BELGIAN
NATIONAL CLIMATE CHANGE ADAPTATION STRATEGY

NATIONAL
CLIMATE
COMMISSION
DECEMBER
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Foreword

Mankind has spread to all corners of the world, surviving under harsh conditions. Customs and traditions are handed down from generation to generation, which enabled men and women to survive in these extreme places. But recently, in the time span of just a few generations and sometimes even faster than that, the climate is changing everywhere. The knowledge of our ancestors is becoming obsolete. If we hold on to our old ways, we'll become more and more vulnerable.

We have three opportunities to respond: mitigate (trying to reduce climate change), adapt (accept the climate change and adjust our way of living accordingly) and suffer (normally the result of not actively responding to the climate change and hoping the results will be manageable). It should be clear that these three possibilities are closely linked.

It is of the utmost importance to try and avoid the climate changing, but even our best efforts will never lead to an unchanged climate, so, if we don't want to 'suffer', we should also adapt to the inevitable changes.

Studies have shown that coastal areas, areas prone to river flood and urban areas (such as cities) are amongst those considered to be especially vulnerable to climate change. Since all of these areas are present in Belgium, adaptation to climate change has been an important part of Belgian climate policy and will remain so in the foreseeable future. In Belgium, the scientific research conducted in cooperation with the government has calculated that the north of Belgium is more vulnerable to the inundations from the sea, while the south will suffer more from the heat and drought. This impacts a great variety of different sectors.

In order to be prepared for the coming changes, the National Climate Committee has instructed members of the federal and regional (Flanders, Wallonia and Brussels) governments to prepare this adaptation strategy. This strategy report was largely based on the conclusions of different adaptation studies on this subject which have been carried out or are going on in Belgium. We believe that following the strategies explained in this document, coupled with the efforts done in mitigating the climate change, gives Belgium the best chances in minimizing the impact of the climate change.

National Climate Commission

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Content

Executive summary

Climate change is a reality. Furthermore, as a result of human activity, the climate will continue to change for the coming decades. Climate change will have a profound impact on the way we live our lives. To keep this impact bearable, we need both to mitigate and adapt.

The precise change in climate is difficult to predict, especially on a smaller geographical scale like Belgium. Belgian research in this field will continue. Nevertheless, national and international research reveals several future challenges for Belgium. The most obvious are sea level rise and inundations which will affect the coastal and lower areas and droughts and heat waves which will affect the forests in the southern part of the country. In Belgium a substantial part of the necessary adaptation to the climate change has already been initiated from the bottom up. Both on local level as on sector specific level, the sense of urgency has inspired many people to take action in fields as diverse as health, tourism, agriculture, forestry, biodiversity, ecosystems, water, coastal, marine and tidal areas, production systems and physical infrastructure. To cope with the climatic changes, they started to construct monitoring schemes, to build physical barriers and to induce changes in people's behaviour. For these areas a quick overview of the effects of climate change and the adaptation measures already taken, have been included. It is interesting to note that the actions in these fields are not only based on the defence against threats, but also on finding new possibilities and capitalising on favourable changes.

Belgium now faces the challenge to further extend the scope of adaptation in order to cover all areas influenced by climate change. This holds especially for aspects which fall between the classic policy areas. Extensive linkages between the different policy areas and their adaptation efforts could lead to synergies and could further avoid maladaptation. This will ultimately lead to a more complete and coherent adaptation policy. In order to further facilitate adaptation (from a policy point of view) a set of principles, an outline and a roadmap have been identified that describe a route to a future and comprehensive national adaptation plan.

Introduction

1

Over the past 20 years, climate change has evolved into an international concern of increasing importance. When discussing climate change responses, it is widely accepted that efforts should focus on two 'major areas', namely efforts to reduce or 'mitigate' greenhouse gas emissions (mitigation), and efforts focusing on helping societies and the environment to adapt to climate change (adaptation).

Within the international context, the United Nations General Assembly decided in 1990 to address climate change. At the Earth Summit or Rio Summit in 1992, the Parties adopted the United Nations Framework Convention on Climate Change (UNFCCC) ratified by Belgium on 31 May 2002. Adaptation is referred to specifically in Article 4(1) (e) which provides that all Parties shall "cooperate in preparing for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods".

The EU White Paper on Adaptation was published in April 2009. Titled 'Adapting to Climate Change: towards a European framework for action', the paper encourages Member States to 'promote strategies which increase the resilience to climate change of health, property and the productive functions of land, inter alia by improving the management of water resources and ecosystems' and to develop National and/or Regional Adaptation Strategies with a view to considering mandatory adaptation strategies from 2012, as well as the adoption of a European, comprehensive adaptation strategy in 2013. The Belgian National Climate Plan (2009-2013) was adopted on 3 April 2009. The Plan specifically mentions that the Belgian government will evaluate the possibility of developing a National Adaptation Plan, building on experiences gained from the regional adaptation efforts {1}.

In response, the Belgian National Climate Commission (composed of representatives from the Belgian federal government and the regional governments of Flanders, Wallonia and Brussels) created a working group to develop a joint Belgian Adaptation Strategy. The Strategy will have 3 objectives:

- to provide coherence between the existing Belgian adaptation activities (evaluations of the impact and vulnerability to climate change, as well as adaptation measures already implemented)
- to better communicate on a national, European and international levels,
- to start developing a National Adaptation Plan.

It is noteworthy that a number of adaptation initiatives, both local and regional, are already in place in Belgium. However, as a result of this bottom up approach, these initiatives may not have been easily recognisable in international inventories.{3, 4, 5}. [1]

1 — In this context, the 2009 PEER report (Partnership for European Environmental Research), titled 'Europe Adapts to climate Change – Comparing National Adaptation strategies', is of great importance. The report compares a number of national adaptation strategies based on written and published materials. Belgium is completely absent in this report, since there is no existing national adaptation strategy. In other surveys as well, Belgium retains a weak position compared to other countries (for instance, on the website of the EEA).

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Climate framework 2

Towards a widespread international attention for climate change

The first important global environmental concerns were raised by the Club of Rome, in their report 'Limits to Growth' (1972) which received considerable public attention. Later, at the Earth Summit or Rio Summit in 1992, the Parties decided to adopt the United Nations Framework Convention on Climate Change (UNFCCC). This Convention paved the way for the famous Kyoto Protocol, and currently discussions are under way in trying to reach a consensus about an ambitious legal framework for climate change for post 2012 period.

On the scientific side, concerns were raised about the anthropogenic causes of global change during the Stockholm conferences in 1971 and 1972. In 1979, the first World Climate Conference raised the necessity for international climate research and the creation of the International Panel on Climate Change (IPCC). The IPCC was founded in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO). The mission of the IPCC is to conduct elaborate, objective and transparent analyses of the scientific, technical and socio-economical information concerning the risks of human-made climate change and its consequences, as well as the options for mitigating climate change and adapting to its consequences. It issues scientific assessment reports on a regular basis, which receive much public attention and serve as an input into international political negotiations. The IPCC work is shared among three Working Groups, a Task Force and a Task Group. One of the working groups (WG 2) focuses on impacts, adaptation and vulnerability to climate change, and its work is thus of extreme relevance for all those involved in adaptation.

As the research in Europe is scattered, important coordination steps are taken with the Joint Programming Initiative (JPI) on Agriculture, Food Security and Climate Change. Under the JPI, 20 European countries will work together to define, develop and implement common strategic research agendas in areas that weigh heavily on the minds of Europeans, specifically issues affecting their well-being and prosperity. The JPI is focusing on strengthening researcher collaboration, bolstering the effectiveness of national funding that would top the EUR 1 billion mark each year, coordinating potential work so as to maximize value for money and avoid duplication, and sharing existing research results.

A preparatory meeting to set up an Adaptation Steering Group (ASG) was hosted by the Commission in November 2009 and the first meeting of this group convened on 23 September 2010. Technical working groups will be created in support of the ASG. A first example is a group on the development of the knowledge base, including the proposed climate change 'Clearing House', vulnerability indicators, identification and assessment of adaptation options. The ASG will also utilize existing working groups as necessary. Belgium participates in the ASG and the relevant working groups as appropriate.

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The scientific basis - Global

Research into the scientific basis of anthropogenic causes of climate change has been ongoing internationally for some time.

Research has also been progressing on addressing the impacts and adaptive responses to climate change internationally.
The most recent Fourth Assessment Report (AR4) {6} gives us an alarming overview of the current climate change implications throughout the world, as well as estimates of future impacts of climate change.

According to the IPCC, the global temperature trend for the last 25 years is 0.177 ± 0.052 °C per decade for the period ending 2006 {6}. When observations from 2007 and 2008 are included, the trend becomes 0.187 ± 0.052 °C per decade {7}. Projections for future temperature increase are situated between +0.3 and +6.4°C in 2090-2099 depending on the Special Report on Emissions Scenarios (SRES). For example, best estimates are +1.8°C in the B1 scenario and +4°C in the A1F1 scenario {6}. Thus the recent observed climate trend is one of ongoing warming.

Long-term trends in precipitation amounts are observed between 1900 and 2005 {6} with an increase in northern Europe. Projections suggest an increase in precipitation amount in Northern Europe and a decrease in Southern Europe. The Copenhagen diagnosis {45} states that new findings show that atmospheric moisture content over the oceans has increased, that rainfall has decreased in the northern hemisphere subtropics and has increased in the middle latitudes, and that this can be attributed to human caused global warming. The authors note that existing uncertainties in AR4, once resolved, point to a more rapid change and more sensitive climate than we previously believed.

The global sea level has risen by about 20 cm since 1870 {44}. Satellite measurements, which began in 1993, suggest an acceleration of the rise in sea-level rising {7}. New projections now suggest rises of between 0.5 m and 1.5 m for 2100 relative to 1990 {8}, much higher than the often cited +0.18 to + 0.59 m from the AR4 {6}.

The scientific basis - Belgium

In Belgium, various theoretical and practical studies have been conducted on climate change impacts and adaptation. One of the first bodies to support the climate change adaptation research in a structured way was the Belgian Federal Science Policy Office through the "Science for a Sustainable Development" programme . This program is financing research conducted by interdisciplinary networks mostly consisting of researchers from universities and research institutes. The implementation of follow-up committees, stakeholders and user groups for each project enhanced the cooperation with the people in the field and enables the direct implementation of this research in terms of policy measures. (see chapter 4, Adaptation actions on an inter-sectoral level a) Research)

Recently a Climate Centre was created by the Belgian Federal Science Policy Office with the goal of creating coherence in climate research and services across the federal research institutes. These institutes include:

ROB	Royal Observatory of Belgium
RBINSc	Royal Belgian Institute of Natural Sciences
RMCA	Royal Museum for Central Africa
RMI	Royal Meteorological Institute
...	...

The office also hosts the Belgian IPCC focal point.

Other regional institutes and administrations also support climate research examples of which can be seen in the table below (this list is not limitative).

