Urban Environmental Protection

The strategic research agenda of the German Environment Agency

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Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

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Foreword

Towns and cities are full of life and variety – they are our cultural centres and form a nucleus for knowledge and innovation as well as for modern lifestyles. They offer opportunities for social, technological and environmental developments. Urban settlements are centres of human consumption of energy and resources and the generation of much environmental pollution. At the same time, they are more resource-efficient than other forms of settlement, for example because they are more densely inhabited and involve shorter trips for daily mobility.

With steadily growing demands on housing, mobility, and consumption, the densely populated urban settlements offer considerable potential for reducing environmental impacts. In order to allow healthy urban surroundings and a high quality of life in vibrant green quarters for the residents, urban development must be closely linked with environmental quality targets.

As Germany's central environment agency, our focus is on people and the environment. We have therefore set ourselves the goal of paying greater attention to the interface between urban development and environmental protection and of highlighting causal relationships by means of an interdisciplinary approach. The focus will be on new strategies and topics, but will also address "old problems" for which existing strategies have not yet been implemented.

The German Environment Agency has developed the strategic research agenda "Urban environmental protection", which views urban development from an environmental perspective and formulates specific questions and focal topics. Over the next five to ten years we want to follow up the topics of the research agenda with specific analyses and projects. It is also our goal to see that the results of our research find practical applications without undue delay. With the publication of our Research Agenda we invite actors in the fields of politics, science, commerce and civil society to work together with us on sustainable and environmentally compatible urban development.

We look forward to proceeding along this path together with you!

Maria Krautzberger

Urban Environmental Protection

Summary

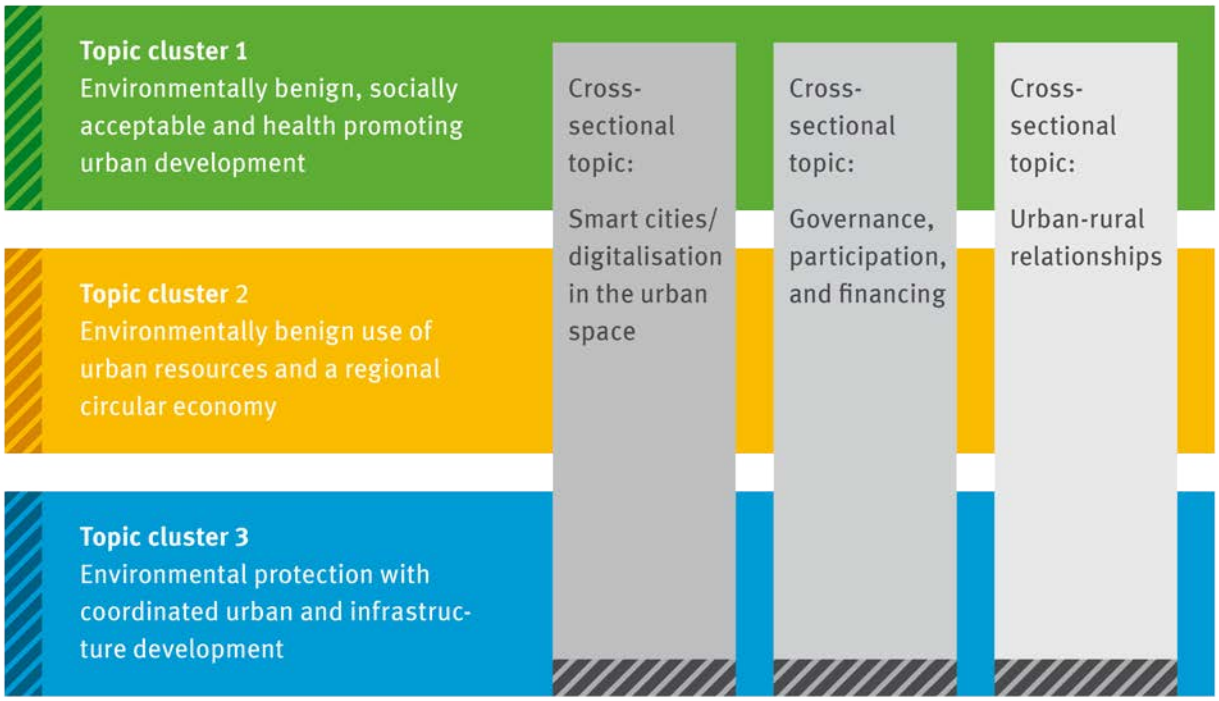
"Urban environmental protection" is a cross-sectional task in the German Environment Agency (UBA). In this strategic Research Agenda, the UBA identifies focal points for future research towards the **development of settlement areas in accordance with environmental quality goals.** The Agenda also highlights gaps in our knowledge about environmentally oriented, socially acceptable and health promoting urban development. The objectives of the Agenda are:

- Defining environmental targets in the urban space and the identification of obstacles to achieving these,
- Addressing questions arising from an integrated, interdisciplinary perspective,
- Identifying causal relationships and proposing solutions to problems
- Applying effective instruments for the development of environmentally benign, socially acceptable and health promoting urban settlements.

The UBA research agenda focuses on topics which are of particular relevance for the development of urban spaces **from an environmental perspective** in view of the current conditions, trends, and challenges. In particular it raises issues for which an **interdisciplinary approach** promises to offer added benefits. Many of the proposals and findings can only be implemented through the **combined efforts of various actors and specialist disciplines**. Close cooperation is therefore essential with research institutions, authorities, municipal actors, associations and networks, civil-society organisations, and other multipliers.

On the basis of past, present and future activities of UBA and other agencies and institutions, the Agenda shows the integrative, transdisciplinary and interdisciplinary fields of urban environmental protection in which **the UBA will be increasingly active in the next five to ten years**. This research agenda supports the research programme of UBA in the field of urban environmental protection. It augments and establishes links between the specialist fields of research of UBA. In addition to municipalities, the results of the research will also be addressed to the Federal Environment Ministry and other German federal ministries. The **results of the research** should flow into programmes, strategies, legislation, communications and information instruments of the Federal Government.

The topic clusters and cross-sectional topics of the UBA research agenda "Urban environmental protection"



Source: UBA presentation

Main research topics

The agenda describes **three topic clusters** and **three cross-sectional topics** with an interdisciplinary character that have been identified as priorities in the Agenda process, along with **key research questions**:

The three topic clusters are:

- **Environmentally benign, socially acceptable and health-promoting urban development:** This cluster deals with the various conflicting demands on built-up urban areas. It addresses environmentally-related synergies and conflicts with social and economic concerns of urban development and formulates environmental targets for healthy lives in settlement areas.
- **Environmentally benign use of urban resources and a regional circular economy:** This cluster deals with challenges and opportunities regarding the use of resources in the urban space and aims at improving the understanding of urban material flows and their environmental impacts.
- **Environmental protection by harmonised urban and infrastructure development:** This cluster focuses on the resilient, environmentally benign und socially acceptable shaping of settlement-related infrastructures and sector interfaces with their interactions, and searches for systemic goals and potentials for an environmentally-oriented transformation of urban infrastructures.

The three cross-sectional research topics **"Smart cities and digitalisation in the urban space", "Governance, participation and financing"** and **"Urban-rural relationships"** deal with broader structural issues which extend beyond the spatial and institutional boundaries of settlement areas. Gender mainstreaming will be implemented in the topic clusters and cross-sectional topics, in particular for questions relating to social matters, health, governance, and participation and communications.

For each of the **three topic clusters** and **three cross-sectional topics**, examples are given of key research questions which will be addressed by UBA's research:

Topic cluster	Key research questions
Environmentally benign, socially acceptable and health promoting urban development	How can the focus of urban development and planning processes be shifted to concentrate more on environmental and health aspects, and social concerns? How can an environmentally just neighbourhood development be implemented on a broad scale? How can all citizens participate effectively in neighbourhood development in a socially differentiated society?
Environmentally benign use of urban resources and a regional circular economy	Which indicators are suitable for monitoring resource-conserving urban development? How can the environmentally benign use of resources be promoted at the municipal level?
Environmental protection with co-ordinated urban and infrastructure development	How can infrastructure systems be transformed? What are the criteria for choosing the right time for incremental renewal of infrastructures or their radical, disruptive transformation? Which strategies result for the realisation of integrated, environmentally benign, resource-conserving and resilient urban infrastructures?

Cross-sectional topic	Key research questions
Smart cities/digitalisation in the urban space	What are the environmental effects, advantages and risks of new applications for information, communications, data and control technologies in urban areas? How can negative impacts and rebound effects be avoided?
Governance, participation and funding	How can national environmental programmes and policies be formulated so that they effectively, efficiently and sustainably promote the development of socially acceptable, healthy neighbourhoods and integrated infrastructures that have low impacts on the environment and climate and also conserve resources? How can participation and cooperation be organised in order to achieve the goals of sustainable urban development?
Urban-rural relationships	How can environmental impacts be reduced by inter-communal cooperation? How can regional inter-connections be optimised?

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Why do we need an agenda for urban environmental protection?

In Germany, some three-quarters of the population live in towns and cities, and the proportion is still increasing. By 2030, it is predicted that the population in German municipalities will increase by some five per cent above current levels, while a worldwide increase of 15 per cent is predicted (UN HABITAT 2010, UN DESA 2015, Population Reference Bureau 2017, Statista 2017). As a consequence, towns, cities and conurbations will not only cause environmental impacts, but will increasingly also be affected by these. With its **strategic research agenda for urban environmental protection,** UBA is therefore directing attention to the interface between urban development and environmental protection.

The report of the German Science Council (WR 2015) on the German Environment Agency (UBA) recommended, among other things, increased forward-looking research to improve the early warning function, which requires appropriate framework conditions. The research strategy of the UBA lays out how it intends to maintain and improve its research performance by further institutional developments. The UBA research programme describes its scientific profile and research activities in 15 fields and defines key specialist areas for research activities. This Agenda augments the research programme in the field of urban environmental protection.

The many activities relating to sustainable urban development illustrate the relevance of the topic, but also highlight the necessity for links between them to allow an exchange of information. The further development and shaping of urban areas that are good to live in is a complex process, involving numerous sectors and disciplines and requiring responses to dynamic development processes. In addition, the developments in settlement areas are also linked by direct interactions and feedback loops to the local, regional and global environment.

The UBA Agenda sets the normative objective of an environmentally benign urban development within the planetary boundaries (cf. BMUB 2016a: 24; UBA 2009: 6; UBA 2017), as well as strengthening environmental and health protection in accordance with the goals of urban development. The framework is formed by sustainable development which takes into consideration the environmental economic, and social dimensions. This requires the joint analysis and new determination of urban problems and goals – beyond the boundaries of the various disciplines and actors.

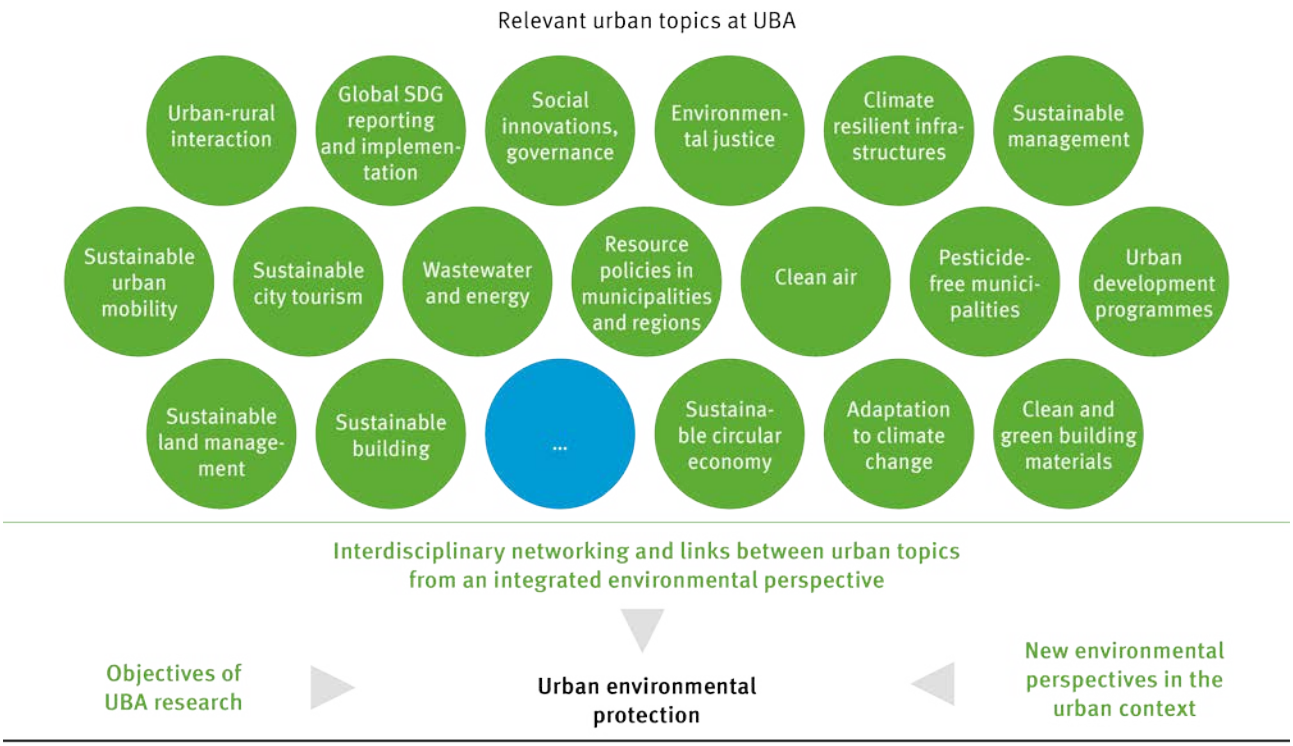
With this Agenda, UBA wants to contribute to environmentally benign urban development by identifying research priorities for the development of urban areas which are based on environmental quality goals. The main objectives are:

- The formulation of urban environmental goals for approval, the identification of obstacles, and the proposal of ways to overcome these,
- Interdisciplinary analysis and processing of environmental and health concerns in an urban context,
- Formulation of arguments for environmentally benign urban development in political debate,
- Setting priorities for action where research results are already available, but action is impeded by questions of financing or by conflicting objectives.

