

Five principles for climate-proof municipalities and cities

Prof. Dr Christian Kuhlicke^{1, 17}, Prof. Dr Christian Albert², Prof. Dr Daniel Bachmann³, Prof. Dr Jörn Birkmann⁴, Prof. Dr Dietrich Borchardt⁵, Prof. Dr Alexander Fekete⁶, Prof. Dr Stefan Greiving⁷, Prof. Dr Thomas Hartmann⁷, Prof. Dr Bernd Hansjürgens⁸, Prof. Dr Robert Jüpner⁹, Prof. Dr Sigrun Kabisch¹, Prof. Dr Kerstin Krellenberg¹⁰, Prof. Dr Bruno Merz¹¹, Prof. Dr Roland Müller¹², Prof. Dr Dieter Rink¹, Dr Karsten Rinke¹³, Prof. Dr Holger Schüttrumpf¹⁴, Prof. Dr Reimund Schwarze¹⁵, Prof. Dr Georg Teutsch¹⁶, Prof. Dr Annegret Thieken¹⁷, Dr Maximilian Ueberham¹², Prof. Dr Martin Voss¹⁸

Introduction

Recent events make it drastically clear: The weather fluctuations are becoming more extreme. In July 2021, heavy and prolonged rainfall in the German federal states of North Rhine-Westphalia, Rhineland-Palatinate, Bavaria, and Saxony led to the unprecedented destruction of infrastructures and buildings as well as injuries, missing persons, and deaths. In 2018 and 2019, on the other hand, agriculture and forests, surface waters and groundwater, and people and ecosystems suffered the consequences of prolonged drought and heat. Recent climate studies suggest that the probability of both extremes will increase.

Every extreme weather event can be an existential threat. The recent flooding events in Germany have caused serious damage and led to the loss of material, non-material, and irreplaceable cultural values. This makes it all the more important to learn the right lessons. However, it is still too early to draw comprehensive conclusions from this particular event. More accurate data and analysis is needed to better understand the mechanisms and factors that lead to these huge humanitarian and financial impacts of extreme events. These includes hydrological processes as well as questions of early warning and risk management, land use, and human vulnerability. Only then can well-founded goals and requirements for action be derived for a better and more future-proof development of municipalities and cities.

The recent events are the reason for this statement, with which we want to initiate a joint discussion process. Climate change poses enormous challenges for municipalities and cities in particular.

¹ Helmholtz Centre for Environmental Research GmbH – UFZ, Department of Urban and Environmental Sociology, Leipzig

² Institute of Geography, Ruhr-University Bochum, Bochum

³ Magdeburg-Stendal University of Applied Sciences, Working group Flood Risk Management, Magdeburg

⁴ University of Stuttgart, Institute of Spatial and Regional Planning, Stuttgart

⁵ Helmholtz Centre for Environmental Research GmbH – UFZ, Department of Aquatic Ecosystem Analysis and Management, Magdeburg

⁶ Cologne University of Applied Sciences, Institute for Rescue Engineering and Hazard Prevention, Cologne

⁷ TU Dortmund University, Department of Spatial Planning, Dortmund

⁸ Helmholtz Centre for Environmental Research GmbH – UFZ, Department of Economics, Leipzig

⁹ University of Kaiserslautern, Hydraulic Engineering and Water Management, Kaiserslautern

¹⁰ University of Vienna, Department of Geography and Regional Research, Vienna

¹¹ Helmholtz-Zentrum - GFZ German Research Centre for Geosciences, Hydrology Section, Potsdam

¹² Helmholtz Centre for Environmental Research GmbH – UFZ, Centre for Environmental Biotechnology, Leipzig

¹³ Helmholtz Centre for Environmental Research GmbH – UFZ, Department of Lake Research, Magdeburg

¹⁴ RWTH Aachen University, Faculty of Civil Engineering, Aachen

¹⁵ Helmholtz Centre for Environmental Research GmbH – UFZ, Department of Economics, Leipzig

¹⁶ Helmholtz Centre for Environmental Research GmbH – UFZ, Managing director, Leipzig

¹⁷ University of Potsdam, Institute of Environmental Sciences and Geography, Potsdam

¹⁸ Free University of Berlin, Disaster Research Unit, Berlin

Climate change poses enormous challenges for municipalities and cities in particular. Therefore, it is necessary to jointly drive the transformation of cities and municipalities, of buildings and infrastructures as well as ecosystems, and to adapt to new weather dynamics.

