7.3 CLIMATE ASPECTS IN URBAN LAND-USE PLANNING

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1. Abstract

Through increasing building and population densities, the expansion of the urban settlement areas, a shift in the age structure, and an increase of extreme weather conditions caused by climate change, the urban population will increasingly be exposed to environmental stress. Climate-induced effects (i. e. heat periods, torrential rain) are further exacerbated within the city center as a result of high degrees of soil sealing, a decreased exchange of the near surface atmosphere, and an increased air pollution.

One of the biggest challenges in the field of urban land-use planning will be to find solutions for these climate-inducted effects. In Germany there are two scale levels of urban land-use planning. The overall urban development is defined at the scale of the urban area. This planning is specified in the zone plan by setting the legal bindings for the small-scale development, infrastructure areas, and open space structures. Enhancing the climate aspects of planning the German legislator included the climate protection clause into the building code (BauGB). This change in 2011 should contribute to take account of climate mitigation and adaptation, particularly in urban development, through concepts and the concrete definition of building measures.

The legislator has also included specific fixing options for climate adaptation in § 9 para. 1 BauGB, which regulates the contents of the development plan. As a result, urban land-use planning offers good opportunities for the implementation of comprehensively integrated spatial climate mitigation and climate adaptation concepts in urban areas. However, in planning practice, due to a lack of concern or ignorance, the climatic concerns are given little importance. Therefore, a systematic and structured approach is needed to respond and act on current and future challenges.

2. Introduction

The Federal Republic of Germany takes a comparatively important role in international comparison in the context of climate mitigation and climate adaptation. Even before the European Directive on the Use of Renewable Energies become law (Directive 2009/28/EG of the European Parliament), the Renewable Energies Act (EEG) was introduced in Germany in 2000. This regulates the expansion of renewable, climate-friendly energy sources and their feeding into the power grid. Primarily, the

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implementation of this EU directive serves the climate mitigation. To take account on climate change the German Adaption Strategy to Climate Change (Deutsche Anpassungsstrategie an den Klimawandel – DAS) was introduced in the year 2009. This strategy contains the following long-term objectives:

- to name dangers and risks ➔ increase transparency of probabilities, damage potential and uncertainties,
- to sensitize of involved actors,
- to provide fundamental information, which enables the different actors to take precautions,
- to show options for adaption actions and to define responsibilities ➔ formulate and implement appropriate measures

In order to be able to make concrete statements about Germany's vulnerability in fact of climate change, national vulnerability was determined in the course of developing the DAS. The Vulnerability Authority Network (Behördennetzwerk Vulnerabilität) presented the impact of Germany on climate change thematically and regionally. In addition to meteorological values, regional data (e. g. population and economic structure) were also considered in the analysis and were linked to each other. This resulted in a climate statement with regional references. In this context, the levels of regional and land-use planning are classified as particularly relevant levels to adapt climate change.

The DAS was followed by the so-called Adaptation Action Plan (Aktionsplan Anpassung - APA) in 2011 to develop and implement the initital measures. This reinforces the cooperation between the levels of the federal, state and local authorities as well as the various actors from politics, business and society. The APA defines three strategic national pillars and one pillar with regard to cross-border, international measures.

1st Pillar: Provide knowledge, inform, empower

➔ general knowledge is expanded, information is provided and conveyed

2nd Pillar: Federal framework

➔ greater consideration of climate change adaptation by social actors by the means of a legal framework

3rd Pillar: Activities under direct federal responsibility

➔ climate-adapted design of federally owned areas, real estate, infrastructures (e. g. federal waterways, railways) and construction projects

4th Pillar: International responsibility

➔ provision of information on European and international initiatives (development and research cooperation) for adaptation by the federal government

Based on these pillars there are numerous activities (e. g. the project "Spatial Development Strategies for Climate Change" (Raumentwicklungsstrategien zum Klimawandel - Pillar 1) or the adaptation of

legal regulations in the Federal Building code (Baugesetzbuch – BauGB - Pillar 2).