UBA is already carrying out research on many environmental topics in settlement areas (cf. Fig. 1) and with this Agenda it is focusing on the integration of environmental and urban development policies. Interdisciplinary approaches can generate added value, affording new perspectives, raising further-reaching issues, and offering integrated solutions. In addition to taking on new topics, UBA will also link existing fields of research more closely together and develop these further, with the aim of orienting them towards current developments and challenges. As an addition to the past, present and future activities of other agencies and institutions, the Agenda shows areas of urban environmental protection where UBA should become more active in the coming years. The German Environment Agency will also continue to work on specialist topics which are not directly focused on urban development policies, e.g. sustainable building.

Figure 1

Urban environmental protection as an interdisciplinary topic with an integrated environmental perspective



Source: UBA

The research objectives

The topic of environmental protection in municipalities and conurbations raises numerous pressing research questions. This is demonstrated by the topic clusters and cross-sectional topics of this research agenda. These draw attention to gaps in our knowledge with the aim of developing an **information and data base** for the processing of necessary strategies for action (e.g. environmental quality goals for urban and infrastructure development or for the efficient use of natural resources). In addition, **new questions and causal relationships** are identified for the development of environmentally benign solutions, based on existing knowledge and an integrated approach to the topics. Together, these two aspect serve as a basis for the formulation of lines of argument that can promote the consideration given to environmental and health concerns in strategies, programmes and decision-making processes and improve the quality of the environment in towns and cities.

Many of the research questions have as their goals the further development and improved application of **instruments for environmentally benign urban development**, e.g. legislation and regulations, or incentive mechanisms and funding instruments. The research should also help municipalities to achieve sustainable development. It is therefore implementation oriented. A further key goal is the preparation of information and the development of tools for **knowledge transfer** with political actors, administrations, municipalities, associations, and the specialist public.

In addition to research questions, the Agenda also addresses **decision-makers and movers**. Where existing research results have not been fully implemented, this is often due to institutional barriers or unresolved questions about financing or governance. Such constraints must first be identified and then tackled by all the various actors involved.

UBA has developed this Agenda through an **internal and external dialogue process**. Focal topics and contents were developed by a group of some 40 experts from all UBA departments. In parallel, there were also discussions with representatives of environmentally oriented urban research institutions, associations, municipalities, ministries, and agencies, in order to examine the relevance of research questions and priorities. Gender aspects and gender mainstreaming are integrated in the research as lead principles where relevant, e.g. with regard to health matters, social issues, or questions of participation.

The following vignettes give outlines of the activities of UBA experts involved in the Agenda process:

Sustainable rural-urban interactions

In the RUN project (Rural Urban Nexus – sustainable land-use and urbanisation) political approaches and recommendations are developed that are aimed at integrated and sustainable rural and urban development. The project contributes to an integrated and intermediary development approach between urban and spatial planning and land use, and help to overcome the silo mentality while bringing together relevant policy-making sectors and focusing more on rural areas, which are frequently neglected in the urban-rural discourse.

Material flow management

We bring together regional actors and processing chains and shape the conditions for effective material flow management in a resource-conserving circular economy.

www.umweltbundesamt.de/themen/abfall-ressourcen/abfallwirtschaft/urban-mining/stoffstrommanagement-im-bauwesen#textpart-1

Sustainable urban mobility

We investigate current trends in urban mobility and develop scenarios and measures which can strengthen the role of public transport, walking and cycling, promote sustainable logistics, and reduce vehicle emissions.
www.uba.de/themen/verkehr-laerm and the UBA brochure “Tomorrow’s cities”

Urban mining

By mapping anthropogenic reserves, we aim to make urban mining for resources more effective and to introduce a paradigm shift in the Anthropocene epoch. This requires a resource-conserving approach with the effective management of anthropogenic material reserves.

https://www.umweltbundesamt.de/publikationen/urban-mining-ressourcenschonung-im-anthropozaen

Urban development – Social municipalities

Urban development, and in particular the “Social municipalities” programme, forms a good starting point for the utilisation of synergy potentials between environmental and social goals. A research project shows that among other things this is enabled by involving neighbourhood residents in their local environment.
https://difu.de/projekte/2015/moeglichkeiten-derverstaerkten-nutzung-von-synergien.html

Sustainable city tourism

Cities are attractive destinations for short trips and excursions. Cultural and sporting events, trade exhibitions and conferences attract a wide range of guests.

In the context of urban environmental protection, we aim to investigate the impacts of city tourism. Project “Environmental considerations of tourism in urban planning”, FKZ 3718 150010.

Wastewater infrastructure

We investigate how the wastewater infrastructure can be functional in the long-term, with a low environmental impact, despite the challenges of climate change and the demographic developments. Appropriate solutions in the field of rainwater management and novel wastewater handling strategies are considered, as well as the maintenance of the existing sewerage systems.

Adaptation to climate change in towns and cities

We want to make municipalities fit to face more frequent and more severe weather extremes. This requires not only smaller and greater changes to infrastructure, including buildings, but also behavioural changes. www.anpassung.net, for best practice examples see: www.umweltbundesamt.de/tatenbank

Environmental justice

Our objective is to ensure healthy environmental conditions for everybody, irrespective of their social situation. We develop integrated environmental strategies and measures intended to create the best-possible health opportunities for all.

https://www.umweltbundesamt.de/en/topics/health/environmental-impact-on-people/environmental-justice-environment-health-social#textpart-1

Legal instruments for sustainable urban mobility

We investigate the effects of laws and regulations as obstacles to or drivers of innovations leading to more sustainable mobility in an urban context. (R&D RechtSinnMobil – Infos N. Salzborn)

Global SDG reporting

We provide the German contribution to the Global Sustainable Development Report (GSDR) including the analysis of political options for the global achievement of the SDGs. A central aspect is the ambitious implementation of SDG 11 for towns and cities, also involving the international involvement of Germany. “German Contribution to the Global Sustainable Development Report”, FKZ 3717 181020

Greenhouse gas neutral air conditioning and heating

We investigate how buildings and dwellings can be provided with air-conditioning and heating in an energy-efficient manner without creating urban heat islands. We support the further development of air conditioning systems and heat pumps that use natural refrigerants.

https://www.umweltbundesamt.de/en/topics/economics-consumption/products/fluorinated-greenhouse-gases-fully-halogenated-cfcs/application-domains-emission-reduction/building-air-conditioning

Sustainable circular economy

We analyse systems for the separation and disposal of settlement waste and develop measures for resource-conserving waste management, while taking demographic developments into account.

https://www.umweltbundesamt.de/en/topics/waste-resources/waste-management

Compact and green urban development

Urban development which is both compact and also offers a high environmental and recreational quality in the neighbourhoods is an important goal. We develop recommendations for compact and environmentally benign urban structures with green areas and open spaces. www.uba.de/themen/nachhaltigkeitstrategien-internationales/planungsinstrumente/umweltschonenderaumplanung/stadtentwicklung

Pesticide-free municipalities

We inform about the impacts of pesticides (plant protection products and biocides) on humans and on the environment, and offer alternatives to the use of pesticides. Local authorities can then act as role models for their residents. www.uba.de/pestizidfreie-kommune

Sustainable development goals at the municipal level

The Agenda 2030 and the sustainable development goals provide an internationally accepted framework for sustainable actions. Municipalities have an important role to play in achieving these goals. The aim of our research is to support local authorities in the implementation of the SDGs.

Wastewater and energy

We accompany projects for the implementation of measures for energy-efficient wastewater treatment and investigate ways of linking the energy infrastructure and wastewater infrastructures.

www.umweltbundesamt.de/themen/foerderprogramm-fuer-energieeffiziente

Clean urban air

We want people in municipalities to have clean air to breathe. We analyse national strategies to reduce air pollution, e.g. from traffic, and domestic fires, and consider how these can be combined with measures at local levels in order to improve the quality of urban air.

https://www.umweltbundesamt.de/themen/luft/regelungen-strategien/nationaleluftreinhaltung#textpart-2

Sustainability initiatives/social innovation for urban environmental protection

A number of UBA research projects are investigating the contributions that sustainability initiatives can make for society and how these initiatives can be given political support.

www.umweltbundesamt.de/themen/nachhaltigkeit-strategien-internationales/gesellschaft-erfolgreich-veraendern

Clean, green building materials

We support the development and use of clean, low-emission building materials by establishing criteria for the assessment of environmental and health-related properties, their labelling (e.g. with the “Blue Angel” environmental label), and the formulation of ambitious European regulations.

www.umweltbundesamt.de/themen/wirtschaft-konsum/produkte/bauprodukte; www.blauer-engel.de/de/produktwelt/bauen

Sustainable building

With the support of our Commission for Sustainable Building (KNBau), we promote environmental and health aspect of construction, e.g. the energy efficiency of buildings and manufacturing processes, as well as the recycling of building materials. We also support labelling and assessment systems (BNB, DGNB, EPD).

https://tinyurl.com/knbau; https://tinyurl.com/energie-bauen; https://tinyurl.com/bauabfall

Resource policies at municipal and regional levels

The projects RegioRess and KommRess work on the development and promotion of special information and consultancy services as well as other support activities as part of the further development and implementation of the German Resource Efficiency Programme (ProgRess).

www.ressourceneffizientekommune.de

Sustainable land use management

Land consumption for settlements and traffic is to be reduced to 30 hectare per day in 2020 and to a net value of zero by 2050. We are developing strategies, instruments, practical measures, and policy recommendations to promote careful, efficient and environmentally oriented land use.

www.umweltbundesamt.de/daten/flaechennutzung

Noise abatement in towns and cities

As inner cities become busier, noise problems can grow worse. However, solutions can be found for this problem. We develop strategies for the coordinated application of a number of individual instruments. These range from mobility strategies and urban planning, through vehicle engineering and permanent way technologies, to the acoustic insulation of residential buildings.

www.umweltbundesamt.de/themen/verkehr-laerm/nachbarschaftslaermlaerm-von-anlagen

Resource conservation in wastewater disposal

We investigate current developments in slurry disposal in terms of resource conservation and material cycles. In particular we support research on and implementation of measures for phosphorus recovery.

www.umweltbundesamt.de/publikationen/klaerschlammentsorgung-in-bundesrepublik

Turn it down – Public participation in noise abatement plans

We promote an innovative method for effective public participation in the development of noise abatement plans. Taking the example of Leipzig, knowledge is being accumulated for noise abatement measures that are effective in the short-term and are relatively cost-effective. These are presented in an attractive form for the public and made available for municipalities throughout Germany.

www.oekoloewe.de/machsleiser.html; www.umweltbundesamt.de/search/content/machs%2520and%2520leiser?keys=machs%20leiser

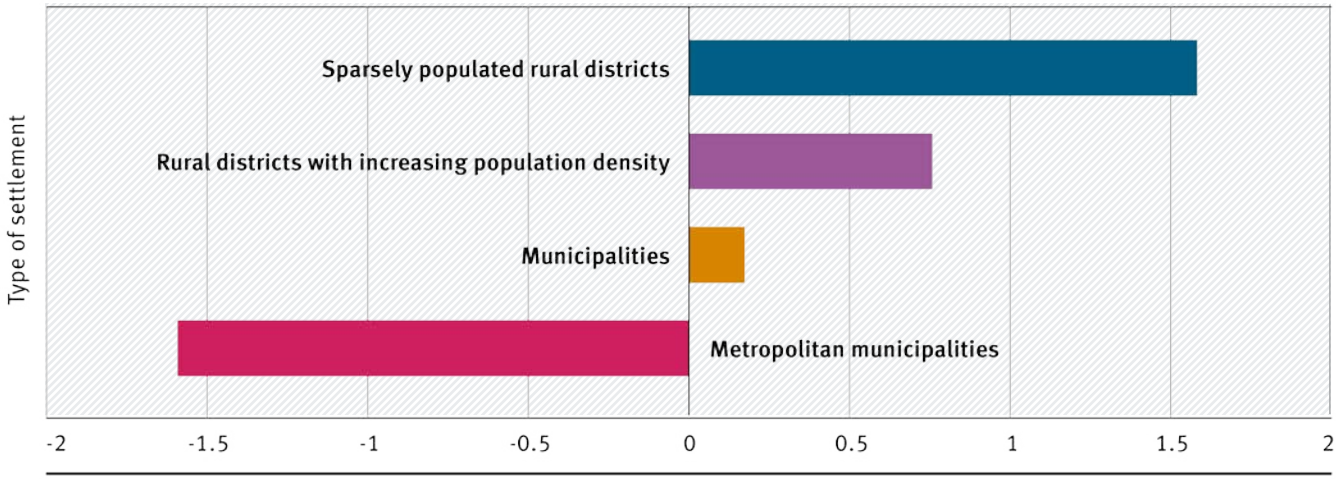
2

The environmentally oriented development of urban spaces

Western industrialised countries experienced their major period of urbanisation in the twentieth century (cf. WBGU 2016), but German municipalities are expanding once again (BReg 2017). In addition to major cities such as Berlin, Hamburg, Munich and Cologne, this also applies for smaller urban regions, university towns, and research locations such as Jena, Leipzig, Dresden, and Freiburg (BBSR 2015). Due to the different demographic developments in the towns, cities and regions, they each face their own environmental challenges. In the growth regions, there are increasing land use demands and growing conflicts of interests (see Fig. 3), which makes it increasingly difficult to meet the demands for dwellings and infrastructure. Where the numbers of inhabitants are decreasing, the challenges lie in maintaining public services and in dealing with growing numbers of unoccupied dwellings.

