UFZ HELMHOLTZ Centre for Environmental Research

SAFEGUARDING THE FUTURE

RESEARCH FOR THE ENVIRONMENT

THE UFZ ON ITS WAY TO THE YEAR 2025+

PREAMBLE

SETTING THE COURSE

A healthy environment is imperative for human existence and social development – there is no doubt about that. People will always need clean water and intact soils for growing food crops; forests that supply timber, store water and sequester carbon dioxide; water bodies as suitable habitats for fish; natural resources that not only provide food and materials but also sources of energy; and landscapes for living and recreational purposes. And yet increasingly more people are competing over the same resources. Much of our natural resource base is being depleted or suffering from impaired quality. Water is not only becoming scarce, but also increasingly contaminated. Soils are being eroded or sealed. Rivers are losing their floodplains. Genetic resources, plant and animal species are disappearing along with their habitats.

Our integrated research and synthesis approach is indispensable in light of the close interdependence between causes and effects, the highly complex nature and scope of the environmental topics.

In 1991 it was the environmental and social problems in the region around Leipzig, Halle und Bitterfeld strongly characterised by the chemical and lignite industries, decades of overexploitation of natural resources and a study on the state of environmental research in the new German states, that led the German Federal Ministry of Education and Research and the German Science Council in 1991 to establish a “broad-based centre to conduct research on the ecology of concentrated industrial areas” in Leipzig or Halle. When the UFZ finally commenced its work on 2nd January 1992, it was the first and only research institution in the Federal Republic of Germany that exclusively addressed environmental research – and until now it is still the only research centre in the Helmholtz Community with this unique profile. On the one hand, the UFZ’s tasks covered fundamental scientific research to understand environmental problems in highly contaminated landscapes and to make contributions to the development of methods and theories in ecosystem research. On the other hand, research was also conducted to establish which technical and socio-economic requirements are essential to remediate and restore highly stressed landscapes and ecosystems.

Since the start of the new millennium, the UFZ’s research strategy has shifted: since then the focus has no longer been limited to land remediation and restoration and the region surrounding Leipzig, Halle and Bitterfeld, but has extended to global environmental issues caused by climate- and land use change, demographic changes and migration, rising food and energy requirements or the loss of biodiversity.

Today, the UFZ (with its 1100 employees) is a nationally and internationally recognized competence centre for environmental research. The subject of our research is the terrestrial environment as part of the Earth system. Our strength is our integrated research and synthesis approach, which is indispensable in light of the close interdependence between causes and effects, the highly complex nature and scope of the environmental topics. It is our tradition to play an active role in fundamental scientific research and follow it through to its application. We are reliable partners,

knowledge mediators and consultants: the expertise of our UFZ-scientists on the Intergovernmental Panel on Climate Change (IPCC) is as much in demand as it is for the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), for the Bioeconomy and Hydrogen Council or in the Expert Council on the Environment, which advise the Federal Government. We have expedited the research on sustainable water resources management and its implementation at the global level. We have helped to initiate and establish research infrastructures in demand internationally for environmental monitoring and modelling. We lead research studies and projects such as the World Water Quality Assessment of the United Nations, or those on sustainable urban development, on sustainable land use or on soil protection. We contribute our expertise to help with the implementation of the EU's chemical regulation, with the Water Framework Directive, with national nature conservation acts or the Convention on Biological Diversity and the turnaround in energy policy.

Many of today's challenges will become the challenges of tomorrow. Our 2025+ strategy means that we are ideally positioned to continue developing and nurturing our competences as one of the most distinguished research institutions in the field of environmental and climate adaptation research. Thereby, in this era of dynamic global change we will keep setting the course – a course that will enable the goals of social development and a healthy environment to be compatible.

PROF. DR.
ROLF ALTENBURGER
Scientific Director

DR.
SABINE KÖNIG
Administrative Director

COMITTED, EXCELLENT AND RELIABLE

Our Vision

The UFZ is one of the world's leading research centres in the field of environmental research, enjoying high social recognition. It demonstrates ways in which a sustainable use of our natural resource base is possible for the benefit of both humankind and the environment.

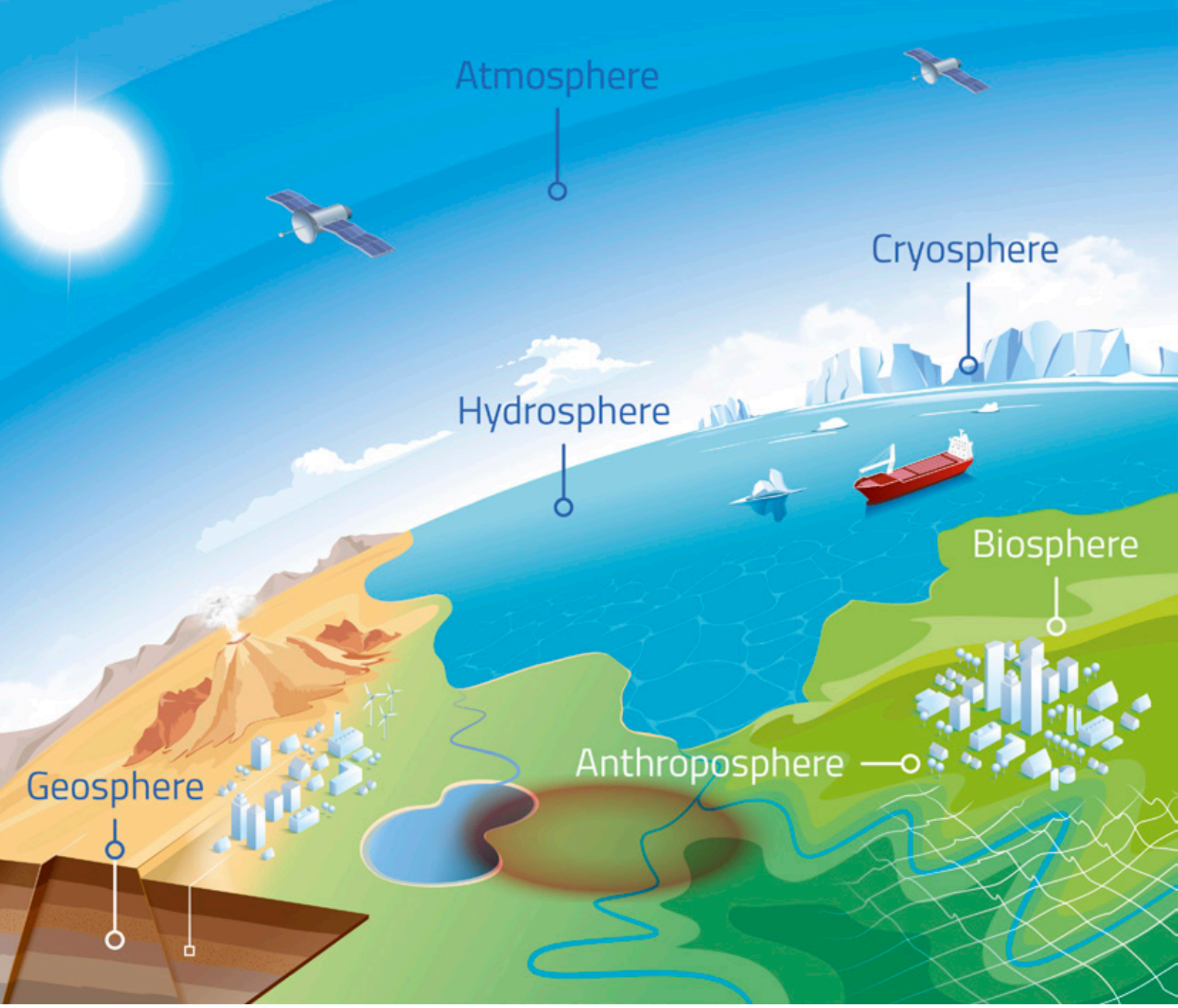
Our Mission

Biodiversity, functioning ecosystems, clean water and intact soils all make up our natural resource base. In the face of global change, employees at the Helmholtz Centre for Environmental Research (UFZ) are united by the goal of demonstrating ways to combine societal development with a healthy environment.

The UFZ conducts excellent research and takes on a shaping role in the scientific community. As a reliable partner, the UFZ supports the political arena, the economy and the general public to better understand the consequences of human actions on the environment and to develop options for social decision-making processes. For this purpose, the UFZ responds to the stimuli created by society and by producing know-how and technologies that should help to rapidly identify problems comprising conflicting priorities between the environment and society. The UFZ will consequently work on precautionary measures.

In dealing with complex environmental issues, the disciplinary borders between the natural-, engineering- and social sciences need to be overcome. The UFZ has extensive competences in integrated environmental research. It boasts innovative scientific infrastructures and nurtures indispensable national and international cooperation, enabling problem-solving at the highest level.

Attractive working conditions, the creativity and motivation of UFZ employees, their personal and professional development, and the promotion of young scientists as leading international researchers are all key factors when it comes to successfully promoting this mission.

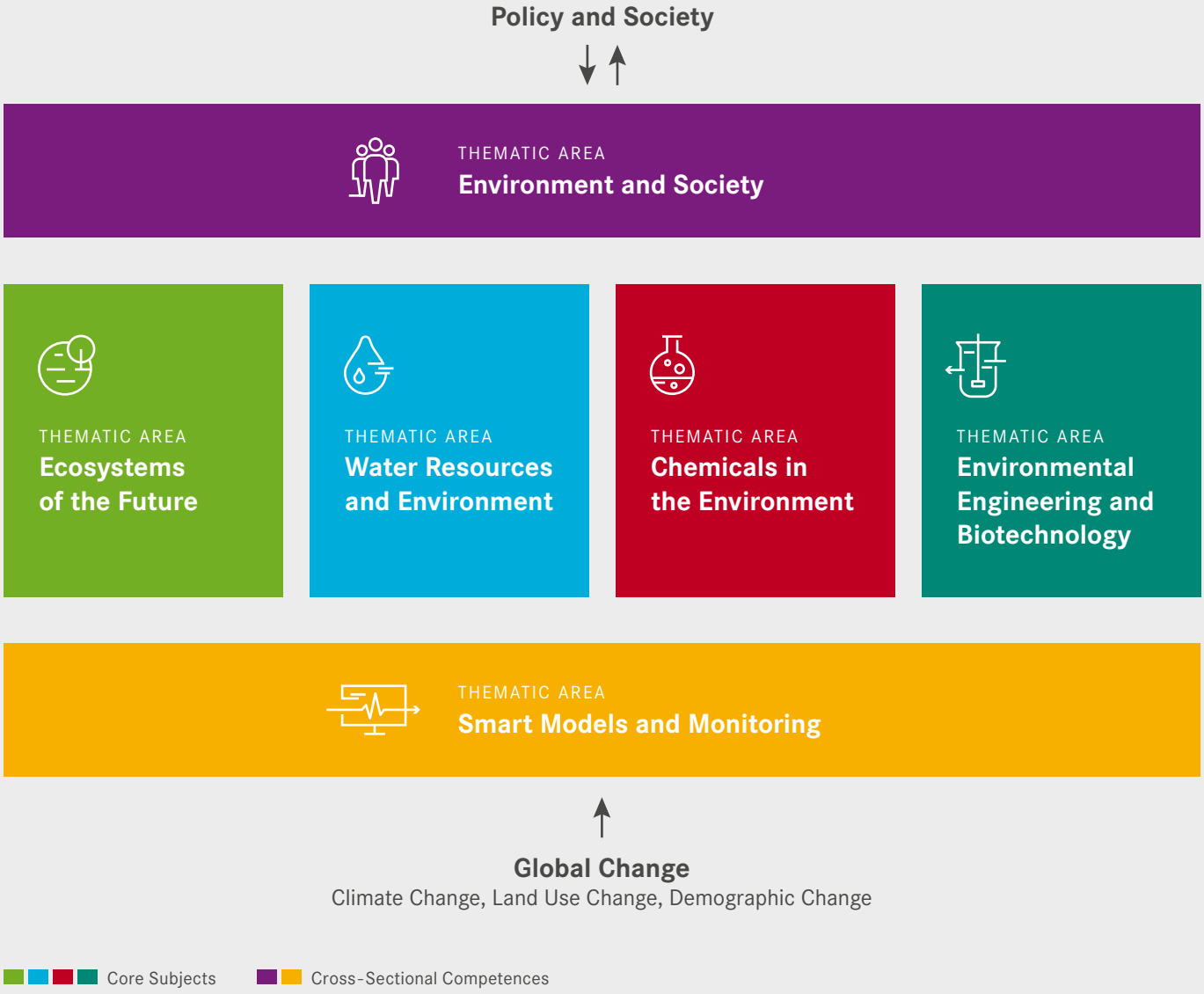


THE HELMHOLTZ RESEARCH FIELD EARTH AND ENVIRONMENT

PROMOTING RESEARCH ON THE EARTH SYSTEM

As a member of the Helmholtz Community the UFZ conducts cutting-edge research with strategic programmes to contribute to solving major and pressing issues facing society, science and the economy.