The above explanations on the national regulations show the continuously adapted activities and measures according to the dynamic processes of climate change. This is also reflected in the legal framework of the Federal Republic, in which spatial planning as well as regional and land-use planning are integrated. In terms of urban land-use planning pillar 2 is the most notable. For example, the changes in the BauGB (inclusion of § 1 (5), 2 - climate adaptation as a planning guideline and corresponding options for determining) based on the content of this pillar.

3. Climate concerns in (spatial) planning

The spatial planning system in Germany is structured in stages based on the existing administrative levels. The first level is the federal government, which primarily specifies principles and guidelines (e. g. Regional Planning Act, ROG) and only makes specific planning statements for especially selected areas (e. g. exclusive economic zones).

The second level is the state level. The third one is the level of the regions. The federal states draw up country-wide spatial planning plans which, in the sense of § 1 (3) of the ROG, set the regional goals for development. Based on this, the competent authority at regional level then draws up regional plans that specify the statements of the higher levels (in accordance with § 8 (2) ROG). The requirements at the state and regional level are in particular in the form of goals and principles of spatial planning (within the meaning of § 3 (1), 2, 3 ROG). Goals are weighed and binding specifications that must be observed in subsequent planning in the sense of an adjustment. The principles are statements for subsequent weighing and assessment decisions, which need to be considered, specified and further weighed up as part of local level planning.

At the municipal level, the national and regional requirements must be implemented (in accordance with § 1 (4) BauGB). The municipal land-use planning is in responsibility of the municipality in accordance with § 1 (3) BauGB. This has to draw up the site plans as soon as and as far as it is necessary for the urban development. This task is defined by § 1 (1) BauGB. It is crucial that different requirements for an area are coordinated with one another, that occurring requirements are taken into account and potential conflicts are avoided. It follows that spatial planning is an important instrument with regard to climate protection and adaptation, particularly due to the spatial character of numerous climate impacts (e. g. urban warming) and the vulnerability of existing space uses and structures.

In order to strengthen the role of spatial planning, amendments to the relevant legal foundations have resulted in the past, which integrates content related to climate mitigation and adaptation. This affects all planning levels in the German planning system.

	Planning tool	Statutory basis
Federal level	General principles of regional development	Federal Spatial Planning Act (Raumordnungs-gesetz - ROG)
State level	State development plan	Federal Spatial Planning Act (Raumordnungs-gesetz - ROG)
Regional level	Regional plan	Federal Spatial Planning Act (Raumordnungs-gesetz - ROG)
Local level	Land-use plan Development plan	Federal Building Code (Baugesetzbuch - BauGB) Federal Land Utilization Ordinance (Baunutzungsverordnung - BauNVO)

Tab. 1: Planning levels in Germany

4. Transferibility options for climate adaptation in land-use planning

In urban land-use planning as an instrument of spatial planning on the municipal level, the conditions are created for legally enforceable bindings for climate adaptation measures. This is possible in the course of drawing urban development plans with area- and measure-related determinations. The land-use plan (preparatory land-use plan) covers the entire municipal area. The climatic effects relating to the urban site as a whole (e. g. from informal planning or regional planning) can be included. The representation of the land-use plan is extensive - this is also the basis for the options of acting on climate mitigation and adaptation. So, in land-use plan the provision of areas for cold air production areas and ventilation paths, the distribution of structural uses in the region and also the density of urban areas can be represented. The urban land-use plan is substantiated in the urban development plan. In the catalog of provisions in Section 9 of the BauGB, § 9 (5), 1 provides the specific option of ordering special constructional measures or security measures against natural forces for the development. E.g., this can be used for the protection against flood or storm hazards. Areas that are to be kept free of the development (according to § 9 (1), 10 BauGB), as well as infrastructure areas (§ 9 (1), 21) can be used for the containment of heavy rain and drainage channels. In general, the stipulations of the development plan regarding the type and dimension (density) of the structural use, construction method and coverable areas can specifically for climate adaptation. Determinations in accordance to § 9 (1), 20 BauGB can be used for local greening (also on facades and roofs). Though, the focus is on the content of development plans, which are of particular importance with regard to the binding definition of measures for climate adaptation on a local level.