Figure 2

Changes of settlement and traffic area per resident in percent, from 2011 to 2014



Source: Area survey of the Federal Government and the Laender, calculations of BBSR, Own presentation

Challenges such as climate change, the environmental impacts of the digital transformation and the economic and environmental consequences of globalisation are having impacts on cities and conurbations. There are a **range of new tasks** that municipalities must address, including questions of climate action and adaptation to climate change. As the numbers of residents and the population density rises or falls, new strategies are required for an environmentally benign conversion or reduction of urban infrastructures. Municipalities must develop in a way that ensures the sustainable use of natural resources. And in order to provide a high quality of urban life, intensive efforts are needed for

Info box 1: Key challenges and objectives of an environmentally benign development of urban areas in the context of the UBA research agenda "Urban environmental protection"

Challenges

- Climate action and climate change adaptation
- Uncertainties and environmental impacts of the digital transformation process
- Growing shortages of non-renewable resources
- Demographic change
- Economic and social effects of globalisation
- Changing patterns of consumption, leisure, and travel

The goal is to become:

- Compact and offering mixed uses
- Energy and resource conserving
- Greenhouse gas neutral and adapted to climate change
- Socially just and participatory
- Resilient
- Free from excessive pollution and noise pollution
- Healthy
- Intelligently networked
- Regionally anchored.

urban environmental and health protection. Finally, digitalisation is changing consumption patterns at a rapid rate, as well as ways of life and structures in urban areas.

The UBA Research Agenda contributes to formulating and addressing questions concerning an environmentally benign conversion of urban infrastructures, the sustainable use of natural resources in towns and cities, and an urban development which creates healthy living conditions. This requires a **fundamental transformation** to achieve sustainable development and to shape settlement areas and their structures – not least in order to achieve the aims formulated in the United Nations' Sustainable Development Goals (SDGs), the New Urban Agenda, the international and national climate policies, the German Sustainability Strategy, or the Integrated Environmental Programme 2030 of the Federal Environment Ministry.

The transformation pathways are varied and depend on the conditions and potential of each municipality. Structures that are compact and green, offering mixed uses and consuming less land are included in the integrated environmental programme of the Federal Environment Ministry as models for the development of urban areas in Germany (cf. BMUB 2016a). This must be backed up by specific targets for environmentally benign development (see Info box 1). Environmental protection and urban development are not in conflict; rather the aim must be to identify and make use of the shared range of opportunities for intervention.

The urban perspective

There are considerable differences between the urban structures in the industrialised countries, emerging economies and developing countries with regard to buildings, planning procedures, and legislation, but of course there are also significant social, economic and topographical differences. Whereas in countries with rapidly expanding economies such as China, new cities are planned and erected on greenfield sites within only a few years, cities and conurbations in many developing countries are expanding without controls and often without ensuring the availability of basic public needs. In industrialised countries like Germany, the attention is concentrated primarily on the further development of existing municipalities and the improvement of the quality of life in urban settlement areas.

The UBA Research Agenda takes as its starting point the situation in urban areas in Germany. As noted in the introduction, more than three-quarters of the German population live in built-up or heavily built-up agglomerations (Destatis 2014), and nearly 50 per cent of these live in towns with fewer than 20,000 residents (Deilmann 2016).

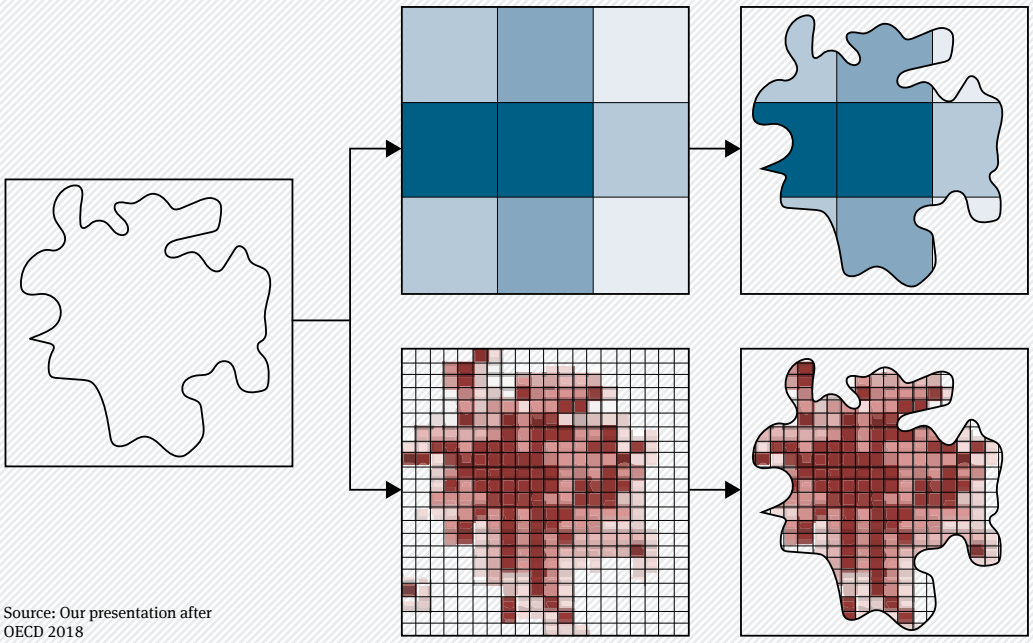
Towns and cities in Germany vary in size from Berlin with some 3.5 million residents to Arnis in Schleswig-Holstein with only 279 inhabitants (Statistikamt Nord 2016). However, since environmental impacts can be relevant for all settlement types, irrespective of classifications such as size or density, the term municipality is used in this Agenda to cover this broad range of urban settlement areas (see Info box 2).

Info box 2: The scope of the term "urban" in the UBA Research Agenda "Urban environmental protection"

Municipal spatial structures in Germany include cities and towns, metropolitan areas, linked urban regions, and urban-peri-urban relationships. In urban research, various distinguishing criteria are used (cf. BBSR 2017a). The term urbanism was introduced by sociologists such as Louis Wirth, who listed as characteristics the size (number of inhabitants), density, and heterogeneity (Wirth 1938).

Depending on the initial situation (population density, density of construction, commuter flows, economic relationships, administrative structures, etc.) and the questions being addressed, the depth of focus and the boundaries of the area being investigated can vary considerably. This is shown by the figures below (Source: OECD 2018).

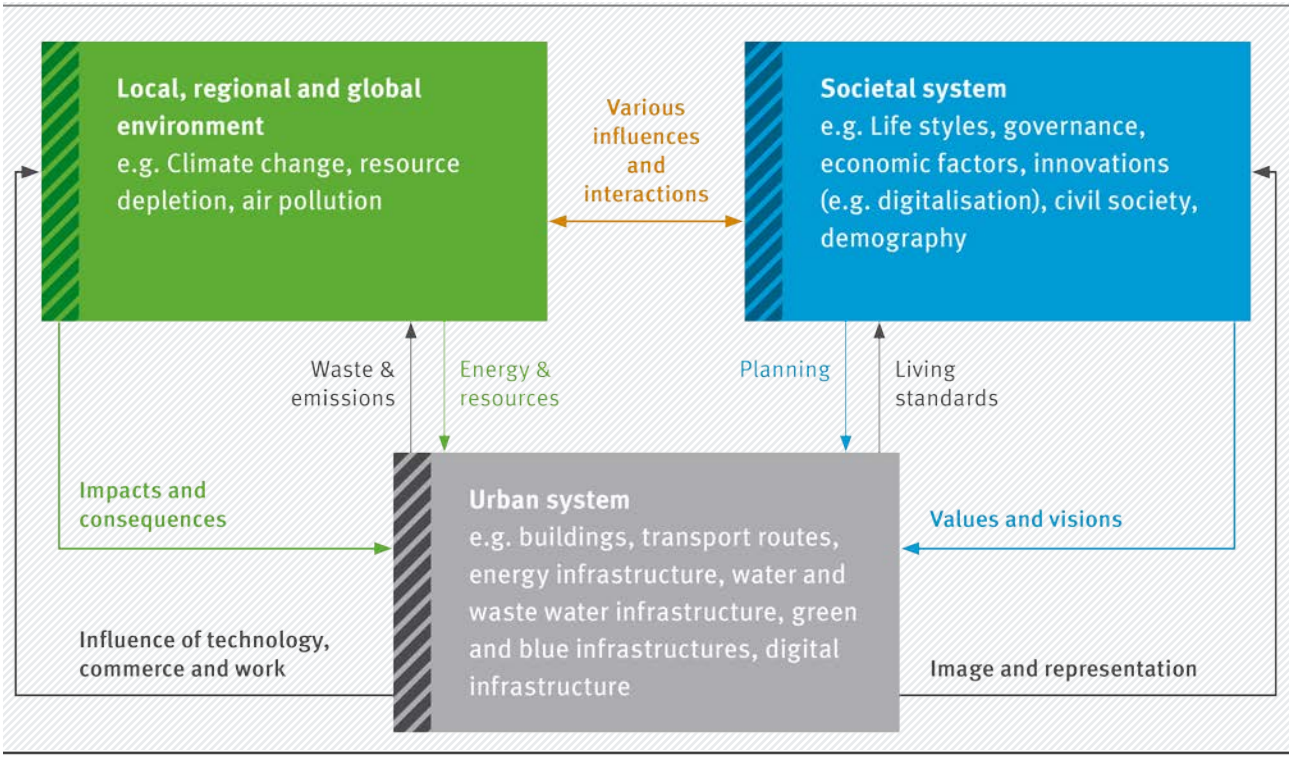
For example, an investigation can consider individual neighbourhoods (bottom row) or can be based on administrative boundaries (top row). It can consider less densely inhabited suburban areas and the peripheral areas or the spatial relationships in a municipal region and beyond. The focus of this Agenda is on densely built-up settlement areas, but by intention no distinctions are made between the various types or size of municipalities.



Source: Our presentation after OECD 2018

Figure 3

Interactions between environment, society and urban system



Source: Own presentation after Bai (2016)

Urban systems are characterised by complex interactions between technological, societal, economic, environmental, legal, social and cultural aspects. They are always interacting with the environment and the societal system, as outlined in Figure 3.

Many environmentally relevant challenges (see Info box 1) call for the active conversion of municipalities and cooperative urban development. The municipality is therefore a **main level of action for sustainable development**. However, many municipal administrations and their networks (e.g. businesses, cooperation partners) face the challenge of independently identifying their scope for action and fulfilling their role for sustainable development. They can be drivers of innovations, centres of creativity and a starting point for civil-society initiatives which start processes of change towards sustainable lifestyles and patterns of consumption. Municipal associations and networks such as ICLEI (Local Governments for Sustainability) or the Covenant of Mayors are leading the way towards sustainable development.

Municipalities are embedded between the responsibilities of various higher political levels and have to take into consideration the interests of numerous actors, including those of civil society and the private sector. The German Environment Agency views urban development as a **cooperative task** which is controlled by formal and informal planning instruments and processes and requires the weighing up of various interests. At the same time, legal, social or technical requirements and economic constraints also have to be taken into account.

By means of participation processes, a wide range of interests can be integrated in the shaping of towns and cities (cf. BBSR 2016). Urban planning can open up space for the activities of various actors. Environmental protection is in the general interest and is of value for the whole society; it should be the basis for a process which is influenced and negotiated by many actors.

Activities at the interface of urban development and environmental protection

Sustainable urban development is already on the political agenda in Germany. The Federal Government formulated the vision of a CO2-neutral, climate-adapted, and energy-efficient city in its High Tech Strategy 2012 (BMBF 2014). Various federal ministries in Germany (Research, Environment, Building, Trade, and Transport) have set up the "National Platform for the City of the Future" (NPZ). In an application-oriented, inter-departmental and interdisciplinary process involving scientists and practical experts, pressing research questions were collated in a "Strategic Research and Innovation Agenda" (BMBF 2015). On the basis of the results of the NPZ process, the Federal Government has since 2016 been supporting the programme "Research for Sustainable Development" (FONA) of the Federal Ministry of Education and Research (BMBF) as part of the measures "Sustainable Transformation of Urban Spaces" and "Implementation of the initiative on tomorrow's cities", aimed at the development and practical testing of transformation processes in urban spaces (BMBF 2015a). Following on from the NPZ, in 2016 the "Innovation Platform for Tomorrow's Cities" (IPZ) was established to close gaps between knowledge and practical applications, and to apply scientific findings in municipalities.

The German research associations (Helmholtz Association, Fraunhofer Society, Leibniz Association) and universities are carrying out research on various aspects of sustainable urban development. One aim is to bring together expertise from the fields of engineering, natural sciences, and social sciences (KIT 2015) as well as technology-oriented approaches (FhG 2017). UBA supports these activities in a number of ways.

At the international level, the UN Agenda 2030 included Sustainable Development Goals (SDGs) for cities and settlements. The goal of SDG 11 is to "Make cities inclusive, safe, resilient and sustainable" (UN 2015, p. 24). Ten associated targets further specify this goal. The New Urban Agenda endorsed by the UN General Assembly takes up the provisions of SDG 11 and establishes criteria for achieving sustainable, integrated urban development in an international context (UN 2017). In 2016, the EU agreed on an urban agenda in the "Pact of Amsterdam" which addressed the complexity of urban development in terms of priority topics such as urban poverty, energy transition, or air quality (EU 2016). With the revision of the "Leipzig Charter", which is scheduled for the German EU Council Presidency in 2020, this topic is to be addressed once more.

Augmenting the activities already described, the UBA Research Agenda explicitly includes an environmental perspective and highlights **new interdisciplinary research questions and contexts within its departmental research**. As Germany's central environmental agency, UBA wishes to address in an integrative manner urban research issues related to the environment that have previously been neglected. The aim is to define environmental goals, identify synergies and constraints, and outline potential solutions (see also the Introduction). Opportunities must be used for cooperating with institutions that are also working on sustainable urban development and carrying out urban sustainability research (e.g. by means of joint research projects, coordinated programmes, and the practical implementation of UBA research results with other authorities and institutions).

