boundaries might move to the present minus 6 °C limit. It should be noted that Denmark is already now outside the present natural area of growth.
(According to: J. Bo Larsen).

More storm incidents, and storms of greater intensity, may, however, be one of the negative consequences of a changed climate in Denmark – and amongst the negative impacts on the forests, massive windfall is the most severe.

The rotation time of forests is 50-150 years, if we disregard Christmas trees. Many of the trees we plant today must therefore also be able to grow in the climate of the 22nd century. Therefore, we have to start adapting to the effects of climate change in Denmark already now.

Danish studies show that the climate change envisaged will generally enhance tree growth, mainly of species having their northern boundary of distribution in southern Scandinavia. Reduced volumes of precipitation in the summer may, however, reduce this benefit, and more drought-tolerant species may be preferable. Even if we cannot be sure how the climate will develop over the next century, we still have to base our decisions on the future climate scenarios that are available.

The Danish forest programme

The Danish forest programme takes the first steps in this direction by planning major changes to the forests, the most important one being a shift from current forestry practices to close-to-nature silviculture. The forest programme sets out guidelines for sustainable forestry, which forest owners can use on a voluntary basis as a practical tool for sustainable forestry practices – including also a sound economic basis. One of the guidelines focuses on the introduction of forests consisting of a mixture of native species, which are more robust on our latitudes. The aim is to increase the stability of the forests by allowing the forests to develop more on nature's own premises than does traditional forestry.

This strategy is also very well suited to take into account future climate change.

Mixed species forests include a larger number of tree species in different age groups, thus spreading the risk of windfall and drought. Another benefit is reduced vulnerability to diseases and pests that might otherwise cause problems in a changed climate, and increase the consumption of pesticides. Mixed species forests also enhance the diversity of animal and plant life.

Plenty of reasons to integrate concerns for future climate change into forestry developments

- Tree production will be required also in the future.
- The forests have many visitors and are used for a range of recreational activities.
- The forests serve a valuable purpose by contributing to safeguarding the groundwater resources and by offering habitats for the many different animals and plants living in our forests also in the future.
- The forests act as carbon sinks, thus mitigating the climate change.

The implementation of the forest programme provides a number of options for promotion of close-to-nature forestry management.

The Norway spruce is on the decline

Norway spruce has been planted in Danish forests since the end of the 18th century, and now accounts for approx. 27 per cent of the Danish forest area, which makes it the most common tree in forests in Denmark. It is also the only tree species in Denmark that we are fairly certain will show a declining trend in a warmer climate.

An important element in a more robust forest development will be to stop planting Norway spruce in mono-culture and less suited soil conditions. The share of Norway spruce must be reduced in Danish forestry, but, pending more certain climate projections, Norway spruce can still be used to mix with other species in well-suited localities.

Since the storm in 1999, the Danish forestry sector has started thinking and acting along the lines presented in the strategy.

Already now the Norway spruce is showing signs of weakening – most recently in 1989-1991, possibly because winter temperatures were above those most suitable for Norway spruce.

Forest fires

In a warmer climate with less rain in the summer, forest fires may become more frequent, but this is not expected to cause a major problem in Denmark. Still, it would be wise to review the fire contingency closely, to see if we are properly prepared, should fire accidents happen.

The Copenhagen Metro and other infrastructure

A flooded metro is one of the worst situations that planners and people responsible for the daily management of the Copenhagen Metro can imagine. It is no wonder that the risk of heavy rain or storm surges – with or without climate change – was considered when the metro was built.

Such events are rare, but still not quite improbable for people working with infrastructure that are supposed to operate for a hundred years or more. Few of us can imagine a storm surge in the Copenhagen area, but nevertheless it can happen, most recently it happened in 1825 and 1872.

Beside the general risk, the consulting engineers dealing with this matter have considered the extra risk implied in future changes of the climate in Denmark.