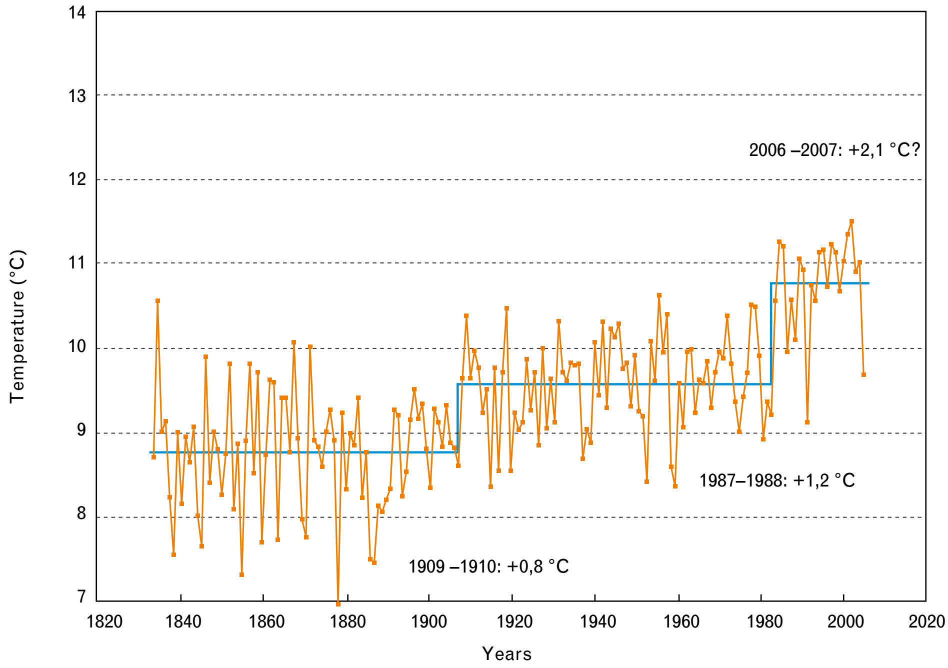
IWT	Agency for Innovation by Science and Technology Flanders
INBO	Research Institute for Nature and Forest (a scientific institute of the Flemish government)
WL	Flanders Hydraulics Research, Scientific institute of the Flemish Government, Division of the Department of Mobility and Public Works
MDK	Agency for Maritime Services and Coast
IRSIB-IWOIB	Institute for the encouragement of Scientific Research and Innovation of Brussels
IBGE-BIM	Brussels Institute for Environnemental Management
DGARNE	Walloon Administration for Environment and Agriculture
LNE	Flemish Department of Environment, Nature and Energy
BELSPO	Belgian Science Policy Office
AWAC	Walloon Agency for Air and Climate
VMM	Flemish Environment Agency
...	...

Climate research is also conducted in universities financed by several sources such as:

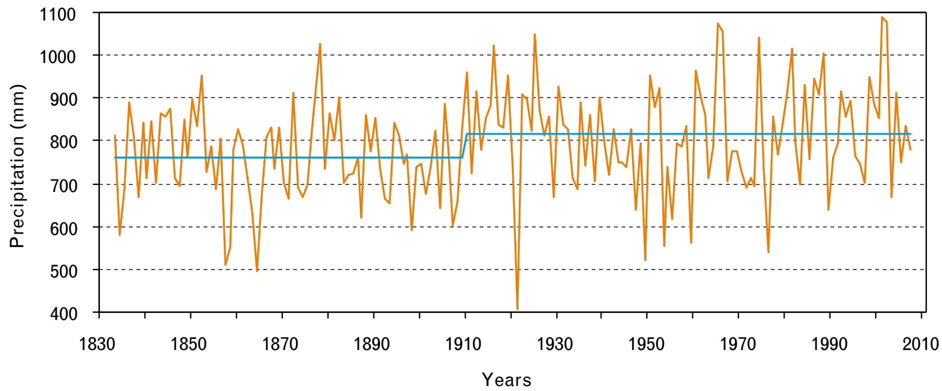
FNRS	National Fund for scientific research.
FWO	The Research Foundation Flanders
...	...

Furthermore, Belgium collaborates with its neighboring states in Interregional Research Projects such as TIDE (Tidal River Development), AMICE (Climate Changing? Meuse Adapting!) or Future cities (Future Cities - Urban Networks to Face Climate Change).

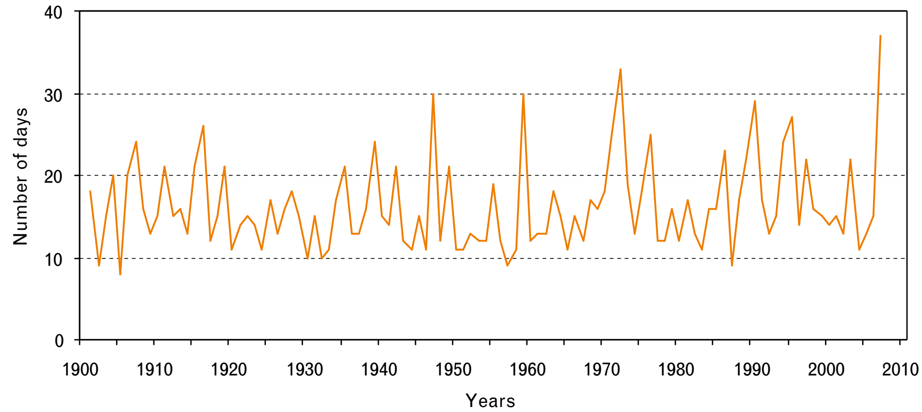
"Annual" temperatures series, calculated from the 12 monthly means between July & June, in Uccle, for the period 1833 – 2007



Annual quantity of precipitation in Saint-Josse-ten-Noode/ Uccle 1833-2007



Duration (in days) of the longest period without appreciable daily precipitation (daily minimal quantities < 0.5 mm) during the 6 hottest months of the year, In Uccle, for the period 1833-2007



[source: IRM, 2009 {9}]

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According to a recent report {9}, meteorological observations in Ukkel since 1830 point to a temperature increase of ~2 °C over the entire period (1830-2010). Contrary to what is often thought, the temperature increase is not gradual but occurs in marked and quite severe steps, of the order of ~1 °C, (this was first observed around 1910 and then again in the 1980s). The stepwise increase is observed in seasonal and annual temperatures.

Observations on rainfall show that between 1833, when recordings began, and at the end of the 20th century, the Brussels region has seen an increase of roughly 7% in annual rainfall with increases of around 15 % in winter and spring. Moreover, over the past 50 years, most climatological stations in the country have revealed a trend towards significant or highly significant increases of annual extremes of rainfall extending over several days; this type of extreme precipitations usually only occurs in winter. On the other hand, annual maxima for precipitations over 24 hours remain stable, except near the coast where, daily annual maxima are already showing a significant increase {9}. After analyzing all the precipitation data, neither the intensity nor the frequency of violent storms in the whole of the country have shown any marked increase over the past 50 years, with the exception of the area close to the coast. With regard to drought, a preliminary study {9} shows that the longest periods without significant recorded precipitation show no major change since the early 20th century.

On a climate zone scale, Belgium is a small country (30.528 km²), while most climate models have a resolution between 50 and 300 km². Consequently, it is not easy to provide climate change projections for the country. However, the publication of a number of climate change simulations has provided valuable information for Belgium {10}.

In the Environmental Outlook {34} three climate scenarios were used from a wide range of simulations by climate models. These climate scenarios outline a range of climate change variation in Flanders/Belgium by the end of this century. They include both the differences in the possible greenhouse gas emissions and the uncertainties linked to the climate models used:

- The wet climate scenario (a 'high' scenario) results in the greatest increase in the level of precipitation that leads to high runoff discharges, high water levels in the rivers, flooding, high soil water and groundwater levels in winter.
- The dry climate scenario (a 'low' scenario) results in the greatest problems with low river flows, low soil water and groundwater levels during dry summer periods. In the spring there may be somewhat higher groundwater levels.
- The moderate climate scenario (a 'middle' scenario) results in moderate results, both for high and low flows and wet and dry periods.

Temperature projections for Belgium, which are illustrative of the global trend, predict winter temperature increases ranging between 1.5°C and 4.4°C and summer temperature increases between 2.4°C and 7.2°C (up to + 8.9 °C in August) by the end of the 21st century {11}. Over the last 25 years, high temperatures in Belgium have beaten all records and heat waves have caused substantial casualties, in particular the heat wave during the summer of 2003 which had a large number of social, economic and environmental repercussions {12, 13, 42}. Regional projections for Belgium, based on regional and global climate models, predict a maximum increase in winter precipitation up to 60 % and a maximum decrease in summer precipitation with 70 % for the period 2071-2100 compared to 1961-1990 {10}. At the Belgian coast and in the Ardennes region, the precipitation increase is expected to be more important while the precipitation decrease in summer is expected to be less strong than other areas in Belgium.

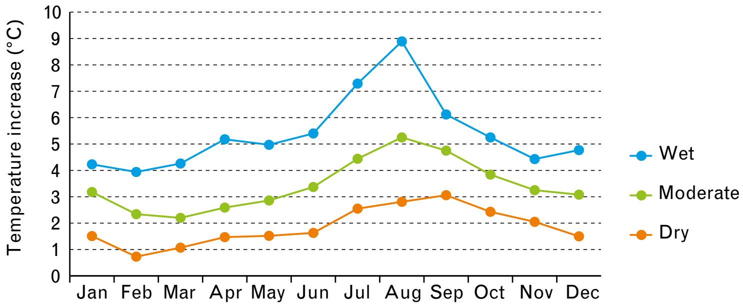
Sea level in Oostende rises at a rate of 1,69 mm yr^{-1} since 1927, although an increase in this sea level rise seems apparent it is not yet statistically proven.

For Belgium, projected changes in winter precipitation during the 21st century reveal a moderate increase in precipitation (between 0 and +60 %), whereas summer precipitation are expected to decrease, although quantitative findings vary here (ranging from only a small decrease to up to 70 %). The frequency of significant rain events is also set to rise {10, 12}. During the winter months, the groundwater recharge is expected to increase. Although this may partly compensate for the summer drying, in specific regions (mining areas in particular) higher levels in aquifers[2] may possibly contribute to flooding {30}. Increases in the flow of watercourses reaching 4 to 28 % in 2100 are projected {31}, resulting in an increased risk of flooding for all water basin catchments studied. Water demand during the summer will increase, in particular if irrigation becomes a widespread agricultural practice. Dry summers, with increased evaporation and possibly reduced precipitation, will probably reduce the groundwater level significantly {30, 32}. In contrast, increased winter precipitation will contribute to larger groundwater recharge. Changes to aquifer levels cancel each other out over a year or so and should therefore not be problematic.

2 — aquifer: an underground layer of water.