Within the Helmholtz research field Earth and Environment the UFZ pools its competences into research on the terrestrial environment on all continents. This includes the compartments: soil, surface waters and groundwater. Along with other research centres active in the research field Earth and Environment, the UFZ works at the interfaces of terrestrial ecosystems with coasts and oceans, with the atmosphere and with the deep underground environment. The common goal within the framework of the research program „Changing Earth – Sustaining our Future“ is to promote research on the earth system and to understand the earth system holistically.



OUR RESEARCH STRUCTURE

BEING EXCELLENTLY POSITIONED

With its research on the environment, the UFZ demonstrates a unique portfolio, which is oriented towards global trends and the Sustainable Development Goals of the United Nations: population growth and scarcity issues for society, globalization, urbanisation, climate change and decarbonisation, the loss of biodiversity, an increasing amount and variety of chemicals that affect human health and the environment, as well as new trends in national and global governance. These closely interconnected global trends clarify, just how intricately complex societal, ecological and social relationships are. Not least because of this, we realise that it is imperative to conduct integrated research in the field of environmental and climate adaptation research. At the same time it is important to develop syntheses supported by data and models about the current and future state of the environment.

To support this integrative research and synthesis approach to environmental research, the UFZ's research is organized into six thematic areas, to which a total of 38 methodically organised departments are assigned.

These thematic areas are intended to make up the core of the UFZ's research. They reflect the main topics and the cross-sectional competences of the UFZ and are linked to one another through Integrated Platforms and projects.

ECOSYSTEMS OF THE FUTURE

SAFEGUARDING ECOSYSTEM SERVICES.

Vision

Ecosystems of the future must fulfil the different needs and requirements of humans and society.

To that end, we need to understand how processes in ecosystems work and how they are connected. We need to develop strategies and instruments that ensure the persistence of various ecosystem services and the resistance of ecosystems in times of global change and increasing pressure, because they are the foundations of life and a guarantee for the persistence and the development of human societies.

Ecosystems need to be observed by various indicators on different scales of time and space to identify how land use and climate change have an impact on biodiversity, its functions and services.

Challenges

Like never before, humans are having an impact on their natural resource bases – ecosystems (and the services that they provide), which ultimately guarantee the persistence and the development of human societies. Many ecosystems are currently operating at their limits.

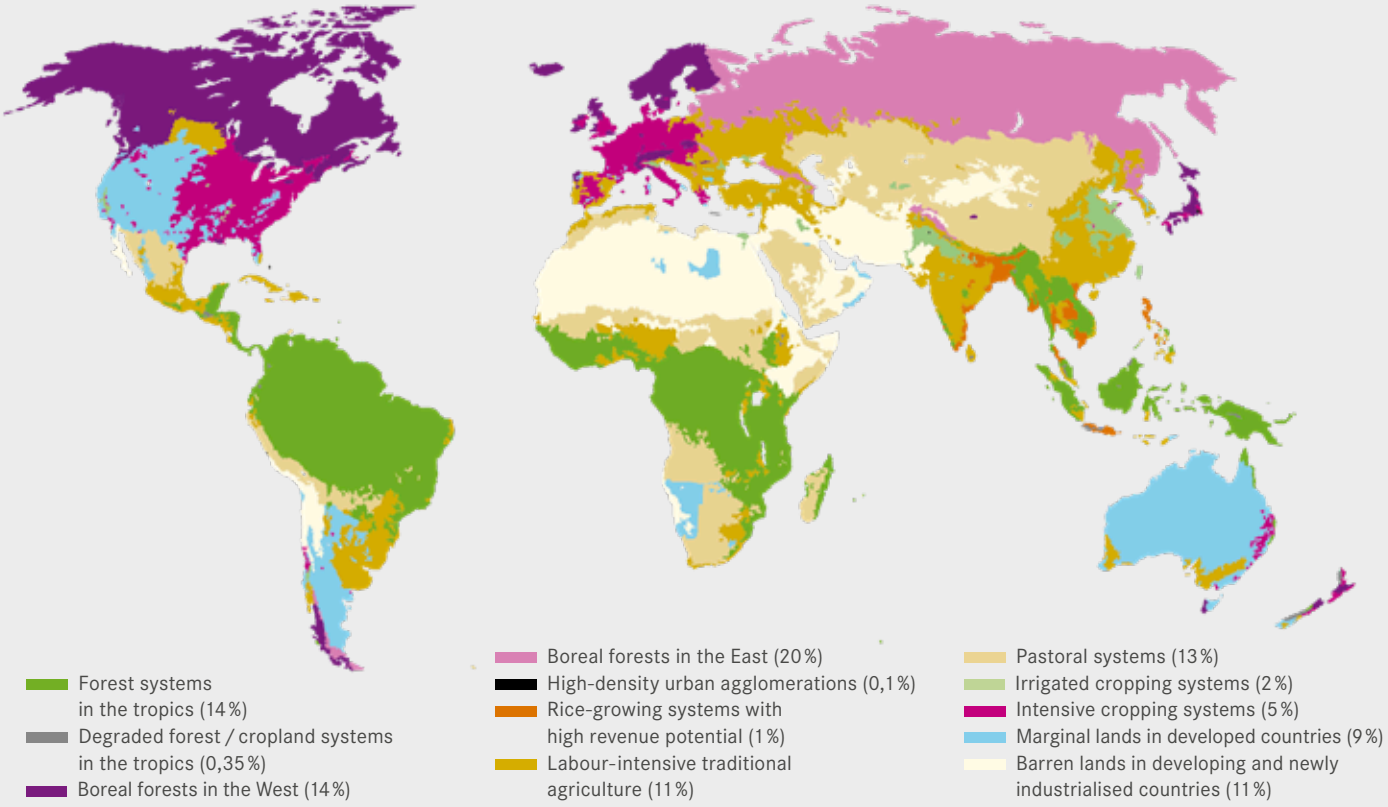
> With their global trade in food and raw materials, Germany and the EU have a responsibility for the international use and distribution of natural resources.

The rate at which humankind currently appropriates its natural resources is much higher than the rate at which they can be replenished. Germany and the EU have a responsibility for the global use and distribution of natural resources. The growth rates for the use of many natural resources exceeded their climax at the start of the 21st Century. Thereby, the limited resource 'land' is at the crux of the matter – not only in Germany, but also in other countries around the world.

The answer to these challenges is a sustainable development of rural and urban areas and a sustainable provision of ecosystem services – goals that are embodied in the Environment Programme of the German federal government and in the Sustainable Development Goals of the United Nations.

Questions

But how do ecosystems work? How exactly are they influenced by complex biotic and abiotic interactions? How much stress can they withstand and absorb? When will they lose their ability to regenerate? What are the functions of species and species communities? What exactly do ecosystems provide to society? Which economic and legal instruments can contribute to reconciling land use conflicts and maintaining ecosystem functions and services?



This map of the world shows twelve global land-use patterns, so-called archetypes. More than 30 indicators taken from agriculture, the environment, the climate and socio-economic situations were assessed by researchers to obtain these results.

Goals and products

Scientists working in the thematic area 'future ecosystems' conduct research on the material and energy flows in ecosystems, on structural and functional aspects of biodiversity as well as the causes and impacts of anthropogenic changes. For example, they investigate on different scales, which and how many species occur in specific ecosystems, which ecosystem services and resources they generate, how stable populations and ecosystems are, which environmental stress factors affect them and what kind of regeneration potential they have. Researchers develop sustainable policy options for managing natural resources sustainably – beyond the simplified alternatives of "protection" or "use". This means that they have to take into account basic economic, legal and social conditions, while also considering ecological and technical knowledge and the fact that the ecosystems being used also provide numerous services and that it is therefore of upmost importance to protect them.

In selected model landscapes in Germany, Europe and 'hot spot' regions of the world such as South East Asia, case studies are being implemented to explain how ecosystem services can be maintained and optimised for the long term: provisioning ecosystem services such as food provision, supporting ecosystem services such as carbon sequestration or nutrient cycling, regulating ecosystem services such as natural pest control or flood water control and cultural ecosystem services such as recreation. Research is being conducted to establish the drivers of land use change in rural, forest and urban systems and how a better land use management can not only preserve the multi-functionality of a landscape, but also its biodiversity and resilience – in other words the ability of an ecosystem to maintain its basic functions after disturbance or overexploitation.

> Researchers are developing policy options beyond the simplified alternatives of "protection" or "use".

In order to make the state, development trends and potential of an ecosystem both measurable and comparable, indicators are being developed to assess the state of ecosystems and the services that they provide – comparable to those indicators that were developed for the good chemical and biological condition of surface waters. Instead of using chemicals or technology solutions that are energy and raw material-intensive, "nature-based solutions" like the natural pollination potential or biologically-driven material cycles and other naturally adapted processes can help with pest control for example or with the adaptation to climate change.

Methods and infrastructure

Researchers from different disciplines have access to various tools: laboratories for genetic analyses, large databases with biological and abiotic information, new model approaches, so-called Ecotrons (fully air-conditioned research units for the manipulation and measurement of complex ecological processes), controlled field experiments such as the Global Change Experimental Facility (GCEF) or observatories and monitoring platforms, which they themselves have initiated, developed and set up. Models enable the process-based knowledge from experiments, monitoring and databases to be linked together; they allow for integrating the results of structural and functional biodiversity research; they enable impacts on the level of organisms to be followed over time; and they allow potential landscape changes under different land-use scenarios to be simulated. This broad spectrum enables holistic system solutions to be developed.

Networks and knowledge transfer

In the field of ecosystem research, the UFZ has initiated extensive national and international projects and networks or at least supported them with its expertise. Examples are the cooperative project BonaRes, a measure funded by the German Federal Ministry of Education and Research (BMBF) where the system soil is the focus as a sustainable resource for bioeconomics, or the cooperative project GLUES within the programme „sustainable land management“ of the BMBF. With the HORIZON 2020 project eLTER, the European research infrastructure is to be linked to long-term research on ecosystems. Furthermore, the global network Drought-Net is investigating the sensitivity of terrestrial ecosystems to droughts, whereas the efforts of the international research co-operation Nutrient Network allow the effects of nutrients to be recorded all over the world. One of the most important partners thereby is the German Center for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, for which the Universities of Halle, Jena and Leipzig, the UFZ and other research institutions are founding members.