3

The three topic clusters of the research agenda

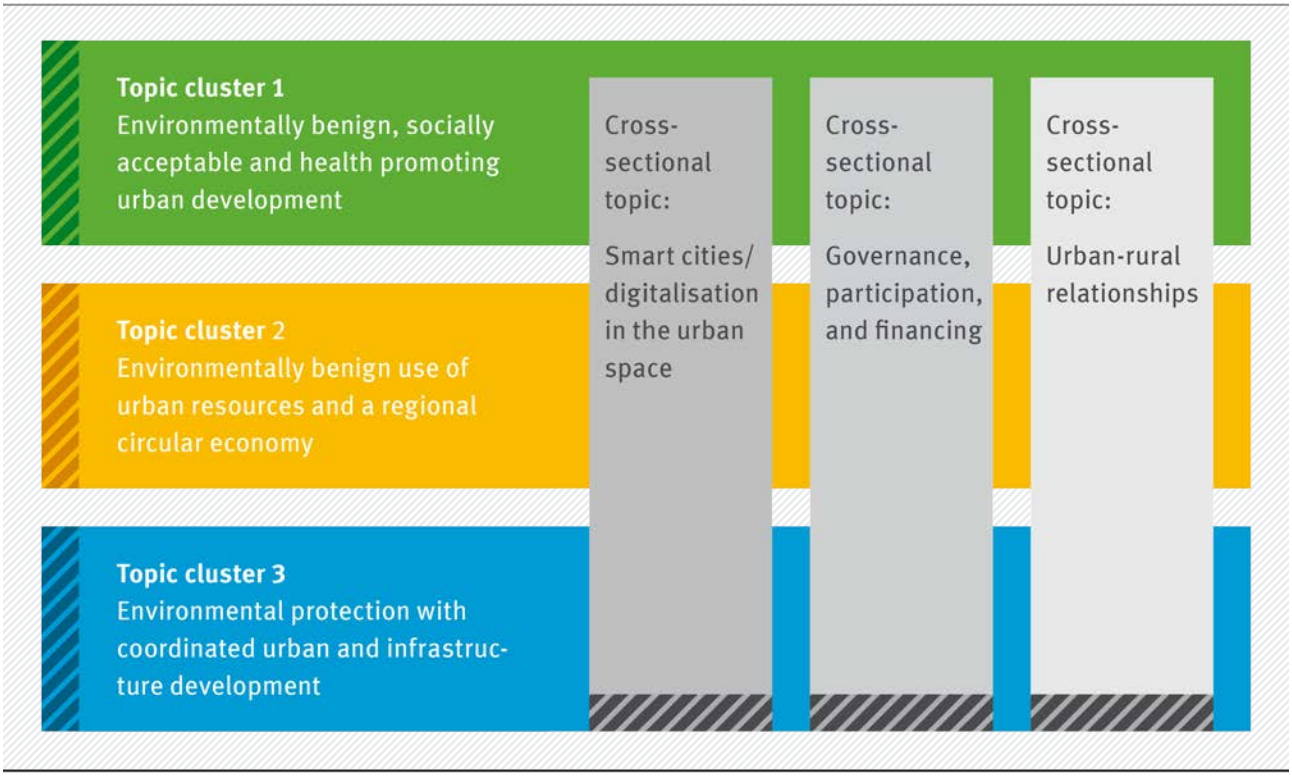
In the course of the inter-departmental UBA Agenda process, **six central topics** with an interdisciplinary and integrating character were identified for future research in addition to the topics of the individual departments (Fig. 4). In view of current challenges, **three topic clusters** were identified as priorities for urban environmental protection (cf. Chapter 1, Info box 1).

The topic cluster **"Environmentally benign, socially acceptable and health promoting urban development"** addresses the various demands on land in heavily built-up areas. Environmental and health concerns give rise to challenges and fields of action resulting from the increased pressure on land use, in particular on urban open and green spaces. In addition, there are challenges arising from climate change and the energy transition, increasing mobility demands, excessive noise pollution, and poor air quality. The topic cluster **"Environmentally benign use of urban resources and regional circular economy"** focuses on the challenges posed by the relatively high consumption of natural resources in urban settlements. Among other things, the topic addresses the recommendations of the German Advisory Council on Global Change (WBGU) and the action areas of the German Resource Efficiency Programme (ProgRess II) (cf. WBGU 2016, BMUB 2016). It is important to improve our understanding of urban material flows in order to develop appropriate resource-conserving strategies and measures. This topic cluster also considers how urban spaces can conserve resources, for example by the sustainable management of anthropogenic reserves. The topic cluster **"Environmental protection by harmonised urban and infrastructure development"** considers the interface between urban development and the planning and development of infrastructures. Urban infrastructures form the basis for almost all areas of modern urban life and provide key public services. At the same time, energy and resource consumption can lead to considerable environmental impacts. The topic cluster therefore considers synergies and interactions, mutually-agreed environmental goals and criteria, and the potential for reaching agreements and setting up networks for the creation of resilient, socially acceptable und environmentally benign municipal structures and infrastructures.

In addition, **three cross-sectional topics** have been identified (see Chapter 4) for which the effects are very broad or very profound, so that they influence many areas and levels in the urban context. These are: **Smart cities and digitalisation in the urban space**, **Governance, participation und financing**, and **Urban-rural relationships**. They link various individual topics and draw attention to broader research questions concerning urban environmental protection, so that all topic clusters relate to the three cross-sectional topics.

Figure 4

The topic clusters and cross-sectional topics of the UBA research agenda "Urban environmental protection"



Source: UBA presentation

3.1 Topic cluster 1 Environmentally benign, socially acceptable and health promoting urban development

Formulating and achieving **ambitious environmental quality goals** for a healthy life in towns and cities must be made a priority. At the same time, more must be done to make use of synergies with social and economic aspects of urban development and strategies developed to reduce conflicts with these. It is important to maintain or achieve a good environment and healthy living conditions in municipalities in accordance with the needs of socio-culturally and socio-economically disparate parts of the population and the multifunctional demands placed on urban areas. These must be weighed up against the goals of socially acceptable urban development, for example by creating affordable housing, with functional and socio-spatial mixing.

Urban development and urban planning should coordinate all spatial issues and integrate these. Environmental and health-related responsibilities are affected in many ways by urban development processes. However, environmental protection is only one concern among many that have to be taken into consideration in planning and decision-making processes (Hinzen/Bunzel 2000). The same also applies for health concerns, which were already being considered as an element of planning many decades ago (see the Athens' Charter, 1933). Nevertheless, they have only recently been given due attention in strategic planning once more, e.g. in the context of overheating, noise pollution, open spaces, and room to move (Rüdiger/Baumgart 2016: 15f; Adam/Othengrafen 2016).

In future, greater attention must be paid to **environmental and health concerns** in urban development processes and to identifying commonalities with socially acceptable urban development. The state of the urban environment and healthy living conditions are crucial for the quality of life in municipalities (Bunzel/Hinzen 2000; Böhme/Kliemke/Reimann/Süss 2012; Adam/Othengrafen 2016:6). Urban environmental protection and public health should not be regarded as a constraint, but should be emphasised as a precondition for successful urban development and integrated in daily municipal actions.

There are significant interactions between environmental, health and social issues in urban development. These are addressed under the heading of environmental justice, which requires the creation of environmental conditions offering the best-possible health opportunities for all. The differing demographic and economic situations of individual municipalities and the countryside around them (e.g. business locations, property market developments) are important factors influencing specific environmental qualities and associated problems. The widespread implementation of innovative solutions for environmentally and socially acceptable, health promoting urban development therefore involves more than addressing pioneers and promoting good examples.

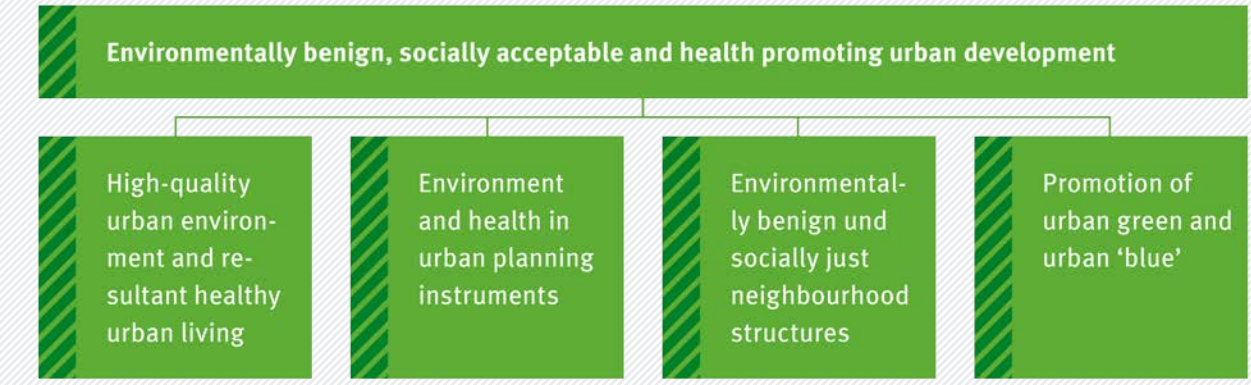
It is also necessary to reach actors and social groups that have been less visible (e.g. actors in small and medium-sized towns).

Health promoting, environmentally and socially acceptable urban development must also provide sufficient open and green spaces, compact and mixed-use structures, with varied, high-quality design. Conflicts are unavoidable in some fields, for example as a result of segregation and gentrification, rising rents, and the concentration of environmental impacts in particular neighbourhoods. Equal access to social infrastructures and public spaces, as well as to instruments of participation in planning and decision-making processes are crucial in view of the various demands on the use of urban land. Questions of participation and governance play a central role in a digitalised world.

Which research topics in the broad field will become particularly significant in the future? In the strategic research agenda, **four priorities were identified** together with relevant research requirements (Fig. 5). The sub-topics are inter-related in many cases, and cannot always be clearly separated from one another. But they make it possible to approach the issues from various perspectives and with differing priorities.

Figure 5

Work priorities in the topic cluster
"Environmentally benign, socially acceptable, health promoting urban development"



Source: Own presentation

3.1.1 High-quality urban environment

A high-quality urban environment and resultant healthy urban living are the goals of environmentally and socially acceptable urban development. The list of necessary measures is long and varied: Improvement of air quality (internal air circulation, but also background pollution and air pollution generated by traffic), maintaining and restoring the quality of soils and surface waters, noise abatement measures, measures for local climate regulation and adaptation to climate change, safe and environmentally-friendly mobility, the creation of spaces for recreation and movement that are accessible for all population groups.

Research requirements

A central consideration is the reduction of health threats from environmental pollution. Key research questions are:

- How can a socio-spatial concentration of multiple burdens due to environmental problems (e.g. noise, air pollution, bioclimatic impacts, or a lack of green spaces) be avoided or reduced in municipalities in the interests of improved environmental and health protection (including data availability and registration)?
- How is it possible to operationalise the requirements for "living and working conditions which are conducive to good health" in land use planning (Section 1 (6)1 German Federal Building Code), urban planning legislation (in accordance with Section 136, Building Code, Definition of urban deficits) and the building regulations of the Länder, together with "environmental justice" in the administrative agreements on urban development funding?
- How is it possible to overcome constraints on urban development that result from contaminated sites and soils? What must be taken into consideration to avoid creating the contamination of tomorrow (e.g. mode of construction, building materials)?

3.1.2 Environmental and health concerns in urban planning instruments

An important topic is the role of **environmental and health concerns in urban planning instruments**. It is important to introduce environmental and public health issues in planning processes in a constructive fashion, to demonstrate the potential benefits of appropriate measures, and to help to resolve conflicts and contradictions with other issues, while retaining or creating the scope for weighing up various planning measures. It is necessary to highlight the relevance of urban environmental quality and to systematically anchor environmental goals, despite the pressure to reach decisions and the increasing speed of urban planning processes (cf. BMBF 2015:18). It is also necessary to investigate how effective existing instruments are for achieving environmental and health goals in urban development and in urban-periurban relationships (cf. KNBau 2016a).

Research requirements

The central question concerns the integration of environmental and health issues in everyday planning:

- In planning processes, how can issues of environmental and health protection contribute to tackling the current challenges of urban development and to the reduction of conflicts about objectives (e.g. challenges of inward development) while at the same time ensuring high levels of environmental protection?
- How can planning instruments be used to create compact urban and neighbourhood structures, with short trips, reduced land consumption, high quality public spaces, and also resource-conserving modes of construction (regarding building materials, use intensity, natural resources, infrastructure, etc.)?
- How can land regulations and planning instruments contribute to the achievement of environmental quality targets at the urban level? How can the obstacles to achieving higher environmental standards in urban planning be overcome?

- How can environmental plans (green plans, clean air planning, heat action plans, stormwater management, health service plans, etc.) and urban planning at the municipal level improve the quality of the environment and health protection in municipalities? This requires making environmental information and data available for environmental plans as the basis for integrated urban development, together with the harmonisation of reporting for specialist environmental plans (e.g. noise abatement, clean air).

3.1.3 Environmentally benign and socially just neighbourhood structures

Neighbourhoods are important for daily life in towns and cities. Therefore **environmentally benign und socially just neighbourhood development** is of particular importance, with the existing stock of buildings and the direct effects on residents. Synergies must be identified between environmentally- und socially-acceptable strategies and health promoting concepts and forms of construction, and use must be made of these (KNBau 2016b). The consideration of neighbourhood and spatial interrelationships can open up new scope for action (Walter 2016; Rittel et al. 2014). Many people would like to initiate changes in their neighbourhood and municipality which would improve their own situation and have a positive effect on how people live together. As an example, it would be important to investigate how urban development could promote innovations supported by civil society.

Research requirements

Research is needed on key factors that influence the quality of life in neighbourhoods:

- Identifying conflicts and potential solutions for environmentally und socially acceptable neighbourhood development and the refurbishment of existing buildings. How can the building stock in urban neighbourhoods be refurbished and further developed to increase energy- and resource-efficiency and ensure that the various objectives such as climate action and social considerations are not played off one against the other? (E.g. noise abatement, gentrification; environmentally- and socially-acceptable city tourism concepts; affordable and healthy dwellings in higher-density developments).

- How can options that may increase or decrease impacts in neighbourhoods be compensated for and linked to other local developments (e.g. inward development and creation of open and green spaces)?

