

Position Paper on Adaptation to Climate Change

– Recommended Measures to be Taken By and For Cities –

I. Preliminary remarks

German cities have long been actively committed to mitigating climate change. As well as implementing energy-saving measures and using renewable energies, cities have also focused on the energy-efficient refurbishment of buildings, and environmentally friendly modes of transport. Climate change mitigation criteria are increasingly being made a part of urban land-use planning. This is an important contribution toward reducing carbon emissions in cities.

However, climate change is also posing major challenges for the cities. The risks to their inhabitants, municipal infrastructure and green spaces will continue to rise as a result of midsummer extreme temperatures, heavy rainfall, periods of drought and storms. This will require additional adaptation measures in the operation and further development of infrastructure. As well as general urban development planning, the surfaces and corridors for the production and exchange of cold and fresh air within urban areas are also of major importance for the urban climate. Therefore, scenarios and forecasts should be drawn up, on the basis of which district-specific measures to improve the urban climate can then be planned and implemented. These efforts, which where possible should be undertaken by the municipal administration on an inter-departmental basis and with the necessary human resources, must aim to minimise the impacts of climate change in and for the city. In all investment measures, the anticipated climate changes should be taken into account.

The following list of measures for adaptation to climate change in the fields of planning, construction, green spaces, mobility/traffic and transport, water, soil and species protection, and health, identify key areas of activity for the future orientation of the adaptation process in the cities. It also includes further recommendations for climate change mitigation measures. Priority should be attached to measures that combine climate change mitigation with adaptation. The paper also considers the outlook concerning the needed holistic approach to planning the adaptation process, and the creation of a coordinator's position for coordination of the various measures.

The results achieved will need to be evaluated in the medium and long term.

However, the cities themselves will not be able to finance the additional investment required on their own. Therefore, in the future Germany's federal government and federal states will need to provide further financial support to enable the cities to realise these envisaged climate change adaptation measures.

II. Adapting to climate change in the cities

1. Health

The main impacts of climate change on health could be:

- Flooding, and the acute and chronic diseases which that entails
- Heat stress and heat-induced diseases
- Infectious diseases – transmitted indirectly by insects or directly via foodstuffs

- And other diseases such as allergies (e.g. common ragweed, or *Ambrosia artemisiifolia*) or irritation triggered by environmental stimuli (e.g. the oak processionary moth).

The increase in the number of swelteringly hot days, tropical nights and hot spells poses a serious health risk to the urban population. The health of the elderly, the chronically sick and children is particularly at risk from heat. During the hot summer of 2003 in Europe, some 70,000 people died as a result of the heat wave. The vast majority of them were over 65 years of age. Given the demographic change in German cities, it is to be assumed that the heat-related health risk to the population of a city will continue to increase over the coming decades.

Allergologists anticipate more symptoms among allergic patients not only as a result of longer flowering periods (which also begin earlier) and the longer pollination periods this entails; they also expect more symptoms to result from the appearance of new, potentially allergenic plants. They have warned in particular against *Ambrosia artemisiifolia* (common ragweed), whose flowering phase extends from July to the first frost. Ragweed will probably profit from a climate change-induced prolongation of the vegetation period into the autumn, as this species will then be able to produce more seed and disseminate more effectively.

The further dissemination of the oak processionary moth is also seen in connection with climate change. This thermophilic moth has continued to disseminate in many cities in recent years. Its fine setae trigger toxic reactions of the skin and the airways. Since 2007, many intensive preventive control measures have been carried out. Oak trees in parks, school playgrounds, kindergartens and sports facilities have one-by-one been preventively sprayed with a bacterium (*Bacillus thuringiensis*) that damages the caterpillars but is harmless to humans. Forest areas are sprayed from helicopters. In spite of this the caterpillar has continued to spread, such that the nests of the oak processionary moths have had to be removed from the infested trees by suction.