In order to make knowledge and new insights available to various stakeholders in society as well as decision-makers, they are comprehensively and continuously involved in projects, networks and processes. An important interface is the German Network-Forum for Biodiversity Research (NeFo), which is coordinated at the UFZ. Citizen’s science projects such as the Butterfly Monitoring Scheme Germany are increasingly inspiring citizens to get involved in research or to come up with their own research questions. Socio-scientific studies on agrarian landscapes or co-operation with science-policy platforms encourage dialogues with central decision-makers. It is of great importance that UFZ scientists participate in national and international platforms and committees such as the Intergovernmental Panel on Climatic Change (IPCC), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) or the Bioeconomy Council. In doing so, they make important contributions to the implementation of Germany’s national biodiversity strategy and to the Convention on Biological Diversity (CBD).

Thematic Area »Ecosystems of the Future«
Strategies to safeguard their performance and resilience

Head of Thematic Area Prof. Dr. Ralf Seppelt

The Global Change Experimental Facility (GCEF) is the only long-term experiment of its kind worldwide. Scientists from all over the world conduct research on the impacts of climate change and land-use change on ecological processes subjected to different kinds of land use. The results are of profound importance for conservationists, planners, farmers and political decision-makers.

WATER RESOURCES AND ENVIRONMENT

ENSURING WATER SECURITY.

Taking water samples from the river Kharaa in Mongolia. The north of Mongolia is a model region for integrated water resources management, because the rivers in Central Asia will be particularly affected by climate change, agricultural and pastoral systems as well as the exploitation of natural resources over the coming decades.

Vision

Water must remain secure in the future in sufficient quantities and in the required quality for humans and the natural environment.

To make sure this happens, we have to understand how the water cycle is functioning on the local, regional and global levels. We require science-based knowledge about how the quantity and quality of the groundwater and surface waters are affected by natural and human impacts, if we are to develop strategies for a sustainable water management that can be implemented in selected regions around the world.

Challenges

Water is essential for all life on Earth. To achieve sustainable development, societies, the economy and the living environment (terrestrial ecosystems) all need freshwater in sufficient quantity and quality. Climate change, extreme weather events, the global population growth and international markets are all factors that exert direct and indirect pressures on natural water resources. Impacts are regionally very diverse, ranging from extreme water scarcity to high chemical loads or even new kinds of micropullutants.

The UN has adopted the goal “Clean Water and Sanitation” on its “2030 Agenda for Sustainable Development”.

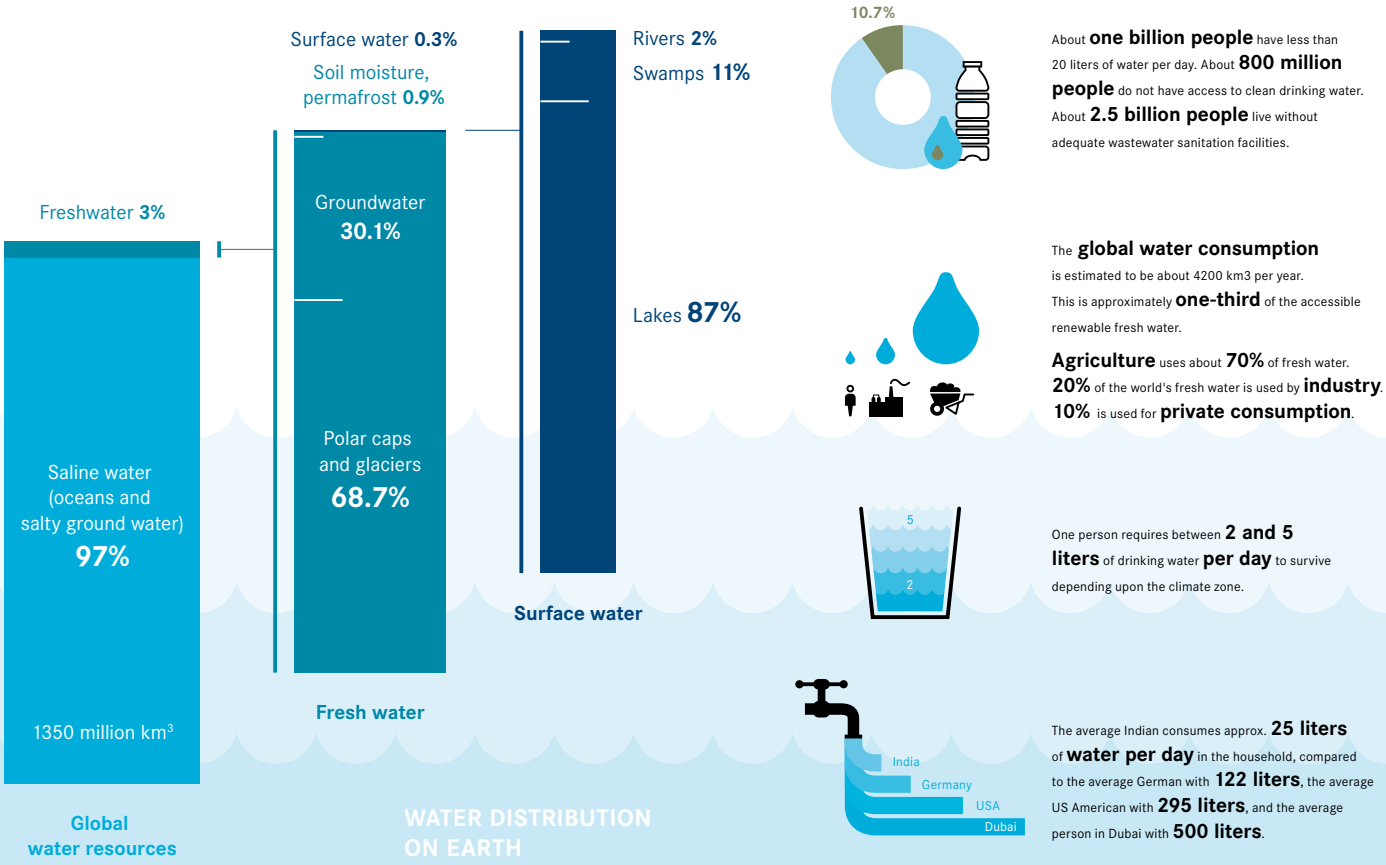
With its European Water Directive, the EU has already set a clear goal for the sustainable management of water resources. Moreover, the United Nations has adopted the goal “Clean Water and Sanitation” on its “2030 Agenda for Sustainable Development”. Politics, economics and science in industrialised nations as well as in developing countries all share the responsibility for implementing and achieving these ambitions.

Questions

How exactly does mankind use and alter the groundwater, lakes and rivers? How are the water cycle and ecosystems connected? Under which conditions can water bodies regenerate themselves? When is technological assistance required? How can the socio-economic and climate change processes affecting our water resources be analysed?

Goals and products

Scientists of the thematic area “Water Resources and Environment” observe, explore and analyse the various compartments of the water cycle. On the one hand, they quantify water availability in selected catchment areas. On the other hand, they investigate which substances from natural and anthropogenic sources get into the water cycle and through which pathways, how they are converted along flow and transportation routes and which processes are crucial for the status and development of water bodies. Moreover, they want to qualitatively and quantitatively determine the functions of aquatic and terrestrial ecosystems for the water and matter balance as well as qualitatively and quantitatively analyse biodiversity in such a way that they are more than a mere description of their state. For a more efficient water management they are looking for control options, under which the total level of pollutants can be



From a global perspective water is sufficiently available. However, only a small fraction of it can be used directly as drinking water – and this small fraction is unequally distributed in the world.

kept within safe boundaries. It is therefore about minimising direct loads (nutrient loads such as nitrates and phosphates or hazardous substances such as pesticides), as well as indirect loads such as pharmaceutical residues or household chemicals that enter the water cycle through waste water. Here, basic economic conditions play a substantial role.

Scientists are developing concepts for new techniques and methods, with which aquatic ecosystems (in particularly vulnerable catchment areas) can be characterised, monitored and analysed in Germany as well as in other countries all over the world.

The UFZ took on an advocacy role for the German water research community with the Water Science Alliance.

New and robust modelling tools, reduced to an optimal complexity, help to reliably portray the changes to water and matter fluxes and thus interrelated ecosystem processes on different scales in space and time (even with less reliable or very limited data sources) – both for the past and for the future. With the help of new indicators, the functions and services of water body ecosystems can be recorded and described. In cooperation with the thematic area “Environment and Biotechnology”, researchers are developing various solutions and technologies for the remediation of contaminated surface waters and groundwater or for the treatment of wastewater, like for instance in Jordan – one of the most water-scarce regions in the world.

Methods and infrastructure

A unique infrastructure is available for the complex and coherent monitoring of water bodies. This includes for example the observatories of the Helmholtz observation platform TERENO in the catchment area of the River Bode in the Harz Mountains in Germany; the MOBICOS mesocosms (container-based mobile laboratories with their high degree of flexibility for use in different watercourses); the research vessel ALBIS, which has been specially designed and equipped for conducting research on the river Elbe; or the laser-scanning microscopy, which is particularly useful for investigating micro-biological processes in water bodies. With their wide-ranging expertise in the geo-hydrological sciences and the integration of ecotoxicological as well as sociological issues, UFZ scientists have the unique

The Dead Sea and its 7,000 square kilometre catchment area are the focus of research conducted by geologists, hydrologists and meteorologists for the increasingly scarce freshwater resources of the Middle East.

opportunity to conduct research on hydrological and biogeochemical cause-and-effect chains and feedback effects from anthropogenic changes on different scales.

Networks and knowledge transfer

The UFZ has initiated national and international networks and alliances in the field of water research. The Center for Advanced Water Research CAWR pools the competences of the UFZ and the TU Dresden in research, education and knowledge transfer on the topic of water research. Furthermore, the UFZ took on an advocacy role for the German water research community with the Water Science Alliance, giving this community an international voice. The UFZ also coordinates the European Topic Centre for Inland, Coastal and Marine Waters ETC - ICM. This makes the UFZ an important strategic partner in a network, which develops application-oriented concepts for national, European and international water politics.

Whether it is the Water Framework Directive or access to clean water as a basic human right, the implementation of these challenging goals can only work through coherent knowledge transfer. Considering that, strategic partners are indispensable, such as the European Environment Agency (EEA), the German Environmental Agency (UBA) as an authority of the Federal Ministry of the Environment or the Environment Program of the United Nations (UNEP). On the other hand, institutions such as the German Society for International Cooperation (GIZ) or the German Water Partnership (GWP) also play an important role in transferring results, since it is only through close co-operation and training that knowledge and technologies end up where they are most needed.

Thematic Area »Water Resources and Environment«
Water security in the 21st Century: Sustainable pathways in multi-functional landscapes

Head of Thematic Area
Prof. Dr. Dietrich Borchardt

CHEMICALS IN THE ENVIRONMENT

MAKING CHEMICALS IN THE ENVIRONMENT GREENER.

Vision

Chemicals will be developed in the future in such a way that they no longer pose a threat to human health or the environment.

To achieve this goal we have to adopt a new way of assessing the hazards of chemicals – that is to no longer examine individual substances with selected test organisms, but to look at diverse forms of chemical contamination that have different impacts in the real environment on different ecosystems, species communities and organisms. The risk assessment of chemicals in the future must therefore be an integrated assessment that combines ecotoxicology with human toxicology.