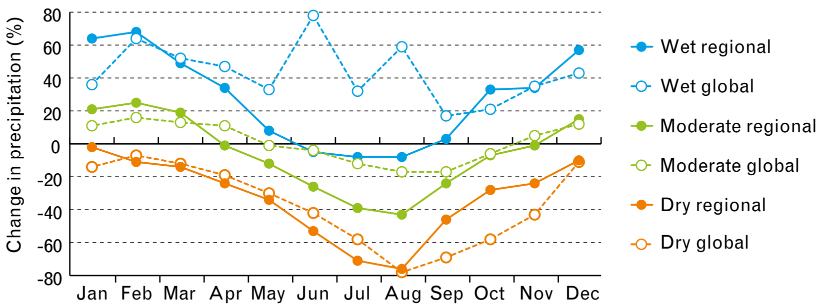
Increase in monthly mean ambient temperature according the to 3 climate scenarios

(Ukkel, scenario period 2071-2100 compared with the reference period 1961-1990)



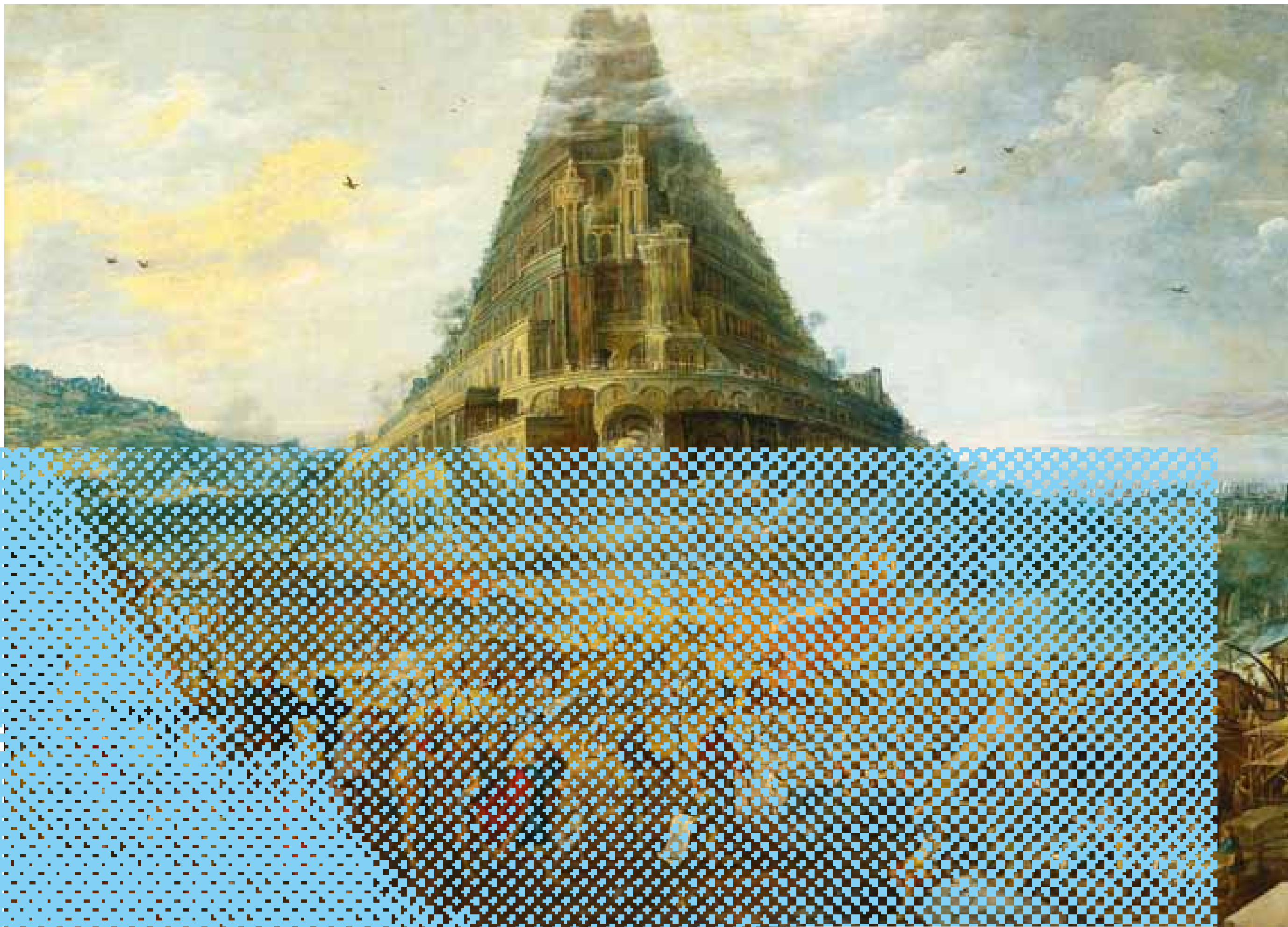
Change in monthly mean precipitation according to the three climate scenarios

(Ukkel, scenario period 2071-2100 compared with the reference period 1961-1990)



'Regional' concerns the results with regional climate models, 'global' concerns the results with global climate models.

Source: Flanders Environment Outlook 2030 (Flemish Environment Agency)



3 Impacts of climate change in Belgium

Introduction

The European White Paper on adaptation regards coastal zones, river flood prone areas, cities and urban areas (among others) to be particularly vulnerable to climatic changes. All these vulnerable areas exist within Belgium, which makes the need for a specific Belgian Adaptation Strategy more urgent.

In Belgium, water and heat (and the combination of this two) can be considered as the most important domains, which will be impacted on by climate change. Lack of water associated with high temperatures results in severe impacts on public health. Agriculture and forestry can suffer as well from lack of water, causing irrigation and water management problems. Inland navigation can also suffer from low water levels in rivers and channels. On the other hand, increased and more intense precipitation can generate floods with severe impacts on coastal and river flood prone zones (flooding and subsequent salinity problems), on agriculture (erosion), on cities and urban areas (infrastructures, sewage systems, roads, ...), and on biodiversity (changes in phenology[3], ...). Climate change is only one pressure among others that the different sectors have to deal with. However, in several cases climate change will increase the already existing problems.

All economic sectors can be exposed to impacts related to climate change.

Below, the main impacts of climate change in Belgium are detailed for different sectors. The approach taken follows that set out in the EU White Paper. A coordinated approach to research has not been pursued in Belgium to date. This has resulted in fragmented (but valuable) sectoral information.

3 — Phenology = chronology of seasonal periodic events linked to the vital cycle of living organisms such as flowering, nest building, migration, etc.

Main impacts in the different sectors

A - HEALTH

Heat waves — Although heat waves in Belgium are still uncommon, according to the IPCC report, climate change may cause heat waves in the European region every other summer by the end of the century. The heat wave of the summer of 2003 was the most severe ever recorded in Belgium. It resulted in about 1,300 deaths mostly among the people over the age of 65 {15}. Research is still needed to assess the importance of high ozone concentrations which are connected to heat waves. However it is clear that heat waves have a significant adverse health impact, such as exhaustion due to sweating, leading to water and salt deficiencies, and heat strokes caused by a loss of temperature control in the body which is a severe and potentially lethal condition. The most vulnerable groups are babies and young children, elderly people and top class sportsmen and -women {16}.

Higher mean temperature — It is expected that higher temperatures will reduce the prevalence of some winter diseases (e.g. cardio-vascular diseases), although no detailed studies on this issue are available for Belgium.

Diseases — Europe could face an increase in the outbreak of diseases such as botulism caused by warm anaerobic water and vector-born diseases. The vector-borne diseases are transmitted by arthropods such as ticks (e.g. tick-borne encephalitis (TBE), Lyme disease), mosquitoes (e.g. Chikungunya fever, Dengue fever, malaria, Rift Valley fever), or sand flies (e.g. visceral leishmaniasis). Climatic changes, such as hotter and longer summers, warmer winters, and/or increased annual rainfalls could enable these cold-blooded organisms to shift their habitats, potentially introducing diseases to places where they have not been seen before or reintroducing them to places where they were previously eradicated {17}.

The number of cases of Lyme disease in Belgium increased rapidly from 137 in 1991 to a peak in 2000 of 1442 cases {18}. Climate change may indirectly play a role in the increase of the number of people affected, by favouring better conditions to disease vectors development. Furthermore, also food-borne illnesses are likely to increase due to the warmer climate as they tend to occur more during the warmer months.

B - TOURISM

A moderate rise in the mean temperature could have an overall positive effect on tourism in Belgium (particularly at the coast) {14}. A similar effect has been observed in Great Britain: after one or more sunny summers, more British tourists stay in the country and there are also more foreign tourists {19}. Additional efforts will nevertheless be needed to deal with the added stress on infrastructure (both by tourists and associated goods), maintenance of beaches due to increased coastal erosion, and the quality of bathing water. There are also limits to tolerable temperature increases, in particular due to heat waves, even though the drier air should make heat more acceptable. River sports and associated activities could be negatively impacted by reduced river flow in summer but warmer temperatures may also favour "nature tourism". Winter sports, which are already compromised due to warmer winters, may completely disappear. Rainy and possibly cloudy winters will not favour outdoor activities. Indirect impacts of climate change on other sectors may also have effects on tourism, e.g. deterioration of natural zones, damage to infrastructures or historic buildings due to flooding, etc. Furthermore, it should be kept in mind that socio-economic factors may also have significant impacts on tourism.

C - AGRICULTURE

Below a three-degree rise in local temperature, the impacts of the climate change on agriculture expected in Belgium during the 21st century, should be limited and even positive for certain crops such as wheat {20}. However, a rise in mean temperature tends to lower the yields of many crops. This is mainly a consequence of faster plant growth, resulting in more rapid maturity and reduced accumulation of organic matter. Up to around 2-3°C, yield reduction tends to be compensated for by the fertilizing effect of increased CO_2 concentration for most crops. Carbon dioxide also improves the efficiency of water use in plants, and increased temperatures are favorable for some crops such as maize. However external events such as heavy rains and the probable spread of diseases and exotic animal and plant pests may also have a yet unknown significant (negative) effect. Up to around 3°C, the expected impacts are thus quite limited. Adaptation measures such as changes in crop choices, changes in sowing dates, improved humus content of agricultural land and possibly irrigation, may help reduce the severity of climate change impacts and will result in fewer losses caused by the changing climate. On a Flemish level, the financial losses will be moderate, between 0.1 % and 4.1 %, depending on which climate Flanders will evolve to in the future {21}. If agriculture adapts itself to the changing climate, the losses might decrease from 0 % to 0.4 %. Summer drought will especially have a negative influence on crops with superficial rooting, such as beetroot and potatoes.

The maize crop has expanded spectacularly over the last 40 years in our country: from 2.000 ha in 1966 and 20.000 ha in 1970, until 247.700 ha in 2009. This expansion is also seen in other European countries (Denmark, Ireland and Norway). Thanks to milder temperature during the crop period (and in particular the absence of frost under -1°C between May and the end of September), the areas like the Ardennes which were often judged too cold in 1980s, are now more suitable to the cultivation of maize, with yields doubling since the 1980s. As long as the precipitation is not altered greatly in our regions, this global warming is rather positive for this plant, coupled with the elevation of CO_2 concentration, plant growth is expected to be better. Nevertheless, this climate change can also bring new diseases (e.g. the helmonthosporiosis) to which we must pay attention in our selection programs. For example, the presence of the maize pyralid (Ostrinia nubilalis), a butterfly whose caterpillars cause damage in maize crops. This nocturnal butterfly has not yet economic impacts in our crops but its movement into Wallonia from the South can be considered as a climate change indicator (Communication from the CIPF).

D - FORESTRY

In 2000, Belgian forests covered 693.100 hectares or 22,6 % of national territory. Deciduous and coniferous species covered 51% and 49% respectively of the area. Belgium has the second highest net annual growth increment in Europe (after Germany) {22}. This large growth of biomass amount is due to good forest management practices and also to the age structure of tree populations. It is expected to continue for 10 to 20 years before reaching a natural ceiling.
To anticipate the effects of climate change on Belgian forest ecosystems, various scientific studies have been undertaken in the past decade {23, 24, 25}. The results show that increasing CO_2 concentration in the atmosphere will accelerate forest growth. However, in the medium-term, this growth will be limited by soil fertility on the

one hand and the relative drought caused by higher temperatures and precipitation changes on the other hand. Some conifers, the spruce for example, will be increasingly less suited to the climate because of the milder, rainy winters. In time, broad-leaved trees (such as beech) could also become poorly suited to the climate due to periods of drought.
Although the direct link with climate change has not been demonstrated, beech stands have recently been invaded by timber-boring insects, the impact of which was the destruction of more than 10% of standing volume. Climate change may favour the extension of the distribution of pests to the north or lower latitudes.

In recent years, certain exceptional climatic events such as storms or long periods of drought have also had significant impacts on growing stock. The impacts of one-off events are all the more pronounced on weakened stands. Contrary to the results of research in the agricultural sector, in time, the impact of droughts in forestry could be more negative. Other indirect effects are also expected, but are currently hard to quantify. Policies and measures to develop biomass energy production will probably have a major impact on both the choice of species (favouring fuel wood) and forestry practices (development of short rotation stands). The development of this sector needs to be aware of the potential impacts of climate change.