- What contributions can the housing industry, businesses, or cooperatives make for stronger environmentally and socially acceptable urban development? How can these actors be supported in socially and environmentally oriented urban development (e.g. what alliances are there, where could/should cooperation be supported)?

- Urban development/urban planning as an enabler for healthy lifestyles that are environmentally and socially acceptable. How can the potential of environmental topics (e.g. environmentally oriented refurbishment of building stocks; sufficiency) be utilised for an integrative neighbourhood development? Where are their alliances with other actors for sustainable urban development, e.g. with social and welfare institutions, the health and education systems, or youth welfare? How can cooperation be stimulated and supported? Can historical building and the existing building stock gain new importance for touristic purposes?

3.1.4 Promoting urban green and urban blue

Closely related to the other priorities is the **environmental relevance of urban green and urban blue**. These terms refer respectively to the various parks, gardens, roadside verges, or roof greening, and to the urban surface waters (rivers, lakes, flood plains). Both make major contributions to the environment and the quality of life in municipalities, as well as to the promotion of health and the preservation of biodiversity. Various kinds of open spaces or buildings that are characterised by vegetation or water are elements of this infrastructure (Hansen et al. 2017: 3). Increased inward development, which is desirable in the interests of environmental protection, can exert growing pressure on green and open spaces in growing municipalities. In order to achieve a balance between higher building density and good-quality open and green spaces it is necessary to define new forms of multifunctional urban green and urban blue and to include their management in planning provisions. Urban and regional green areas and surface waters can open up opportunities for public participation and increase local interest in environmental concerns, as well as improving social cohesion. Strategies for an environmentally benign und socially just use of urban green and urban blue also serve environmental protection goals, such as adaptation to climate change, reductions of land consumption, and increased social cooperation.

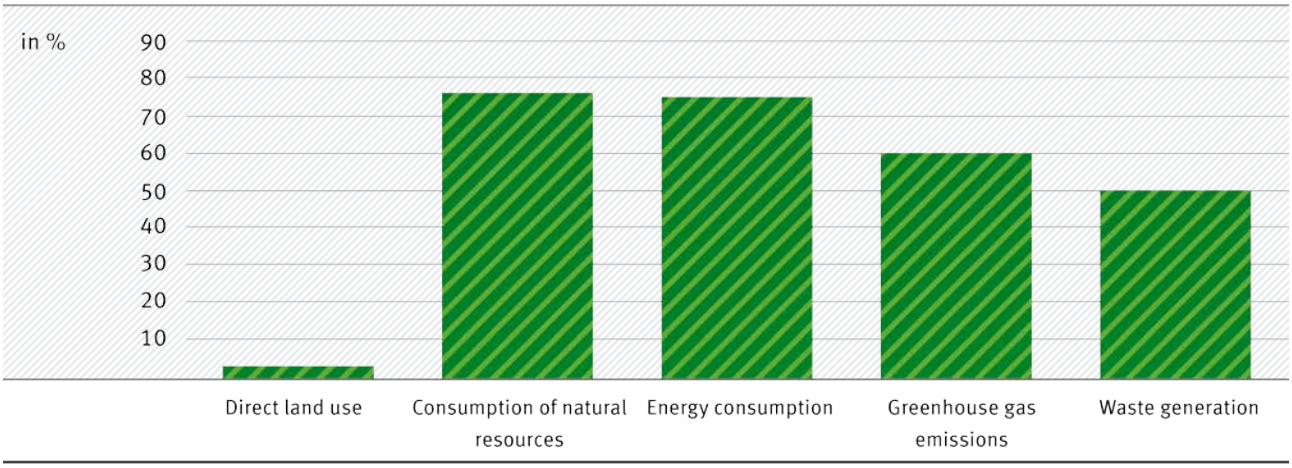
Research requirements

The central issue is the potential for targeted green space planning, taking social and environmental factors into consideration:

- What is the situation regarding green space planning and the implementation of a ‘sponge city’ approach to urban development in German municipalities? How can such instruments contribute to urban environmental and the promotion of public health, e.g. adaptation to climate change, noise abatement, clean air measures, or restrictions on the use of pesticides? How is green space planning linked with urban and infrastructure development, soil conservation, and biodiversity?
- Which management strategies can support the provision of environmentally-relevant urban green and blue areas (where is there potential to learn from others?)
- What environmental benefits (e.g. reduced pollution from pesticides) and risks (e.g. increased exposure to harmful substances) does urban micro-farming offer? Environmental quality can be experienced in the urban space and linked with environmental education (e.g. projects for the use of urban spaces to grow food).
- To what extent can urban green contribute to reducing the use of air conditioning systems in buildings? How can urban green and blue help to reduce urban heat islands?
- To what extent can improved urban green and blue in residential areas reduce the burden on peripheral recreational areas and also reduce traffic flows? How can use conflicts be reduced between local residents and pleasure seekers (key word: noise pollution)?

Figure 6

Urban contributions to global energy and resource consumption, greenhouse gas emissions and waste generation



Sources: United Nations Environment, 2012; World Bank, 2009. Own presentation

3.2 Topic cluster 2 Environmentally benign use of urban resources and regional circular economy

Globally, towns and cities account directly for only two per cent of land use, but in contrast they consume a considerable proportion of global natural resources (Fig. 6). It is predicted that by 2030 some 81 per cent of global consumption will take place in conurbations, and they are expected to be responsible for 91 per cent of the increase in global consumption between 2015 and 2030 (McKinsey 2016). In some cases in developing countries and emerging economies completely new settlements and supply and disposal infrastructures must be erected (UN DESA 2015). The German Advisory Council on Global Change (WBGU) emphasised in its main report in 2016 that emerging economies in particular are responsible for enormous urban resource flows. For example, China used more cement in construction between 2008 and 2010 than the United States did in the entire 20th century (WBGU 2016).

This trend is also reflected in Germany, where new construction work is concentrated in particular in urban regions (Destatis 2016). According to calculations, some 120 million tonnes of building materials were used in urban housing construction and other construction work in 2010. **The material stocks in German towns and cities are therefore growing**, because in the same year only some 42 million tonnes of material was removed after demolition and refurbishment (BBSR 2017). Germany is therefore accumulating rich anthropogenic resources, presenting new opportunities and challenges. The sustainable 'urban mining' of these reserves will be a central task in the future (see also UBA 2017a).

The **high rate of consumption of resources** in the towns and cities indicates the need for action. The expansion of residential and settlement areas and of the infrastructure per resident continues unabated (Deilmann 2016). In accordance with the principle "Make savings where the consumption is highest", resource conservation in urban development is increasingly a focal point for science, commerce, administration and politics (cf. BMUB 2016, BMUB 2016a).

There is scope for the sustainable use of natural resources in various fields. For example, the re-use and conversion of urban building stocks, the refurbishment of buildings and neighbourhoods, efficient land management, and a regional circular economy in various sectors (e.g. the manufacturing sector,

Figure 7

Work priorities in the topic cluster "Environmentally benign urban resource use and a regional circular economy"

Source: Own presentation

agriculture/food, the building industry), the promotion of a sharing economy, and promoting the use of regional building materials and a regional building culture. The refurbishment, conversion and new construction of buildings and infrastructure opens up a window of opportunity for decisions about the consumption and use of natural resources with effects which in some cases may be felt over centuries. Use must be made of this potential in order to develop regionally adapted strategies for resource-conserving urban development throughout the life-cycle of buildings and infrastructures.

With this topic cluster, UBA has formulated key research requirements for the promotion of an environmentally benign use of urban resources and regional circular economy, taking urban-peri-urban relationships and local characteristics into consideration. The key terms are used in accordance with the UBA glossary on resource conservation (UBA 2012).

3.2.1 Environmental impacts of resource use

In order to identify fields of action for the **sustainable use of natural resources in the urban space**, it is first necessary to consider the **environmental impacts** of urban and regional activities. More research is required here, and in particular there is a lack of suitable basic data (cf. WBGU 2016).

The morphology of a municipality has an increased influence on the flow of resources. The local demographic situation, economic factors, and the local geography all influence the use of natural resources. Categorisation is required, particularly when deciding which levels are most suitable for the life-cycle analysis of certain substances and materials. It is also necessary to identify which material flows are relevant for a municipality and its periphery. Relationships between the goals of sustainable urban development and the environmental impacts of the urban resource use are another important sector for the identification of central options. Among other things, this raises questions about the effects of spatial policy decisions and the relationships between urban quality of life and the consumption of natural resources in settlement areas. Finally, the temporal dimension is an additional important factor which is also considered under this sub-topic.

Research requirements

The focus is on research that leads to a better data situation and makes it possible to model key relationships between urban material flows, the consumption of resources, and the environmental impacts:

- How can a sound data basis be developed for material flow models and the modelling of the urban metabolism, and how can models be developed for different types of municipality in order to be able to identify resource effects and environmental impacts?
- Which causal relationships can be identified between the use of natural resources and private patterns of behaviour or municipal decision-making (e.g. urban consumption patterns, municipal investment decisions, municipal decisions on land policies, regional forms of buildings, etc.) and how do they influence the environmental media?
- What are suitable indicators for monitoring a resource-conserving settlement development given a robust data situation?
- What are the appropriate levels (neighbourhood – municipality – urban region – national) for a sustainable regional circular economy? Which strategies for building materials, electronics, foodstuffs, etc., work best for the various levels?
- How can temporal and spatial dynamic scenarios be modelled for building activities (e.g. demolition, extension, or conversion) together with their corresponding environmental impacts? Here it is possible to draw on the work of the UBA project "Greenhouse gas-neutral Germany 2050".
- What are the implications of the urban digital transformation (Smart City) for future resource conservation, considering the various possible development options?

3.2.2 Shaping the environmentally benign use of resources and transformation to a circular economy

By means of a targeted mixture of environmental regulations, economic und planning instruments, incentive systems and cooperative measures, it is possible to considerably reduce the consumption of natural resources in the urban space. With regard to **shaping the environmentally benign use of resources and transformation to a regional circular economy** it is possible to distinguish between Bottom-Up approaches (actor oriented) and Top-Down approaches (planning and regulation oriented). Examples of bottom-up approaches include sharing concepts at the neighbourhood level, the development of incentive schemes to increase the use of recycled materials or clean, green building materials, increased resource sufficiency, more efficient collection and processing systems for waste, and incentives for private consumers to conserve resources.

Top-down approaches include the targeted use of urban planning instruments for resource conservation (through the Federal Building Code), measures to reduce litter, e.g. by encouraging the re-use of "coffee to go" cups and pool systems, regulations for longer useful lives for products, municipal "nudging" by means of visual elements or fees and taxes, and regulations for resource-conserving public consumption and the associated logistics.

In addition, legal, economic and planning constraints should be identified which affect the placement of public and private orders and the use of alternative materials. Where appropriate these should then be eliminated. In particular, real-estate investors require legal security. The identification of responsibilities in certain areas of municipal control is important in order to identify central actors and understand how they see their role. Above all, the relationships between municipal financing and urban resource use have mostly not been investigated. This is why lifecycle strategies often fail to overcome financial obstacles.

Research requirements

At the centre are concepts, instruments and incentive mechanisms that can reduce resource consumption, improve resource efficiency, and promote a regional circular economy:

- Systematic surveys of regulations, support policies and economic policies that give the wrong incentives for the urban resource protection, and proposing adaptations where necessary.
- Determining incentive mechanisms in order to promote urban lifestyles and behaviour in various milieus for population groups in accordance with environmentally benign resource use.
- Comparing the resource impacts of various sharing concepts and cooperative neighbourhood strategies taking into consideration potential positive and negative resource effects resulting from digital transformation.
- Scrutinising the potential of various Federal Government measures to support local resource conservation and promote the local circular economy (e.g. central information platform, municipal resource manager, promotion measures, etc.) and identifying particularly effective instruments/policy mixes.
- Investigation of possibilities for timely planning of sustainable use strategies with modern instruments and tools (e.g. building information modelling), and the derivation of recommendations for planners, architects, and investors.
- In SDG 15.3, land degradation includes not only pollution and soil erosion, but also the use of land for building. So how can land be protected in the urban space against the background of increasing conflicts about land resources (also in connection with peri-urban areas)?

3.2.3 Knowledge transfer between key actors concerning resource use and circular economy

The variety of actors is a specific feature of conurbations and the surrounding areas. However, actors often lack information about instruments and measures for the conservation of resources, and sometimes it is not even clear who the main actors are. For an efficient application of instruments, generalised solutions are not suitable. The question is how an appropriate and efficient **knowledge transfer between key actors** can be ensured and what this requires.

This sub-topic therefore addresses the following questions: How can relevant knowledge and information be transferred as efficiently as possible and made available for all key actors equally? What must be adapted, developed and operationalised in accordance with the local, administrative, economic and social circumstances? How can topics of particular relevance be communicated more effectively between German cities/regions, between the federal levels (municipalities, Länder, Federal Government) and other actors (business, civil society, science, etc.) and what are these topics? The knowledge transfer and the exchange of information between municipalities and the peripheral areas must also be considered, so that all areas are equally involved.

Research requirements
Measures and concepts are required with which to improve or enable communications, cooperation and knowledge transfer:

- Concerning urban and regional resource use, who are the most important actors when viewed vertically (groups of actors) and horizontally (administrative and political levels)?
- Are the proposed concepts of urban resource conservation applicable in the various contexts (local, political, societal, economic, etc.)?
- How can effective and efficient urban-rural networking measures for resource use be communicated as effectively as possible to relevant target groups and what is the best way to integrate the actors? (see "Urban-rural relationships")
- How can measures for the reduction of resource consumption or the improved separation of waste before collection be communicated effectively to most relevant target groups?

3.3 Topic cluster 3 Environmental protection by harmonised urban and infrastructure development

Urban infrastructures provide **key public services**, such as supplying energy and drinking water, sewage disposal, or functioning traffic and transport systems. At the same time they may generate high environmental impacts. Technical infrastructures in this context are understood not only in their physical dimension, but as **socio-technical systems** (cf. Hughes 1987, Geels 2002) which are characterised by interactions between spatial, temporal and social levels. They form the basis for order in the public sphere (cf. van Laak 2001, Monstadt 2009) and are confronted with a range of changes and development processes: Climate change, demographic change, digitalisation, travel and leisure behaviour, energy and mobility transitions. These result in **opportunities for an environmentally oriented transformation** of urban infrastructures, but a specific framework must be set to exploit them.