Measures

- Following the impacts of the heat wave in 2003, considerable efforts were made in some cities to put preventive measures in place for future heat waves. In other cities and regions models are currently being tested for preventing heat-induced diseases among elderly people who live alone and are not visited by the regular care services. These include sponsorship schemes to ensure that old people drink enough, and outreach networks for prevention in the community etc.
- In all 16 federal states, up to county level top-down heat warning systems have been introduced on the basis of administrative agreements with the German Meteorological Service. These systems will notify the cities immediately of any impending extremely hot weather. However, there are indications that heat warnings may not reach the most vulnerable sections of the city populations in time, and may not reach enough of them. This could be optimised by introducing more binding rules governing the tasks and responsibilities of the actors involved in the heat warning systems.
- The spread of pathogens that are already endemic in Germany (such as hantaviruses, Borrelia, TBE) or new pathogens (e.g. transmitted by the Asian tiger mosquito, dengue or Chikungunya viruses), and the possible occurrence of new infectious diseases, are being monitored by the local health authorities. To date there is no indication that these diseases are occurring more frequently. Cities should continue to monitor events in the region and the international literature, so that they are ready to respond rapidly to any new developments.

- The local health authorities should continue their information campaign on the aforementioned issues in the press and the media, and should use flyers, websites, training measures for doctors and other publications.
- Contingency plans for sensitive facilities such as homes for people with disabilities, senior citizens' homes, care homes and hospitals, should be reviewed. Where such plans are not in place, they should be drawn up.
- We consider it important that sensitive facilities also be monitored more frequently and more closely during hot spells (to keep an eye on the food cooling chain and freshness of food, drinking water supply).
- Since the oak processionary moth can only be controlled successfully and sustainably through a coordinated regional approach, control measures in the region should be coordinated and harmonised.
- Ragweed should be made reportable, and control thereof made mandatory (PR work, fact sheets, the Swiss model). Dissemination in sunflower seeds in seeding material should be prevented by prior seed testing. For land leased by the municipality this can be stipulated in the lease agreements.

2. Disaster risk management and response

Climate change and the extreme weather events resulting from it will increase the need to ensure vital general-interest services for the affected population. In this context, the structures for disaster risk management and response need to be optimised. Here we need to take into account that neighbouring local authorities will be affected by the same extreme weather events with increasing frequency, which may make it more difficult or impossible to provide mutual assistance.

The optimisation of disaster risk management and response:

- Establish an efficient and effective warning and information system, including a wake-up function, to provide the population with warnings and information when the conventional (electronic) media (TV, radio, Internet, mobile telecommunications) are not operating or are not being monitored (e.g. at night-time).
- Identify and protect critical infrastructures against the impacts of extreme weather events. Here, particular attention should be paid to ensuring that an emergency power supply and heating is available for emergency response infrastructures, e.g. fire brigades and the buildings where their appliances are stored, base stations for digital BOS radio, and care facilities.
- For properties or facilities that are needed to ensure the functionality of civil protection and general emergency response, in future more attention should be paid to designing and locating them such that their functionality is not itself impaired by the damaging event (e.g. they should not be located in a flood-prone area etc.).
- Protective clothing for the emergency services should incorporate redundant (possibly multiple) design features to ensure that it can withstand prolonged deployments.

- Municipalities should be willing to integrate their fire services into regional, or possibly also national deployment plans, and to meet the obligations arising from this.
- Bearing in mind the demographic trend, support programmes should be launched to recruit and retain capable young people for the voluntary civil protection system.
- The departments responsible for deployment planning should be provided with the material and human resources needed to guarantee planning, command and control in case of an event.

3. Urban planning

In a number of cities the demand for land for residential development will continue to increase over the next few years, while in many other municipalities there will at least be a demand for refurbishment and renewal within the existing stock. Furthermore, this trend will be reinforced by a renaissance of city dwelling. In the context of climate change, urban development policy will revolve around the issue of whether the potentials that exist within the housing stock (land conversion, development of vacant plots) are sufficient, or whether additional land would need to be developed at the expense of green and open spaces, assuming that this can be realised in a manner that does not adversely affect the urban climate.

In future, greater importance will be attached to adaptation to climate change in architectural details (e.g. protection against the sun/shade/storage mass/roof design). This will apply to the construction of new houses, the existing housing stock, and office and business premises. Otherwise, energy consumption for air conditioning in buildings will increase when temperatures are high during the summer.