Xylosandrus germanicus, a beetle attacking several tree species accidentally introduced into Europe about 50 years ago, has an altitude range limit of 350 m in Belgium. Global warming could allow this species to settle permanently in the whole of the Ardennes area, which until now has been free of it {26}.

4 — Phenology is the study of biological seasonal cyclic events or interannual variations, mostly concerning the annual first appearance of animals or plants.

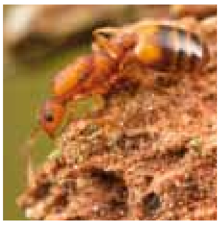
5 — Pollinator is the vector that brings the pollen (male) to the stem (female).

E - BIODIVERSITY, ECOSYSTEMS AND WATER

According to the IPCC, global impacts on biodiversity are an important cause for concern, even for relatively small increases in temperature (1-2 °C). Changes in ecosystems are already being observed, with species moving to the north or to higher altitude environments. The evidence of the impacts of climate change on biodiversity has already been observed in Belgium. For example early migrations of some species of birds and insects (such as dragonflies and butterflies) have been identified in our regions {27}. This is not simply a matter of the interactions between species, which can cause complex disruptions to ecosystems. In Belgium, as elsewhere in the world, biodiversity losses can be felt indirectly in air, water and soil pollution, fragmentation and destruction of habitats, intensive agricultural and forestry practices, exotic invasive species etc. Climate change however is becoming an increasingly important factor in this equation
One climate-related threat involves changes to the phenology[4] of certain species, which at times is causing disruption to existing interactions between species. For example, if the flowering period of one specific plant and the emergence of its specific pollinator[5] don't occur at the same time, it can endanger both the survival of the plant and that of the pollinator concerned. The arrival of new species adapted to the warmer climate may have adverse effects. Some species will disrupt the structure of existing ecosystems or modify relations between species, in particular due to competition for food or habitat. At the same time, species that are already present in Belgium but only in warmer areas such as buildings and/or cities may spread in the natural environment, where the result may be competition with indigenous species.

Future warming is expected to increase the number of marine species in the North Sea, as warmer waters tend to suit particular species. New species will arrive either as invasive species from more southern European waters or in the form of non-indigenous species from warm marine regions elsewhere in the world. There are strong indications that the ecosystem in general and the (commercial) fish stocks especially were, are and will be affected by climate change. The spatial distribution and/or recruitment of species important for the Belgian fisheries like sole, plaice, and cod were already negatively affected by climate change {29}. More southern commercial species, like red mullet and John Dory, which are currently not important for Belgian fisheries but have a high economic value, are likely to increase their northerly presence in response to climatic warming. Further rises in temperature are likely to have profound impacts on commercial fisheries through continued shifts in distribution and alterations in community interaction {14, 22}.

The probability of flooding will increase (especially in coastal regions) because of an increased sea level rise, surges and potentially more intense and/or frequent storms. Possible consequences for the ecosystem include an alteration in water quality and quantity and changes to habitat and biodiversity. Damage linked to an increased risk of flooding mainly involves the economic and safety impacts with secondary social impacts such as loss of property and potential loss of human life. The erosion of beaches could also reduce the appeal of the coast, whereas if this is managed, it could have a positive impact both on its biodiversity and attractiveness. Another secondary effect of sea level rise is the erosion of sand dunes. This effect will not only result in a reduced appeal of the coast but also reduced natural protection against flooding from the sea, and thus increase the penetration of salt water into the polders. Loss of dunes means also loss in typical species and habitats and might even have effects on the salinity of the inland. Furthermore, reduced water flow (in summer) can lead to increased pollution of surface water (where water levels are markedly low, concentration of pollutants is higher). In addition to this, the rise in the water temperature during these same periods (which in the future are likely to be more marked in summer) can lead to a reduction of oxygen saturation rate, which could damage the survival of fish and other aquatic organisms.



Four exotic species of ants are currently found in Belgium only in warmer places such as buildings and/or cities {28}. The South-American Coypu has been present in the country since 1900 but its population has been limited by cold winters. Recently its population increased. Similar findings have been observed for the Californian tortoise.

It is suggested that the recent increase in the amount of heavy rainfall leading to floods within the sewer network, is caused by hydrometeorological[6] conditions that are less or as extreme as those observed during the 1960s {10}. Of course, land use has changed significantly in the meantime (for example, urban areas have become larger with large-scale sewer networks constructed). Consequently today's hydrological impacts are very different from those of the 1960s. As a general rule, since the 1980s a trend towards increased evapotranspiration[7] has been observed in every season; over the past decade, however, the most pronounced changes have been during the winter (as is the case for precipitations). These changes are consistent with current temperature trends which indicate warmer winters than previously observed. Various studies have also indicated that winters are likely to become milder in the future, which would imply that the evapotranspiration rate will increase. This would in part explain the increased precipitation during winter, given the larger quantities of water vapour in the atmosphere. In contrast to the findings on rain, there were no clear indications of cyclical behaviour in the case of evapotranspiration. In Belgium, changes in mean river flow are either positive or negative, according to the different climate change scenarios. The result is determined by the balance between increased precipitation and a higher rate of evapotranspiration, which largely depends on the river basin catchments.

Due to the high uncertainty over precipitation changes, particularly in summer, it is very difficult to draw any conclusions. Increased evaporation due to temperature change is a fact, and it may be that parts of Belgium will increasingly need to import water from other areas. In parts of the country, specifically in Flanders, the availability of water per capita is low {27}. Water management is already an important concern in Flanders, which imports a significant fraction of its drinking water from Wallonia.

6 — Hydrometeorology: a branch in between meteorology and hydrology that studies the water and energy flows between the land surface and the lower atmosphere.
7 — evapotranspiration: the sum of evaporation and plant transpiration from the land surface to atmosphere.

Climate change will represent additional pressure on water resources, especially in summer. During present-day dry years, the availability of water is also reduced in canals, which necessitates groups of ships crossing the locks together.

The changes in precipitation together with evapotranspiration and, consequential the linked reduced water flow in summer, as well as the loss of dunes for the coast in particular, will negatively influence the availability of drinking water. This need is life-threatening and will become more often a source of conflict.

Climate change impacts on insects have been observed in Wallonia over the last 10 to 20 years. In the mid-90's, dragonflies were observed to move from the South to the North (Lestes barbarous, Crocothemis erythrea, Sympetrum fonscolombii). The phenomenon was attributed to the succession of warmer and dryer summers (and so linked to climate change). Soon after, the phenomenon was also observed in other groups of insects: grasshoppers, crickets, butterflies (Brenthis daphne, unknown in our country and observed for the first time in 2006 in Belgian Lorraine where it spread progressively; Pararge aegeria which reached the Ardennes summits where it was absent 20 years ago), wasp, bee, ant, spider, … Another phenomenon clearly shown in neighbouring regions is the earlier emergence of some species (e.g. dragonfly and butterfly) during the annual cycle. This can lead to the apparition of supplementary generations along a season, as it was reported in Wallonia during the particularly favourable summer in 2003. (Communication from the DEMNA)

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F - COASTAL, MARINE AND TIDAL AREAS

Changes in sea level will not be the same in all parts of the world, and not much is known about future regional variations. New statistics are available, indicating that the speed at which sea levels throughout the world are rising is accelerating (between 0.8 and 1.5m by the end of this century) {33}. Regional changes stem from variations in thermal expansion, changes in ocean currents, and land movements (in particular postglacial rebound). In Belgium, observations in Ostend for the period 1927-2006 show an increase in mean sea level estimated at 16 to 17 cm/century, with possible sign of acceleration during recent decades {14, 27}.

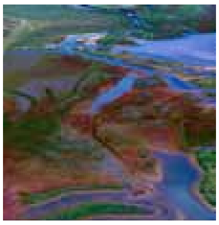
An analysis of temperature data reveals an annual increase ranging from 0.023°C in the north to 0.053°C in the central and southern parts of the North Sea. Based on the study of literature, data analysis and scenarios developed in neighbouring countries, various scenarios have been produced for Belgium {14}. These range from a moderate scenario (with a 60 cm increase in sea level for 2100) to an extreme scenario (with a 200 cm increase in sea level between now and 2100). Hydrodynamic, wave and sediment-transport models were adapted with a view towards assessing the impacts of these various scenarios on, for example, waves on the near shore. Results show that currents can increase by 10% to 20%, and a significant increase in waves along the coastline {14}.

8 — Perpendicular transport is the transport in a right angle to coastline

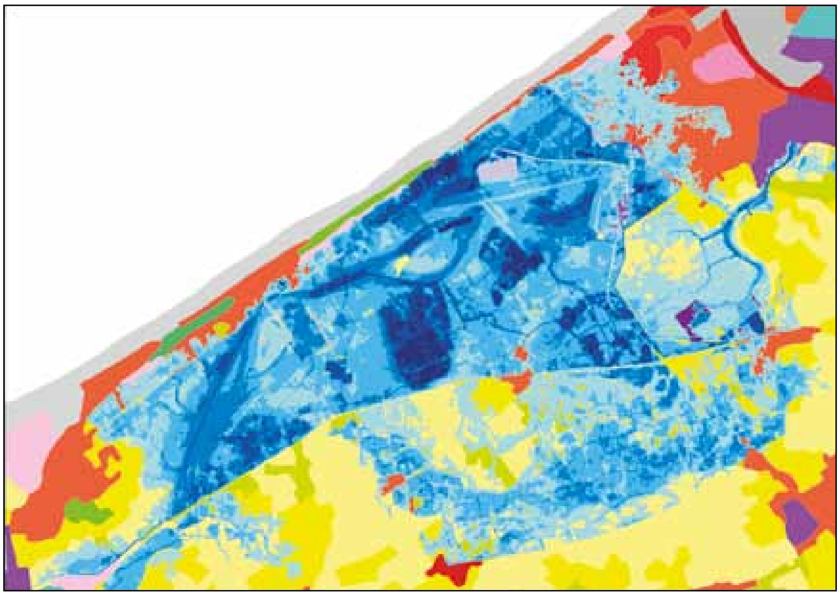
Climate change exposes the coastal region to three main types of impact: floods during storms, coastal erosion, and deterioration or loss of natural ecosystems, including wetlands.
The Belgian coast has a length of 65 km, half of which is protected by seawalls. Every 5 years a thorough investigation of the safety level of the coastal protection is executed. Currently, there is a higher risk of flooding through the coastal towns of Oostende and Wenduine and through the coastal harbours of Nieuwpoort, Oostende, Blankenberge and Zeebrugge.

Beaches and dunes also have an important role in protection against flooding. Beach erosion is variable: some beaches are stable, a small fraction is growing, but around one third has been eroding continuously for a long time (based on annual monitoring and as a net result of all movements, being the longitudinal transport by currents and the perpendicular transport[8] by wave action, winter cycle encroachment by storms and summer cycle alluviation (accumulation) of sand on the foreshore of the beach). Moreover, rising sea level will also influence the swell and the impact that this will have.

As a rule, a rise in sea level may also affect coastal natural areas. Other expected impacts of an increase in sea level are rising groundwater levels and an increase in soil and groundwater salinity.



The Zwin reserve, a Ramsar wetland at the border between Belgium and the Netherlands, is an example, of an inward space give over to the natural environment. The ecological value of this natural zone is due to the fact that seawater regularly enters the area, while there is no external freshwater input from surface waters. Although sea level rise should affect this wetland by more floods, there is an opposite evolution by natural accelerated sand suppletion.