Urban and infrastructure developments are **closely interrelated,** in each case affecting the form, function and patterns of use. However, there are significant deficits in the coordination and harmonisation of the development of urban structures and infrastructures. For example, the planning of infrastructure is still based on the existing sectoral system boundaries and is inadequately reflected in the planning instruments of urban and regional development (Moss 2011, Einig 2011, Matern et al 2014). However, for the development of innovative and sustainable solutions for the cities of the future, **infrastructures must be considered within an holistic system** and linked with one another (cf. BMBF 2015, Libbe et al. 2010, Tietz/Hühner 2014). Conflicts of interests between the infrastructure sectors or diverging political and institutional responsibilities must also be resolved, e.g. different planning cycles and logics of the individual actors (e.g. politicians, administrators, infrastructure operators, users).

Infrastructures are often **closely linked with peri-urban areas** (cf. the cross-sectional topic Urban-rural relationships). The rural areas around a municipality supply it with important resources such as water, foodstuffs, or also energy, and frequently provide for the disposal of waste and wastewater, as well as meeting important needs for leisure and recreation. Only a regional perspective allows a comprehensive assessment of development options, so that use can be made of potentials (cf. BMBF TransStadt). In addition, infrastructures reflect lifestyles (e.g. mobile work, travel behaviour). Thus, **interactions between consumption and infrastructure development** also have to be addressed. A coexistence of work, housing, local supplies, leisure and recreation, education and culture forms a central element of the development of compact municipalities that are attractive to live in.

Currently, there is a window of opportunity to develop **regionally adapted, resource-saving and resilient concepts**. In many German municipalities there are considerable investment deficits in various sectors, and numerous systems must be refurbished (cf. KfW 2017). In addition, changing technical, political and societal demands lead to a need for the expansion, conversion, and new construction of infrastructure facilities. The aim is to prevent undesirable commitments to non-sustainable structures for the coming decades. At the centre are **trans-sector questions** such as the linkage of infrastructures and the development of integrated solutions.

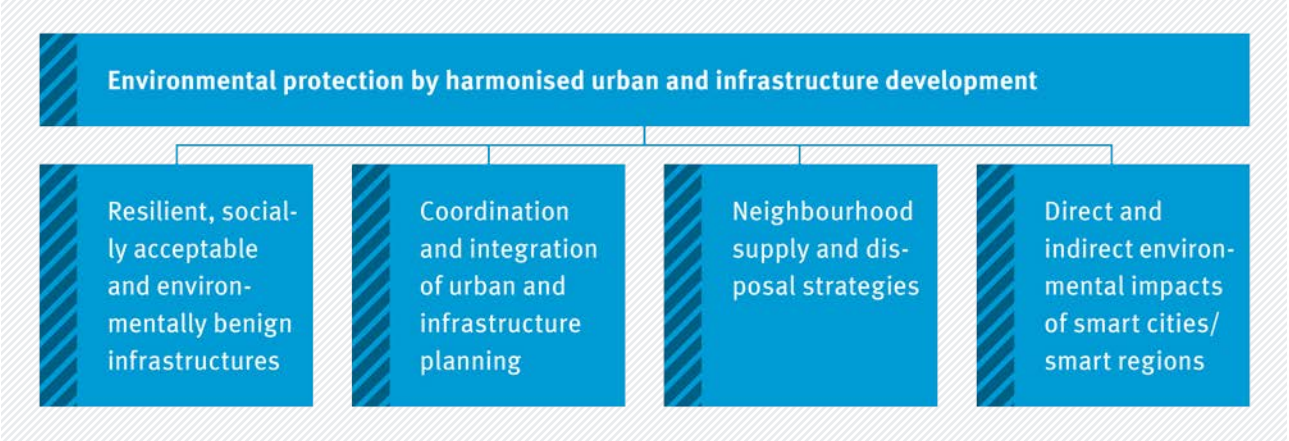
Digital networking and the development of urban spaces to form **Smart Cities and Smart Regions** present new challenges for urban and infrastructure development, but also offer opportunities. Innovative instruments can make infrastructures more efficient and safer while reducing environmental impacts, but they can also offer new services, business models, cross-system linkages, and synergies. However, the effects of digital systems on humans and the environment require further investigation. For municipalities, there will be new demands for the development of infrastructures (e.g. networking of sectors), but also changing demands on basic public services (e.g. new constellations of actors, increased private participation). Despite limited financial scope and budget restrictions, municipalities must realign their responsibilities. The principles, guidelines, and recommendations of the Smart City Charter, formulated with the participation of numerous municipalities, offers an initial orientation (BBSR/BMUB 2017).

In order to do justice to the systemic challenge of sustainable infrastructure development, the research within the framework of this Agenda should not only lead to the formulation of goals for individual infrastructures, but should above all determine **systemic target points**. Which infrastructure facilities will be needed in future, and in which form? What visions are there for the future, and what are the timelines? What are the scenarios for sustainable infrastructures in 2030 or 2050? How can transformation points be determined and which technical, economic, social and institutional innovations will be needed?

A key role is played by the systematic **registration and evaluation of synergies and conflicts of interests**: What do changes in one sector mean for the changing systems in other sectors? How can conflicts of interests between the infrastructure systems be identified and resolved? What environmental impacts could novel, innovative strategies have? Are there synergies, and where do contradictions or negative interactions develop?

Figure 8

Work priorities in the topic cluster "Environmental protection by harmonised urban and infrastructure development"



Source: Own presentation

3.3.1 Resilient, socially acceptable and environmentally benign infrastructures

New concepts and mechanisms are required for the implementation and shaping of **resilient, socially acceptable and environmentally benign approaches to infrastructure development**. They should contribute firstly to harmonise and link the development of urban neighbourhoods and infrastructure systems and secondly to improve the coordination between the various infrastructure sectors. A main focus thereby should be the resilience. Resilience is the ability of a system to maintain functionality under stress and in circumstances characterised by massive external disturbances and internal outages (Gleich, cited by Petschow 2016). The main demands on sustainable infrastructures include flexibility and low environmental impacts, the sustainable use of natural resources, and systems that are adapted to climate change. Central criteria for the development of infrastructure facilities are the possibilities for conversion, expansion and reduction, and the adaptability and ability to learn in cooperation with the settlement structures they serve (cf. BMBF INIS, TransStadt). Novel concepts in the context of digitalisation and the linkage of sectors (e.g. electromobility and power generation or storage) also require better harmonisation between the various infrastructure systems and sectors.

Research requirements

Central questions address networking and synergies, implementation and transformation, in order to adapt urban infrastructure to meet the challenges of the future:

- How is it possible to systematically register and evaluate synergies and contradictions (e.g. between resilience and efficiency) as well as negative interactions between sectoral infrastructure strategies? Where are interfaces and how can these be made resilient? And how can multifunctional infrastructures meet multiple needs (e.g. water reservoirs for flood control and drought prevention)?
- Which environmental goals and criteria establish the framework? How and under what conditions should sustainable urban infrastructures be designed (e.g. central/decentral, growing/shrinking regions, cross-sector concepts)? And how can impulses be created for system changes (e.g. by exchanges of information and networking of actors)?
- Analysis of the organisational and technical networking potentials of infrastructures: Which actors should be involved in order to raise the environmental potential of integrated strategies? Who are the relevant actors when it comes to expanding the infrastructure for supplying power for e-mobility (vehicle manufacturers, users, etc.)? For example, how can industrial waste heat be used for district heating, and what constraints are there (e.g. lack of financing, responsibilities) and how can these problems be resolved?
- Determining transformation points: Which criteria establish for each sector the time point for incremental or radical system change and which strategies for action can be derived from this for the realisation of integrated/innovative concepts?
- Development of evaluation tools for the comparison of alternative options and concepts for the user/implementation level (e.g. reductions of environmental impacts in the mobility sector by behavioural changes for e-vehicles, car sharing, cycling, or in the building sector by cooling buildings via the building shell rather than using air-conditioning technology).

3.3.2 Coordination and integration of urban and infrastructure planning

The development of solutions beyond the boundaries of sectors and disciplines requires cooperation. For improved **coordination and integration of urban and infrastructure planning** it is necessary to pay more attention to the concerns and logics of all relevant actors. These also include private sector operators of infrastructures with their own strategies. The aim must be to identify not only obstacles to improved harmonisation, but also shared goals for integrated planning and the scope for environmental protection. These must then result in trans-sector strategies for action. In addition, the formation of the interfaces between the various planning instruments has central consequences for the urban environmental impacts and environmental quality. Urban planning with its claim of integrative sectoral planning should establish the parameters for the development of sustainable urban structures and lifestyles in municipalities. This requires determining interactions and conflicts of interests between the sectors and actors and how these in turn affect the environment. Also important are the concepts and strategies by which municipalities, as key actors, can make better use of their situation at the interface of the various interest groups (framer, motivator, model, provider of space for experiments, etc.).

Research requirements

Central issues are methods and instruments for improved coordination and harmonisation of an integrated urban and infrastructure development:

- Development of mechanisms to improve coordination of planning administrations, commercially oriented infrastructure companies, and participation procedures of civil society: How can urban planning, infrastructure development, and social matters be coordinated more effectively and joint goals identified? What needs are there for the expansion or conversion of infrastructure facilities and for which planning horizon?

- Systematic analysis and further development of the formal instruments for stronger integrated planning: Where are contradictions in the various sectoral planning instruments and where is an improved coordination and harmonisation of instruments required (e.g. energy strategies and neighbourhood development strategies)? Clarification of duties and responsibilities.

- Coordination of environmental plans and infrastructure planning: e.g. How can clean air and noise abatement plans be harmonised more effectively with traffic planning, or the traffic and open-space planning with water management and flood protection plans and transport infrastructure planning, for example so that urban green and open spaces can function as temporary flooding areas during severe rainfall events.

- Spatial planning coordination of settlement and infrastructure development: How can urban and regional settlement structures and infrastructure be developed together to a greater extent (for example, railway lines as development axes for new settlements)?

- Taking the requirements of integrated sustainable infrastructure development into account in urban development at an early stage: How can the various requirements already receive better consideration during the planning process? These can include land requirements (e.g. for retention and seepage areas), options for waste disposal (e.g. for residential complexes), or the adaptation of urban infrastructure supplies on the basis of existing (e.g. the commercial potential for district heating).

3.3.3 Neighbourhood supply and disposal strategies

For the development of sustainable infrastructures, **neighbourhood supply and disposal strategies** will play a greater role in the municipalities of the future. Against the background of steadily changing requirements (e.g. growth/shrinking) flexible and adaptive solutions are required for various urban spaces and user groups (e.g. residential, commercial and industrial areas). Increasingly, urban infrastructure supplies will be characterised by a range of approaches operating in parallel, including smaller-scale solutions (e.g. decentral wastewater treatment). Many municipalities currently need to adapt their infrastructure facilities (e.g. modernisation, adaptation to climate change and demographic change) and this offers a good opportunity for the implementation of resource-conserving, multifunctional concepts (e.g. basins or reservoirs for stormwater retention or for irrigation). Key questions are: System delimitations (central/decentral), possible synergies (e.g. use of process heat or existing industrial structures), governance questions (e.g. responsibilities for integrated projects), social questions (taking user interests into account), the integration of renewable sources of energy or of local infrastructure strategies in the overall urban planning.

Research requirements

At the centre are integrated solutions to adapt supplies and disposal to the challenges of the future:

- Evaluation of the opportunities and limitations for supplies and disposal at the neighbourhood level: In which sectors and under which conditions (population density, economic structure, etc.) do decentralised, local solutions make sense and how decentrally can the various infrastructures be organised? Development of a position of UBA and the German Environment Ministry on centralised and decentralised supply and disposal systems for the various infrastructure sectors.

- Analysis of networking potentials: Which networking potentials are there at the neighbourhood level between the various infrastructures and with other utilities (e.g. commerce/waste heat utilisation)? How can overlapping responsibilities be resolved in integrated approaches and how can responsibilities be reallocated?

- Determining criteria at the neighbourhood level: Which spatial and functional definition of a neighbourhood as part of a municipality is required for which infrastructure? Which sectoral criteria are relevant for integrated infrastructure strategies (e.g. settlement density, existing business structure, infrastructure, social structure, etc.)?

- The practical application of model concepts: How can trialled concepts for the sustainable and climate-neutral supply and disposal of neighbourhoods be transferred for mainstream application? For example, from a planning/infrastructure point of view, how can neighbourhood heating supplies be optimised in an environmentally and socially acceptable manner while ensuring energy efficiency and making use of renewable sources of energy? Who are the relevant actors and which instruments are required?

3.3.4 Direct and indirect environmental impacts of Smart Cities/Smart Regions

Increasingly, digital solutions in combination with information and communications technologies (ICT) are influencing urban and infrastructure development. So far, there has been insufficient investigation of how to fully exploit the potential of ICT, e.g. for reducing environmental impacts and increase resource efficiency by **intelligent control systems in the infrastructure sector**. Both the **direct** and **indirect environmental impacts** of innovative infrastructure concepts for **Smart Cities** or **Smart Regions** will therefore have to receive increased attention in future. Risks such as system dependencies and capital commitments are already being discussed (cf. BBSR/BMUB 2017). From an **environmental perspective,** smart solutions are to be considered in particular for their positive effects and synergies for the environment.

As a rule, proof is not be provided for reductions in environmental impacts due to ICT concepts by the approaches and technologies developed primarily by the private sector. An extensive evaluation of environmental and rebound effects or social consequences and effects on individual behaviour is also lacking (cf. van Laak 2017). However, "smart" approaches in the infrastructure sector do have **considerable potential for positive environmental effects**. These should be systematically assessed and strengthened. In the field of mobility and logistics there are already examples of sustainable, resource-conserving approaches such as the integration of regenerative forms of energy in transport systems, coordination of freight and goods flows, or traffic reduction by parking guidance systems, and further potentials remain to be identified.

