Vulnerability analysis: increasing Wallonia's resilience through adaptation to climate change

Scenarios, impacts and measures

Executive summary

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1. Background

As part of the fight against climate change, the United Nations Framework Convention on Climate Change (UNFCCC) has presented mitigation and adaptation as two joint responses to climate change.
Mitigation aims to limit the rise in greenhouse gas concentrations in the atmosphere. Adaptation aims to reduce the vulnerability of systems or territories through actions that reduce the impacts of climate change or improve society's response capacity.
The work of the Intergovernmental Panel on Climate Change (IPCC) has shown that greenhouse gas emissions linked to human activities are responsible for the climate change currently under way. In its latest report analysing the emissions gap (UNEP 2024), the United Nations Environment Programme concluded that the world remains on track for global warming of +3°C (average global warming compared with the pre-industrial period 1850-1900, with Europe warming faster and more than the global average).
However, the report emphasises that if all the most ambitious provisional commitments to emissions reduction already made individually by countries under the Paris Agreement were implemented, and taking account of commitments to achieve 'net zero' emissions in the near future, then there would be a 66% chance of limiting global warming to between 1.8 and 2.3°C. Under this scenario, the probability of reaching +3°C would be virtually zero.
Efforts to mitigate climate change should therefore be given priority over any adaptation measures, as they have a significant impact on the scale of the challenges that will need to be addressed. Indeed, the social, economic and environmental consequences of a 1.5°C rise in temperature are described as endangering populations and causing significant material and human costs (IPCC, 2018[1]). However, the consequences of a +2°C rise in temperature are disproportionate, as the impacts are not linear. The consequences beyond +2°C are very difficult to estimate.
Adaptation plans have therefore begun to emerge at European and Belgian level.
In Wallonia, the legal framework is provided by the Carbon Neutrality Decree adopted in 2023, which includes a chapter on adaptation, mandating an annual climate change assessment and an adaptation strategy aimed at (i) reducing vulnerability and exposure to risks; (ii) increasing forecasting and response capacity; (iii) strengthening crisis management; (iv) identifying and exploiting the beneficial effects of climate change; and (v) identifying sources of funding and support for measures.
The aim of this study was to facilitate the transition from understanding the climate phenomenon to actually implementing adaptation measures and actions. To this end, 40 experts from four Walloon institutes and universities were enlisted for a period of 20 months.
The first phase involved updating regional climate projections.
Several teams of experts then identified and collected the data needed to develop topical risk indicators and assess risk areas in Wallonia. 30 workshops and working groups were organised and, using the data collected, 40 risk indicators were developed, associated with 700 maps showing, where possible, how these indicators would be likely to change for three levels of global warming, based on six global climate models and two scenarios.
Finally, benchmarking identified appropriate adaptation measures and suggested priorities among these measures, in line with the risk assessment, to inform the future adaptation strategy.

[1] https://www.ipcc.ch/sr15/

2. Climate projections

Climate projections are estimates of future climate conditions based on atmospheric, oceanic and terrestrial models. They differ from forecasts in that they are based on scenarios of changes in greenhouse gas (GHG) emissions, concentration and radiative forcing, based in turn on assumptions about socio-economic and technological developments and the type of policies implemented. They suggest possible changes in a number of climate parameters, which can then be used to model changes in the hazards and risks associated with such climate conditions.
The latest IPCC-validated data were used in six global climate models, refined at regional level using the MAR regional model to obtain a more detailed picture of the Walloon territory.
Two global socio-economic development scenarios (Shared Socioeconomic Pathways, SSPs) were used: SSP3-7.0 (known as 'regional rivalry') and SSP5-8.5 ('fossil-fueled development').
These results are then interpreted according to the average level of warming that would be reached globally compared with pre-industrial levels. Three levels of global warming are explored: +2°C and +3°C based on the SSP3-7.0 scenario, and +4°C based on the SSP5-8.5 scenario. It is important to note that the climate in the region where Belgium is located has so far warmed more, and more rapidly, than the global average.