In view of the forecast changes in urban climate and in the water balance in cities, urban development policy should aim to offer appropriate living conditions for the future. It should also prevent the existing urban heat island effects from creating environments that are uncomfortable or even life-threatening.

Measures

- Priority should be given to the low-carbon development of vacant plots within areas already developed, as opposed to extending the area of land developed.
- Urban planning measures should take account of tendencies for cities to overheat.
- Throughout urban zones, the cold air corridors required to ventilate the inner city should be calculated and maintained, and their functionality developed and improved.
- In future new development (only outside of HQ₁₀₀ flood-prone areas) or rehabilitation activity at still waters or rivers and streams, the buildings should be designed such that the cold air flows can be channelled into the city centre.

- When analysing local climate conditions (cold and fresh air systems), these should be studied in the regional context, as the catchment areas of these air systems usually extend well beyond the city limits.
- Closer attention should be paid to flood control and groundwater protection than in the past, so that the city's continued development is not constrained by an increasing loss of functionality of the urban infrastructures (e.g. as a result of flood damage or groundwater problems).
- In connection with the formation of discrete heat islands in cities, existing and planned infrastructural facilities for specific risk groups (e.g. hospitals, senior citizens' homes) should be reviewed to determine whether special (spatial and structural) protection measures might be appropriate. If circumstances warrant, such facilities should be located elsewhere.
- As a matter of principle, the city should act as a role model by incorporating rainwater management and flood control more systematically into urban planning, road and bridge planning, and construction planning.
- For zones within the city that are already heated up, basic solutions should be sought to reduce this overheating (e.g. green roofs, unsealing measures, tree planting, hydraulic engineering measures, light surfaces etc.).

4. Urban development and construction

When planning buildings, it will become more important to take into account key cold and/or fresh air corridors and the zones in which they arise. It is to be anticipated that high summer temperatures will lead to an increased consumption of energy for cooling and air conditioning purposes. Energy costs will rise, and heat protection measures will therefore become more important. If buildings are located in known flood-prone areas or areas expected to become such, then substantial damage and/or loss of functionality (restricted utility) are to be anticipated. Proactive public information campaigns will therefore be required to raise awareness of the need for self protection as public safety standards decline.

Measures must aim to maintain or improve the quality of experience and comfort in buildings (new buildings and existing stock) and city spaces, while avoiding unnecessary energy consumption for heating and cooling purposes.

Measures

- Review all plans for new buildings with respect to adaptation to climate change (e.g. inclusion of shade during the summer and absence of shade during the winter, solar optimisation) and optimisation of climate change mitigation.
- Flood-adapted planning of private and public buildings (secure cellar wells, sensitive plant such as power distributors located outside of cellar areas).
- Energy and climate change mitigation strategies for new areas of building development (incorporating air pollution control in designated air quality zones).

- Include energy and climate change mitigation and adaptation criteria in competitive bidding procedures, and attach high weighting to these when evaluating bids.
- Include urban climate aspects in the design of buildings and spaces (e.g. cold air corridors kept free, unsealing of surfaces, higher reflectivity, creation of shaded spaces, compensation of unavoidable sealing, green roofs).
- Increase the energy efficiency of public buildings while maintaining user-friendliness.
- Improved summer heat protection (optimise proportion of window area, high-quality sun protection, activatable storage masses, night ventilation plan, green roofs with additional option of integrating solar power plant on roof surfaces facing the sun).
- Increase the thermotechnical refurbishment of existing buildings.
- Include combined heat and power (CHP) and renewable energy in new buildings and existing stock.
- Attach preference to CHP in air conditioning systems for buildings, and to renewable energy use in areas where CHP is not available.
- Protect doors and windows against flooding (recommendation: install at least 20 cm above backflow level).
- Facilitate infiltration of precipitation where possible on-site, or ensure discharge via public rainwater management systems.
- Support and promote unsealing.
- Review residential areas with regard to adaptation to climate change. Prepare recommendations for private developers concerning how to deal with the impacts of climate change in the context of refurbishment and rehabilitation etc.
- Review city standards with respect to the city's role model function.