The UFZ's river experiment with 47 fourteen-meter long artificial gutters helps to investigate the effects of pesticides on aquatic organisms under considerably more realistic conditions than in the laboratory.

Challenges

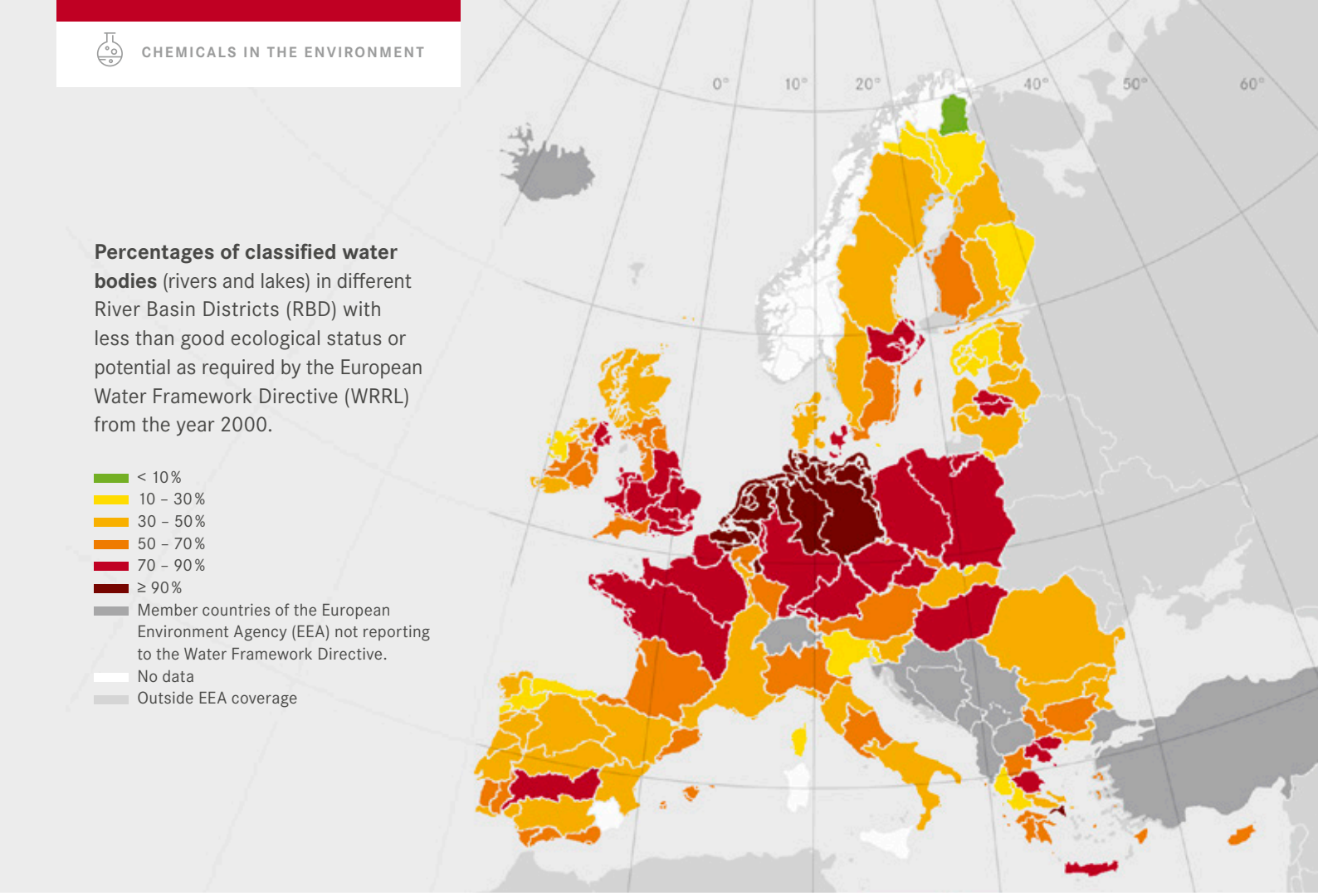
Our society develops, produces, uses and disperses a diverse and vast amount of chemicals – this is not just a current trend but one that is expected to continue into the future. These chemicals are in the form of raw materials, compounds and products and are believed to improve our standard of living.

The material world is shaped by chemical cocktails composed of diverse molecules.

The material world is shaped by many diverse products – all containing various components – virtually chemical cocktails. However, these "cocktails" have the potential to critically harm our environment and humans because chemicals are being distributed extensively in the environment through the increasing recirculation of water, the growing demand for agricultural land or the worldwide growth in prosperity and demand for natural resources. The hazards of chemical substances to humans and the environment has been an on-going topic for decades. Time and time again, individual substances become the focus of public debates or make the headlines. The current approach that is used to assess the hazard potential of chemicals is based on individual substances. However, we need to bear in mind that in reality we are faced with complex mixtures whose composition changes in time and space.

Questions

Given these challenges, what should an integrated assessment approach look like? How can we succeed in developing a better understanding of the processes controlling retention levels, chemical transformation or biodegradation and the effects of chemicals under real environmental



According to the Water Framework Directive, all rivers, lakes, estuaries, coastal waters and groundwater need to achieve a "good ecological potential" by 2027. Europe is still very far from achieving this objective. Therefore the monitoring, assessment and management of pollutants (and the regulation itself) need to be improved.

conditions? How can the (bio) transformation of pollutants be measured in the environment? Which role do ecosystem services play? Can model systems be developed that enable the effects of chemicals to be accurately assessed for different organisms? How can the effect of chemical mixtures and their impacts be predicted? Will there be substances in the future with a "built-in expiry date"?

Goals and products

Scientists of the thematic area "chemicals in the environment" are pursuing three goals to achieve the goal that chemicals will no longer pose a danger to humans or the environment. First of all they are trying to understand the transformation of chemicals in the environment as a characteristic of the system. Secondly, they want to undertake integrated assessments of the impacts of chemicals on humans and the environment. Thirdly, the biological effect in particular – not the chemical concentration – is to be understood as a measure. With these goals in mind, researchers are systematically analysing and projecting the degradation and retention rates of chemicals (the dynamics of matter) and the impacts of chemicals on biological and ecological systems. They are qualitatively and quantitatively recording the ecosystem service "chemical degradation" and want to predict, assess and manage it to the landscape level. They are analysing the overall impact on human health and the environment and developing concepts to assess these impacts. Lastly, they are using concrete case studies to identify key molecular and ecosystem processes that affect the impacts and degradation of chemicals, leading to technical, social and regulatory solutions for an improved chemical management. With this novel approach to assessing chemicals, the researchers in this thematic area want to promote precautionary principles and preventative measures in order to avoid the need for remediation later on.

We want to promote the development of green chemistry.

With new observation methods, measuring techniques and models at hand, scientists strive to enable forecasts and an early identification of critical contamination and harmful effects on humans and ecosystems. This knowledge will enable new approaches for risk assessment to be developed. They are developing procedures whereby the drivers of chemical risks can be identified in complex chemical mixtures or in scenarios with a multitude of other stress factors. They are making fine adjustments, to make sure that the

degradation of chemicals in technical or natural ecosystems to the landscape level can be purposefully controlled or an unwanted discharge of chemicals avoided. Furthermore, they define the criteria, by which the carrying capacities of ecosystems can be assessed and the development of "green chemistry" can be promoted.

Methods and infrastructure

The expertise and the portfolio of tools range from chemical analysis and bioanalytical methods to isotope-based methods and research on the degradation of chemicals, as well as technical solutions for pollutant retention or degradation and human-toxicology model systems to observation, experimentation and modelling systems that are internationally competitive.

Big data sets and information about cells, genes, proteins and metabolites are to be managed and made available.

For example, the high-tech laboratory ProVis allows us to observe chemical and biological processes on the cellular level. Furthermore, the CITEpro analytical and bioanalytical platform enables a high-throughput screening of chemicals and environmental samples. MetaPro – a central bioinformatics and omics platform – will make it possible to qualitatively and quantitatively manage the big data sets and information about cells, genes, proteins and metabolites and make this information accessible. Molecular biology tools are applied to shed some light on endogenous changes in response to chemical contamination and help interpret data from epidemiological studies, cohorts of patients and field surveys.

Networks and knowledge transfer

To implement this new approach to chemical assessments and treatments, ecotoxicologists and health researchers have joined forces with environmental chemists, environmental microbiologists and technologists. Research co-operation takes place with European, international and national partners in the form of research alliances, collaborative projects and scientific communities. The European project SOLUTIONS, for example, wants to provide solutions for present and future emerging pollutants in water resources in a close dialogue with stakeholders. On the regional level for example a strategic co-operation has been set up with the University of Leipzig to establish one of the largest child cohort studies in Germany (and in Europe for that matter) – the LIFE child study, which focuses on the exposure of children to environmental factors.

The CITEpro bioanalytics and MetaPro analytics platforms enable a high-throughput screening of chemicals and environmental samples.

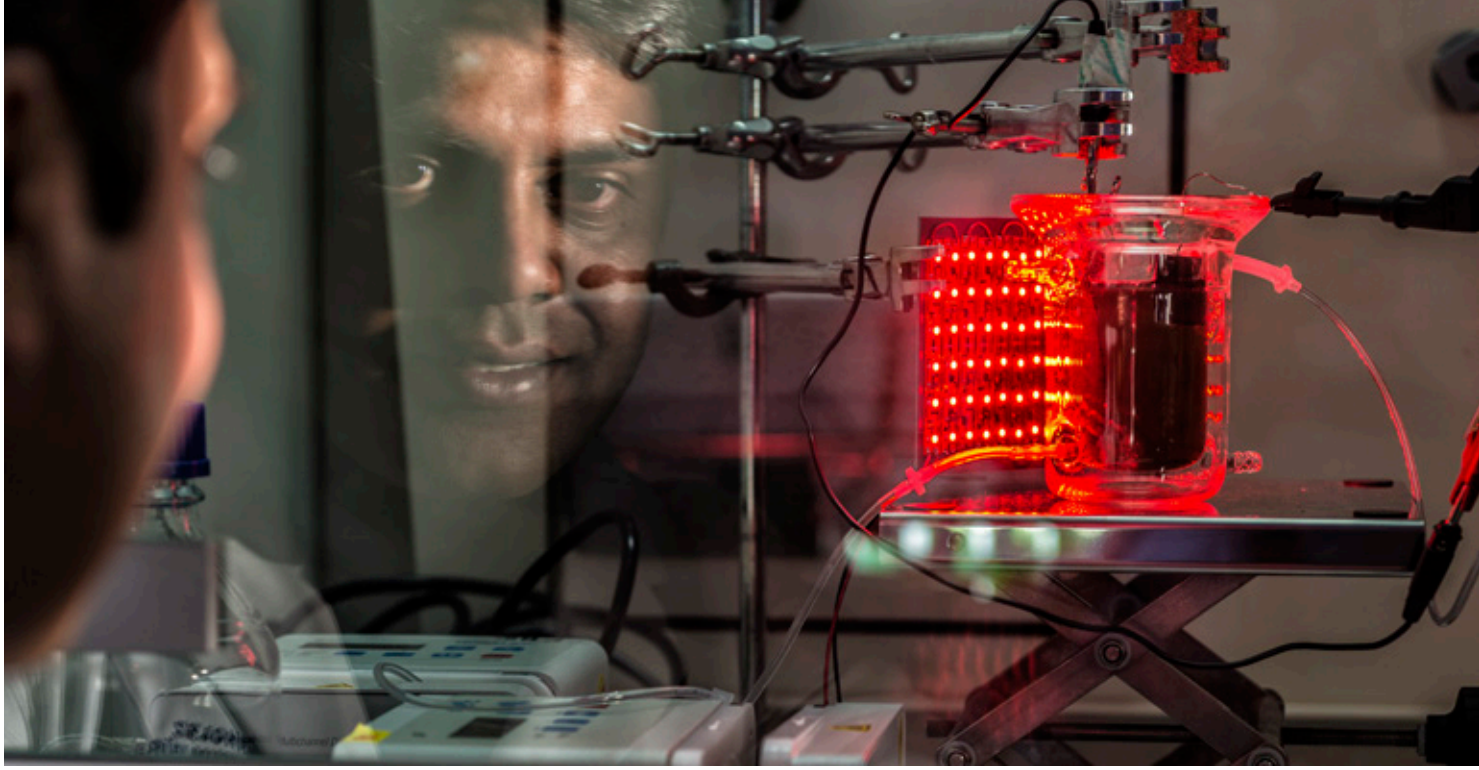
A close information exchange with national and international committees, authorities and institutions that are responsible for assessing chemicals, is a prerequisite for transferring knowledge and results into practice. The broad spectrum of professional knowledge in system-, cell and ecotoxicology, epigenetics and molecular systems biology as well as unique analytical and bioanalytical facilities make the UFZ a sought-after partner and expert for the scientific community, the authorities and the chemical industry. The German Environment Agency (UBA), the Federal Institute for Risk Assessment (BfR), the Institute for Environment and Sustainability (IES) of the European Commission's Joint Research Centre (JRC), the European Food Safety Authority (EFSA) and the Environmental Protection Agency EPA in the USA are all important strategic partners in the field of environmental research on chemicals.