As was the case with climate protection, it is time to launch a large-scale climate adaptation programme. It is necessary to further strengthen the risk management of weather extremes and civil protection as well as strategic planning in municipalities and cities. The goal must be to bring the climate security of municipalities and cities to another level. This requires the further improvement of our knowledge as well as the cooperation of all people involved, including politicians, federal and state authorities, private companies, associations, and local individuals.

Five principles for climate-proof cities and municipalities

We present key principles that should guide the transformation of cities and municipalities in order to increase their climate security. The principles proposed here are well established in the scientific community. Many of the demands were already made public after the major floods of 1993 and 1995¹⁹ on the Rhine as well as in the aftermath of the destructive floods of 2002²⁰ and 2013²¹. This statement is also intended to underline the importance of these once again. The principles go beyond municipal and city boundaries. Although many measures have an impact on cities, they have to be decided and implemented at other regional or federal levels. These principles are intended to help prioritise the climate security of cities and municipalities more strongly. However, the solutions must always be developed in the respective context. The challenges in the low mountain ranges with its many small river catchments are different from those in the lowlands. While some principles should be addressed immediately and implemented promptly (e.g. early warning and population protection), others can be implemented only in the longer term (e.g. restructuring of infrastructure systems, increase of the storage capacity of landscapes). However, the foundations for longer-term transformation processes must also be laid in a timely manner. The time to act is *now*.

1. **Improve early warning systems and strengthen civil protection:** It is important to improve the forecasting of flood waves and to establish reliable warning systems for smaller river basins. In addition to the development of robust forecasting models, permanent and reliable communication with the representatives of cities and municipalities as well as local citizens is essential. Only a warning that people understand and trust will lead to the desired actions.
2. **Increase water retention and storage capacity:** In addition to established protection solutions such as dykes, walls and polders, it is becoming increasingly necessary to design communities, cities, and landscapes in a way that leads to improved water retention in the landscape. Every cubic metre of water that is not discharged into streams and rivers via the sewage system helps to flatten flood waves. But as can be seen from the 2021 events, it cannot prevent them. It is therefore important to increase the water retention and storage capacity of riverine floodplains, forest, and agricultural landscapes as well as in the more densely populated areas by incorporating more green and open spaces. Especially for extreme precipitation, additional storage areas and green infrastructure must be designed in such a way that they can be used as emergency waterways in the event of an emergency. A high storage capacity for water helps not only in times of flood but also in times of drought.

¹⁹ https://www.lawa.de/documents/leitlinien_1552299715.pdf

²⁰ https://www.dkkv.org/fileadmin/user_upload/Veroeffentlichungen/Publikationen/DKKV_29_Lessons_Learned_Kurzfassung.pdf

²¹ https://www.dkkv.org/fileadmin/user_upload/Veroeffentlichungen/Publikationen/DKKV_53_Hochwasser_Juni_2013.pdf

3. **Enforce climate auditing of critical infrastructure:** In the rehabilitation, post-disaster reconstruction, and new construction of public infrastructures and buildings – especially critical infrastructures – it is important to assess the consequences of climate change and to renew design values accordingly. This also includes the consideration of cascading effects because of the interruption of supply services in infrastructure systems. Infrastructures (e.g. supply of water, electricity) are the backbone of our modern society and must be designed in such a way that they also function in extreme weather situations or allow corresponding fall-back options. It is unacceptable if, especially during a crisis, necessary communication networks, medical services, and facilities fail because they are not sufficiently prepared for such extreme events.
4. **Promote climate safety of buildings:** When constructing new buildings or refurbishing existing ones, it is important to consider the climate safety of buildings from the beginning and to raise the standard of protection, especially for facilities that accommodate particularly vulnerable groups such as children, senior citizens, or people with disabilities. Similar to energy-efficient renovation, this requires financial support and incentive instruments as well as the establishment of precaution-oriented insurance premiums. Appropriate information on heavy rainfall or flood hazards should also be systematically provided and requested in building applications and before property sales. It will not be sufficient to try to address future challenges in the building stock reactively.
5. **The will to shape and assert is just as necessary as cooperation and solidarity:** The transformation requires the will to innovate and design on the part of cities, municipalities, investors, and private individuals as well as the use of financing and incentive instruments on the part of the federal government and the federal states. It requires assertive tools in planning as well as coherent and standardised frameworks and procedures. Furthermore, the benefits and burdens of the transformation to climate-proof cities and municipalities must be shared in a spirit of solidarity. Just to name an example: Communities that create more space for water on the upper course of a river will benefit only indirectly; but communities in the lower course will benefit directly because the risk of flooding is reduced.