The entrepreneur and the engineers have made sure that all entrance plateaus and descents are elevated to prevent them from being flooded, even at the worst of storms – not even in a hundred years, when the water level in the Sound may have risen by about 0.50 m above today's level. Fortunately, the surface of the ground is also rising, so that we will prob-

ably only see the water rise 30-40 cm.

The Metro company has made an agreement with the Copenhagen Road Directorate that the level of adjacent roads will not be raised in connection with the establishment or renewal of roads, because the measures taken to protect the Metro would otherwise be inefficient.

Action along these lines has also been taken for the Great Belt Tunnel, at the ramps at Sprogø and Halskov.

Large infrastructure is often planned with a time horizon of more than 100 years, and therefore possible water-level rises should also be considered.

The measures have added to the costs, but have been less costly than would have been the case if entrance plateaus and descents had to be rebuilt later.

Also roads and railways are to some extent dependent on the climate. The time horizon of changes is, however, so wide that specific adaptation measures can be taken on a current basis. Special attention

should, however, be given to road and railway infrastructure in coastal areas.

Climate considerations and new buildings

In general, climate issues must be considered when planning new buildings. There is nothing new in that. Also in the past, considerations for the fairly rough Danish climate have focussed on wind, rain, subzero degrees, snow, insulation etc. What is new is that the climate does not remain the same. For instance increasing wind can put more pressure on roofs and facades on i.a. single-family houses. Also light glass facades should be strengthened or replaced by facades with small window panes.

Building regulations set out standard requirements for construction work, focusing on new buildings and major rebuilding.

The regulations are administered by the municipal authorities, and the competent authorities should integrate climate change in future revisions of the building regulations.

In coastal areas with low-lying houses, the sea-level rise can cause problems relating to buoyancy and stability. It may be necessary to change the building regulations accordingly, and for instance prohibit building in exposed areas.

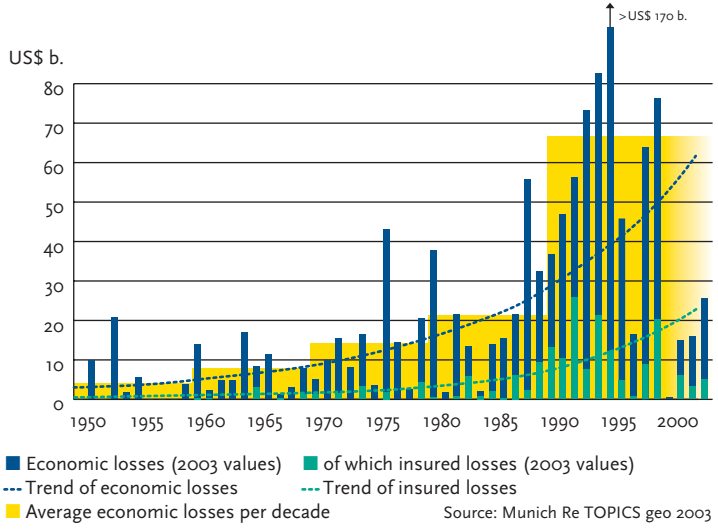
Building with large windows
Houses can be built with windows acting as photo-cells, generating power from solar radiation.

The price of insurance will increase

Insurance companies will have to consider the risk of changes in the frequency of extreme weather incidents, for instance storm surge, heavy rain, hailstorm, or "the storm of the century", like the one that hit Denmark on 3 December 1999. The losses caused by natural catastrophes, often resulting from extreme weather conditions, have been increasing, and if the trend continues, this will affect the price of insurance. No matter whether it is the worse weather conditions, or the greater possible losses of value, the result is the same: vulnerability increases.

Annual damage caused by natural catastrophes

The figure shows the economic and insured losses – adjusted to present values. The trend curves verify the increase in catastrophe losses since 1950.