The projections point to the following trends:

2.1. +2°C: possible by 2030 - 2060

Global warming of +2°C compared with the pre-industrial period (1850-1900) could be reached as early as 2030-2040 in several SSP scenarios. It would be possible to cap global warming at this level in the long term if we reduce our greenhouse gas emissions drastically and quickly (the most ambitious commitments currently made) and achieve net zero emissions by 2050. According to the ULiège regional climate model, based on six global IPCC models and applying the SSP370 scenario, this would entail an average temperature increase of around +1.4°C in Wallonia compared with the recent climate (reference period 1981-2010). That is, a climate similar to the current climate in the Loire Valley in France, but with more instability and extreme weather conditions. In such a world, the frequency (twice as frequent) and intensity (+7%) of heavy rainfall would increase, especially in winter (~ +25%), causing heavy runoff that could lead to erosion, mudslides or flooding. Heat waves are also expected to double (averaging 10–15 days per summer), and droughts are expected to become more severe (~ +15%). We would see more and more exceptionally rainy summers like 2021, 2023, and 2024, or exceptionally hot and dry summers like 2019 and 2022. Finally, the risk of late frosts would remain high.

2.2. +3°C: possible by 2060 - 2080

If the most ambitious commitments are not followed through and we simply pursue the existing climate measures, against a backdrop of regional rivalries, the latest IPCC (2023) report suggests that we are heading for global warming of +3°C by the end of the century compared with pre-industrial levels (SSP370 scenario). Such a world would bring us closer to the current climate in Charente-Maritime, with even greater instability and extremes. The risk of heavy rainfall would continue to increase (~ +14% and three times more frequent) according to the MAR model. Events such as 14 July 2021 (when 100 mm of rain fell in one day in the Vesdre valley) would have a return frequency of approximately 20 years. In such a world, however, the frequency and severity of heat waves (nearly five times more frequent than in the period 1981–2010, an average of almost one month of heatwave annually) would probably become the most significant risk. Combined with the problem of drought, the risk of major forest fires would be high in Wallonia in almost every other summer.

2.3. +4°C: possible by 2080 - 2100

If policies were to reverse course on climate action and instead focus on rapid development driven by fossil fuels (SSP585 scenario), global warming could reach +4°C above pre-industrial levels. This would result in a climate similar to that currently found in the Gers region of France, but with greater interannual variability and more frequent extreme weather events. Flooding and heavy rain would continue to worsen along the same trajectory. The temperatures used to define heat waves would become the norm throughout the summer. Tropical nights (temperatures not falling below 20°C, which affects sleep and health) would occur during one to two months in summer. Significant periods of water restrictions and forest fire risk every summer, as in the south of France, would apply in Wallonia.
These figures, worrying as they are, probably do not reflect the full extent of the disasters that such a trajectory would entail, given the many other factors of uncertainty (tipping points, feedback loops, combinations of events, etc.).

3. Climate challenges

A risk analysis was then conducted based on future climate projections. 40 indicators and 700 maps have been produced to explore climate risks to ecosystems, agriculture, the economy, populations and the built environment.

If no adaptation measures are taken in Wallonia, the damage caused by these risks would result in significant material and human costs. A literature review was used to identify some of these 'costs of inaction' (not all damage can be quantified or monetised).
Among these costs, heat waves are expected to have the greatest impact (more than €1 billion per year) due to the deaths and health problems they cause, as well as the decline in productivity at work. The loss of gains associated with ecosystem services would also be very significant. For the few ecosystem services that have been quantified (timber production, freshwater cycle regulation, carbon sequestration and leisure services), these benefits would decrease by nearly €600 million per year. Next comes agriculture, severely affected by lower potato and wheat yields, resulting in estimated annual losses of nearly €200 million. However, year-on-year variability would have a particularly significant impact on farmers, with the potential for years with no harvest.
Again, only some of these costs could be estimated in +3°C and +4°C scenarios, so it is impossible to provide an overall estimate for these levels of global warming.