Principle 1 - Improve early warning systems and strengthen civil protection

Forecasting and early warning systems are important investments to protect lives, property, and livelihoods. Early warning systems are used to predict the extent, location, and timing of potential disasters. Early warning should first and foremost save human lives and, if possible, prevent damage to property. If both are achieved, these systems are very successful. Early warning systems are complex and susceptible to failure because it involves many people working together and processes along the warning chain need to function quickly and smoothly. It is also important to improve the forecasting of flood waves and to establish reliable warning systems for smaller river basins. Equally important is the establishment of permanent and reliable communication along the entire warning chain, including cities, municipalities, and local citizens.

- Extreme weather events will also occur more frequently in Germany. So far, the rainfall intensity can usually be predicted. However, the decisive factor for the impacts on people, buildings, and infrastructures is the occurrence of large, destructive amounts of run-off – both as surface run-off and in flowing water.
- The weather models must therefore be coupled with hydrological models. On the other hand, the possible socio-economic impacts must be integrated more strongly into early warning systems. Established warning systems in Germany do not provide estimates of impacts (e.g. the expected extent and distribution of physical damage to exposed buildings, disruption of infrastructure, or financial losses)²². Such impact-based forecasts can be an important basis for warning particularly endangered areas (e.g. particularly exposed settlements) or particularly vulnerable groups (e.g. residents of retirement/nursing homes and hospitals) earlier and more effectively and evacuating them if necessary. The need for action thus becomes clearer. This can immediately save lives and reduce the number of casualties.
- In addition to the further development of the model, comprehensive communication along the entire warning chain is essential. This includes not only the specialised authorities but also districts, cities, and municipalities, operators of critical infrastructures (including hospitals), particularly exposed settlements and areas, and the entire population in general. Studies in the aftermath of the major floods in 2013 show that the situation has improved significantly compared with the floods in 2002²³. However, the situation in smaller catchments is much more critical because the run-off processes are faster. In addition, the time of the storm (during the day or at night) plays a decisive role in the accessibility of people.
- Communication channels should be regularly reviewed and explicitly stated in management plans. It is important to implement redundancies in the communication paths (e.g. the warning was also received) so that the information transfer also functions if individual infrastructure systems (e.g. power, mobile phone networks) fail or if the interruption of a warning chain is noticed at an early stage. Between events, campaigns must be undertaken (training and behavioural education) in order to maintain the expertise and capacity to act of those affected.

²² <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020RG000704>

²³ https://www.dkkv.org/fileadmin/user_upload/Veroeffentlichungen/Publikationen/DKKV_53_Hochwasser_Juni_2013.pdf

- It is now much more important to warning the population in a way that is appropriate for the target group and to provide concrete instructions for action (“Prepare for a possible evacuation”, “Avoid cellars, subways, etc.”, “Keep yourself informed about the further course of events”). Between events, campaigns must be undertaken in order to maintain the expertise and capacity to act of those affected. In order to reach all parts of the population, all available communication channels must be used. In particular, the media (radio, television, press) are to be integrated into communication concepts.