Research requirements

The difference in views about "smart" concepts highlights the need for an integrated approach to the technology and its economic, environmental and social effects. At the centre is the development of need-based, environmentally benign and resource-efficient infrastructure solutions:

- Analysis and evaluation of innovative ICT approaches in the urban space with regard to environmental and rebound effects: Which savings can be achieved over the entire life-cycle of infrastructure installations? The analytical separation of direct and indirect effects is necessary.
- Evaluating the environmental impacts of new service concepts and business models: For example, how should the combination of goods supplies and waste disposal be evaluated (e.g. assessing the benefits of autonomous (goods-) transport)?
- Development of evaluation tools: Which tools can support the assessment of the sustainability and environmental impact of smart approaches? These also increase the transparency between the various options and provide evidence of environmental effects.
- Addressing all relevant actors: Which actors should be involved? How can both the private sector and civil society actors be integrated appropriately in the development of smart infrastructure strategies?
- How should networks, infrastructures and hardware be designed in order to keep energy and resource consumption as low as possible, so that digitalisation actually contributes to improved sustainability? How can the sustainable and resilient coupling of infrastructures be developed in existing buildings and in new constructions? This involves considering technical, organisational, and financial aspects.
- How can actors (municipal administrations, urban utilities, and the general public) be mobilised for the active shaping of environmentally and socially acceptable Smart City/Smart Region concepts?

4

The cross-sectional topics of the research agenda

Urban environmental protection covers a variety of interactions and synergies in individual fields of actions and sectors. The following cross-sectional topics are reflected in all three topic clusters and are to be understood as integral elements of the clusters. All cross-sectional topics influence urban development, the use of natural resources and the development of infrastructure. The research requirements here are therefore intentionally formulated in a more general way, since the issues are relevant for each topic cluster.

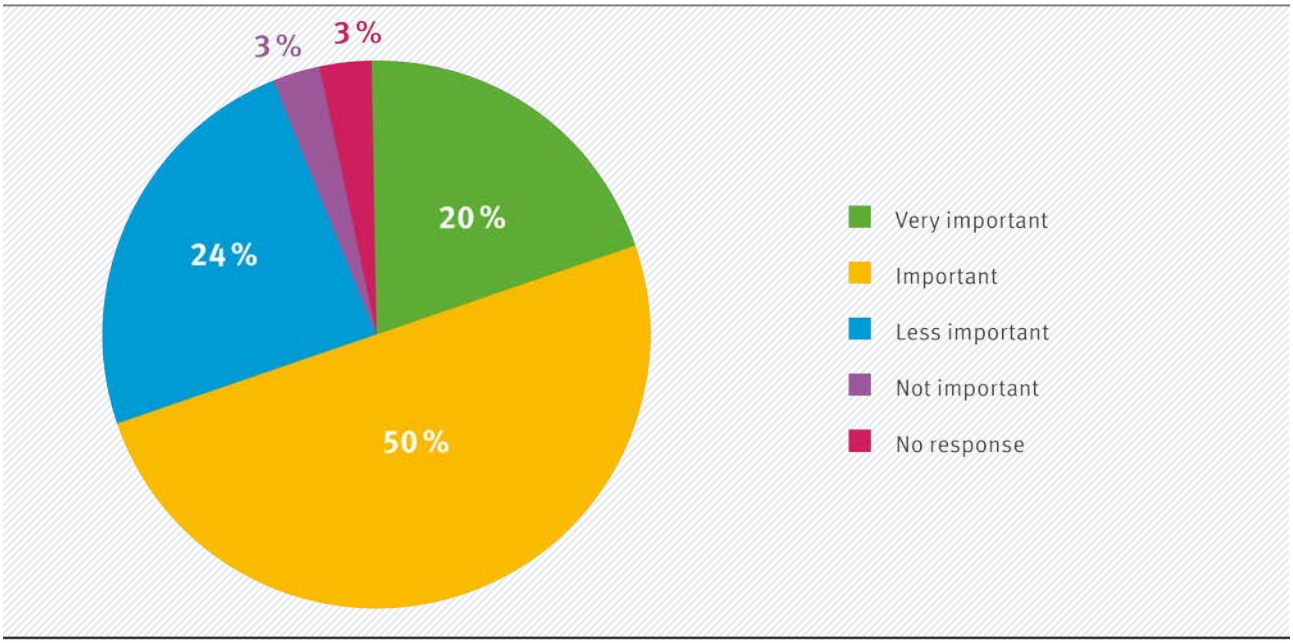
4.1 Smart cities and urban digitalisation

Smart city approaches envisage using **information and communications technologies (ICT) to support urban development,** and worldwide they have developed a considerable dynamic. However, the concept is interpreted in differing ways. Some countries plan to create completely new "intelligent" cities (e.g. India with its 100 Smart Cities Programme or Abu Dhabi with "Masdar City" as a zero-emissions city). Mostly, however, the plans involve a further development of existing cities using new digital technologies and networks. ICT offers possibilities for the intelligent control and linkage of data, processes, and functions in order to improve the quality of life in towns and cities and to make processes in the urban system efficient and sustainable.

The development of smart technologies is driven mostly by new business models of technically oriented companies. In contrast, Smart Cities are being discussed in the municipalities or by actors involved in urban supply and disposal systems in a broader context of urban development and with diverse key aspects (Smart Mobility, Smart Grid, Smart Buildings, Smart Waste Management, etc.). In the German context, **principles, guidelines and recommendations for digitalisation in the urban space** have been formulated in the Smart City Charter, with the participation of numerous municipalities (BBSR/BMUB 2017). The topic has meanwhile also come to play a very important role in urban development strategies (Fig. 10).

Figure 9

The importance of digitalisation in the development strategies of German municipalities



Source: PricewaterhouseCoopers AG, 2015. Own presentation

Over the past thirty years, digitalisation has changed lives, consumption patterns, and employment in towns and cities. As a result, cities are having to make provisions for the necessary infrastructure. Digitalisation has also offered **new roles for consumers** as prosumers, consumer citizens, members of a cooperative, or self-producers. Citizens are now more than just consumers. They ask questions about the efficiency and resilience of production processes or sustainably produced regional goods. This gives rise to specific demands being placed on urban digitalisation. From an environmental perspective, it is therefore necessary to analyse **how and under which conditions digitalisation can benefit sustainable development**, and how innovation and digitalisation can be linked with sustainability.

As a cross-sectional topic, digitalisation is relevant for all three topic clusters described in Chapter 3. A key field of action for UBA lies the environmental relevance of the concept. What is "smart" from an environmental point of view? Are the solutions only innovative, or can they also be sustainable? By focussing on the opportunities and risks of digitalisation for the environment, on the actual effects for energy and resource consumption, on ways of linking "smart" with resource-conserving and participatory concepts for sustainable development, UBA aims here to address **important gaps in our knowledge**.

Research requirements

In the following, examples of research topics are given for the two sub-topics in the field of smart cities and digitalisation in the urban space.

Sub-topic 1: Digitalisation and services of general interest in urban situations

- How can environmental and sustainable considerations be anchored in Smart City approaches? This includes establishing concepts such as "Smart cities/Smart regions" as an instrument for an environmentally benign and resource-conserving urban and regional development which is measurable in terms of real effects.
- What consequences does digitalisation have for a reformulation of public duties? What environmental impacts are associated with this and what are the implications for data protection and digital competence as an aspect of general public services?
- How are planning and decision-making processes changed by digital participatory formats and the digital availability of information? What are the consequences for environmental and public health concerns?

- Which instruments do municipalities need in order to increase environmental potentials through digitalisation? This raises questions about the transparency of municipal data (e.g. concerning energetic urban refurbishment) and about securing data ownership (who can use data?)

Sub-topic 2: Chances and risks for the environment

- Life-cycle analyses and investigations of the rebound-effects used in order to reach scientifically-sound conclusions: How will digitalisation lead to an increase in the consumption of resources and energy (both directly and also indirectly due to rebound effects)? Under which conditions do "smart concepts" actually lead to a reduction of energy and resource consumption?
- What scope is there for cooperation with the private sector on the development of Smart-City strategies and how can the possibilities be used better? Which business models are compatible with the municipal remits while offering synergies for both sides? Which measures and preconditions would be required (e.g. when dealing with municipal data)?
- Which new use strategies (e.g. sharing instead of owning for leasing or mobility) are being generated by digitalisation and what environmental impacts, benefits and risks are involved?

4.2 Governance, participation and financing

Towns and cities in Germany are subject to a **hierarchy of regulations and responsibilities** from the federal level through the Länder down to the municipal level. Higher political levels limit or change the local scope for action by allocating tasks or specifying services to be provided. At the same time, municipalities with their actors and networks are also an independent level of action for environmentally oriented sustainable development. They are drivers of innovations, and experimental locations for new sustainable lifestyles and environmentally benign business models and technologies. Municipal actions follow a variety of planning cultures and administrative responsibilities, they have to take into account changes to technological and legal framework conditions and react to changing public expectations with regard to participation and involvement. In many cases, municipalities are subject to financial constraints and uncontrolled dynamics which limit their scope with regard to environmental issues (WBGU 2016: 414; Brandt 2016). These framework conditions are valid for each of the topic clusters presented in Chapter 4.

The German Federal Government should provide a framework for efficient and targeted "Urban Governance" with an environmental orientation and in this way strengthen the municipal level as a level of implementation for national policies. National programmes and strategies should be translated into specific measures for the urban level. The municipalities should be given easy access to information about novel forms of cooperation and strategic alliances of local actors for sustainable urban development. The Federal Government must support and empower the municipalities in order to promote cooperation. Many financial decisions are made at the federal or Länder levels. But successful environmental measures and programmes at the municipal level are dependent on **adequate financing and human resources**. Therefore, measures and programmes for sustainable urban development require prioritisation when it comes to the allocation of funds. It is also necessary to consider whether innovative financing instruments and strategies could be developed in order to increase the involvement of the private sector.

Various stakeholders play an active role in urban development, including businesses, housing associations, organised civil society groups, the media, educational institutions, or the health sector. Environmentally oriented urban development, in the sense of a societal process of searching and learning, therefore requires broad participation in order to ensure that the relevant conflicts are visible and can be resolved. This requires a **new form of participatory culture**, in which participation is understood as the involvement of stakeholders with responsibility for the future, providing impetus for societal learning processes. Participation and involvement are most likely to emerge where people live, work, or spend their leisure time, for example in neighbourhood settings. All those who are affected can contribute their skills and experience how they can participate in the formation of places worth living in and to sustainable urban structures.

The cross-sectional topic "Governance, participation and financing" has close links to all three topic clusters presented in Chapter 3, so that a number of topics can be identified. The municipalities should play a stronger role as contributors to sustainable urban development. This includes helping administrations to make full use of the scope for shaping sustainable urban development, and the operationalisation of national policies for the municipal level (including tasks which are not directly part of the municipal remit, such as climate action and adaptation to climate change). Efforts should be made to harmonise the goals of environmentally benign, resource-efficient, socially acceptable, health promoting urban development and planning with public financing (see Info box 1), combined with the **simplification of the funding architecture** and the development of **innovative financing instruments**. Other key elements are improved participation and a new planning culture for the improved integration of environmental protection in urban and infrastructure development, not least more transparent decision-making processes reflecting diverging interests and the range of actors.

Research requirements

Research questions relating to governance, participation and financing can be grouped under three sub-topics:

Sub-topic 1: Strengthening implementation at the urban level

- How can national programmes and policies find application at the municipal level, e.g. by the further development and specification of the urban development funding of the Länder or the German Resource Efficiency Programme "ProgRess" for the municipal or neighbourhood levels?
- Which structures and capacities can be used to support municipalities in the active shaping of sustainable urban development, e.g. for the development of strategies for environmentally benign and climate-neutral energy supplies?
- How can urban actors be linked to one another, and better use be made of their contributions to environmentally benign and socially acceptable urban development? Which governance structures will have to be improved or expanded?

Sub-topic 2: Financing instruments for sustainable urban development

- How can an inter-departmental strategy and funding models be developed by the Federal Government and the Länder for the integrated financing of urban infrastructures, as well as a resource-conserving, socially acceptable and health promoting development and refurbishment of neighbourhoods that also adapts these to climate change?
- How can the allocation of funds and Federal funding programmes be tailored to meet the needs of the municipalities?

Sub-topic 3: Participation and transparency

- How can digital participation formats support the efforts of the public to promote the quality of the environment in their own living space and contribute to improved participation and consideration of citizens' interests? What are the limits to digital participation?
- How can actors be brought together and empowered to act in the interests of sustainable urban development (e.g. by identifying common goals of housing development companies, neighbourhood networks, etc.)?
- What structures are suitable for promoting participation and identification with the goals of sustainable urban development? How can these possibilities be used for the implementation of measures as part of environmental and health plans (e.g. stormwater management, heat action plans)?