Potential adaptation measures have been explored for each risk.
In general, the levers for adapting to climate change are closely linked to sectoral strategies and plans that strengthen the sustainability and resilience of vulnerable systems. It is not a question of developing a new, separate strategy, but rather of supporting the adaptive aspects of the measures recommended in each of these systems.

Eight 'resilience pillars' are discussed in the following pages: (i) key issues identified in the risk analysis and (ii) adaptation options and priority measures consistent with initiatives currently in place.

3.1. Biodiversity first and foremost

Wallonia's biodiversity is currently in a critical state: 95% of natural habitats are in poor condition, and nearly one-third of animal and plant species are threatened. In addition to anthropogenic pressures such as land artificialisation and fragmentation, intensive exploitation, pollution and invasive species, climate change is now also a factor.

Climate impacts are wide-ranging: shifting species ranges, disrupted natural life cycles (such as flowering and reproduction), and altered relationships between species. Climate change also threatens so-called 'ordinary' biodiversity in agricultural and urban areas and compromises the ability of ecosystems to provide essential services such as carbon storage, flood control, local climate regulation, pollination, water quality and recreational activities.
The monetary equivalent of some of these ecosystem services and the reduction in the benefits they provide us with are among the major items in the estimate of the costs of inaction.

The analyses reveal that in Wallonia, the six habitats studied are at risk when global warming reaches +4°C. As for species, 84% of those studied would leave their climate niche. Beech woods, particularly those grown as monocultures, are the ecosystems most at risk, even with global warming of just +2°C. Finally, invasive non-native species could benefit from climate change: around one third would thrive in changing climate conditions. These species have adverse effects on both ecosystems and public health (e.g. allergenic pollens).

In short, the resilience of Walloon ecosystems must be at the forefront of any regional adaptation strategy, because they are highly vulnerable to climate risks and play a crucial role in protecting socio-economic systems against climate impacts, but only if they are healthy. Adaptation measures should aim to restore an extensive, connected ecological network in an excellent state of conservation. The first priority is to diversify the monoculture beech and spruce forests in the Ardennes, where improving their role in regulating the water cycle will bring significant added value.
In terms of funding, ecological network restoration is currently mainly financed through European funds such as the LIFE programme.

3.2. Living with water

Climate projections regarding rainfall are uncertain. What is more, we are facing a twofold challenge: increasingly severe droughts on the one hand and a higher risk of flooding on the other. Drought causes two types of stress:

- Hydrological drought, affecting groundwater and watercourses, with the risk of conflicts over use (food, irrigation, industry) during periods of scarcity.
- Edaphic drought, reducing the amount of water available in the soil for natural vegetation and crops, exacerbated in shallow soils poor in organic matter.

In contrast, heavier winter rainfall promotes runoff, soil erosion and the leaching of agricultural pollutants into surface waters.

However, the major challenge today is not climate change, but the ever-increasing artificialisation of land, which has a major impact on all the risks inherent in the water cycle.

The indicators examined reveal:

- Flooding: runoff (which is also a good indicator of the risk of flooding due to overflow) could more than double in some regions if global warming reaches +4°C, particularly in the Vesdre, Roer and Semois river basins.
- Soil erosion: the severity of erosive rainfall will increase everywhere.

- Groundwater drought: certain bodies of groundwater, particularly in the Ardennes, are at risk of depletion.
- Soil drought: the grassland region and the Ardennes will see their water deficit worsen by up to 20 times in a world that is 4°C warmer, according to the driest global climate model.
- Nitrate pollution: a general increase is expected, worsening the already precarious quality of surface and groundwater.
- Land sealing: expected to increase by nearly 10% by 2070, especially around urban centres.