5. Procedure for taking local or district-specific climatic concerns into account planning urban quarters

In order to adequately take the adaptation into account by planning urban districts, it is advisable to take a holistic view of the existing content of the various planning levels. The aspect of climate adaptation must be included at an early stage of planning in order to integrate it as seamlessly as possible into the overall planning concept. An exemplaric procedure in form of a two-part test scheme is available for this. Thereby, the focus is on the impacts of urban warming indicated by climate change, a decrease of

exchange of the near surface atmosphere and flooding due to heavy rain events.

5.1. Procedure and system

The topic of climate adaptation is often marginally considered (e. g. planting trees, creating compensation areas). Although it must be dealt comprehensively in accordance to the BauGB regulations. An urban planning draft forms the basis for a development plan planning urban quarters. This should take climate adaptation into account within the meaning of § 1 (5), 2 and § 1 (5) BauGB. However, the development plan usually fixes the content of the urban design by making appropriate stipulations. If the design does not take the aspect of adaptation into account arranging different uses and structural structures, this is usually reflected in the development plan.

Accordingly, it makes sense to take the issue of climate adaptation into account in urban planning processes before the actual land-use plan procedure. In principle, climate adaptation should already be included in the basic concept development stage. First of all, an important prerequisite is to determine whether the respective community is or could be affected by the effects of climate change (increase of temperatures, number and intensity of heavy rain events and storms). Therefore, an analysis of various local climate information is required, which does not have to be as detailed yet. At this early stage, the only thing that needs to be determined is a potential burden on the community. In this context, it makes sense to use existing sources (e. g. statements from plans of various informal and formal plans). A procedure helps to check a potential need for adaptation at an early stage in the planning process. Following the review, specific content can be transferred into the urban design according to a diagnosed need. If there is a basic need for climate adaptation, it could be taken into account in the development process of the development plan. In addition to the regulations in § 1 (5), 2 and § 1 (5) BauGB, the environmental assessment within the meaning of § 2 (4) BauGB must be given particular weight. In addition to effects on the climate, the environmental assessment must also take account of environmental effects on people and their health as well as the population (§ 1 (6) BauGB). This includes the challenges posed by climate change, which cause potential threats to people and their health.

Based on this problem, a test scheme was developed that can be used as part of the environmental review. Comparable test schemes already exist for species protection issues. With the help of this test scheme, a concrete need for action with regard to climate change-related burden should be considered within the urban planning process.

The structure of this approach taking climatic issues into account planning urban districts consists of two modules. The first module provides information about a potential need for adaptation in the respective community. It is indicative and should be used early in the planning process. The review is based on existing plans of formal and informal planning at various levels with regard to existing climatic effects and information (see Fig. 1).

The second module contains a test scheme for urban warming, a decrease of exchange in the near surface atmosphere and flooding due to heavy rain events. The analysis of different indicators and, at the same time, the identification of potential areas of stress can make appropriate suggestions for fixing. It is important that even if there is no information in the first module, the respective community can be burdened by climate change. Module 2 represents only a section of possible content to be checked. By checking the content of existing plans, the module anticipates the land-use plan procedure. Due to the focus of the first module on local climate content, early consideration of climate change and adaptation in the planning process will be supported. The second module, which can be integrated into the environmental assessment, can and should also be used independently of the first module (see Fig. 1).

5.1.1. Module 1

Module 1 intigrates five different levels, which extend from the federal level to the municipal district level. A certain number of questions are formulated for each of the parts, which can be answered with "Yes" or "No". There is no specific weighting of the different levels. In total, there are eighteen questions for the entire module. The more questions that are answered with “yes”, the more the assumption that the aspect of climate adaptation with regard to urban warming, a decrease of exchange of the near surface atmosphere, and/ or flooding due to heavy rain events should be considered in the urban planning process (see Fig. 3). At the same time, it can be deduced from this module that detailed on-site studies should be carried out (if these are not already available). In particular, municipalities that have not yet implemented any or hardly any approaches adapting to the climate can