Thematic Area
»Chemicals in the Environment«
Safety for humans and the environment under complex and fluctuating chemical stress

Head of Thematic Area
Prof. Dr. Werner Brack

ENVIRONMENTAL ENGINEERING AND BIOTECHNOLOGY

MAKING USE OF NATURE'S POTENTIAL.



Hydrogen could play a major role in replacing fossil fuels. In order to obtain hydrogen, UFZ scientists believe in cyanobacteria as future hydrogen producers.

Vision

Nature is an inexhaustible source of concepts and raw materials for producing and transforming chemicals and energy.

With this vision in mind we need to recognise and understand the biochemical potential and the ecological principles that are hidden in nature and make use of them to satisfy human needs with the help of innovative environmental- and bio-technologies.

Challenges

Whether it is impacts from climate change, the increasing demand for resources or the material flows that pollute the environment – it is not only an energy transition that is necessary, but a complete change to a product-oriented and integrative environmental protection. Material cycles must be closed to ensure resource- and energy efficiency in production processes. Substances that cause harm to the environment must be replaced by ecologically compatible ones. The use of fossil- and inorganic resources must be reduced. Pollutants should not be released into the environment – and where this cannot be avoided, their fate must be controllable.

> The use of fossil- and inorganic resources must be reduced.

New procedures in environmental- and bio-technology will play a key role in the search for solutions. Already back in 2012 the global market volume for environmental technologies and efficiency technologies was approximately two trillion Euros. According to estimates by the German Federal Ministry of the Environment this figure will more than double by 2022.

Questions

How can nature's renewable resources be transformed into sources of energy or chemicals? Which characteristics do microorganisms possess for converting substances into energy or chemicals? How can we find out what different microorganisms are capable of? How does one succeed in converting promising laboratory results into industrial standards? Are new environmental technologies and efficiency technologies really ecologically compatible and efficient? How can unwanted by-products and side effects be minimised? Can we increase nature's capacity in the purification process or optimise it in production plants?

Goals and products

Scientists working in the thematic area "Environmental Engineering and Biotechnology" work on procedures and technologies that can be used for a decentralised production of platform chemicals and energy sources from renewable raw materials as well as for removing the risk element from pollutants in natural and technical ecosystems. They therefore pursue the goal of closing material cycles and preventing or treating unwanted by-products. They value the microbiological and biochemical attributes of nature and promote so-called "nature-based solutions". They use renewable sources of carbon, non-food biomass, carbon dioxide,

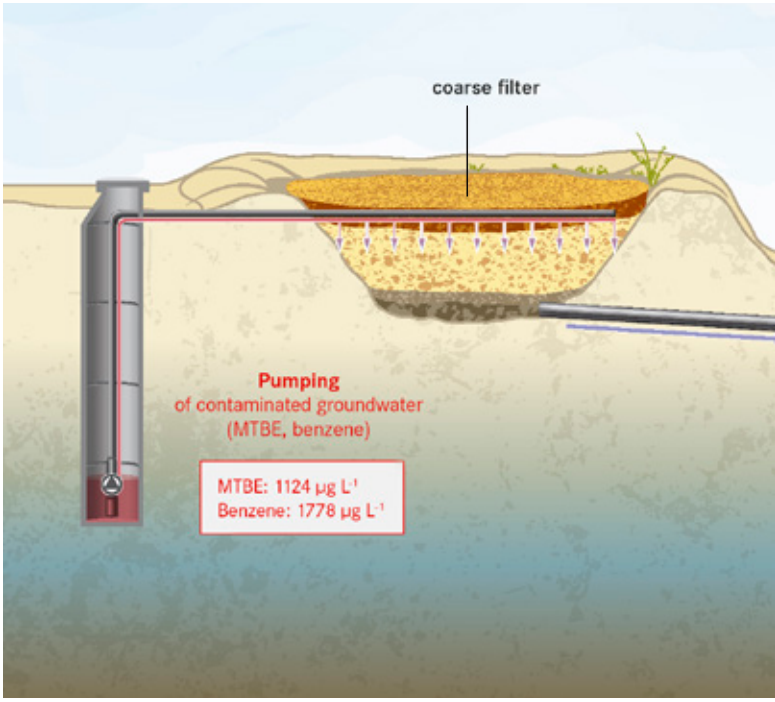
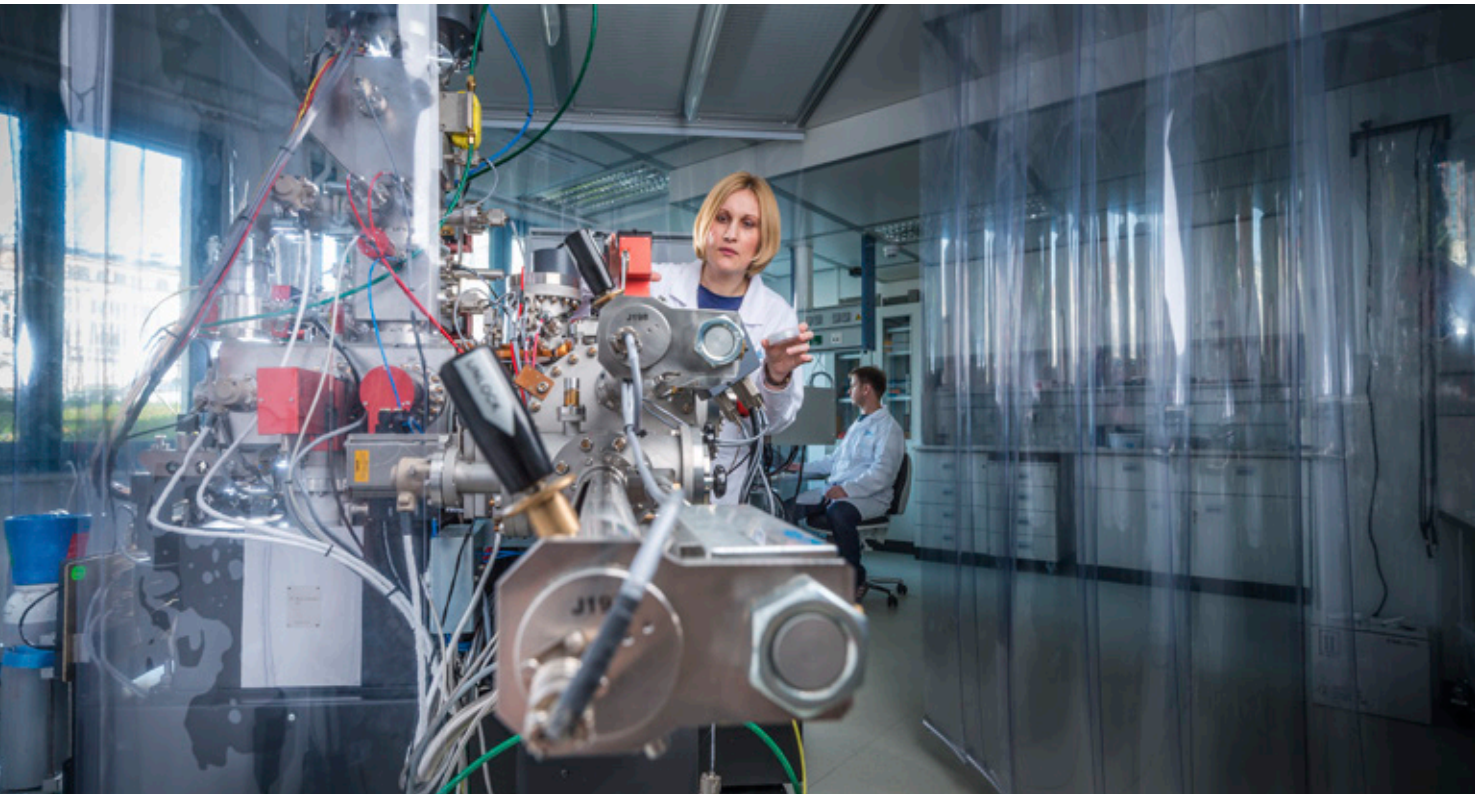