In summary, sustainable water management is becoming a major strategic issue in limiting the combined impacts of climate change on the environment, agriculture, health and the economy in Wallonia.
It is important to aim for minimal disruption to the water cycle. It must be stored, slowed and infiltrated as close as possible to where it falls. This process occurs naturally by significantly increasing the organic matter in the soil and densifying surface vegetation.
We should also consider restoring water to its natural flow path, particularly with regard to meanders and major river beds. It is natural for a river to overflow.

One priority measure would be to continue implementing the Vesdre strategic plan, using its lessons to inform future flood risk management plans, update hazard maps to take account of climate change, and replicate similar strategic plans in five other at-risk river basins: lower and upper Meuse, Ourthe, Senne and Haine.

3.3. A thriving agricultural sector

This sector, heavily dependent on weather conditions, is seeing its prospects disrupted by climate change. The possible short-term benefits of increased growth due to higher CO_2 levels will quickly be offset by the adverse impact of extreme events (droughts, heat waves, irregular rainfall, floods), which will have harmful consequences for crops and livestock: yield losses, reduced animal productivity, increased mortality and the emergence of new diseases.

Climate projections vary depending on the models used for yield estimates, but in all cases a sharp increase in yield instability (large variations from one year to the next) is expected, exposing farms to increased economic risks.

When it comes to grasslands, grass growth is more intense in spring and autumn but significantly reduced in summer, requiring adjustments to feeding practices.

For livestock farming, heat stress will become a major problem, particularly in Hesbaye and Lorraine:

- Pigs and poultry are the most sensitive: at +4°C, they could suffer up to a month of lethal heat stress per year.
- Ruminants, although not exposed to lethal stress, will experience a significant decline in well-being and productivity.

In short, without rapid adaptation, Walloon agriculture risks seeing its stability, productivity and profitability severely undermined by climate change.

Adapting to this variability requires a transition to agroecology, which allows for diversification of production and increases the capacity of crops and animals to respond to stress.
The priority measure would be to continue the work of the Terrae project, which has identified a set of Walloon agroecological practices and studied the feasibility of large-scale conversion of Walloon farms to these practices.

3.4. Cool and permeable cities

Urban areas are particularly vulnerable to climate change due to the density of exposed structures, space constraints and the high degree of network interconnection. In Wallonia, cities are particularly affected by three major issues: flooding, heat waves amplified by urban heat islands (UHIs) and, possibly in the future, the risk of fire.

In addition to the first two issues, there is also the problem of unequal exposure: the most vulnerable populations are proportionally more present in city centres, which are themselves often built around waterways. As a result, the most vulnerable populations are proportionally more exposed to flood and heat hazards.

These risks are compounded by aggravating factors such as extensive soil sealing, air pollution and adaptation constraints, for example water stress and space for urban trees to grow.

Given these challenges, cities in particular (but this is also true in rural areas) will need to combine increased greening, improved air quality and adaptation of the urban fabric to protect their populations from the growing impacts of climate change.
The priority measures are to (i) strengthen the aspects relating to overheating in the EPB tool; (ii) raise the level of ambition (by including climate projections for rainfall) and the binding nature of the Walloon reference framework for sustainable rainwater management; (iii) integrate climate risk aspects into municipal development plans and municipal planning guidelines; (iv) strengthen training on climate risks for local and construction stakeholders.

3.5. Committed and well-equipped businesses

Climate change poses a major risk to the Walloon economy, with potential impacts on businesses, infrastructure, jobs and tourism.
The Walloon economic fabric, mainly consisting of SMEs, is particularly vulnerable, not least because of its strong presence in high-risk areas:

- Flooding: 28% are located in areas at risk of flooding due to overflow and/or runoff.
- Heat: at a +3°C temperature increase, two-thirds of businesses will be exposed to medium to very high heat risk, impacting workplace comfort and productivity (this is the highest item in the estimated costs of inaction).
- Fire: approximately 11% of businesses are located in areas at risk of fire.