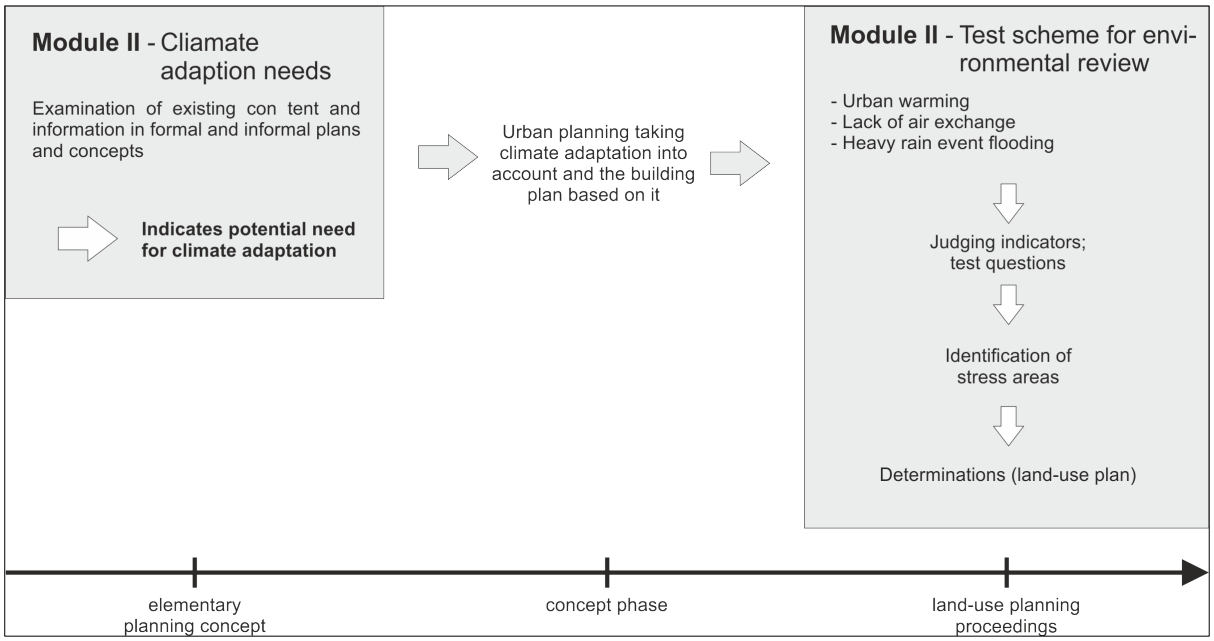


Fig. 1: Structuring and systematics of the analytical procedure for evaluating local climate issues in land use planning

receive first indications of a possible need for adaptation.

At this point it should be explicitly pointed out again that the result of this module is only indicative and that further on-site investigations on the effects of climate change are recommended.

The first part of the module serves to classify the community on a large scale. For this purpose, the location in densification areas and the location on rivers or coasts to the respective municipality are queried. This is done on the basis of the national challenges identified by DAS and their thematic and regional vulnerability (urban warming in urban areas, exposure to heavy rain and storm events, exposure to floods in general).

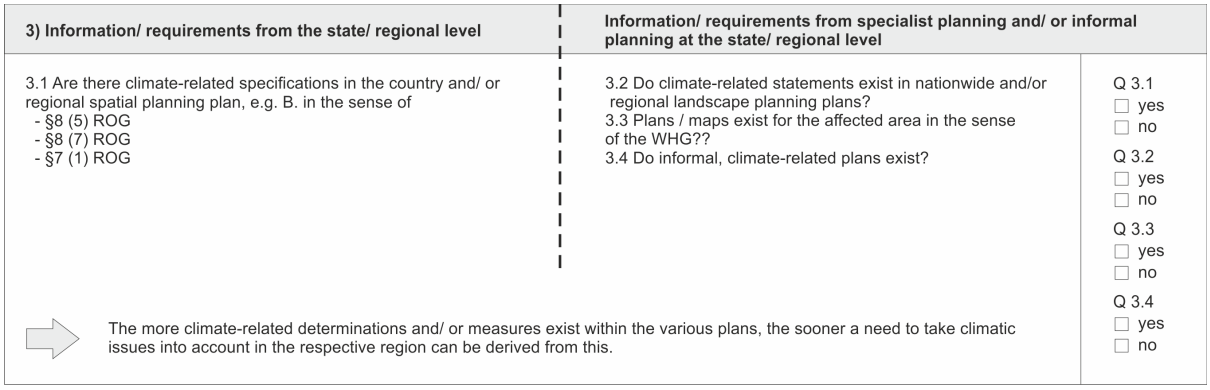


Fig. 2: Question "Information and requirements from state and regional level"

The assessment of the community with regard to its location in densely populated areas, on rivers or on the coast provides a first indication of potential burdens.