Principle 2: Increase the retention and flood absorption capacity of landscapes, cities, communities, and neighbourhoods

In addition to established protection solutions such as dykes, walls and polders, it is becoming increasingly necessary to design communities, cities, and landscapes in such a way that leads to improved water retention in the landscape. To this end, priority must be given to the planning and the protection or restoration of green and blue infrastructures. Increasing the storage capacity for water helps in times of both drought and floods/heavy rainfall. In addition to dams and retention basins in the upper courses of rivers and the relocation of dikes along major rivers, the principle of the flood-resilient city must be established in planning practice. The combination of these measures can by no means completely prevent the negative consequences of extreme and heavy rainfall. Nevertheless, the measures can contribute to reducing the extreme run-off quantities or to extending their duration. The destructive flood events usually do not occur in the urban area itself but rather in the catchment area upstream. That’s why measures are most effective there. Urban flood-control structures perform important functions for this in times of drought; the rainwater collected is used in times of need.

- In principle, it is important to minimise rapid run-off paths (e.g. surface run-off, drainage structures) and intensify slow run-off paths (i.e. with infiltration and longer soil passage). In order to achieve this, various measures must be implemented in urban and rural areas. Large-scale drainage structures must also be revised (e.g. melioration measures, drainages, rainwater management). Groundwater, as the largest water reservoir in the landscape, is able to bridge longer periods of drought only if it is recharged to the maximum during wet periods (i.e. increasing infiltration).
- Outside of municipalities and cities, it is important to improve retention and storage capacity in floodplains, forests, and agricultural landscapes and thus also make an important contribution to groundwater recharge. Along the larger rivers, about two thirds of the former floodplains have been lost. Giving rivers more space again is therefore a central task because only functional floodplains are able to hold back water masses and cap flood peaks.
- The existing retention basins, polders, and dams are often optimised according to the aspects of flood protection. However, they require a differentiated consideration. The potential of dams is largely exhausted. Further expansion can be associated with many problematic side effects such as loss of land, high costs, and natural degradation. Moreover, the multiple uses of dams require trade-offs. “Green basins” (i.e. polders and retention basins that are used only in the event of flooding) are more advantageous here and can certainly fulfil important regional functions for decentralised storage. Particularly favourable are polder farms, which, in terms of habitat structure and secondary use, can certainly also be used by agriculture.

Highly effective measures in rural areas include the creation of natural retention areas through river restoration, revitalisation of wetlands, and dike relocations.

- In urban areas, multifunctional blue–green infrastructures or nature-based solutions²⁴ can help buffer the consequences of climate change for cities and their inhabitants. They lead to a flattening of the extreme run-off peaks; thus, up to 80% of the surface run-off can be retained locally. The water stored can also be used to provide irrigation water for dry summers. This is essential for maintaining the urban greenery and improving the urban climate. There are various technical options for dealing with surface water. They range from large-scale to smaller-scale infiltration troughs such as tree infiltration troughs to storage options in cisterns or green roofs. For example, multifunctional land use can be supported by green roofs (also with a retention function), better seepage options on open areas (trough/rigole systems), decentralised storage options (cisterns, retention boxes), and near-natural retention zones. Temporarily filled storage spaces in settlements and parks also enhance habitats and promote biodiversity and structural diversity.
- Overall, the nature-based approaches outlined²⁵ often require more space, longer planning periods, and a greater degree of cooperation between different people. Such areas are mostly privately owned and used. Better water management is therefore inevitably also a question of land policy. Therefore, a reliable legal framework and a clear set of rules that will contribute significantly to increasing the storage capacity of municipalities, cities, and landscapes are needed. New funding and incentive instruments are just as necessary as a willingness to innovate and design on the part of cities, municipalities, and investors. This requires interdisciplinary, fast, and clear planning as well as decision-making structures with active public participation. People from administration, (landscape) planning, architecture, the building industry, water management, science and civil society must work more closely together to pursue the goal of water-conscious regional and urban planning.

Principle 3: Enforce climate auditing of critical infrastructure

Critical infrastructures are the backbone of our modern society. The failure of these infrastructures is often associated with negative cascading effects in other areas and paralyzes public life or can lead to particularly critical and life-threatening situations (e.g. failure of life-support equipment in hospitals). Climate-proof infrastructures must therefore be designed to function even in extreme weather and hazardous situations. Disasters are associated with much suffering and should therefore be prevented at all costs. At their core, they also offer the opportunity to accelerate changes for better climate security (i.e. in the current reconstruction, not the same but rather improved precautionary standards are required).