5. Urban green space

A further increase in drought stress is to be anticipated for roadside trees, shrubs and trees in parks, and forest stands and agricultural land at locations remote from the groundwater. Greened roofs, courtyards, green façades and thoroughfares will become more important, and the need to reduce heat radiation from façades will increase. Extreme weather events (e.g. storms, drought) will occur more frequently, which will affect tree stands and their composition. Increased temperatures will promote the migration of species. Neobiota such as the oak processionary moth, the chestnut leaf miner moth, ragweed (*Ambrosia*) and masa plants will increase. Overall, changes in biological diversity are anticipated.

Measures

- Green and open spaces should be maintained and extended in order to ensure and further increase the delivery of cold air, without reducing density.
- Urban green and open spaces should be linked to surrounding habitats via ‘green rays and spokes’.
- New park areas (e.g. on converted land) create recreational spaces and improve the local climate in their district.
- Existing urban parkland should be safeguarded on a permanent basis, and every opportunity taken to extend it (e.g. abandoned thoroughfares).
- For large sealed areas, unsealing and greening options should be reviewed more systematically.
- In heavily built-up areas, tree-lined stretches of road can help network the urban green spaces.
- To promote the greening of roofs and façades an investment and consultancy programme could be initiated, and the planning law requirements put in place.
- Unsurfaced suburban railways should be turfed over.
- The urban tree stock should be safeguarded in the long term and further developed.
- The composition of the tree stock lining the roads should be diversified, and thus made more stable in the face of climate-induced changes such as the emergence of new pest organisms. New, non-native tree species are often more resilient to the impacts of climate change, and are being used increasingly along roads.
- Urban forests perform a large number of functions (e.g. carbon storage). Forest areas should therefore be made permanent, and expanded where possible. Sustainable management combined with the selection of appropriate tree species that are resilient to future climate changes will safeguard the stock.
- For agricultural land, adaptation strategies should be devised and applied (cultivation methods and products, growing cycles, negative impacts of new forms of pest).
- Spruce monocultures should be converted to stable mixed deciduous forests.

6. Mobility, traffic and transport

The increasing heat burden can lead to a situation in which the city loses its attraction as a place to live, thus reinforcing a tendency to migrate to the rural environs. Recreational and leisure traffic will increasingly be directed toward those areas. During hot periods, the demand for transport during the day will peak at the beginning and end of the day. When temperatures are high, transportation vehicles and systems will heat up to such a degree that the well-

being of users and the usability of systems may be impaired. During summer hot spells, surfaced thoroughfares will further increase the rise in temperature. Pronounced heat waves may damage road surfaces and rail tracks, thus restricting use. Heavy rainfall may jeopardise the stability of transport systems and impair use. More frequent precipitation in winter will have a negative impact on pedestrian and bicycle traffic. Strong wind events may impair the stability of traffic systems, especially large traffic signs, roofing, lighting and signal masts. They may also negatively impact the use of traffic systems, and in case of windthrow may also bring traffic systems to a standstill.

People's mobility needs can be realised on an environmentally sound basis by promoting pedestrian and bicycle traffic, and public transport. Traffic and transport infrastructure should be adapted in response to meteorological change.

Measures

- Air conditioning on public transport should be continued, to ensure that these systems can continue to be used during heat waves. More measures should be implemented to provide sun protection measures in vehicles (heat protection) and shade at waiting positions (depots, termini).
- To prevent road and street spaces from heating up, more shade can be produced by trees and/or structural protection against the sun. Sun protection is especially important for waiting passengers (e.g. at bus or tram stops).
- For underground traffic and transport systems, the possible need to focus greater attention on air conditioning/ventilation should be explored.
- The information channels of the integrated traffic management centre should be used to convey additional information and recommendations to the public.
- Brighter surfaces (achieved e.g. by adding corresponding admixtures to bituminous surfaces) can increase reflectivity and thus reduce heat build-up. Here it is appropriate to review whether the objective of lighter surfaces is compatible with other requirements placed on the surface (e.g. concerning noise reduction).
- To protect the road surface, temporary road use bans can be imposed on vehicles weighing a total of more than 12 tonnes in order to prevent damage to the carriageway.
- For traffic and transport systems whose stability or functionality may be jeopardised by heavy rainfall events or flooding resulting from that, the plant and infrastructure design, and especially drainage infrastructure, should be adjusted so that the existing levels of structural and plant safety are maintained.
- The present quality of drainage for rail-bound public transport systems and a strategic segment of the road network (e.g. main emergency access routes) should be maintained. Special attention should be focused on the underground or low-lying systems. For instance, pumps in underpasses should be reviewed and if necessary retrofitted.