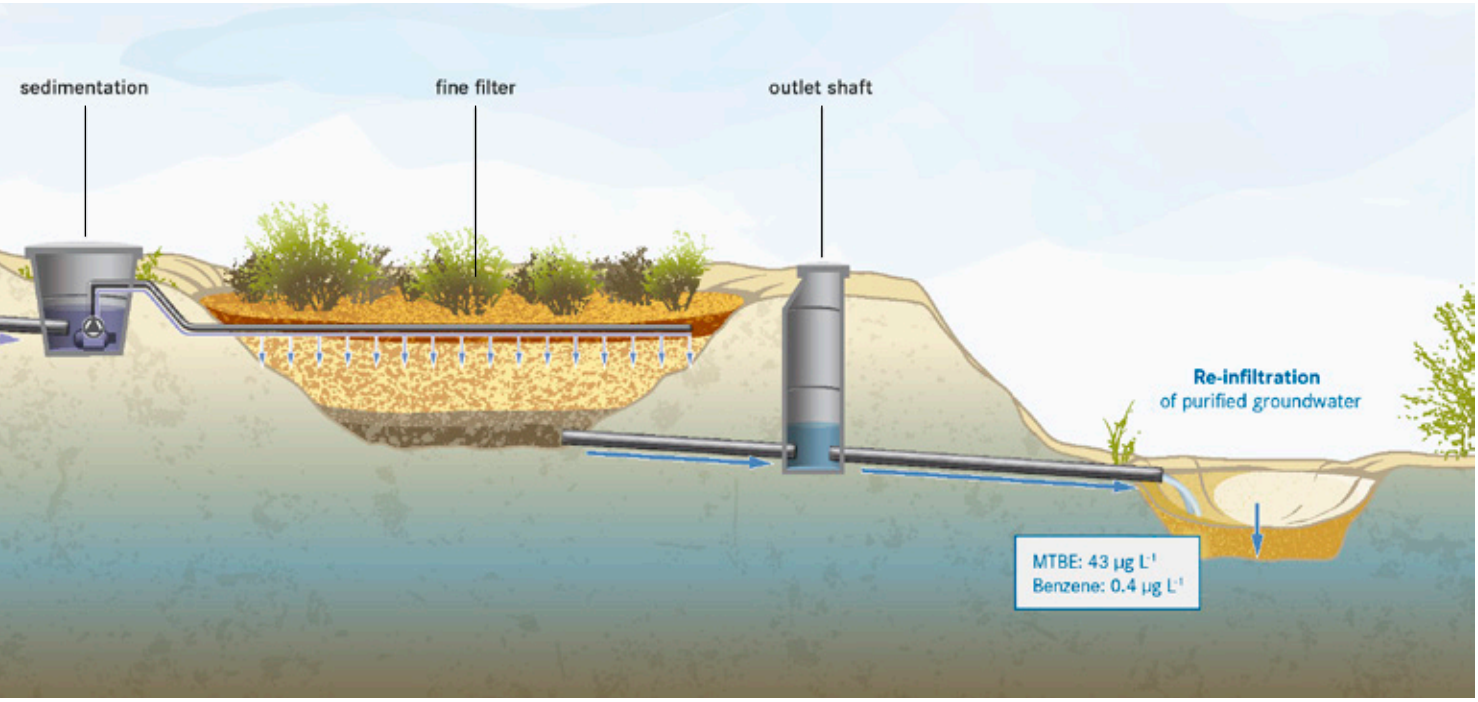
Diagram showing a vertical filter system for the treatment of groundwater. The Ecotech-procedure that is implemented in commercial-scale plants and was discovered and researched by UFZ scientists, treats 500,000 litres of contaminated groundwater every day and is based on bacteria, which can get rid of benzene and other pollutants in the water through biodegradation.

hydrogen, solar radiation and electrical energy and skilfully link synthesis processes with utilisation concepts for waste, energy and (waste-) water. It is thereby imperative to acquire detailed knowledge about which microbial processes are behind which substance conversions and how beyond the realms of biology, chemical and physical methods can be implemented. To make biotechnological production procedures and processes suitable for industry, ways need to be discovered that make them more efficient and more flexible.

With the Centre for Biocatalysis in Central Germany (MIKAT), a strategic network is coming together for bioprocess engineering, photo-bio reactor development and tapping into alternative raw materials.

In the context of projects and case studies, scientists are developing unique solutions, for example an integrated technological concept based on (bio-)artificial photosynthesis for the production of hydrogen to be applied as a decentralised, self-containing energy production facility. Other energy sources such as biogas or electricity as well as platform chemicals should be produced on the basis of micro-biological and electrical biocatalytic processes. To help with the degradation of pollutants in technical and natural systems, researchers are focusing mainly on natural microbiological or plant-based procedures, which (if necessary) can be supported by physical-chemical processes. Furthermore, for the extraction of mineral resources and the recovery of valuable substances such as metals, rare earths or organic acids from waste streams or unused mineral sources, it is biotechnological concepts that show the most favourable eco-balance for research and industry. However, to find





out just how ecological, marketable and valuable these procedures and concepts are in reality, they still need to be analysed and addressed.

Methods and infrastructure

For this integrated research approach, which extends from process understanding to technology transfer and also covers socio-economic aspects as well as issues regarding environmental law, extensive expertise is available at the UFZ in all thematic fields in addition to state-of-the art infrastructure: a pilot plant for environmental technology and biotechnology for scaling up from the laboratory level to the technical scale, omics platforms for molecular analyses, the hightech laboratory ProVIS for the visualisation of micro-biological biochemical processes on the cellular level, high-performance computers for the modelling and visualisation of complex environmental processes, system-biological analysis methods as well as research and demonstration locations for decentralised waste water treatment in Germany and abroad.

Networks and knowledge transfer

The thematic area “Environmental Engineering and Biotechnology” takes on a central role in the science that is interested in sustainable technologies, for instance through international conferences and workshops. It promotes networks with partners from industry as well as with SME’s. With the establishment of the Centre for Biocatalysis in Central Germany (MIKAT) that was initiated by the UFZ, an important strategic network is coming together for bioprocess engineering, photo-bio reactor development and tapping into alternative raw materials. Beyond that, close partnerships also exist with the Society for Chemical Engineering and Biotechnology (DECHEMA), with the German Environment Agency (UBA), with the German Biomass Research Center (DBFZ), as well as with experts on the European level.

An early involvement of partners from industry in research and demonstration projects and the continuous feedback with associations and authorities not only ensures a transfer of knowledge and the observance of regulatory frameworks and regulations, but also increases the chances that concepts and procedures will be implemented in industry and practice. In this way, for instance in Jordan – one of the most water-scarce regions in the world, it was possible to establish an integrated water management system that was based on trust and co-operation over several decades with partners from science, economics and politics. Biotechnological procedures for wastewater treatment can be found at the heart of this system, making their contribution indispensible for the conservation of ground water.

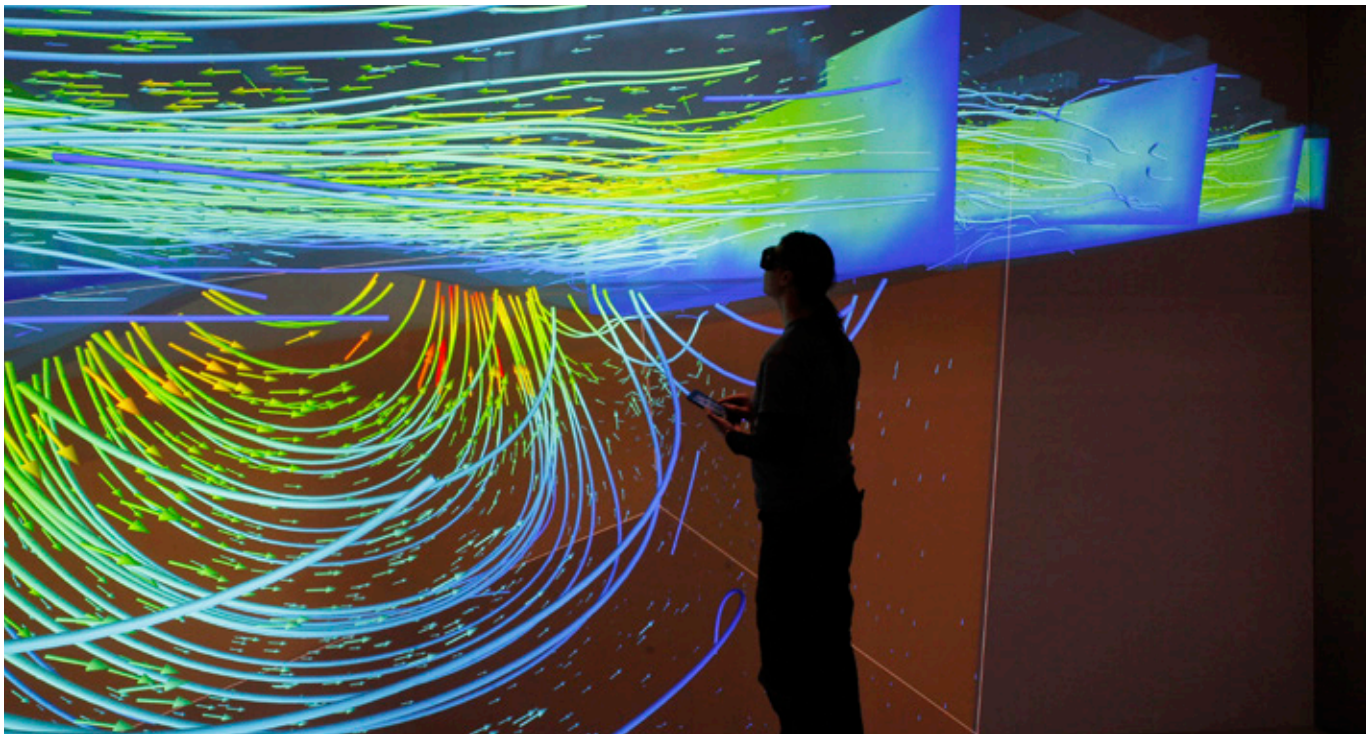
Thematic Area »Environmental Engineering and Biotechnology«
Sustainable use of resources and material flows through ecosystem services

Head of Thematic Area
Prof. Dr. Hauke Harms

With a unique compilation of modern equipment in the UFZ-hightech laboratory ProVIS, individual cells, interactions between cells and microbial communities can be studied in detail so that they can be used in applications of biotechnology.

SMART MODELS AND MONITORING

MONITORING CHANGES AND RELIABLY PROJECTING THEM.



3D-visualisations help, in spite of heterogeneous data to maintain a holistic system understanding and a better insight into the complex behaviour of environmental systems on different temporal and spatial scales.

Vision

Smart models and monitoring allow complex environmental systems to be analysed and reliable predictions to be made about how environmental systems will react to anthropogenic disturbance.

To this end we have to succeed in reducing models to the absolute minimum required level of complexity and in optimally parameterising them. This is a tremendous challenge in light of the complexity of environmental systems, the countless human-nature interactions, the extent, range or limitations of data, the different temporal and spatial scales and the human factor.

Challenges

Environmental systems are extremely dynamic, shifting from chaotic and unstructured complex states to diverse but structured complex states and vice-versa. Their characteristics and driving forces are not only heterogeneous, but also move on different temporal and spatial scales. If one then considers the multiplicity of interacting change processes on different scales that can lead to nonlinear and delayed reactions in environmental systems, it becomes clear just how difficult it is to explore and observe environmental systems in a measurable way or to describe and analyse them using models.

Even if we succeed in developing predictive regional models for water-, energy- and material flows, biodiversity or ecosystem functions, then these results are largely afflicted with factors of uncertainty and it is imperative that such uncertainties are quantified and communicated. Furthermore, we are becoming more and more conscious of just how important it is to include the unpredictable human factor in models.

Uncertainties in predictions need to be quantified and communicated.

Questions

What is the right amount of simplicity or reduced complexity for environmental system models that will still provide us with reliable predictions? How does one reduce complexity? How can environmental systems such as the geological underground, soils, entire forest systems or river catchments be explored and observed over longer periods of time? How can gaps in the data be filled? Is the answer only through monitoring? Or can existing data also be extrapolated?

Is there any quality control for big data sets? How (in) accurate are forecasts? Can the human factor really be portrayed in models?