Heating or cooling

The total building space in Denmark is about 600 mio. square metres, and new buildings, with floorage reaching about nine mio. square metres, are constructed every year. Assuming a typical lifetime of 100 years or more, the buildings will have to face a changed climate.

The building technology is expected to develop, introducing new materials and ways of construction, for instance window panes that act as photo voltaic cells. Annual costs of heating are approx. euro 800 mio. Other things being equal, in 2100 we might save about 25 per cent of this amount as a result of higher outdoor temperatures. On the other hand air conditioning may be required.

From the point of view of the environment it would, however, be better if a more pleasant indoor climate could be achieved by new construction methods – also on hot days without use of energy.

Climate and health

Although the risk of extreme heat waves is limited in Denmark, we may have to set up systems to handle the health problems resulting from a warmer and moister climate. There may be a need to monitor exposed groups – mostly the elderly, but also people suffering from ailments related to weather and climate.

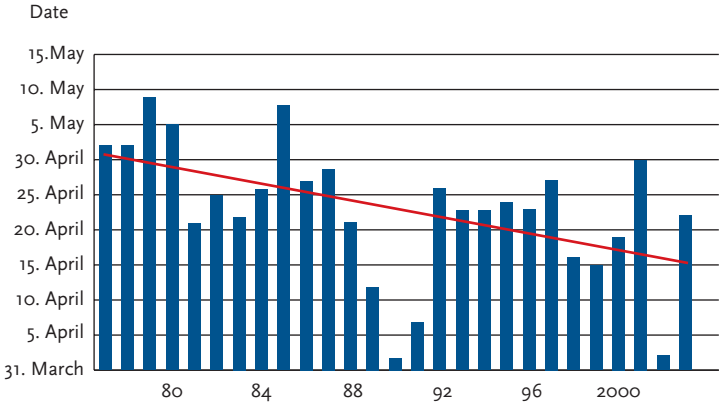
Most Danes know about the daily pollen counts from the DMI on radio and TV – useful for people suffering from hay fever and for other air tract allergists. In addition, in recent years an air pollution warning system has been launched, to inform people suffering from respiratory diseases. The National Environmental Research Institute is in charge of the daily air pollution forecasts prepared for heavily trafficked streets in Copenhagen.

In a warmer climate the nature of air pollution can change, for instance the photochemical air pollution, where nitrogen oxides and carbon hydrates from traffic forming i.a. ozone under the influence of solar light, can get worse. On the other hand, emissions of certain pollutants may be reduced when the consumption of car-

The pollen season is longer

The columns show the starting dates of birch pollen – today three weeks earlier than 25 years ago. The DMI has observed significantly elevated pollen counts, and the pollen season – not only for birch, but also for alder and hazel – starts several weeks before it used to. This may be part of the explanation of the increasing number of recorded hay fever sufferers. The earlier pollen season is a more indirect effect of the warmer climate we have seen in Denmark especially in the 1990s and later.

(Data from Alix Rasmussen, the Danish Meteorological Institute)



Date of start of birch pollen season in the last 27 years. The red line is a linear regression through the data in the period 1977-2002 and illustrates that generally the season starts earlier.

According to Alix Rasmussen, the DMI, 2004.

bon, oil and gas for heating becomes smaller. The overall result could be an improved air quality – at least locally.

In step with the changed climate conditions, special efforts may be required, for instance along the lines of the system in England, where meteorologists submit forecasts of weather-related effects on health to the hospitals.

Growing tourism – both good and bad

Not all future trends for climate and health are negative.

According to climate modelling, the climate in Denmark and the rest of Northern Europe will probably be more pleasant than in Southern Europe, where there is a risk of very hot summers. Tourists may change habits, and go to the north for their summer holiday. This will be good for the Danish economy on the one hand, but, on the other, it may also increase the risk of diseases which only occur very rarely today. More focus will also be required on environmental management, in order to cope with the increased pressure of tourists on the environment.