- In subordinate sections of the road network, temporarily closures may possibly be unavoidable. For critical sections of the network, contingency plans and supplementary traffic management strategies can also be prepared.
- When planning roads it should be remembered that in the future roads may offer more flood control space in case of heavy rainfall events. This is important for protecting buildings against flooding, because it will not be possible to adapt rivers and lakes, or rainwater drainage, to climate change. This should be balanced with the aim of achieving full accessibility. This will mean considering whether at least key crossing points can be elevated such that they remain above the backwater level. The decision as to whether bicycle traffic should be routed along the carriageway or along a side path should also be taken in the context of this issue. The impacts of precipitation events on the choice of means of transport can be minimised by roofing over waiting areas, bicycle parks and heavily frequented paths.
- The possibility of roofing over/shading parking spaces at large car parks, e.g. at shopping centres, and including integrated photovoltaic systems, should also be explored.

7. Water

The anticipated increase in winter precipitation and the drier summers with extreme rainfall events will impact rivers and streams. These may reach low water levels or even dry up in summer, which will burden the aquatic fauna and flora and adversely affect water quality. The more intensive and more frequent flood events, especially in winter, will require the development of strategies for action and for dealing with flooding in cities. They will also require technical facilities (retention basins, dikes and protective walls) to be secured, maintained and developed. For standing waters and springs, the increase in temperatures especially in summer will lead to a deterioration in water quality (lower water levels and exchange, lower oxygen solubility, increase in eutrophication), and thus to a further increase in the need for management and maintenance. Reduced spring discharges or dried-up springs will lead to water stress in the draining watercourses and downstream wetlands. Groundwater levels will fluctuate more widely over the course of the year. Groundwater levels will be affected by more frequent withdrawals for construction purposes. The reduction in water levels of many watercourses during the summer will mean that groundwater is tapped increasingly to irrigate agricultural land. The increasing use of geothermal energy will also affect the groundwater, which will continue to be required for obtaining a portion of drinking water. Due to the more frequent extreme heavy rainfall events in the summer, drainage networks are likely to be overloaded more often. Drainage comfort will then decrease due to more frequent backwater and flooding on roads and streets. This will entail an increase in combined sewer overflows into watercourses. In summer the anticipated dry spells may also entail increased operating demands for sewer cleaning. The structural engineering guidelines already include several aspects of climate change mitigation and flood protection, as well as rainwater management. The more frequent flooding of roads and streets in case of heavy rainfall is likely to lead to an increase in claims for damages.

For rivers and streams, one objective is to optimise flood management and thus minimise the risks to humans and the environment. Important goals include maintaining stream outflows in the summer, and the improvement of water quality in line with the EU Water Framework Directive (WFD). For standing waters the aim is to ensure high water quality at minimum maintenance input. The quantity and quality of groundwater must be maintained in order to ensure continued drinking water production. Private and public sector infrastructure should be pro-

tected against flood damage. This should include in particular energy providers, telecommunications companies and subterranean infrastructure (e.g. underground trains), and private flood protection. Drainage comfort should be maintained as far as possible. At the same time (e.g. by reducing combined sewer overflows) the burden on water bodies should be reduced. Bearing in mind possible groundwater fluctuations and high water levels caused by flooding, structures should be designed on a groundwater-appropriate basis so as to prevent damage to buildings caused by wetness and for buoyancy control purposes.