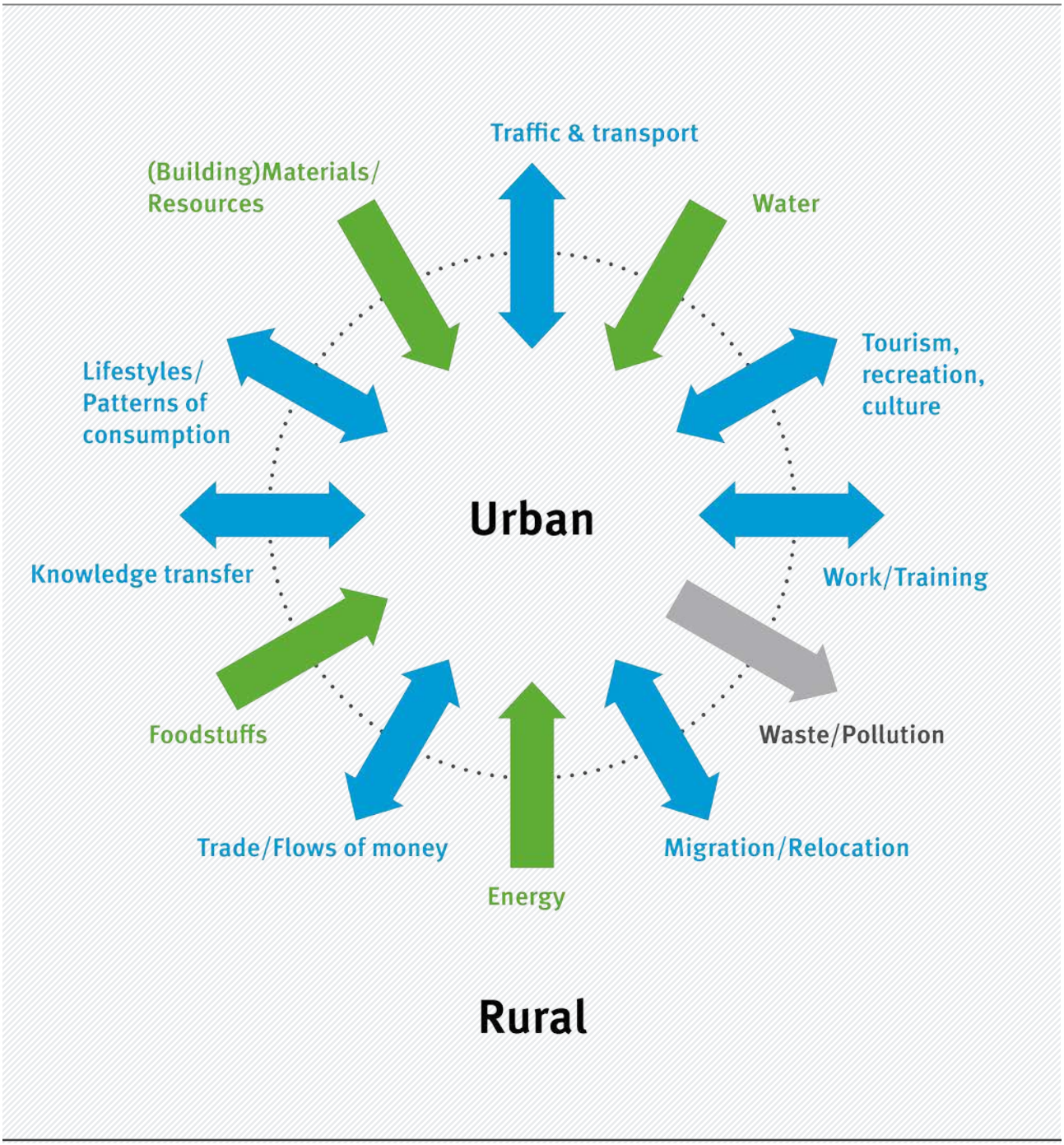
4.3 Urban-rural relationships

Towns and cities are linked in a variety of ways with the countryside. In growing urban regions, the peripheral areas fulfil important functions, e.g. for the housing market or as a space for recreation. The economic structures of many towns and cities are closely intertwined with rural areas, through commuting, leisure and consumer behaviour, trade, and flows of money (Repp et al. 2012). Culture and tourism also have an urban-regional dimension, and it is also necessary to analyse how supply and disposal infrastructures and transport relationships are organised beyond the municipal boundaries (see Fig. 11). Many environmental aspects cannot be discussed in detail without considering urban-rural relationships. A clear case is the networking of material flows, because municipalities and rural areas are either source or sink for one another in many respects (e.g. regarding foodstuffs, building materials, energy, or waste). Technical infrastructures such as power grids, water supplies, wastewater disposal and waste handling installations form direct physical networks linking urban centres and surrounding rural areas. The environmental impacts of urban traffic cannot be reduced without taking commuters and the flow of goods into and out of municipalities into account.

For historical reasons, town and country have often been considered separately (the urban-rural dichotomy), although various functional relationships are now blurring these distinctions, and attention is being directed to the urban-rural nexus. Municipalities and the surrounding rural areas are reacting to the growing need for cooperation by setting up administratively anchored regional associations, sectoral associations for transport infrastructure, or supply and disposal infrastructures. Complex issues such as adaptation to climate change, demographic change, regional economic structures, education, and digitalisation are also increasingly being addressed in the urban-rural context. Spatial and regional research examines forms of cooperation and new spatial relationships; urban-rural relationships are also of growing importance for environmental and sustainability research.

Figure 10

Interactions and exchanges between urban core and rural periphery



Source: UBA 2017. Own presentation

Research requirements

The following four categories of research topics reflect the scope of urban/peri-urban relationships.

Environmental impacts of urban development on surrounding areas

- How can peri-urban housing be made environmentally acceptable and the land consumption minimised?
- How can public health threats caused by environmental pollution be addressed at the urban-regional level (e.g. transport hubs, flight routes)?

Environmentally relevant urban-rural interactions

- Which instruments are suitable for registering exchange relationships and identifying potential for inter-municipal cooperation?
- What potential is there for agriculture anchored in urban regions regarding the quality and experiential value of regional urban green? How can local or regional material cycles be closed?
- How can material flows between municipalities and rural areas be analysed in terms of various substance groups?

Cooperation between municipalities

- How can environmental impacts be reduced by cooperation between municipalities? This includes the harmonised development of infrastructures e.g. by cooperation, synergies or by consolidated regional commercial development.
- How can it be made easier for municipalities to enter into cooperation agreements? What are the obstacles (fiscal, administrative, etc.)?

Intelligent supply strategies

- How can individual concepts for environmentally benign smart approaches be promoted in accordance with the framework conditions for regions and core municipalities? How can planning for urban developments and the further development of rural areas be better coordinated (e.g. with public transport networks)?
- What framework conditions are necessary for the environmentally benign organisation of urban-rural logistics (e.g. by coupling supply and disposal infrastructures, avoidance of empty return trips, setting up central logistical hubs, etc.)?

5

Implementing the research agenda and the use of the research results

The issues raised in the UBA research agenda "Urban environmental protection" will form the basis for research activities to be initiated by the German Environment Agency in the coming years. An important instrument is the Departmental Research Plan (ReFoPlan) of the Federal Environment Ministry (BMU). On the basis of the research questions, with the participation of various UBA departments working in close consultation with the Ministry, interdisciplinary research projects will be developed and supervised by the UBA. The projects will be carried out with exchanges and close networking between disciplines in order to obtain integrated research results that provide practical benefits.

Apart from this, UBA also carries out its own research on selected topics, not only in the form of literature reviews and the desk-top analysis of available data, but also as measurement programmes on the state of the environment or experiments at various laboratory locations and trial stations and demonstration facilities located in Berlin Marienfelde. UBA also has an environmental samples bank which is a valuable archive covering the changing state of the environment over recent decades. Third-party research on selected topics augments the resources and capabilities of UBA. Participation in research associations leads to networking on an equal footing with partner institutes in Germany and Europe, and also affords insights into the research field. In-house research together with third-party research represents an important strategic element of UBA research agenda "Urban environmental protection".

Furthermore, where work on broader cross-thematic topics would exceed the resources of the Federal Environment Ministry, the German Environment Agency endeavours to feed relevant research, or proposals for model trials or living labs, into research programmes of other Federal Ministries, in particular Education and Research, Transport and Digital Infrastructure, or Health, or to initiate appropriate research programmes and to provide specialist accompaniment. This could also put UBA in a position to conduct evaluation projects, in order to transfer the varied results (e.g. from programmes of the Federal Ministry of Education and Research (BMBF)) in a targeted manner into the work of the Federal Environment Ministry. As part of the BMBF programme "Stadt-Land-Plus" for improved cooperation of municipalities in the regional context, UBA has already supervised such an evaluation project within the framework of third-party research.

With regard to research projects and model trials, cooperation will be intensified with other institutions carrying out urban and environmental research, e.g. with the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), and the German Federal Nature Conservation Agency (BfN).

The results of the ReFoPlan project will feed into specific programmes, strategies, and legislation, but will also be reflected in information and communications instruments, and exchange and dialogue platforms. In addition, they will support UBA's implementation-oriented programmes, e.g. the environmental innovation programme, project promotion, or association promotion. In the field of international politics and knowledge transfer, relevant programmes supervised by UBA are the "Advisory Assistance Programme" to support projects aiming for environmental protection in the states of Central and Eastern Europe, the Caucasian countries and Central Asia, as well as countries neighbouring the EU in the Mediterranean Region, or the "UNEP/UNESCO/BMUB International Training Programme on Environmental Management for Developing and Emerging Countries". The approach adopted will depend on the research questions being addressed and the process status of the specific programmes, strategies, and laws.

Examples of central **options for implementation and further use** include:

- National strategies and programmes: German Sustainability Strategy, Climate Action Plan 2050, Integrated Environmental Programme, German Strategy for Adaptation to Climate Change (DAS) (DAS), German Resource Efficiency Programme (ProgRess), White Paper on Green in the City,
- International strategies and programmes: Implementation of the SDGs, the New Urban Agenda, and the EU Circular Economy Package, further development and implementation of the Leipzig Charter and the EU Urban Agenda,
- Laws and regulations, e.g. the German Building Code, Federal Land Utilisation Ordinance, Regional Planning Act, Waste Management Act, Model Building Regulations,
- Research programmes and research funding, e.g. from BMU, BMBF and the EU,
- Urban development funding programmes or the Joint Scheme for Improving Regional Economic Structures (GRW),
- Dissemination of information material, practical aids and tools, e.g. for (municipal) service centres, communicators, dialogue platforms; increased distribution of software tools such as Building Information Modelling (BIM),
- Further development of evaluation instruments, e.g. in cooperation with the German Sustainable Building Council (DGNB) or on the basis of the Evaluation System for Sustainable Building (BNB), etc.

The international context

The greatest challenges from urbanisation are faced primarily in the developing countries and emerging economies of Asia and Africa. Although the UBA Research Agenda focuses on Germany, the international context will also be considered where appropriate. The activities of the UN (e.g. UN Habitat, SDGs) and the EU (e.g. the Leipzig Charter) offer important orientation for German urban development policies, particularly from an environmental point of view. The municipal implementation of the SDGs, for example, will be a key topic for German municipal policy-making in the coming years. Learning from and with other countries with similar framework conditions and spatial structures that are facing comparable challenges (particularly in Europe) can be beneficial for some research questions. As a next step, the nationally-oriented Research Agenda could be given broader international links.

Reference points can be found above all in international knowledge transfer, for example concerning the high rates of consumption for natural resources. Above all China and India, but also other rapidly growing countries are consuming far more natural resources than Germany, so that targeted knowledge transfer also influences urban development there and can help to conserve natural resources. Equally, Germany can benefit from knowledge transfer, for example regarding the further development of infrastructure in heavily built-up agglomerations with growing populations.

UBA is active internationally in research projects and committees (e.g. Network of Environmental Protection Agencies) as well as with consultancy projects. However, there has so far been no particular focus on topics relating to environmentally oriented urbanisation. **Potential research topics and networking activities** for UBA include:

- Screening of national and international Best-Practice concepts for the reduction of the urban consumption of natural resources and associated negative environmental impacts and deriving nationally applicable approaches (e.g. organisational forms, collection systems, incentive mechanisms, etc.);
- Checking the applicability of national strategies for urban environmental protection in an international context (EU, global), exchanges of concepts and testing their specific suitability;
- Potential for networking and expanding existing cooperation with international institutions and initiatives such as the Municipal Solid Waste Initiative (MSWI) of the Climate and Clean Air Coalition (CCAC);
- Testing national strategies and measures for their applicability in the Post Habitat III process and for contributions to international environmental and sustainability goals; establishing adaptation requirements and possibilities for targeted implementation.


6

Future prospects

This Research Agenda addresses many aspects of urban environmental protection. Not all of the questions are new, but some remain unanswered and in other cases possible solutions have not been adequately implemented. Therefore, the topic clusters also include items where the goal is to communicate existing knowledge and research results more effectively. The Agenda focuses on research topics concerning the development of urban areas that are **highly relevant from an environmental perspective** in view of current conditions, trends and challenges.

At the centre are research questions at the **interface between environmental protection and urban development** – mostly they are of national importance, but in some cases they are also of international relevance. The stance adopted to internationally significant topics of environmentally oriented urban development is a matter for separate consideration, particularly concerning the contributions which UBA could or should make to international debates and processes on global urbanisation and the consequences for the environment.

Many of the topics can only be implemented through **cooperation with a range of partners**. These include research institutions and universities, as well as ministries and other agencies – in particular the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) and the German Federal Nature Conservation Agency (BfN). Further cooperation partners are municipal actors, environmental associations, business associations, association of towns and cities, city networks, and representatives of companies, civil society organisations and other multipliers. Such cooperation is essential for the success of research projects and the implementation of results.

All Agenda topics **focus on the implementation**, but this can only be successful if existing knowledge is linked up with new findings, and research results are communicated in a targeted way to specific addressees. This can reduce barriers to implementation and promote new approaches and concepts at the interface of environmental protection and urban development.

As the Agenda for urban environmental protection is made more specific and research projects are developed in detail, within existing formats or new ones, it is important that a good network is established to link the projects working on the various focal topics. This is necessary to ensure that use can be made of **synergies** and that research results can be combined in order to formulate **convincing arguments** for policy-makers and society about transformative processes to achieve environmental goals in the central fields of action relating to urban development.

With the concept paper "Tomorrow's cities" (UBA 2017b), UBA has already presented a first step towards **environmentally oriented urban development**. Following on from this, it is necessary to identify target values and indicators which can be developed further and integrated in the various fields of actions of sustainable urban development, such as resource conservation, sustainable infrastructure development, and healthy living conditions.

The Agenda will be reviewed, updated and extended at intervals of five to ten years. This will make it possible to react to the **dynamic changes in cities and conurbations** and to newly emerging environmental issues. This will also deliver an updated contribution that will raise awareness about the close ties between environmental protection and urban development. Only in this way will it be possible to ensure that "Living in the city" will in future not only be sustainable, healthy, and adapted to climate change, but also environmentally benign and socially acceptable.

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