The second section in module 1 includes information on various regional climate data (air temperature, air humidity, precipitation, etc.). Free accessible climate data are available by the climate atlas of the German Weather Service (DWD).

The third level in module 1 deals with the review of possible existing information or requirements for climate adaptation at the state or regional level (Fig. 2). It is checked whether such stipulations exist in the state-wide and/ or regional plan or whether corresponding statements are available through other specialist/ subject plans (e. g. landscape planning, flood protection planning). In addition, informal planning (climate adaptation strategies) is a potential source of information. If climate-related content already exists in the above-mentioned areas, this can be used for the urban development planning. In addition, consideration of climate adaptation that has already taken place can indicate a corresponding need in the region.

The structure of the fourth part of module 1 is congruent to the third section. The difference between the third and fourth part is the reference level. In section 4 there is a review of the land-use plan and other specialist planning on urban level as well as informal planning for possible content for climate adaptation.

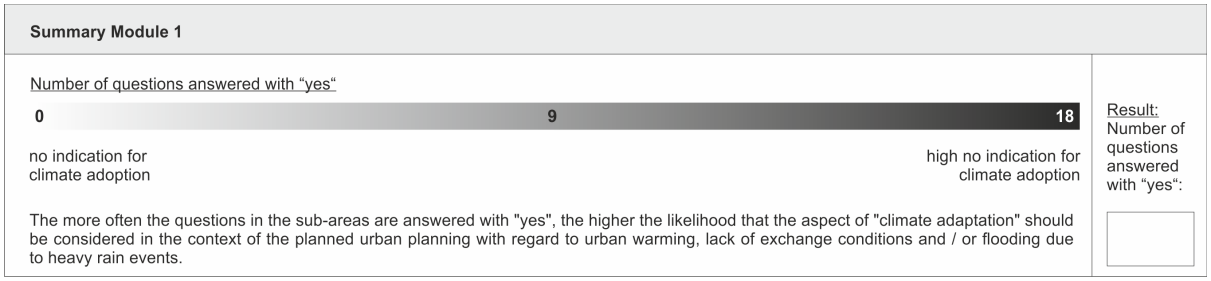


Fig. 3: Exemplary presentation of the results for evaluating the content from module 1

The fifth section of module 1 included selected questions on the planning area. In this section, the location of the area in the municipality is queried. If the planning period is within built-up or sealed areas, it can be assumed that there is an increased risk of local climatic load. However, the potential of loading the planned area can also arise due to geomorphological peculiarities.

Module 1 concludes with a summary of the questions dealt with at the different levels.

5.1.2. Module 2

The second module represents a test scheme that can be used as part of the environmental review. The verifiable potential pollution is urban warming, a decreasing of exchange of the near surface atmosphere and flooding due to heavy rain events. Corresponding test indicators are defined for each of the three potential risk factors and should be checked for the respective planning project. Depending on the result of the analysis of the test indicators, a vulnerability of the reference area can be derived from the checked load. It is important that the processing of the individual test points cannot conclusively and clearly prove a local load. The test scheme only covers a part of the investigation area to be tested. In the case of a statement that suggests a potential contamination, further site-specific and detailed investigations are recommended. Corresponding stress ranges are defined for each of the three stress potentials, which would be particularly affected by possible effects. Additionaly, the urban planning draft, available to the municipality, needs to be checked for these stress areas. These can be identified in the urban design or in the development plan and based on this, a reference to adapted determinations can be given as possible solutions.