Measures

Rivers and streams

- Install additional water gauges
- Install alarm systems for improved advance flood warning
- Look at the entire catchment area in each case
- Restore rivers and streams to underpin multifunctional network links
- Consult and coordinate closely with neighbouring municipalities
- Establish urban and construction planning that includes flood risk management
- Improve private flood risk management through citizen information
- Create retention spaces, also through near-natural river engineering measures.

Standing waters

- Reduce water exchange times by ensuring adequate water feed (e.g. from rainwater management systems)
- Reduce internal nutrient status by lowering nutrient input.

Springs and wetlands

- Protect springs and wetlands through unsealing and restrictions on construction in the catchment areas.

Groundwater

- Improve the collection of groundwater monitoring data in relation to present uncertainties
- Develop groundwater scenarios
- Develop a municipal groundwater management system for systematic enrichment, interim storage or drainage by pumping (in case of high groundwater levels, e.g. during flooding, this may be virtually impossible, and would in any case not be appropriate)
- Prepare irrigation plans for the additional water requirement for agriculture
- Prepare alternative irrigation plans for the urban public green spaces for dry spells to maintain functions affecting the climate (substitution of drinking water and groundwater).

Drainage

- Implement more public (for roads and streets) and private rainwater management measures in areas of new building development and within the existing stock
- Develop and implement 'flexible drainage systems' that can be expanded and adapted
- Conduct in-depth studies on flood risks
- Introduce a separate fee for precipitation water as a supporting measure.

Flooding

- Improve flood risk management (water gauges, alarm systems, regional cooperation)
- Implement public control measures (contingency plans, mobile phone protection systems, dams)

- Take greater account of flood risks in urban and road planning (e.g. through appropriate road design or planning of emergency waterways)
- Improve public information on flood risks
- Promote flood-appropriate public and private building planning, especially by providing information and advice on protective measures (e.g. for light wells or underground car park entrances)
- Be aware of the risk of slope water, and take this into account in urban land-use planning
- No construction projects/spatial development in flood-prone areas (HQ₁₀₀)
- Maintain floodplains
- Create additional infiltration surfaces (e.g. roof greening, use of crushed-stone coverings).

8. Soil

Between the soils and the atmosphere and exchange of gases takes place that affects the climate. Soils play an important role in storing these gases. Measures are therefore required to protect the legally defined functions of the soil (pursuant to the German Federal Soil Protection Act) against the impacts of climate change, to improve or restore the climate stabilisation function of soils, and prevent impacts that reinforce or exacerbate climate change. Soils should be utilised, managed and developed in a way that counteracts the following risks:

- declining humus content
- soil compaction
- change in soil water balance
- water and wind erosion
- mobilisation of pollutants.

The aim is to manage soil utilisation and development such that the positive impacts of soil properties on the climate are maintained, and the impacts of climate changes on the natural functions of soils are minimised.

Measures

- Prepare soil maps on a scale that is appropriate for planning and management purposes. Designate soil units and plots in terms of their value for the urban climate.
- Establishing a soil exchange for excavated earth, to allow professional and rapid re-use.
- Urban planning measures should support the positive impacts of soil management on climate by maintaining green spaces with three-tier vegetation and grassland.
- Former industrial and commercial sites should be returned to green management (fallow recycling). Suitable areas should be designated as sites for renewable energy production.
- Soils with a high carbon storage capacity should be included in planning approval procedures. Review whether interventions in such soils require significant compensation.
- Manage municipal green space, parkland and forest land so as to increase humus.

- Map and evaluate areas at risk of compaction. Use these maps as a basis for planning and action. Adjust the type and intensity of management (e.g. management measures in municipal green spaces, management of municipal forests).
- Protect raised bogs and fens as part of land-use planning. Regenerate municipally-owned drained bogs and fens (provided that the previous mode and intensity of management still allows regeneration – particularly in the case of drained fens under agricultural use).
- Map and evaluate areas at risk of erosion. Use these maps as a basis for planning and action.
- Systematically convert (possibly using financial incentives) land under agricultural use and vegetation-free/low-vegetation land on sloping sites and in cold air and ventilation corridors into compensation areas for construction projects/urban green spaces. Use appropriate plant stock.
- Prepare a soil pollutant register as a basis for decision-making and planning needed interventions.
- Implement soil amelioration and unsealing measures as part of compensation area management.