²⁴ <https://www.eea.europa.eu/publications/nature-based-solutions-in-europe>

²⁵ Sarabi, S., Han, Q., Romme, A. G. L., de Vries, B., Valkenburg, R., & den Ouden, E. (2020). Uptake and implementation of Nature-Based Solutions: An analysis of barriers using Interpretive Structural Modeling. *Journal of Environmental Management*, 270, 110749. <https://doi.org/https://doi.org/10.1016/j.jenvman.2020.110749>

- Critical infrastructure is deeply integrated into everyday life. In Germany, they cover nine sectors (energy, health, IT, transport and traffic, media and culture, water supply and disposal, finance and insurance, food, and government and administration) and a total of 31 industries with responsibility for maintenance and design lying in both private and public hands. Many of these infrastructures are interdependent or depend on each other. Digitalisation, in particular, offers new opportunities for networking and optimisation. However, this also increases the vulnerability of systems. This means that the large-scale failure of individual infrastructures such as power supply or transport can have a negative impact on many other areas of public life. Maintaining the functionality is thus essential for the supply security in Germany.
- Initial studies provide a comprehensive overview of the expected climate impacts in relation to various sectors and highlight the need for action as well as adaptation options²⁶.
- Reconstruction after disasters requires a rapid restoration of the functionality of critical and important infrastructures. It must also be ensured that reconstruction includes higher standards of protection and better strategic planning of such infrastructures in order to make them less vulnerable in the medium and long term. Specifically, it is particularly exposed and critical infrastructures that need to be identified and mapped. This can be an important traffic artery, transformer stations, communication hubs, or bridges as well as hospitals, energy suppliers, and gas and water pipelines. Mapping is not only the basis for changing our infrastructures but also the prerequisite for being able to warn (hospitals) or secure (neuralgic points) earlier and in a more targeted manner in the event of an emergency. In addition, as an incentive, higher precautionary standards should also be supported by increased subsidies.
- Cascade effects pose another challenge; if a flood destroys a drinking water pipeline, a hospital cannot continue to operate. What is lacking most is the basis for evaluation. What is needed is a more robust methodology with which cascade effects can be estimated at an early stage and with which systems can be controlled independently (decentrally) despite networking. Modelling tools are needed to estimate the failures of critical infrastructure in the planning of flood protection measures as well as in the event of a disaster (e.g. in forecasting). Consideration of critical infrastructure in relevant management and planning documents is necessary²⁷.

Principle 4: Promote climate safety of buildings and enforce precautionary insurance solutions

The climate safety of buildings themselves needs to be given greater attention. While energy-efficient building and renovation is now widely promoted, climate-safe building and renovation remains the responsibility of the individual. The amount of damage can be significantly reduced through building precautions. To this end, however, climate protection materials must also be tested for their resistance to the effects of hail, flooding, and the like. A risk-differentiated insurance solution should reward precautionary measures on buildings; it helps those affected to better cope

²⁶ <https://www.umweltbundesamt.de/publikationen/KWRA-Teil-4-Cluster-Infrastruktur>

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https://www.researchgate.net/publication/351450220_Einbindung_kritischer_Infrastrukturen_in_das_Hochwasserrisikomanagement

with the financial consequences in the event of a loss. The possibility of compulsory insurance must be discussed once again in the political arena.