Following, an explanation of the defined test indicators is presented for each of the investigable urban climate effects:

• Urban warming

Eight test indicators are defined for the "Urban warming" section. The average annual temperature and its temporary development provide information about the local climate situation with regard to air temperature. Checking the number of meteorological event days (warm/ hot days, tropical nights) provides information about a potential local heat load. Warm days are characterized by a maximum air temperature of at least 25°C (77°F). Their number also includes the hot days, which are defined by a maximum temperature of at least 30°C

(86°F). Tropical nights are characterized by night-time air temperature values ≥ 20°C (68°F) between 6:00 p.m. and 6:00 a.m. Especially in summer, this phenomenon can be observed during long lasting clear and calm weather conditions. With the help of the analysis of the development of the air temperature conditions and a trend regarding the number of warm/ hot days as well as tropical nights, it is possible to predict how the urban warming situation will develop in future.

In relation to urban warming, four potential stress areas are defined that are particularly affected by climate change.

These include interiors of perimeter development. Due to the isolated location within the building structure, atmospheric exchange is almost impossible. In addition, the air temperature inside the structure is affected by the surface temperature of the buildings/ building materials. This effect is reinforced by the surrounding soil sealed surfaces.

Public spaces usually have a high degree of soil sealing, which causes these areas to heat up significantly. In the absence of shadow, this effect is reinforced by the lack of modules and structures (e. g. trees).

Traffic areas (streets, parking spaces, etc.) also represent sealed areas Due to the changed runoff behaviour of precipitation and the thermal properties of the materials used, they also contribute to urban overheating.

The same effect as caused by traffic areas also occurs on building areas. The higher the building density, the stronger the effects of the physical properties of artificial building materials.

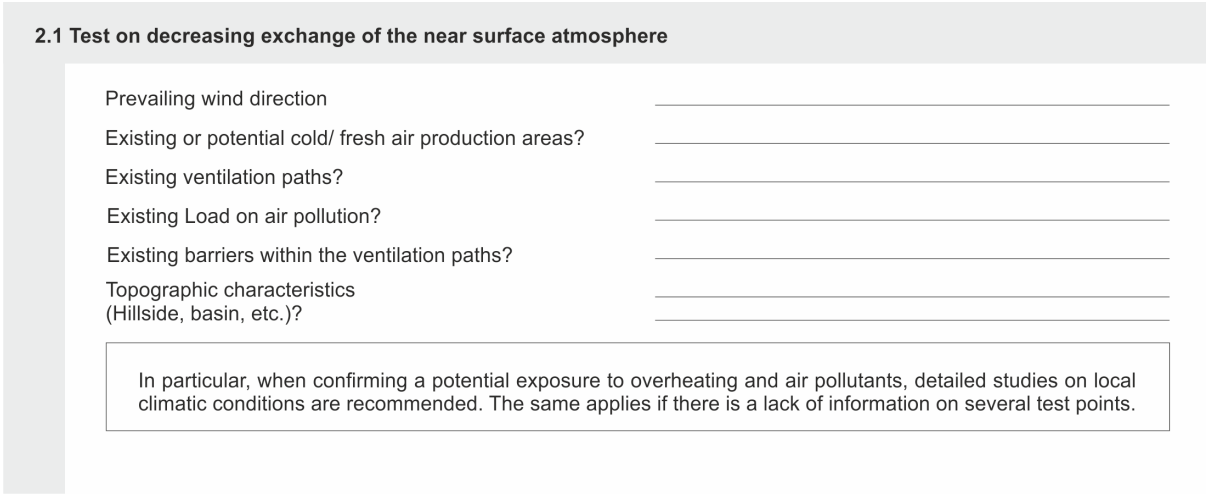
After a potential stress area could be identified, structures can be adapted in the affected area and specific fixing determinations could be made.

• Decreasing exchange of the near surface atmosphere

To qualify a statement on the atmospheric exchange conditions near the ground, it is necessary to determine the prevailing wind direction. In addition, there must be an analysis of existing or potential cold/ fresh air production areas and their potential ventilation paths. Considering their potential settlement-relevant ventilation effect these needs to be used with regard to urban warming. In addition, the existing air pollution and existing barriers to air exchange are queried. Finally, if available, topographical terrain conditions affecting the local climate are analyzed. In the case that the module detects decreasing exchange of the near surface atmosphere, further detailed investigations must be carried out. This applies in particular to a proven exposure to overheating and/ or air pollutants (see Fig. 4).

With regard to the lack of near-ground exchange conditions, three risk areas are defined. These risk areas include areas with pollutant sources, negative topographical properties (e. g. basins) or obstacles in ventilation paths. In particular, areas with a potential exposure to air pollutants require appropriate exchange options in order to ensure that they are diluted.