Corine land cover (2000)

- Continuous Urban Fabric
- Discontinuous Urban Fabric
- Industrial or Commercial Units
- Road and Rail Networks
- Port Area
- Airports
- Mineral Extraction Sites
- Green Urban Areas
- Sports and Leisure Facilities
- Non-irrigated Arable Land
- Pastures
- Complex Cultivation Patterns
- Principally Agriculture, with Natural Vegetation
- Natural Grasslands
- Moors and Heathland
- Beaches, Dunes & Sand Plains
- Water Bodies

Water depth (m)

- < 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- > 2

N

Source:
Department of Mobility and Public Works –
Flanders Hydraulics Research

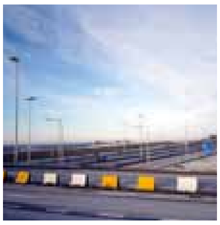
G - PRODUCTION SYSTEMS AND PHYSICAL INFRASTRUCTURE

It's probable but not proven yet that the magnitude or frequency of the most severe storms will increase. The severe storms that struck France at the end of 1999 and 2010 (named 'Lothar', 'Martin' and Xynthia) showed the capacity of such storms to inflict serious damage to buildings and other infrastructure.

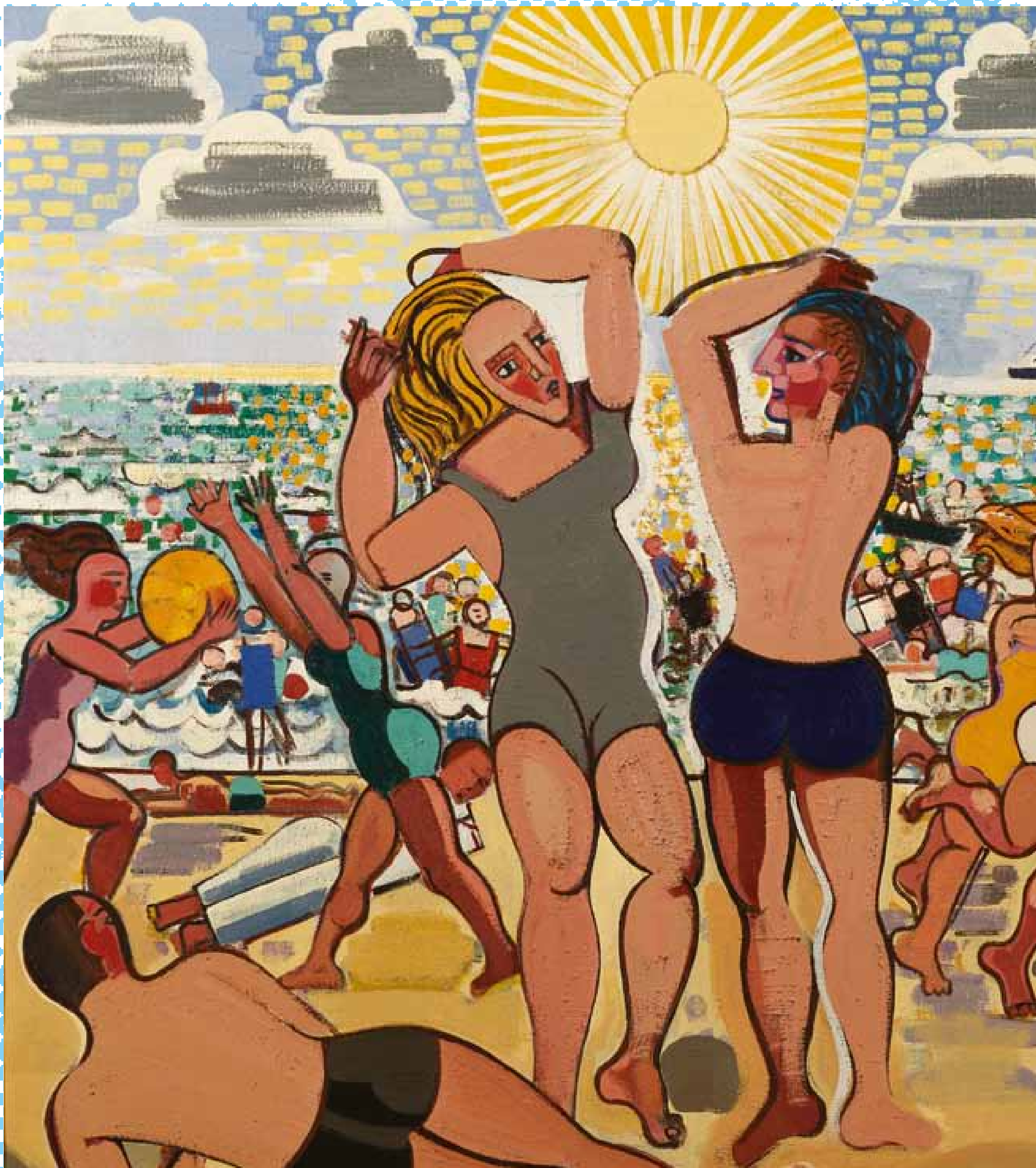
In relation to heat waves, urban areas will be particularly vulnerable. The "heat island effect" will make heat waves more severe in infrastructural (i.e. built) environments than in natural environments. High temperatures during heat waves will also result in decreased labour productivity and more aggressive behavior {35}. Last but not least, photochemical smog[9] will increase as the result of air pollution in combination with sunlight. Thus, spatial planning will play an increasingly important role in adaptation planning and should not be neglected. However, the way spatial planning is organized in Belgium will prove to be a challenge to our ability to adapt.

Energy — Within the impacts on physical infrastructure, special attention is given to energy systems and their related infrastructure For instance, if storms increase in both magnitude as frequency, this poses a bigger risk for damage to power lines. Furthermore, increased temperatures will reduce energy needs for heating in winter while increasing cooling demand in summer. The need for adaptation to severe heat waves and more intensive precipitation is a new concern, and much infrastructure is likely to be poorly adapted, e.g. roads or power stations which rely on river water for cooling.

9 — Photochemical smog is a reaction from sunlight with some air polluters originating from combustion (cars, heating,…). The result is something between smoke and fog clearly visible lying as a veil over a region.



Asphalt roads will not last as long as they were intended to, which means that costs of maintenance of road infrastructure will seriously increase.



Adaptation in Belgium

4

The Belgian institutional structure

At national level, the Working Group Adaptation under the Coordination Committee for International Environmental Policy (CCIEP) monitors and discusses European and international decisions in relation to adaptation, which might have national consequences or bring obligations with them (such as the Green Paper and the White Paper on Adaptation). At the same time, and in order to develop a National Adaptation Strategy, a Working Group Adaptation was created under the National Climate Commission. This group focuses on the issues of domestic adaptation, the follow-up of adaptation policies and measures elaborated in the different regional and federal administrations. In practice, both groups consist of the same people, which operate under a different mandate depending on the context and the theme of discussion.

At regional level, committees and contact groups have been set up in both the Walloon and the Flemish region. These groups are bringing together representatives of various sectors likely to be affected by climate change (such as water, air, agriculture, nature and forests, health, spatial planning, etc.). The roles of these groups are:

- To exchange data and gather information on current actions undertaken by the different departments, which in practice constitute bottom-up climate change adaptation measures, and
- To coordinate an official regional position towards the national level and to identify priority goals and other adaptation strategies to be developed or implemented at regional level (Walloon Region Adaptation Plan/ Flemish Adaptation Plan).

In both the Flanders and the Walloon groups, interregional communication and synergy are actively pursued.

A - HEALTH

As a first step, the federal government has set up a ‘heat waves and ozone plan’ {36} in the framework of the Belgian National Environment and Health Action Plan (NEHAP). This plan involves a series of phased-in measures and communication initiatives in addition to actions targeting the reduction of ozone formation.
The first phase takes place every summer and focuses mainly on preparatory actions and dissemination of public information, and calls for the support of people at risk. The pre-alert phase begins when the mean minimum and maximum temperatures, over a period of two consecutive days, exceed a threshold corresponding to the 95th percentile of summer temperatures. The alert phase is declared when the Royal Institute of Meteorology forecasts a heat wave of three days or more, or when the Interregional Environment Unit forecasts ozone concentrations above the EU information threshold. Warnings are then sent to emergency rooms and geriatric departments of hospitals, rest homes, etc. A survey on the application of concrete measures in these organizations is being conducted. This monitoring is one of the elements taken into account by the authorities when deciding whether it is necessary to move into the crisis phase, which implies the creation of a crisis unit and additional measures. Since 2007, the working group has widened its scope to include air pollution episodes affecting human health.

B - TOURISM

In the European green paper it is made clear that the circumstances for tourism will slightly improve, especially on the west coast of Europe. Better climatic conditions during a longer period are forming the base for this improvement. Specific adaptation measures focusing on tourism will probably not take place; however, investors in tourism infrastructure will need to take climatic changes into account immediately. Possible measures could include: diversification of tourism attractions and revenues, coastal management plans, adjusted building design standards, adjusting of insurance premiums etc.

C - AGRICULTURE

In Belgium, the Agricultural Sector Investment Programme (ISA in Wallonia or VLIF in Flanders) includes a number of initiatives to encourage farmers to take environmental (and climatic) aspects into account in their operational management. Financial support is granted for investments relating to building adaptation, integrated approach to disease control, re-assessment of water and waste water management systems, etc. The agro-environmental programme includes appropriate voluntary measures to address the consequences of a number of extreme climatic phenomena. Measures targeting, for example, the prevention of erosion of agricultural land (such as hedges, fringes, winter land cover, etc) are already available to farmers.

The objective of the current Belgian agricultural strategy is to maintain the carbon content of agricultural land and preserving its potential to capture and store CO_2 (in line with the EC regulation) represents an exemplary measure which serves both mitigation and adaptation. Therefore the conditionality (of the payment of European subsidies to the agricultural sector) linked to compliance with environmental provisions in force is already encouraging the maintenance of permanent meadows and oblige farmers to take action when soil humus is analyzed as too low. Moreover, in Wallonia, the Programme for the Sustainable Management of Nitrogen in Agriculture (PGDA), transposing the Nitrate Directive in Wallonia, incorporates a coherent set of obligations to encourage the maintenance of soil humus content: sustainable management of organic matter via soil binding, winter land cover, etc. All these provisions will be evaluated and, if required, extended to meet the challenge of adapting agriculture to climate change in the Walloon region. In Flanders research has been carried out about the impact of climate change on the agricultural activities and the possible actions that can be taken to adapt to climate change {21}.

D - FORESTRY

For approximately the last 15 years, the regional administrations in charge of forest management have encouraged the replacement of conifers such as spruce and Scots pine by other species better adapted to mild and rainy winters, such as Douglas fir and broad-leaved trees. Regulatory and financial incentives are used, in particular subsidies for planting in accordance with a guide to species adapted to the present climate. The new Walloon Forest Code (approved on 15 July 2008 by the Walloon Parliament) advocates a mixed-species, mixed-age forest, adapted to climate change and able to mitigate certain effects. Forestry practices must therefore try to favour the species best adapted to (present-day) local conditions, which constitutes a first step towards adaptation to future changes. Species diversification and conservation of ecosystems that have remained little altered by human activity also help to enhance the adaptive capacity of forests to changes {37}. Among the measures outlined within the new Forest Code are the retention of dead or fallen trees, the retention of at least one tree of biological interest per 2-hectares area and the introduction of integrated forest reserves in broad-leaved stands. Moreover, in order to improve the resilience of the forest ecosystem, we should encourage complex forest structures, ensure that soil fertility is maintained, manage water resources optimally (enhance soil and groundwater recharge by maintaining good soil structure and limiting the water consumption of the ecosystem through our choice of species and forestry practices), monitoring the density of game populations and correcting imbalances by means of amendments to situations requiring a response. Such provisions also apply in the Brussels-Capital Region.