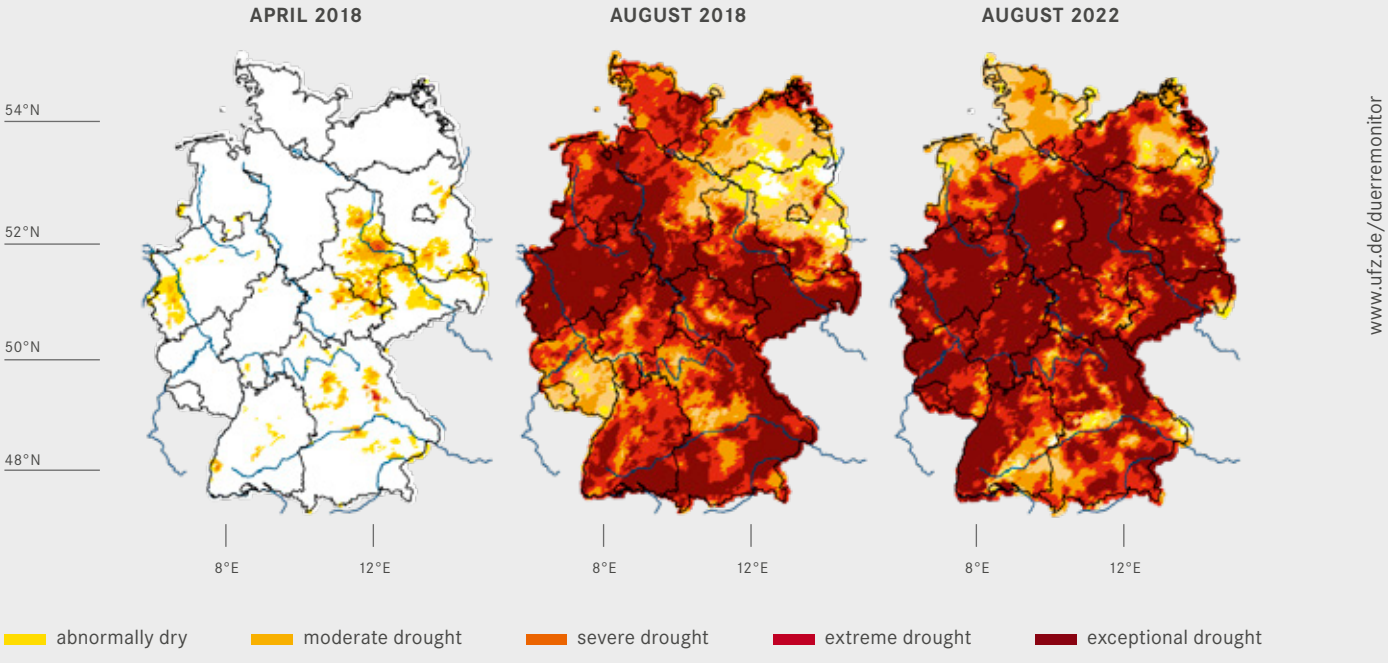
Goals and products

So far the scientific community has taken two different paths. Scientists in this field either tend to develop multi-processing, complex models with an ultra-high resolution both temporally and spatially that are extremely complex and simulate an obviously exaggerated prognostic reliability. Alternatively, they use over-simplified conceptual models, which have been adapted to specific regions, ecosystems or species communities and cannot therefore easily be transferred to other environmental systems or regions. Scientists in the thematic area “Smart Models and Monitoring” on the other hand have adopted a completely new approach. They have developed a hydrological modelling system based on the knowledge that large-scale phenomena such as the regional flow of a catchment area does not necessarily depend on all of the small-scale characteristics of this catchment area.

> Investigation-, monitoring- and measuring campaigns must be driven by the model approach and the question we wish to answer.

Hence, it follows that a model can be made much simpler without losing its predictive power. This characteristic is referred to as the self-averaging property. The model has an optimal degree of complexity, is practical and can be transferred to other regions. These kinds of models are called “smart models”. If the UFZ intends to keep following the smart model path, then data sets that are already available from various sources need to be prepared in such a way and undergo quality control to ensure that they are suitable to answer the respective question. The same applies, if data are missing: investigation-, monitoring- and measuring campaigns must be driven by the model approach and the question that we wish to answer (goal orientation). In order to be able to uniformly and mathematically describe biotic and abiotic environmental systems, gaps need to be closed in the formulation of theories and scaling methods that work in theoretical hydrology must be fine-tuned for more complex environmental systems.

The UFZ develops smart models for three major areas: for terrestrial hydrology, for terrestrial and aquatic ecology and for geo-systems. Regional catchment models are being developed for hydrology, which help to conduct monitoring and measuring campaigns in a more goal-oriented manner or to optimise the management of water resources with better projections. Thereby scientists want to make the leap from complexity-reduced hydrological models to complexity-reduced ecosystem and matter flux models on regional scales. In ecology the goal is to develop a common theoretical fundament for describing environmental systems by sufficiently incorporating biotic and abiotic factors, processes and feedbacks.



The 50 meter-high measuring tower in the Forest-Climate Observatory in Hohen Holz in Saxony-Anhalt is part of the TERENO observatory. Here scientists record numerous variables: climate data, greenhouse gases, data on vegetation, soils and the water budget.

With this fundament – the core of a new generation of more regional, more integrated, "smarter" environmental system models, it should be possible to mathematically describe and project ecosystem processes on the landscape level and at the same time reliably project them for the future. In the field of geo-technical systems THMC-modelling is implemented using strongly interlinked processes (thermal, hydraulic, mechanical and chemical) in order to analyse multi-physical processes in complex natural and technical energy systems.

Methods and infrastructure

At the heart of the environmental monitoring and valuable data suppliers is the hydrological and ecological observatory TERENO (Terrestrial Environmental Observatories). This Helmholtz observation platform is to be extended with a modular architecture in the future from the observatory MOSES (Modular Observation Solutions for Earth Systems). It is to be rapidly and flexibly implemented on a European-wide scale to record extreme events or in regions known for their trends in increasingly longer dry periods. The research infrastructure ACROSS (Advanced Remote Sensing) provides the necessary remote-sensing data on changes to the Earth's water and biomass regimes. The visualisation centre VISLab has established itself as part of the UFZs infrastructure that is specialised in environmental data, enabling processes in technical energy systems, soil particles, aquifers or entire river catchments to be visualised in 3D. In order to meet the higher arithmetic performance requirements of the models, a common computer concept is being developed for earth system modelling with partners such as the German Climate Computing Center (DKRZ) and the Research Centre Juelich.

Networks and knowledge transfer

As a cross sectional field, the UFZ's thematic area "Smart Models and Monitoring" is linked to all thematic areas, in particular "Water Resources and the Environment" and "Ecosystems of the Future" and within the Helmholtz Community itself in particular with the centres of the research field "Earth and Environment", and under it the German Aerospace Centre (DLR) in the field of remote sensing and the Climate Service Centre Germany (GERICS) at the Helmholtz Centre Geesthacht for climate modelling. Important strategic partnerships also exist with specialist authorities such as the German weather service or the National Center for Atmospheric Research NCAR in the United States.

Whether it is remote sensing, big datasets, data quality and data availability or the evaluation of modelling and monitoring concepts, it is only through the exchange of knowledge and expertise on the scientific level and from feedback with users that will allow us to come up with future scenarios as well as early-warning and planning systems as reliable decision-making tools.

Thematic Area
»Smart Models and Monitoring«
Environmental system models:
Data exploration and predictions

Head of Thematic Area
Prof. Dr. Sabine Attinger

The drought monitor that was developed at the UFZ provides daily soil moisture data for Germany and in perspective for Europe. This information is crucial for agriculture, forestry, river traffic, tourism and flood protection.

ENVIRONMENT AND SOCIETY

UNDERSTANDING ENVIRONMENTAL BEHAVIOR.

Germany wants an energy transition: To a decentralized energy system based on renewables as a contribution to the security of supplies and climate protection – an ambitious goal with potential and opportunities that also involve risks, because an energy transition also means land-use change.

Vision

To achieve a sustainable use of natural resources for the well-being of humans and the environment, societal change processes are needed.

We need to understand how stakeholders from the political arena, the economy and society will react to certain environmental issues, which basic conditions and interests propel them to act in the way that they do, how they make decisions and under which circumstances they are prepared to compromise.

Challenges

Demands on nature and society's insatiable appetite for food, energy, land, (raw) materials and products of various kinds continue to grow and lack sufficient coordination, fundamentally changing landscapes and ecosystems. Harmful substances penetrate into the environment. Human health and well-being are compromised just as much as the integrity of nature – to an increasing degree and globally.

> The necessary transformation processes in the economy and to our ways of life will not be possible without resistance or conflicts.

At the same time, democratically legitimate social participation that respects the right of freedom is being given much greater consideration these days in decision-making processes. With the globalisation of the economy and increasing cross-border environmental issues, individual countries now have much less influence on relationships between people and their environment. It is evident that the fundamental and necessary transformation processes in the economy and to our ways of life that lie ahead of us will not be possible without resistance and conflicts.

Questions

How can this societal transformation be designed and fostered? If traditional national policy instruments do not work for environmental issues, which ones will work: requirements, prohibitions, planning? Does the protection of water and ecosystem services require higher prices? Which services do we expect from ecosystems and what would we be prepared to pay for them? How can conflicts be resolved if different stakeholders have different needs and requirements for the utilisation of water and energy resources, land or protected assets? How should aesthetic, cultural, political or religious aspects be dealt with?

How control and planning instruments or everyday practices can tackle extreme events such as floods and droughts and how vulnerability can be reduced, is the subject matter of social scientists at the UFZ.

Goals and products

Scientists of the thematic area “Environment and Society” have the goal of developing concepts and recommendations on courses of action for a sustainable use of environmental resources. To this end, they are investigating which factors affect human behaviour towards the environment – perceptions, attitudes, values, basic economic conditions or social-ecological processes.

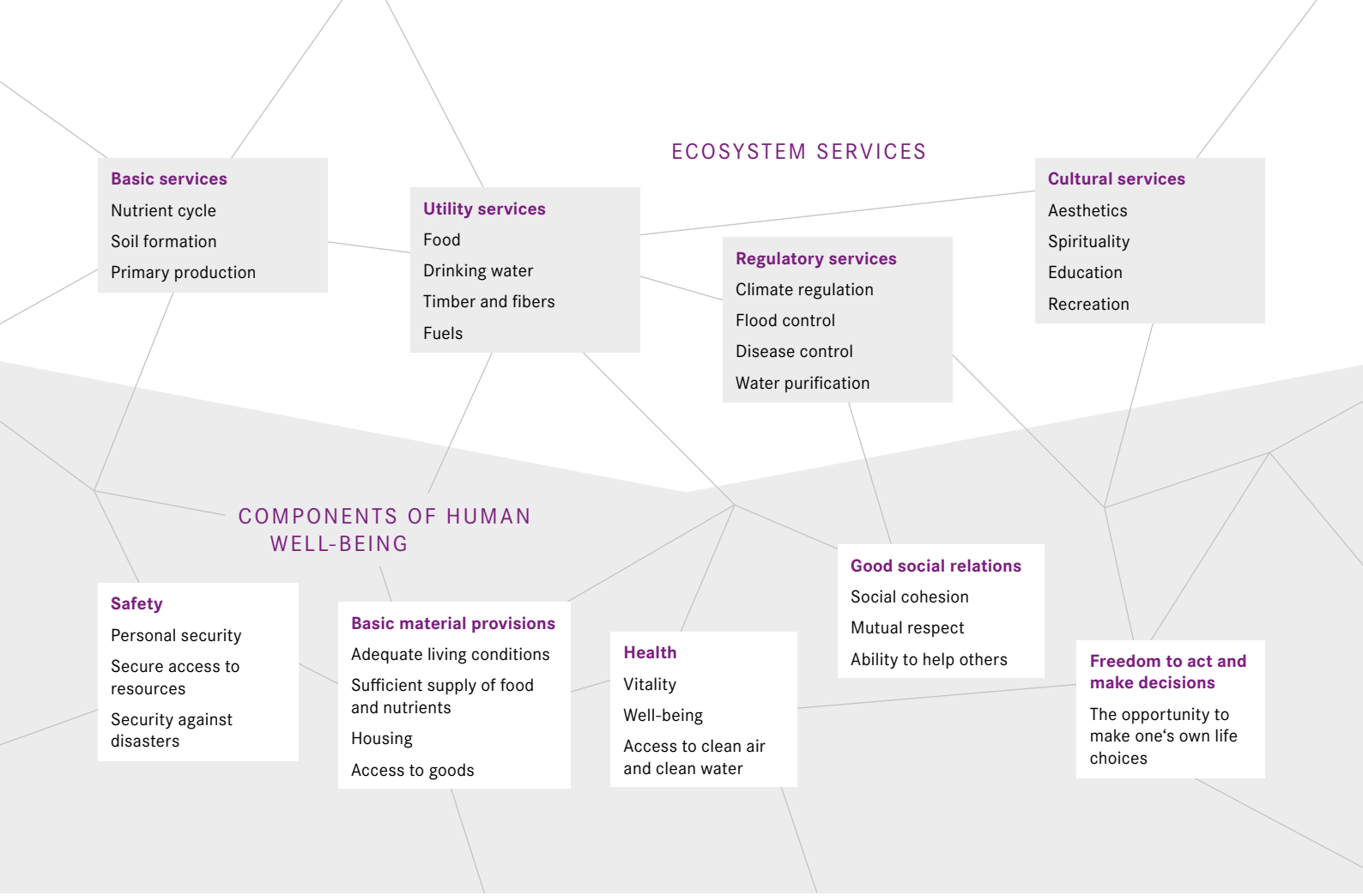
> If the international conventions or the sustainability goals of the UN are to be implemented, governance structures and environmental behaviour must be analysed.