As in the previously explained test scheme "Urban warming", once a potential risk has been identified, the described stress areas can be structurally adjusted and fixing determinations can be made.



2.1 Test on decreasing exchange of the near surface atmosphere

Prevailing wind direction	
Existing or potential cold/ fresh air production areas?	
Existing ventilation paths?	
Existing Load on air pollution?	
Existing barriers within the ventilation paths?	
Topographic characteristics (Hillside, basin, etc.)?	

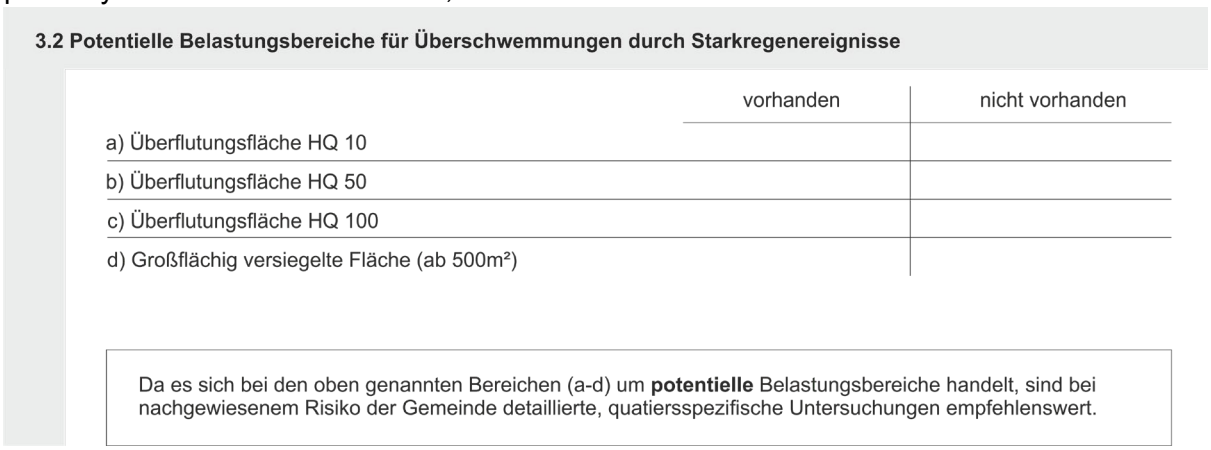
In particular, when confirming a potential exposure to overheating and air pollutants, detailed studies on local climatic conditions are recommended. The same applies if there is a lack of information on several test points.

Fig. 4: Test schemes for potential risk areas due to the lack ground-level atmospheric exchange

• Heavy rain events

To make a declaration on potential detriments caused by flooding as a result of heavy rain events, the average annual rainfall, the relative humidity and their development over the past ten years are primarily considered. In addition, also the number of heavy rain events and their expected development are queried. Unfortunately, there are often no area-based statistics for heavy rain events. However, a potential risk on heavy rain effects can be derived from above-average/ increasing rainfall. If there are no information available, site-specific, detailed investigations should be carried out.

Areas that are declared as flooded areas in flood hazard maps are classified as potential risk areas in the event of heavy rain events. A distinction is made between three categories: areas that are statistically flooded



3.2 Potentielle Belastungsbereiche für Überschwemmungen durch Starkregenereignisse

	vorhanden	nicht vorhanden
a) Überflutungsfläche HQ 10		
b) Überflutungsfläche HQ 50		
c) Überflutungsfläche HQ 100		
d) Großflächig versiegelte Fläche (ab 500m²)		

Da es sich bei den oben genannten Bereichen (a-d) um **potentielle** Belastungsbereiche handelt, sind bei nachgewiesenem Risiko der Gemeinde detaillierte, quatiersspezifische Untersuchungen empfehlenswert.

Fig. 5: Test schemes for potential exposure areas for flooding due to heavy rain events

once every ten years (HQ10), once every fifty years (HQ50) and once every hundred years (HQ100). The longer this time interval, the greater is the potential of flooding (see Fig. 5).