In the Walloon region, a group of experts is studying the impacts of climate change in forest ecosystems. This group has produced a document containing recommendations for policy makers and a good practice guide for forest managers. {46}

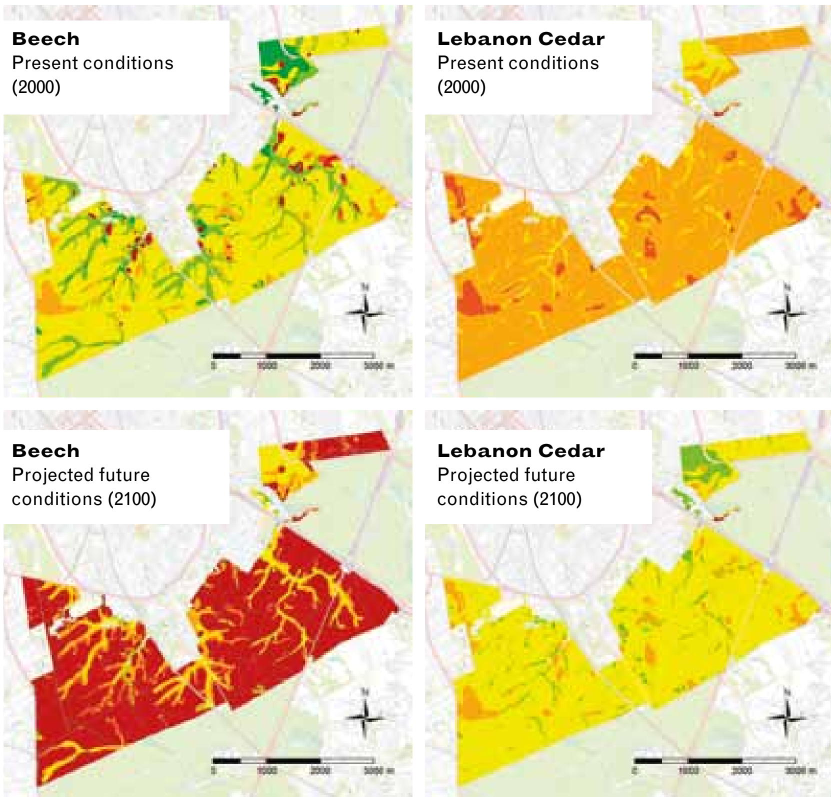
Nature and forest policy in Flanders is not only focussing on the climate aspects, but is shifting towards taking care of the ecosystem on its whole. The aim is towards durable conservation of the multifunctional use of the woodland. The conversion from tree monocultures into mixed forest protects the forest against the climate change. In the new management plan there will be special attention to the speed of this conversion as an adaptation to climate change. Being a part of an international long-term monitoring system enables the government to have a good view on the health of the forest and if necessary change the management.

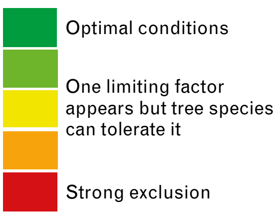
In Brussels there has been a study {36} on the influence of the climate change on the different species of trees in the forest. The study indicates that for example the famous beech galleries will disappear. Based on the results of this study, future tree species will be chosen to be better adapted to the climate change.

Potentiality maps based on the adequacy of the growing conditions for 2 tree species (left: Beech; right: Lebanon Cedar) for the present conditions (2000) and the projected future conditions (2100).

Source: ULg-GxABT, 2009 {43}.

More details such as other tree species examples and the complete legend can be found in the report. Due to the large uncertainties on climate change projections and on their interactions with the tree species, these maps should be interpreted as evolution trend.





E - BIODIVERSITY, ECOSYSTEMS & WATER

Although not focused on climate change, the agro-environmental programme puts forward measures designed to maintain and develop biodiversity (especially creating strips of land, grasslands, meadows with high biological value and preservation of local breeds). The implementation of the Natura 2000 network, which aims to preserve threatened species and their habitats, constitutes a major factor in the preservation of biodiversity. It is believed that agriculture, with its rich array of diversity, will offer within its many facets a great adaptive capacity to climate change.

As far as inland floods are concerned, regional prevention plans already exist[10]. All regional plans aim to improve knowledge of the risk of flooding, reduce and decelerate the run-off of water on slopes, protect, restore and establish flood zones, improve the management of rivers, decrease vulnerability in zones liable to flooding and improve crisis management. A network of stations is measuring the level of watercourses and amounts of rain. Rules banning the construction of buildings in areas prone to flooding have also been imposed[11]. These plans adopt both a preventive and palliative approach. Preventive measures can help to ensure that the built environment is better adapted to increased precipitation, both in terms of improved soil infiltration and short-term water retention on plots of land. Various measures are being implemented to recover rain water (the installation of rainwater tanks is compulsory for new housing and promoted through regional grants for existing housing) and to increase infiltration and evapotranspiration (limit on built-up areas, choice of permeable materials, plantings and green roofs).

One of the response measures in the Brussels region is the construction of a network of storm drains, which are generally connected to the sewer network. When rainfall is extreme, these drains enable runoff water to be stored in order to regulate wastewater flow within the sewer system. The region has more than thirty storm drains, some of which have a capacity of 30.000 m³ and some drains are still at the planning stage. They are big enough to absorb floods likely to occur once every 10 years. If the volume of heavy rains increases by 10%, which is a possibility within 50 to 100 years, this absorption level would drop to flooding likely to occur around every six years.
Furthermore, the 'blue network' being implemented since 1999 by the Brussels Region is an integrated program for the purification and restoration of Brussels' rivers and water bodies. It aims to restore the continuity of the hydrographic system and benefit from its 'flood buffer' function by recovering clean run-off water. This programme also contributes to the upgrading of rivers, ponds and wetlands in urban areas.

In Flanders, building plans, as well as any other plans that might have consequences for water, are checked for their hydrological consequences (a procedure called "watertoets", within the framework of the Coordination Commission Integrated Water Policy[12]). It applies in particular to zones prone to flooding, important for infiltration, or close to a drinking water catchment area. The objective is to avoid negative impacts on the water system, but also to reduce the risk and consequences of flooding. As a consequence, the authorities can demand specific measures if required, such as the use of permeable ground surfaces. In specific situations, the process may lead to the rejection of the building project, even in areas formerly indicated as suitable for building. Flood risk maps have been prepared to facilitate the implementation of these measures.

10 — Plan PLUIES in Wallonia (http://environnement.wallonie.be); Plan Pluie in Brussels Region (http://documentation.bruxellesenvironnement.be/documents/Plan_pluie_2008-2011_FR.PDF?langtype=2060)
11 — In the SDER (Schéma de Développement de l'Espace régional) and CWATUP (Code wallon de l'aménagement du territoire, de l'urbanisme et du patrimoine) and in Flanders in the Watertoets (www.watertoets.be).
12 — Flemish government decree of 18 July 2003.

As the drinking water sector is vulnerable to drought and inundations, a more sustainable use of the ground and surface water resources is set up {2}. Additional operational measures will be implemented both in terms of production and distribution.

At the federal level, new legislative changes deal with flooding and other natural hazards in the form of an obligatory annex to housing fire insurance policies {38}. The insurance cover against natural disasters will not be provided by state funds, except when the global cost exceeds a threshold linked to the turnover of the insurance companies. While the new legislation[13] is not primarily targeting adaptation to climate change, it may have a dissuasive effect on residential construction in areas where the risk of flooding is higher, in particular if this results in higher insurance premiums. In addition, there is a mechanism (price setting board) to limit the premiums for existing constructions in high-risk areas by sharing the cost among all insured parties. There are plans to draw up a map of the high-risk zones in cooperation with the three regions and to exclude any new construction in these zones from the premium limitation mechanism, making such constructions probably uninsurable. The system is still new, however, and prices are not yet known.

13 — Laws of May 21, 2003 and September 17, 2005.

F - COASTAL, MARINE AND TIDAL AREAS

In the past, flooding occurred mainly in the Scheldt estuary and its tributaries, leading to the adoption of the so-called 'Sigma-plan' several decades ago. In this framework, thirteen "controlled flooding zones" were established. These zones are managed so that occasional flooding during very high tides is tolerable and helps to lower the water level.

A seawall protects the land behind the flood zone. Recently, the Sigma-plan has been revised. The new plan, adopted in July 2005, involves new controlled flood zones (spatially reserved for this purpose) with the aim to prevent the navigable rivers from unwanted flooding. The Sigma-plan has to accomplish objectives such as the control of floods, the realisation of nature objectives in the Sea Scheldt basin, conservation objectives and measures for agriculture and recreation. A changing climate will have an influence on the water levels in rivers. A 60 cm rise in sea level is now taken into account (for example, in determining where river bank improvements need to be carried out).

Until the 1970-1980s, hard sea wall measures, such as the building of seawalls, were mainly used to counter the risk of flooding. Policymakers then realized that these hard structures eroded the beach even further as a result of wave action. Since the 1990s Belgium has mainly used beach nourishment as a response measure, ensuring that the beach causes the waves to break further away from the dyke and on the beach (as a result of a shallower water depth) and thus consequently decreases the number of waves crashing over the dyke. Furthermore, sand accumulation or nourishment (at the foot of the dune on the beach or on the foreshore) causes minimal disruption to the dynamic and natural interaction between the foreshore, the beach and the dunes, which is not the case when hard sea barriers are erected. This can be considered as an ecological advantage. Compared to hard sea barriers, these nourishment measures are also much more flexible with respect to the current and future rising sea levels (in terms of expansion and speed of implementation). Nevertheless, the seawalls still have a function as part of the sea defense and therefore they will need to be maintained.

There is currently a large project along the Belgian coast designed to bring the minimum level of protection up to that required to last through a storm that on average occurs once in a thousand years (a '1000-year storm') taking sea level rise till 2050 into account. In addition to that, zones where the risk of flooding[14] is large – usually as a result of severe potential consequences, for example residential buildings in low-lying areas immediately behind the sea defenses , are being designed need to withstand breaching by an even higher storm surge levels.

In conclusion, coastal defense designs can vary greatly and offer some flexibility and tailor made solutions. Beach nourishment allows for a more flexible way of dealing with rising sea levels compared to many solid constructions.
Though it is important to look into the future when selecting alternatives, it is not necessary to design all the measures up to 2100 right now, as the (social) costs of designing everything until 2100 right now are greater than for re-evaluation of possible modifications in 2050. Modifications can also consist of other measures (e.g. extra flood plains).
In the case of engineered solutions and their flexibility it is important to take into account the cost-benefits, the life estimation of these constructions and possible reservation of space for future additional adaptation measures.
The life span of certain hard measures (e.g. sea seawalls) is often 100 years or more and is therefore designed for service even after 2100.

Water management is a cross cutting issue, therefore adaptive measures in this sector will also influence activities in other areas. For instance, some of the measures mentioned above within the framework of flood prevention will also contribute to water availability. Current measures to improve surface and groundwater quality (e.g. in connection with nitrates from agricultural fertilizers) will help sustain the availability of affordable drinking water. These are therefore good examples of win-win measures.