Walloon businesses will therefore be forced to invest in adaptation strategies to protect themselves. This is a significant opportunity for public authorities to establish public-private partnerships to implement joint adaptation measures that will benefit all the stakeholders while ensuring synergies and a rational allocation of resources. For example, the greening of certain urban spaces, or the construction of water storage and infiltration facilities in parks and economic activity zones. The region has an important role to play in communication, raising awareness and coordinating economic players.

3.6. A resilient population

Climate change is exacerbating human, social and territorial vulnerabilities in Wallonia. Three main aspects are involved: the social dimension, health and the location of housing.
Social vulnerability to climate risks is multifactorial: age (children, elderly people), health, economic situation (income, employment, housing) and access to services (health care, green spaces). Large cities, which have a higher proportion of socio-economically disadvantaged people, are therefore high-risk areas.

Climate change poses numerous risks to human health:

- Heat waves: increased excess mortality and hospital admissions during hot weather, especially among the elderly and frail. This is a very important item in the estimated costs of inaction.
- Vector-borne diseases: proliferation of ticks (Lyme disease) and increased likelihood of the tiger mosquito taking hold.
- Other waterborne and foodborne diseases, allergies and stress on mental health.

The healthcare system is under strain: medical staff are overworked; access is difficult in rural areas, exacerbated during extreme events such as floods; and certain healthcare facilities and establishments caring for vulnerable people are located in high-risk areas.

Finally, housing is a direct vector of economic and health exposure to climate risks:

- Thermal discomfort: The buildings in Wallonia, historically designed to protect against the cold, are vulnerable to prolonged heat waves. While currently only 5% of homes are exposed to moderate to very high heat hazards, this figure could rise to 30% in a world that is 2°C warmer and to 87% should temperatures rise by 3°C.
- Flooding: More than 500,000 households are at risk of flooding, often among the most deprived, particularly in the Vesdre and Senne river basins.
- Fire: Due to widespread urbanisation, around 34% of households live close to an area at risk of fire, particularly in certain valleys and on forest margins.

Urban and marginalised populations are the most exposed to multiple climate hazards (heat, floods), thereby exacerbating social inequalities.
Without targeted action, climate change is likely to have a significant impact on the health and housing of the population in Wallonia, putting pressure on public health and increasing inequalities.

The priority measures are (i) to establish quantified targets for reducing climate inequalities with monitoring metrics and (ii) to ensure that each measure in the adaptation plan prioritises vulnerable and weaker people and that none of the actions exacerbate these inequalities.

3.7. Sound infrastructure

Wallonia's infrastructure is very vulnerable to climate change. Built for stable historical conditions, it is increasingly exposed to multiple risks: flooding, extreme heat, fires, and knock-on effects in the event of combined disruptions.
Many essential services (hospitals, fire stations, water and energy networks, schools, etc.) are located in flood-prone areas (up to 107 essential functions per statistical district). This poses a direct threat to their ability to keep running during major floods.
Initial analyses have shown that electricity, gas and transport networks are at high risk of flooding, extreme heat and fire.

Research into the risk of the knock-on effects of flooding on emergency response mobility and on electricity supply to critical services has returned worrying results.
These analyses have yet to be validated and accepted by infrastructure managers. However, they show that Walloon infrastructure is facing increasing climate risks, which could lead to cascading failures.
The priority measure is to require infrastructure managers to conduct detailed analyses of critical points in their networks, then support and coordinate the adaptation and protection of this critical infrastructure.