In addition, large sealed areas are at risk from flooding as a result of heavy rain events, since the surface runoff cannot infiltrate off. The sewage system is often not designed for such short-term heavy rain quantities of water. After the final identification of such risk areas described above, the existing structures can ideally be adjusted and appropriate determinations can be recommended.

6. Conclusion

Climate change has been a subject of constant discussion since the early 1990s. The first international agreements, such as the Framework Convention on Climate Change, created a basis for subsequent regulations. Initially, the focus was primarily on climate mitigation measures (e. g. reduction of industrial emissions, promotion of renewable energies). Climate mitigation precedes climate adaptation. Thus, the topic of climate adaptation from climate protection has developed on the basis of various international and national agreements/ regulations. In Germany, spatial planning plays a crucial role in adapting to climate change, as it coordinates the different spatial requirements in order to compensate for conflicts that arise at the respective planning level. Regional and urban land-use planning is of particular importance since they make concrete and binding statements. The prerequisites for such binding regulations are created by appropriate content in the legal framework.

As the effects of climate change will also enhance urban climate effects in the future, the need for adapted urban development also increases. This finding again underlines the importance of land-use planning when adapting to climate change. The prescribed environmental review when drawing up land-use plans (§ 2 (4) BauGB) already provides the basic prerequisite for taking climate adaptation into account when planning urban districts. However, the adaptation is often not given sufficient weight. This contributes to the fact that the legislators accelerating planning with §§ 13a and 13b BauGB have moved away from the obligation to carry out an environmental assessment in case of a large number of development plans. Though, there is a need for optimization. If the measures for climate adaptation are adequately considered, the existing definition of the development plan in accordance with § 9 BauGB contains numerous options for countering potential climate change-related burdens.

In order to adequately take the adaptation into account planning urban districts, a holistic view of existing content at various levels of spatial planning should be sought. It is important to consider the aspect of climate adaptation at a very early stage of planning in order to integrate it as seamlessly as possible into the overall planning concept.

Various informal plans or programs currently exist with regard to the issue of climate adaptation in regions and urban areas. However, these statements, which are often drawn up in form of master plans, are often

without any concrete reference for implementation and only make generally applicable statements. In addition, such plans are often limited to areas that are structurally strong and already particularly affected by the effects of climate change. Due to recent climate change, increasing densification/ sealing and increasing numbers of inhabitants in urban areas and the number of contaminated areas will increase in future. As a result, adapted solution strategies are required that can be used within the framework of the existing legal regulations.

With the development of the procedure consisting of two modules, an exemplary approach is shown how climate adaptation could be integrated into the planning of urban districts. The decisive factor is the inclusion of the adaptation at an early stage in the planning process. It is also important to ensure that it is adequately taken into account in the environmental review. A standardized solution should be found to integrate the local climate analysis into the environmental review. Since the basic requirements for an adequate consideration of local climate issues, in particular climate adaptation measures, is already given by the existing content in the Building Code, the integration of a structuring test scheme in the environmental assessment can be classified as extremely useful.

7. References

APA - Adaptation Action Plan (2011): Aktionsplan Anpassung der Deutschen Anpassungsstrategie an den Klimawandel. Die Bundesregierung, pp. 93 (in German).

BauGB - Federal Building Code (2017): Baugesetzbuch; in the version dated 20.07.2017 (in German).

BauNVO - Federal Land Utilization Ordinance (2017): Baunutzungsverordnung – Verordnung über die bauliche Nutzung der Grundstücke; in the version dated 04.05.2017 (in German).

DAS - German Adaptation Strategy to Climate Change (2008): Deutsche Anpassungsstrategie an den Klimawandel. Die Bundesregierung, pp. 78 (in German).

EEG - Renewable Energy Sources Act (2014): Erneuerbare-Energien-Gesetz - Gesetz für den Vorrang Erneuerbarer Energien; in the version dated 21.07.2014 (in German).

ROG - Federal Spatial Planning Act (2017): Raumordnungsgesetz; in the version dated 20.07.2017 (in German).

WHG - Water Resources Act (2017): Wasserhaushaltsgesetz – Gesetz zur Ordnung des Wasserhaushaltes; in the version dated 18.07.2017 (in German).