14 — Risk = probability x consequence
15 — http://www.future-cities.eu/
16 — Directive 2002/91/EC, which the Member States must implement by January 2006.
17 — Flemish decree (17 June 2005) setting of criteria for energy performance and interior climatic quality of buildings criteria http://www.energiesparen.be/energieprestatie/infopunt/download.php

G - PRODUCTION SYSTEMS AND PHYSICAL INFRASTRUCTURE

The Interreg IVB-project 'Future Cities - urban networks to face climate change' tries to adapt city structures to the inevitable climate changes. As the cities are more vulnerable to climate changes (for example heat waves) combined measures such as energy savings, greening and bringing water in the cities are possible answers to lower their vulnerability. The city of Ieper in cooperation with the West-Vlaamse Intercommunale (WVI) are involved as partners in this project. A task for the project partners is to develop an ambition note and a master plan, realizing green and blue elements in the project, and to communicate and promote the project[15].
The structural protection of buildings through thermal insulation, solar protection via shutters, ventilation, etc., is another adaptation response to climate change. Initial regulations to further facilitate this were established in the framework of implementation of the EU Directive on the energy performance of buildings[16]. All the Belgian regions have established regulations and / or subsidies (for example on the cost of installing an external solar protection system in the Brussels Capital Region) specifically aimed at reducing the risk of overheating in new houses[17].

Adaptation actions on an intersectoral level

A - RESEARCH

General —The research programme 'Science for Sustainable Development' of the Belgian Federal Science Policy Office (Belspo) 2006-2012 finances two- to four-year projects conducted by interdisciplinary networks of two to five teams with the possibility of including one foreign team. Approximately 15 million euro is dedicated to climate topics, and from this amount € 3.6 million are dedicated to adaptation research, mainly studies on impact of climate change and adaptation possibilities, through a number of case studies. In particular, the issues of surface water, coastal management and fisheries and health are tackled. A small section of the programme is open to research supporting the development of standards for monitoring and implementing climate and atmospheric policy. Two projects deal with the economic value of ecosystems. Additionally Belspo[18] finances a Biodiversity Platform which coordinates and promotes Belgian research and actions on biodiversity (changes in Biodiversity being closely linked with climate change). Indeed climate change represents an additional threat on biodiversity and it is important to link these issues as often as possible in the decisions elaboration process.

Research on adaptation to climate change is also carried out in federal scientific institutions linked to the Belgian Science Policy Office. The latter is also a partner in the Circle and contributing partner in Circle-2 ERA-net (WL is partner), which aims to align research agendas for adaptation to climate change and to promote the development of internationally managed nationally funded research. The Royal Belgian Institute of Natural Sciences, the Royal Meteorological Institute, the Belgian Institute for Space Aeronomy, the Royal Observatory of Belgium, and the Royal Museum for Central Africa are amongst those scientific institutes that carry out the research as well as monitoring of climate change and its impacts. They are since short time grouped in the Belgian Centre of Excellence for Climate Research.

Another important programme to mention is the AGORA Programme, which finances measures of scientific support to other departments and federal institutions. For instance, one project aims at the development of a database in order to investigate the relationships between climate change and public health (collaboration between the Belgian Federal Science Policy Office and the Public Health Department). Furthermore, an important budget line (~€30M) is dedicated to research programmes on remote sensing, monitoring, earth observation (STEREOII, PRODEX, Vegetation,...) which may serve as a possible information basis for adaptation issues.

IWT, the Flemish Agency for Innovation by Science and Technology, helps Flemish companies and research centers in realizing their research and development projects. This agency offers them financial funding, advice and a network of potential partners in Flanders and abroad. It also supports the Flemish Government in its innovation policy. Projects on sustainable development have an advantage in the selection. Climate change mitigation and adaptation fall into this topic.
One of the projects funded by the IWT is the project focusing on Climate change and changes in spatial structures in Flanders (CcASPAR). The aim is to develop strategies to anticipate the possible effects of climate change and to assess new investments in spatial development and to investigate how to make them climate proof so they can withstand the effects of climate change.

Crosscutting the sectors of water, biodiversity, ecosystems, agriculture, health and physical infrastructure, regional entities are partner in several Interreg Projects, such as SCALDWIN, TIDE, AMICE or Future Cities.
The aim of the cross-border SCALDWIN[19] project (2009-2012) is to identify the best measures available for an improvement of the ecological status of surface water and groundwater, and a promotion of biodiversity in the Scheldt basin.
The TIDE project (2010-2013) focuses on a better knowledge of the ecosystem functioning and a coherent management of the estuaries of the Elbe (D), Weser (D), Scheldt (BE/NL) and Humber (UK).

18 — Belgian Science Policy Office
19 — http://www.scaldis.eu/front-page

The AMICE project (2009-2012) is a transnational project about the adaptation of the Meuse and its catchments to the impact of flooding and low waters due to climate change.
The Future Cities - project (2009-2012) aims at making city regions in Northwest Europe fit to cope with the predicted climate change impacts. The Future Cities strategy combines selected strategic urban key components - green structures, water systems and energy efficiency - for a proactive transformation of urban structures.

Federal and regional entities are also involved in international research programming through a number of era-nets (Circle and Circle-2 - climate change adaptation, CRUE - flooding, IWRM-Net - water management, SKEP - environmental protection, Splash water research in supporting developing nations) and JPI's (Click-EU; Healthy and productive seas).

A number of researchers are involved in European projects such as Circle, Blast or Past4future.
Monitoring programmes (e.g. monitoring changes in the quantity and quality of surface and groundwater) for the regional follow-up of climate change and its impacts were set up in the three Belgian regions by qualified partners.

B - INTERNATIONAL COOPERATION

In addition to worldwide reductions in greenhouse gas emissions, adaptation to the adverse effects of climate change has started to occupy a leading position in the list of priorities for international climate negotiations. Today, the adaptation aspect also plays a central role in international cooperation for development, security issues and environmental policy.

Since 2008, the Belgian development cooperation has explicitly included the fight against climate change in its policy as a priority. This is due to the fact that the consequences of climate change in many countries in the south are an important source of instability in terms of food security, biodiversity loss, land degradation and desertification, (environmental) migration, public health and tensions that could lead to conflicts. Developing countries, especially the least developed countries, are the first victims of climate change, even though they are less responsible for the causes and have fewer tools to combat climate change or to adapt their societies. In many developing countries, especially African countries, climate change adds additional pressure to difficulties resulting from long existing problems, such as poverty, poor access to education, weak institutions and governance, inadequate infrastructure, low access to technology and information, poor access to health services, problems with income generation and armed conflicts. These structural problems come on top of the threats that originate from the overexploitation of available natural resources, a quickly increasing population, desertification and land degradation. These stress factors make developing countries, especially the least developed countries, more vulnerable for climate change and make adaptation more difficult. The Belgian development cooperation is active in many sectors where the impact of climate change must be taken into account, such as agriculture and rural development, water, energy, infrastructure and health care. Through its bilateral cooperation, by supporting non-governmental organizations (NGOs) in the northern and southern hemispheres and by supporting scientific institutions, Belgium is contributing to several programmes and projects that all tackle adaptation to climate change in one way or another. In the framework of multilateral cooperation[20], Belgium supports amongst others international agricultural research (mainly the centers of the Consultative Group on International Agricultural Research (CGIAR) and the European Research for Agriculture/ Agricultural Research for Development (ERA/ ARD). In 2009 Belgium contributed to the Least Developed Countries Fund to support implementation of the National Adaptation Programs of Action (NAPAs) of these least developed countries. Belgium is planning to increase this support significantly as part of its contribution to the fast start funding package, negotiated in Copenhagen.

A first step towards a better integration of climate change concerns in the Belgian

20 — Since 2009 Belgium supports its multilateral partner organizations mainly through core contributions instead of earmarking specific projects, programs or objectives. Many of these organisations such as CGIAR, UNEP, UNDP, FAO and IFAD develop or support adaptation activities in vulnerable developing countries and regions.

Development Cooperation was the inventory of challenges and opportunities {39}. After which an operational strategy was set out {40}.
The fight against climate change must be the common thread throughout development policies and the focus must shift to support for adaptation in our partner countries. The main goals of the action plan are: promoting awareness, building a knowledge base on climate change and development and integration of the climate theme. In addition to this report, dialogue with partner countries and other donors (for example in the appropriate OECD DAC-fora[21] and within the EU[22]) helps to improve the Belgian policy on adaptation. Based on the dialogue within the DAC and resulting products, such as the "Policy Guidance on Integrating Climate Change Adaptation in Development Cooperation" an Environmental sustainability toolkit is developed by the research platform KLIMOS (Klimaat en Ontwikkelingssamenwerking, Climate and Development Cooperation) to improve mainstreaming of climate change and other environmental issues in Belgian international cooperation efforts. KLIMOS covers three main research areas: forestry, sustainable agriculture and food security in relation to climate change.

21 — The OECD-DAC created a policy-supporting manual to facilitate the integration of adaptation to climate change via various aid modalities (budget assistance, sector assistance, programmes and projects). In the statistical working group of the OECD-DAC, Belgium was involved in the development of a tracking indicator for adaptation resources. This DAC Rio-marker for adaptation was recently approved in December 2009. It will allow for better monitoring and evaluation of efforts concerning this theme in future.

22 — In September of 2009, an EU Expert Meeting on the Integration of Environment and Climate Change in Development Cooperation has been held, which aimed to start up a process following the invitation of the Council to the European Commission to prepare an ambitious EU wide environment integration strategy by late 2011, in close collaboration with Member States. This work will be continued in 2010, and may require an important input from the part of Belgium.

5 Strategy

The importance of adaptation to climate change needs no further explanation. Several leading reports, both national and international have proven that a climate change is happening and have shown the unacceptably high costs of inaction. This in turn has led to the variety of already implemented adaptation actions described in chapter 4. Although this is still a fragmented picture which lacks the necessary coherence, it does present an idea of the policy areas where adaptation is particularly important in Belgium. From this, one can conclude that in Belgium, adaptation to climate change should focus primarily on managing and adapting to water and heat problems related to climate change.

Water management (as a part of adaptation to climate change) is a crosscutting issue and affects many different areas. Protecting Belgium against possible floods from the sea and the rivers (including the new challenges presented by the development of flooding zones), the development towards a mixed-species, mixed-age forest, which will be better able to adapt to a drier climate and managing the impact of drought and salination in agriculture can ultimately all be seen as forms of water management. Less easily identifiable in Belgium is the issue of heat management, but heat waves and heat islands in public areas will undoubtedly have an adverse effect on public health. Of course one should not focus solely on these two areas; as Belgium is or will be confronted with other problems (as indicated in chapter 4).

When writing this Belgian National Adaptation Strategy, it was noted that a fully comprehensive future adaptation plan could prove to be useful to the further development of the Belgian adaptation policy. It could improve the internal coherence of this policy. And it identifies and fills gaps that, in spite of the actions described in the previous chapters, exist. Certain regional initiatives to develop such a (regional) adaptation plan have already started: the Flemish and Walloon regions are currently initiating a process which should lead to the elaboration of a Regional Adaptation Plan in the near future. The adoption of a National Adaptation Plan (NAP) should then be seen as elaborating and complementing the current National Adaptation Strategy, in such a way that it builds on the regional adaptation plans and tries to identify as much synergies as possible. This National Adaptation Plan could then list the different actions that have been taken or are planned to better adapt our society to climate change. Although, at this moment the extent of these actions is still unknown, in general, one can assume that the responses could be summarized in 5 categories {41}, being:

1. Reducing human and natural vulnerabilities and improving building resilience,
2. Managing water and land to protect natural systems and preserve vital ecosystems goods and functions,
3. Generating the funding and the institutional governance needed,
4. Accelerating innovation take up and technology diffusion,
5. Overcoming behavioural and institutional inertia.

To facilitate the development of such a NAP, this chapter describes the basic principles around which this plan could be centred, a rough outline and a (preliminary) table of content as well as an (incomplete) inventory of the necessary work to be done (a roadmap) before the actual development of the NAP can be initiated.