9. Habitat and species protection

As climate change advances, sensitive biotopes are being subjected to considerable stress. It is to be anticipated that for climatic reasons alone, a significant proportion of all animal and plant species will no longer find appropriate conditions for life in their established habitats. At the same time, what is already clearly to be observed is an increase in species that are adapted to other climatic conditions. Food chains and networks in ecosystems will need to be modified considerably in the future. These processes will take place first of all in urban settings, where the warmer microclimate is accelerating the general warming effect induced by climate change.

For the time being it is not possible to predict exactly where these changes will lead. This is because the climate change models which have been calculated forecast that alongside general warming, extreme weather events will dominate initially, and because the last two winters in Central Europe have been unusually cold. According to a study conducted by the Potsdam Institute for Climate Impact Research, cold winters of this kind in Central Europe might become an established impact of climate change. In that case, Central Europe would acquire a more continental climate rather than a Mediterranean one. How climate change is going to unfold in Central Europe will only become clear over the coming years, as changes are observed empirically. In this respect cities would be well advised to monitor closely the current models being generated by the latest scientific studies.

In the case of wetland habitats, a deterioration in life conditions is to be anticipated during dry spells lasting months. Fluctuations in water levels and a deterioration in water quality in particular are likely to cause a massive restructuring of the species composition, and thus a significant disturbance of ecosystems.

The forests will also be negatively impacted, because individual tree and shrub species will first of all be weakened and then disappear altogether. Woody habitats of this kind would then temporarily become herbaceous meadows. In the long term, the disappearance of tree species is likely to cause animal and plant species that are dependent on these trees to disappear locally.

Comparable changes are also to be expected in many other biotopes. Presumably the migration of southern species, which is already to be observed, will be unable to offset these losses.

The objective should be to maintain biological diversity at the global level. To achieve this we require an operational target at the local level, which is to maintain existing ecosystems in their existing form for as long as possible.

Measures

The fauna and vegetation of all habitats typical of our climate zone should be preserved for as long as possible, in order to delay the disappearance of the species that exist within these biotopes. This is appropriate, because even after climate change has advanced further it will still be possible to initiate systematic rescue measures for the species that were originally native here.

- If native woody plants and perennials need to be planted, then in times of climate change native planting material and seed should be used in order to preserve biological diversity.
- In addition to measures to preserve the fauna and flora of the original habitats, habitats and that are native to more southerly regions could be established here. This would require first of all the establishment of woody plant coverage. Mixed stands of native and southern European trees and shrubs should not be established. Furthermore, initially only insect-pollinated trees should be used. Both these measures will prevent hybridisation of native and southern European species. Given the extraordinary rapidity of change in fauna that has become evident over the last 30 years, it would appear absolutely essential to plant trees and shrubs.
- However, given the current trend in winters it remains unclear whether frost-sensitive tree species from the Mediterranean region can be used, or whether for instance tree species from the northern Mediterranean can still be selected. Since the aforementioned trees obviously grow over periods of decades, in view of the breakneck pace of climate change it is questionable whether a generation of the aforementioned species will be able to grow at all.
- In urban areas, exotic species that can withstand extreme drought stress should be used to line streets and roads. Options would include non-European species, for which there is in any case a long-standing tradition in park management. Drought-resistant species are important, because it is to be anticipated that in urban areas significantly longer and more intensive dry spells will occur during summer heat waves than is the case in rural areas.

III. Overall coordination of municipal climate change adaptation measures

To ensure a holistic approach to the planning of climate change adaptation measure that takes into account all aspects of city planning and cross-cutting issues, a coordinator should be appointed for these tasks in each city. This coordinator should structure and standardise the process. Given the large number of actors that will need to be involved and the diversity of their structures, it will be necessary to discuss and agree on a harmonised approach based on a joint climate model. The coordinator must identify synergy effects and conflicting objectives, and invite and encourage the actors concerned to work on these. Last but not least, the coordinator will gather information on the costs of adaptation measures. He or she will also regularly provide all the relevant information on technical and financial issues to the official municipal bodies.