At global level the World Health Organisation WHO is very concerned about the health problems resulting from a changed climate. Elsewhere in the world the problems will be much larger than we expect them to be in Denmark.

Beside problems of heat stroke and infections, the UN Climate Panel and WHO expect many more cases of malaria every year. Malaria is already one of the World's most severe and widespread diseases, but may become even more so in both the tropics, the subtropics and less protected temperate zones.

Denmark is probably not among the countries that face immediate danger from malaria. But still, we should be aware that with a warmer and moister climate on our latitudes, the risk of diseases transmitted by mosquito and other insects increases.

In recent years we have seen the West Nile virus, WNV, spread by infected mosquitoes to large parts of the USA and Canada. Where it comes from, and what is the exact cause of its successful transmission, we do not know. Therefore nobody knows if it can be explained by unusually high temperatures in these parts of the world.

So far our cold winters have helped us control certain disease germs, but with rising winter temperatures the incidence of infectious diseases may increase. On the other hand, a lot of people catch infectious diseases, for instance a cold, during the winter, when the weather is cold and moist. All in all it is therefore difficult to predict the health implications of warmer winters.

The state serum institute SSI administers a scheme of surveillance and notification of a number of rare diseases in Denmark, under which doctors are obliged to report possible accumulation of inexplicable diseases to the SSI.

More detailed surveillance and recording of climate-related diseases in Denmark, within the framework of a contingency scheme or routine alerting of risks of a large number of weather-related diseases to the general public and to hospitals and casualty wards (like in England), should be considered.

Another relevant aspect is consideration of possible changes of livestock diseases.

WHO Europe is focusing on climate change and health

- The WHO regional office for Europe has launched a project cCASHh (Climate Change and Adaptation Strategies for Human Health in Europe) to assess and enhance the adaptation possibilities to climate-related effects on human health.
- In 2003 WHO published a review of the human health consequences of storm surge in Europe and the implications for public health.

Ideas for further action

Read the recommendations for specific action in the Academy of Technical Sciences report
"Effects of climate change – adaptation in Denmark" (only available in Danish: "Effekter af klimaændringer – tilpasninger i Danmark") background report, September 2003. Available on the website: www.atv.dk

Use the results of the Board of Technology project "New climate – new life? ".
In February 2003 the Danish Board of Technology hosted two scenario workshops at the coastal towns of Næstved and Esbjerg, gathering a number of local stakeholders in a discussion on future planning of the two local areas – on the assumption that they will face a 50 cm sea-level rise. The workshops tested a method to be used by local and regional authorities in order to drive forward the debate and the planning activities in the parts of Denmark that will be affected by an increasing sea level. Read more (in Danish) on the website: www.tekno.dk or phone (+45) 33 32 05 03.

Use the knowledge we have on the future climate in Denmark
The results of the DMI monitoring are very useful. See for instance the DMI climate modelling website (in Danish):
www.dmi.dk/dmi/index/viden/klimamodeller.htm,
and (in English):
http://www.dmi.dk/dmi/climat.htm

In the years to come the DMI will contribute to assembling the knowledge required to understand the mechanisms underlying the climate of the future, regionally and locally. The aim is to map the climate of the 21st century, and to better understand the importance of the climate for the development of Danish society. The DMI will work closely together with other research institutions in Denmark and Europe.

Follow the activities of the Danish Climate Forum
The DMI has for a number of years organised a number of climate forums or workshops, focussing on short and longterm climate variations over both short and long time spans, and on exchange of information and cooperation between Danish climate experts. For further information, see the DMI website (in Danish): www.dmi.dk

Visit the Danish Coastal Authority website:
www.kyst.dk (in Danish)

Look for material at the UKCIP – UK Climate Impact Programme
Climate change and adaptation website: www.ukcip.org.uk

Read about the action taken by the Aalborg Municipality and sewerage department
"How to avoid flooded basements" (in Danish: "Vand i kælderen"). Leaflet published by the sewerage department and Aalborg Municipality. Read the leaflet (in Danish) on the website: www.aalborg.dk

"Storm surge of sewerage – emergency cases" (in Danish: "Opstuvet kloakvand – skadeservicefirmaer fortæller hvor!"). By Mads Uggerby, NIRAS, and Bo Laden, Aalborg Municipality, Sewerage Department, in the magazine DanskVand, no. 8/2003.