- Especially during heavy rainfall events, the protection of buildings cannot be achieved through dikes or walls only. Building and risk prevention is therefore important. Every person is already required to “take appropriate precautionary measures to protect against flood hazards and to reduce damage” (WHG Section 5.2). The effectiveness of building precautions is underlined in meta-studies. Damage can thus be reduced by 20 to 65 %²⁸. Wherever possible (e.g. renovation or new construction) and sensible (not in all hazardous situations can damage be reduced by building precautions), water must be prevented from penetrating structural measures on the building. Backwater flaps, pressure-tight windows, and dam beam systems on doors are effective means. Equally important is an adapted interior use (i.e. the use of relatively flood-resistant materials and flexible and quickly stowable furniture on the lower floors). Important utility installations (power distribution, heating) should be installed on higher floors or made flood-proof. In addition, the areas around buildings or in housing estates should be designed in such a way that heavy rain or floods can be drained off without major damage.
- Professional independent counselling is now offered. Every home-owner can carry out an individual risk assessment and can have an assessment on how effective various risk reduction measures are (e.g. flood passport²⁹ or flood prevention certificate)³⁰. These initiatives are important and provide professional support. Studies show that the number of households and businesses taking structural measures is increasing. However, the total number of households securing their building is still relatively low. It is mainly those households that are repeatedly affected by floods or heavy rain that implement measures³¹. Without experience, often little precaution is taken on the building. It is important to stop this trend.
- Similar to climate protection (keyword: energy efficiency) in existing buildings, it is time to launch a large-scale programme to secure or increase the climate protection of buildings. Appeals will not be enough. Concrete financial support is needed (e.g. in the form of low-interest loans linked to climate-safe construction or renovation). In addition, financial incentives should be developed for combined projects of climate protection and climate adaptation in building conversions.
- The possibility of compulsory insurance must be examined in terms of constitutional law. Heavy rainfall and the associated flash floods have become a general risk of life in Germany and can affect anyone and everyone. Collective solutions must therefore be found so that all home- and land-owners can take out comprehensive natural hazard insurance at reasonable conditions. Insurance conditions must be designed in such a way that they provide incentives for prevention (risk-differentiated tariffs).

Principle 5: The will to shape and assert is just as necessary as cooperation and solidarity

²⁸ <https://link.springer.com/article/10.1007/s11027-014-9629-5>

²⁹ <https://www.hochwasser-pass.com/>

³⁰ <https://www.bdz-hochwassereigenvorsorge.de/de/was-bieten-wir-an/hochwasservorsorgeausweis.html>

³¹ https://gfzpublic.gfz-potsdam.de/rest/items/item_5000380_3/component/file_5000984/content

The transformation requires the will to innovate and change on the part of cities, municipalities, investors, and private individuals as well as the use of financing and incentive instruments on the part of the federal government and the federal states. There is a need for assertive actions in planning. Furthermore, the benefits and burdens of the transformation to climate-proof cities and municipalities must be shared in a spirit of solidarity.

- While the federal and state governments should primarily adjust the legal and regulatory framework and develop financing options for the upcoming transformation processes, the municipalities and cities need find creative and sustainable solutions together with civil society, businesses, and local citizens.
- There is a need for greater standardisation and coherence in all areas of extreme event management and disaster risk reduction. This concerns shared early warning levels and essential reference values to which different organisations and institutions have to refer. Greater coherence must be established horizontally (i.e. between sectors and the various planning and management areas). However, it also needs to be established horizontally from the federal to the state to the municipal level.
- The knowledge base for climate-safe municipalities and cities must be further improved. Research in the field of climate adaptation, risk management of weather extremes, and civil protection as well as planning must be further strengthened. This includes consideration in the relevant research funding programmes as well as in the funding programmes for cities and rural areas. Municipalities that already successfully plan and implement climate adaptation have an important role as models. Good practice examples should be systematically prepared and disseminated in order to overcome hurdles in climate adaptation. Analyses³² show that smaller cities lag behind larger ones in climate mitigation and adaptation because they have fewer resources and expertise. Therefore, smaller and medium-sized cities and municipalities should be supported more in these tasks (e.g. cooperative tandem programmes with other cities). Inter-communal cooperation between municipalities and cities should be given greater priority because solutions to both flooding and, in many cases, heavy rainfall and heat stress require inter-communal cooperation.
- Many aspects that we have described are part of integrated urban and spatial development in which different sectoral fields of action are included in planning and synergies between individual areas and disciplines are identified and used. A strong orientation of future urban development towards the common good, as postulated in the New Leipzig Charter for European Cities of the Future, requires the joint work of all urban stakeholders towards a transformation of cities and municipalities towards more sustainability. The importance of strategic planning should be strengthened in this context because, in many cases, a collection of individual projects alone cannot take these complex problems into account. We thus need to rebuild our cities and communities in order to better cope with extreme weather events, save lives, and reduce property damage.

³² Otto et al. (2021): <https://link.springer.com/article/10.1007/s10584-021-03142-9>