3.8. Participatory and action-oriented research

The 40 risk indicators developed in this study were compiled using data currently available in Wallonia. For each indicator, areas for improvement have been identified, with new data to be collected or new processes to be implemented to enable more detailed risk analyses. Several of these indicators must also be approved and validated by the managers of the at-risk systems. Updating the estimated costs of inaction has also highlighted certain limitations that prevent us from obtaining a truly realistic picture of the socio-economic impact of climate change. Additional assumptions and statistical analyses would also be necessary in order to link the vulnerability indicators identified with the costs of inaction (e.g. linking studies estimating ecosystem service losses in monetary terms with the 0-5 scale established by experts for the ecosystem service risk indicator). This would allow for a more detailed view of these costs at the appropriate scale for each system.
Finally, the information collected for the database of adaptation measures contains very little quantitative data that can be used to calculate the budgets required for implementation. This is partly due to the fact that climate adaptation is still a relatively new topic in Europe. Not enough feedback from the field has been analysed, summarised and centralised to enable us to assess the costs and the effectiveness of the measures.
It is therefore essential that this study should not be regarded as a finished product. Each sectoral analysis must be followed up and used to enrich the web portal developed to explore the vulnerability of Wallonia.
Ideally, further research should now be carried out by bringing together academic experts, the institutions responsible for managing systems or implementing measures, and the beneficiaries of adaptation measures.
Climate adaptation offers a huge opportunity for this type of participatory action research. Sectors such as biodiversity and health already use engaged citizens to collect data. Citizens could also be usefully involved in monitoring indicators such as urban heat islands and the impact of heavy rainfall. Including citizens and the players involved in adaptation not only significantly increases the volume of data collected at a lower cost, but also helps to: (i) ensure consistency between research and practical needs, and (ii) raise awareness of adaptation issues.

4. Towards a strategy for adaptation

Wallonia faces major challenges in financing adaptation. With a very high level of debt, there is limited budgetary headroom for investment. However, failing to invest in adaptation today will cost much more tomorrow.

Integration

Adaptation challenges are integral to sectors and topics that for the most part already have their own strategic, planning and financing frameworks. This means, first and foremost, that we should work within these frameworks to direct available resources towards beneficial adaptation measures that form part of a consistent overarching strategy. In particular, clear objectives, indicators and targets should be adopted that can be readily integrated into regional planning documents.

Regulation

Measures to be applied at local level should preferably be implemented through standards and regulations that enable private investment (by citizens and businesses) to be directed towards appropriate adaptation measures. These may include, for example, the adoption of planning standards to combat overheating or flood risk. In terms of infrastructure, this type of investment is also encouraged by imposing standards on infrastructure managers, with financing reflected in service costs. A first step in this area is to make sure that current regulations are in line with climate change adaptation goals in each sector.

Finance

When adaptation through standards is not possible or requires prior feasibility studies, pilot projects or support for the introduction of technical measures, the Walloon Region will have to assess the investment required (in relation to the costs of inaction).

There are several funds available to finance or expand the implementation of these investments, and options include:

- Using part of the revenues from the Emission Trading Scheme;
- Reviewing certain property taxes, wealth taxes and inheritance taxes to redirect revenues towards adaptation;
- Appropriately applying planning charge principles and compensation mechanisms in permits so that they serve to promote developments that contribute to local adaptation;
- Submitting research proposals and pilot projects on biodiversity or adaptation through European programmes such as LIFE, Horizon, Interreg, and ERDF;
- Directing spending from the Social Climate Fund or the Just Transition Fund to reduce the exposure of the groups most vulnerable to climate risks.

Assessment

Measures should be implemented through an iterative process, in which the assessment of measures plays an important role, integrated into a learning process for which scientific expertise must be maintained and continuously developed. This assessment must consider the contribution to strategic objectives, implementation costs, the impact on risk indicators and, finally, any constraints on adaptation in the area where the measure applies.

Insurance

The existing insurance system in Belgium has not yet adapted to the future climate reality.

Wallonia must exert all its influence to ensure that:

- insurance cover takes account of the major climate risks;
- the pricing framework is conducive to investment in risk reduction;
- extreme events are not left to be managed solely by the State or the victims.

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