A project on the climate change implications for nature in the Nordic countries, with recommendations for specific action, is being carried out by the National Environmental Research Institute and financed by the Nordic Council of Ministers. According to plans the project will be completed in the summer of 2005.

Other sources used in this leaflet:

- cCASHh (climate Change and Adaptation Strategies for Human health in Europe). WHO project on health and adaptation to climate change: http://www.euro.who.int/ccashh
- The human health consequences of storm surge in Europe and the implications for public health: a review of the evidence. Applied Environmental Science and Public Health, 2003, vol.1, No. 1.
- Danish EPA website on climate issues: www.mst.dk. See "Climate & Air" and "Climate".
- Discussion paper on a climate strategy for Denmark. The Danish Government. February 2003. Download the document on the Ministry of Finance website (in Danish): www.fm.dk. Search "Publikationer".
- "Global warming – management and adaptation" (in Danish: "Den globale opvarmning. Bekæmpelse og tilpasning"). by Anne Mette K. Jørgensen, Kirsten Halsnæs and Jes Fenger. Gads Forlag, 2002.
- Technical report, NERI, no. 401. "Danish adaptation to climate change" (in Danish: "Dansk tilpasning til et ændret klima"). By Jes Fenger and Povl Frich.
- IPCC Third Assessment Report – Climate Change 2001

Published by:
Danish EPA
29, Strandgade
DK-1401 Copenhagen K
www.mst.dk

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Helle Pryds Bruun.

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The leaflet is based on a technical paper by Jes Fenger, technical comments by Anne Mette K. Jørgensen and Eigil Kaas, NERI, and interviews with: Ole Damgaard Larsen, COWI, Peter Henrik Andersen, State Serum Institute, Per Toppenberg, Nordjylland County, Lars Vesterdahl, Royal Veterinary and Agricultural University, Mads Jacobsen, Danish Forest and Nature Agency, Peter Mikkelsen and Bjarne Nielsen, Municipality of Ålborg.

The text in this leaflet is the responsibility of the editors only.

Frontpage photo: Scanpix
Other photos: pages 13, 28, 32 and 33: Polfoto
Page 21: Mikkel Østergaard
Pages 2, 4, 7, 9, 10, 12, 15, 16, 17, 19, 20, 23, 25, 26, 27, 29 and 31: Scanpix
Design and illustrations: Rumfang 04277-106
Translation: GlobalDenmark a/s
Paper, cover: Galerie Art Silk 250 g
Paper, content: Cyclus Print 115 g
Printed by: Schultz Grafisk
Impression: 1.000, 1st edition 2004
ISSN 0905-247x
ISBN 87-7614-457-7

The leaflet is labelled with the Swan ecolabel

Adapting to the Climate of the Future

The global climate is getting warmer. In the 20th century, the average global temperature has increased by approx. 0.6 °C. With the global climate the risk of certain extreme weather events will grow, also in Denmark. We have to accept the fact that the Danish climate is changing. By integrating climate change in planning projects now, Denmark can – with simple means – avoid both unpleasant surprises, unnecessary damage, and large costs.

This leaflet does not give ready-to-use answers, but intends to invite decision-makers, business and authorities in Denmark to assess how possible climate changes can be integrated in new projects and in current planning and maintenance activities.

ISSN:0905-247x
ISBN:87-7614-457-7

Copies of the leaflet can be obtained at:
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Environmental Essay no. 29, 2004 · Adapting to the Climate of the Future