Principles

Although some of the following statements may appear self-evident, it is important to describe them in order to identify a common goal for adapting the Belgian society to the impacts of climate change. This way a solid foundation is laid on which adaptation policy on the different policy levels can be built.

The following elements form the background on which a NAP could be developed.

- Coastal areas, areas prone to river flood and cities and urban areas are amongst those considered to be especially vulnerable to climate change in Belgium. Adaptation to climate change has always been an important part of Belgian climate policy and will remain so in the foreseeable future. The development of a NAP should be seen as further strengthening the Belgian determination to be adequately adapted to climate change.
- Needs and measures differ greatly between different policy areas and between different geographic areas (such as the woodlands in the Walloon Ardennes, the coastal regions in Flanders or the urban environment of the Brussels area). Therefore it is not advisable to try and create one single 'adaptation rule' (which was also concluded by the European Union) and a diversified approach is proposed. Because of this, the NAP will have to interact on different levels, within different areas of expertise and with the uncertainty typical for climate.
- An important thread through the NAP, is the need for cooperation at all levels and organisations. In this context one has to draw special attention to concerted action from and with stakeholders.
- Most actions to adapt to climate change will have (often unexpected) side-effects in other areas. Both positive and negative effects are possible. Because of this, the NAP should study adaptation actions in a broad sense and if possible crosslink different initiatives in order to obtain the most effective overall adaptation strategy. This coordinated approach and search for synergies should also allow avoiding maladaptation through introducing counterproductive or conflicting measures.
- Adaptation actions are especially viable to have co-benefits and/or be win-win (beneficial for both mitigation and adaptation) or no-regret actions (measures which would generate net social and/or economic benefits irrespective of uncertainty in future climate change forecasts). These actions, which supersede the realm of adapting to climate change, will be much easier to implement and will thus be considered preferable.
- Because of the highly context specific elements of adaptation to climate change, the majority of adaptation initiatives have been initiated at (semi-)local level. In other words, in Belgium this policy field has developed from the bottom up. These initiatives are highly valuable and this proactive approach should be encouraged. A large number of new adaptation measures are also to be taken at local or even personal level. This calls for clear and tailor-made communication. The measures to be taken are often easy to understand and lead to a clear risk reduction or even the possibility of future profit and this should be recognisable in the tone of communication.
- In addition to the clear need for area specific actions, central and coordinated initiatives are needed, especially in the areas of monitoring, research and the sharing of information (e.g. clearing house mechanism), to make these results understandable for policy use. In addition, making the information available for end users through a climate information system is an important consideration.
- Since climate change and adaptation are relatively new policy areas, most countries are still trying to develop both an effective and balanced adaptation strategies and plans. One of the goals of the NAP will be to enable the national and international community to learn from the described ideas and assessments. Special attention in this context should be given to the Belgian Development Cooperation.
- Prioritising the level of governmental intervention on specific adaptation initiatives can be done by combining vulnerability and the extent of spontaneous adaptation. Special attention must go to the most vulnerable groups.

Outline

From the above outlined principles the objectives and contents of a National Adaptation Plan are possible to discern. In order to further guide the work towards a NAP, the following objectives are identified:

- Centralise and coordinate information and actions concerning adaptation while respecting the competences of the different parties.
- Provide information to avoid a fragmented picture or maladaptation by exchanging the information and search for the cross link connections.
- Make relevant parties more susceptible to take up their part in the adaptation process by giving them higher visibility. This higher visibility will promote also exchange between parties, thereby ultimately leading to a more complete and coherent adaptation policy
- prioritise adaptation initiatives (based on impacts, vulnerability assessment and adaptive capacity)

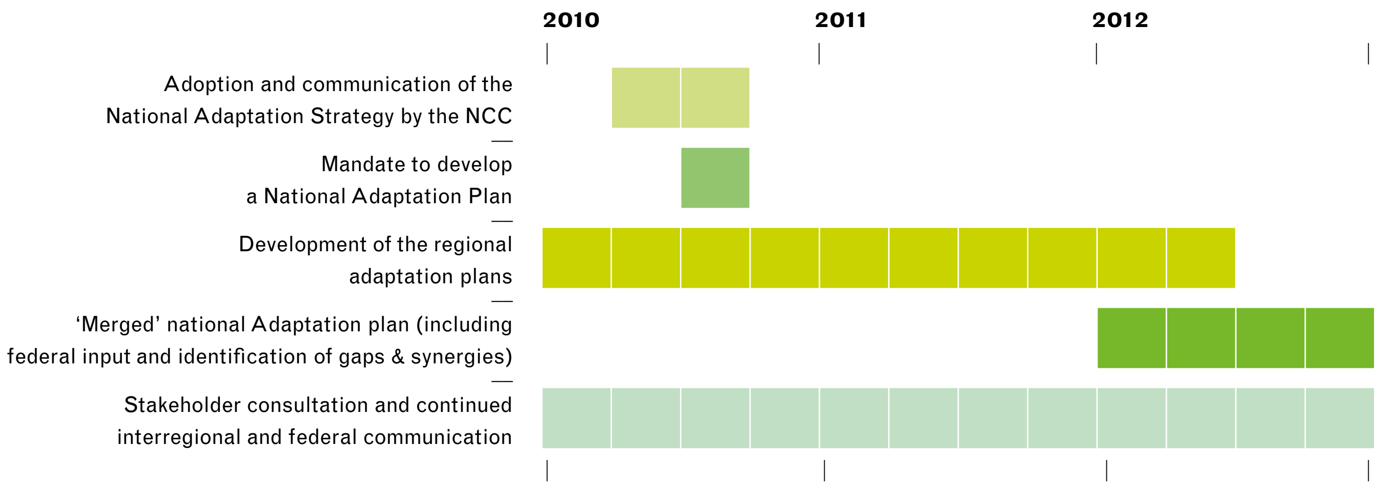
From this, the following objectives of a future National Adaptation Plan can be proposed:

- Cluster and coordinate the work on adaptation
- Ensure visibility for stakeholders, both in- and outside Belgium
- Create awareness and raise the sensitivity of actors
- Identify and communicate dangers, gaps, risks, possibilities and synergies
- Provide coherence and an integral policy and provide a clear structure in which the current activities are positioned
- Indicate action options, coordinate and define responsibilities, draw up possible measures and thus provide a basis for decision-making that enables the various actors to take precautions and to gradually incorporate the impacts of climate change in their private, business and public planning and activities
- Enable cooperation and synergy between the federal, regional and local governments
- Ensure that all levels of government can fully control an effective implementation.

Because of the unique state structure of Belgium, the responsibility for adaptation is shared between the federal and the regional governments and therefore developing and carrying out the tasks in a future National Adaptation Plan will be a shared responsibility as well. Given the context-specific and locally embedded nature of adaptation and including the different sensibilities in the various regions, the most effective way to come to a national plan is to establish a process which allows the different levels to merge their locally developed and adjusted action plans on adaptation into a single National Adaptation Plan, following the objectives as stated above. Coordination, communication and interaction between the different governments are essential to ensure the necessary coherence. More specifically, one central forum should exist where the different initiatives can be discussed, placed in a broader context and (if needed) streamlined. In this context the existing group 'Werkgroep Adaptatie / Groupe de Travail Adaptation' under the National Climate Commission (NCC) includes representatives from the different federal and regional administrations, and seems best suited to coordinate this work.

A Roadmap to a future National climate change adaptation plan

Below, an action plan or roadmap is proposed which could lead to the adoption of a first National Adaptation Plan by the end of 2012 (as indicated in the European White Paper on Adaptation). The first step in the action plan is to define an indicative work schedule.



Although this timescale may look rather straightforward, several important steps must be made in order to ultimately arrive at a widely accepted adaptation plan. The most important actions are noted below.

Identify the different actors and inform, educate and sensitize them on the issue of adaptation is a crucial element when initiating the work on a future National Adaptation Plan. In parallel with the identified needs and priorities, the differences and gaps in terms of people that need to be informed and/or sensitized will have to be identified. In developing these communication methods, it is important to consider whether the communication is most effective stand alone or that a broader spectrum should be sought out, either by working together regionally, or to coincide with the communication concerning mitigation. Given the locally embedded nature of adaptation, it is crucial to ensure a moment in the process of writing the NAP to allow stakeholders express their opinion on the ongoing work, and to use this valuable input in the further development of the NAP.

An overview of the different information campaigns that will be started (or have already been conducted) on the issue of adaptation in its diverse sub-themes could prove useful in this regard.

As mentioned before, adaptation to climate change is an issue that cuts through different sectors. Although this variety of sectors needs a diversified approach, it is then crucial to develop climate proof and general coordinated policies and laws applied in the different sub-themes. The need for this is found in order to create a win-win situation or at least, to avoid a duplication of efforts and a wasteful use of money. Although maybe not carried out in the short term, it is necessary to identify opportunities for mainstreaming adaptation in policy and legislation before or during the development of the NAP.

For future planning across all sectors of society reliable, comprehensive information is necessary. Sound and regularly updated research findings are necessary to develop adaptation measures. Such information should be able to answer questions such as: What changes are likely to affect specific regions? What threats exist, and what is the probability that these risks will occur? This means that information and data must be prepared in a comprehensible form, and made readily available and accessible on a targeted basis. It should also be clear what countermeasures are possible and who is responsible in each case. For example, on the costs of adaptation to climate change in Belgium, there is a clear lack of research in this area, yet policymakers are highly aware of this need. Therefore, the importance of improving the scientific knowledge base through research activities is clear, and is also recognized in the EC White Paper. So, in preparation of the NAP, the institutions and actors who can conduct such research should be identified. It is possible that, based on the knowledge base in Belgium, it is decided to focus the Belgian research on certain specific areas of expertise and for other aspects rely more on the work done in the OECD or within the United nations.

It is important to include climate change adaptation as a theme in the policy dialogue with our partners. In its efforts to improve mainstreaming of climate change adaptation in the cooperation with partner countries, Belgium therefore respects the principles of the Paris Declaration (ownership, alignment, mutual accountability, results based management and harmonization). The needs and adaptive strategies of our partner countries as well as corresponding opportunities for the Belgian development cooperation should be identified. Furthermore, Belgian efforts to tackle climate change, including a National Adaptation Plan, should respect the concept of "Policy Coherence for Development", namely making sure that measures taken in Belgium to adapt to climate change don't have a negative impact on developing countries.

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Place Victor Horta 40 – box 10
B-1060 Brussels, Belgium
http://www.climatechange.be

D — Federal Public Service Foreign Affairs, Foreign Trade and Development Cooperation
DG Development Cooperation
D4.3 International Environmental Policies and Agricultural Research
Karmelietenstraat 15
B-1000 Brussels, Belgium
http://diplomatie.belgium.be/en/

E — Flemish Government
Department of Environment, Nature and Energy (LNE)
Environment, Nature and Energy Policy Division
Koning Albert II-laan 20 bus 8
1000 Brussel - 1000 Brussels
Belgium
http://www.lne.be

F — Walloon Public Service
Walloon Agency for Air and Climate (AWAC)
Rue des Masuis Jambois, 5
5100 Jambes, Belgium
http://airclimat.wallonie.be

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Climate change
will have a profound impact on the way we live our lives. To keep this impact bearable, we need to both mitigate and adapt.

The precise change in climate is difficult to predict, especially on a smaller geographical scale like Belgium. Research reveals several future challenges for Belgium. The most obvious are inundations by sea level rise and riverfloodings, droughts and heat waves.

In Belgium a substantial part of the necessary adaptation to the climate change has already been initiated from the bottom up. A quick overview has been included.

In order to further facilitate adaptation (from a policy point of view) a set of principles, an outline and a roadmap have been identified that describe a route to a future and comprehensive national adaptation plan.

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