They are analysing institutional parameters to establish which constellations of stakeholders, social and legal standards, incentives, restrictions and components of the socio-economic-technical system are most suitable to achieve individual environmental goals and how these can be put together consistently into a comprehensive transformation of our ways of life and economic trends. If the international conventions or the Sustainable Development Goals of the United Nations against famine and climate change are to be implemented for a sustainable urban development, biodiversity or the access to clean drinking water, then governance structures and environmental behaviour need to be analysed. The German energy transition or sustainable urban development concepts are the perfect examples for looking into the conditions and obstacles behind such large transformation processes.

Methods and infrastructure

To save biodiversity and ecosystem functions in spite of increasing demands and competition, scientists are trying to determine for example, which societal goals are linked to ecosystem services. Apart from the type and condition of ecosystems, this also includes value perceptions, individual or collective actions and knowledge, legal and socio-economic requirements as well as the resilience of ecological, technical and social systems.

For an integrated management of water resources – both quantitatively and qualitatively – new management approaches and economic incentives are required, in addition to institutional frameworks such as the cross-border protection of water bodies or the protection from extreme events such as floods or droughts.



We have an ethical obligation to preserve nature. The study "Natural Capital in Germany - TEEB DE" demonstrates how the protection and the sustainable use of nature and biodiversity are worthwhile – also from an economics perspective.

The sustainable provision and use of biomass presupposes a comprehensive systems analysis of renewable resources, which is to be carried out by engineers and scientists working alongside sociologists. While engineers analyse energy systems, lawyers are involved to sort out issues on regulations. Economists are interested in the economic context and the design of economic incentives, political scientists are concerned with governance structures and sociologists with acceptance issues. In addition, policy advice, scenario development and modelling and scenario building belong to a comprehensive assessment of integrated energy systems.

Life-styles, consumer behaviour and management practices are often directly or indirectly associated with the use of chemicals and chemical loads. Examples are the increasing use of pesticides in agriculture or nano-particles in clothes and cosmetics. Social scientists analyse how these risks are perceived, which knowledge is available and whether or not having knowledge (e.g. decision-making under ignorance) influences individual and societal behaviour as well as what the legal control options are.

One of the greatest challenges will be to illustrate the interaction between humans and the environment in agent-based modelling and explorative modelling of environmental systems.

Networks and knowledge transfer

As a cross sectional topic the UFZ's thematic area "Environment and Society" is linked to all thematic areas – through concrete projects such as "The Economics of Ecosystems and Biodiversity – TEEB" or studies and surveys about the prices for the utilisation of water, the renewable energies law, fiscal policies for pesticides, "nature-based solutions" or technical, natural, individual and national flood protection measures. With its long-term expertise in integrative social-environmental research the UFZ is one of the most important contacts and discussion partners within the Helmholtz Community, as well as for national and international research institutes and decision-makers in the government, for the states and the European Union.

Thematic Area
»Environment and Society«
Shaping transformations: Sustainable environmental behaviour in the 21st century

Head of Thematic Area
Prof. Dr. Bernd Hansjürgens

ADMINISTRATION

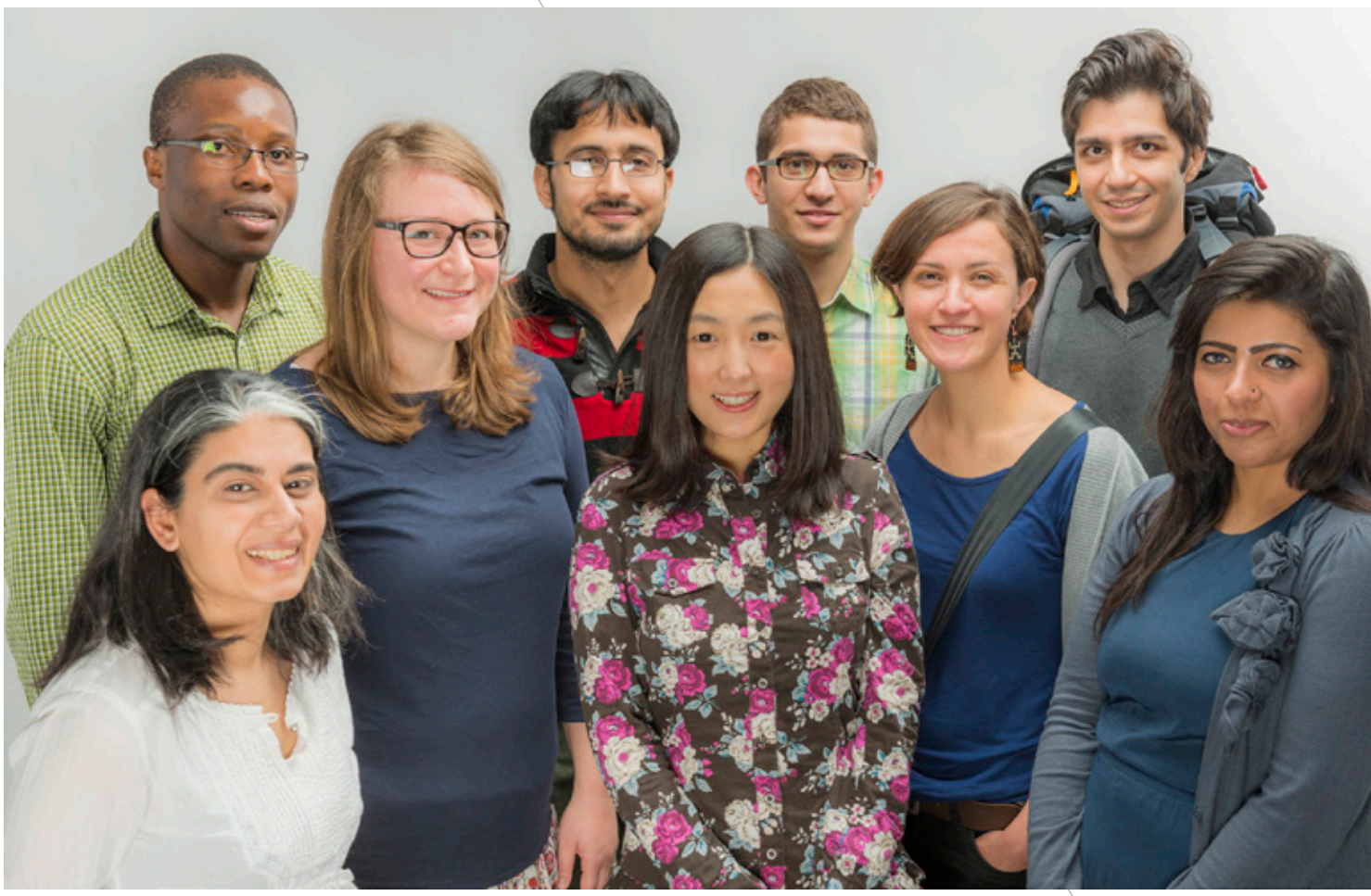
SUPPORTING RESEARCH.

Excellent science needs excellent administrative support that enables scientists to concentrate on their core activity – their research. A modern process- and service-oriented administration at the UFZ ensures that operations run smoothly, whether these are in the planning, implementation or the management of different scientific infrastructures, the appointment, recruiting and strengthening of bonds of highly motivated employees from Germany and abroad, the promotion of junior scientists, the development of programmes for personnel and managers, assistance with internationalisation or with technology and knowledge transfer to politics, the economy or society and the procurement of third-party funding.

SUPPORT FOR YOUNG RESEARCHERS

PROMOTING TALENTS.

Whether it is vocational training, internships for school pupils or students, the supervision of Masters theses, PhD training or experience for Post-Docs, there is breadth and individuality in the academic support for young researchers at the UFZ. The UFZ teaching lab gives secondary school pupils the opportunity to gain insights into the modern world of environmental research and to conduct some experiments themselves, whereas the “Helmholtz Interdisciplinary Graduate School for Environmental Research HIGRADE” qualifies new generations of internationally competitive doctoral researchers in environmental sciences. HIGRADE not only prepares them to carry out excellent integrative environmental research, but also for managerial positions in research, management and politics, for the development of technologies or in consultation and training. Under the direction of the Helmholtz-University junior research groups, young and talented junior researchers receive the opportunity to train their scientific independence and responsibility. The numerous joint chairs held by UFZ scientists at universities throughout Germany and abroad ensure that close networks and joint research projects are created. They also guarantee that junior scientists receive expert training and discover new talent.



CULTURE AND SUSTAINABILITY

RESPECTING VALUES.

At the UFZ, we are committed to diversity, open-mindedness, tolerance, and democracy. A peaceful social development, but also successful environmental and climate research relies on diversity of perspectives and freedom to think. Therefore we are committed to a democratic society in which all people treat each other with respect and without fear. The UFZ boasts a culture of respect, equal opportunities, a work-family balance and the sustainable use of resources that is reflected in its day-to-day operations.

An internal environmental management system, occupational health management, the International Office, the family office, intercultural training, welcome days und the Dual Career Network of Central Germany initiated by the UFZ are all evidence of how the UFZ provides excellent services in this respect. The UFZ has held the „berufundfamilie“ (work and family) audit since 2014 and was awarded the Total-E-Quality rating for the first time for the years 2022 to 2024. In 2022, the UFZ signed the Diversity Charter.

Sustainability - responsible and future-oriented action so that future generations also have good opportunities in life - is one of our guiding principles. Sustainability is therefore not only a core task of research, it is also the living culture of all employees at the UFZ. The UFZ has been certified under the EU‘s Eco-Management and Audit Scheme (EMAS) since 2005. Through EMAS, the UFZ assumes responsibility for reducing its own direct and indirect impacts on the environment.

BEING PART OF HELMHOLTZ.

The mission of the Helmholtz Association

We contribute to solving the major challenges facing society, science and the economy by conducting top-level research in strategic programmes within six fields: Energy, Earth & Environment, Health, Aeronautics, Space and Transport, Matter, and Information.

We research highly complex systems using our large-scale devices and infrastructure, cooperating closely with national and international partners.

We contribute to shaping our future by combining research and technology development with perspectives for innovative application and provisions in tomorrow's world.

We attract and promote the best young talents, offering a unique research environment and general support throughout all career stages.

Hermann Ludwig Ferdinand von Helmholtz
(1821-1894)

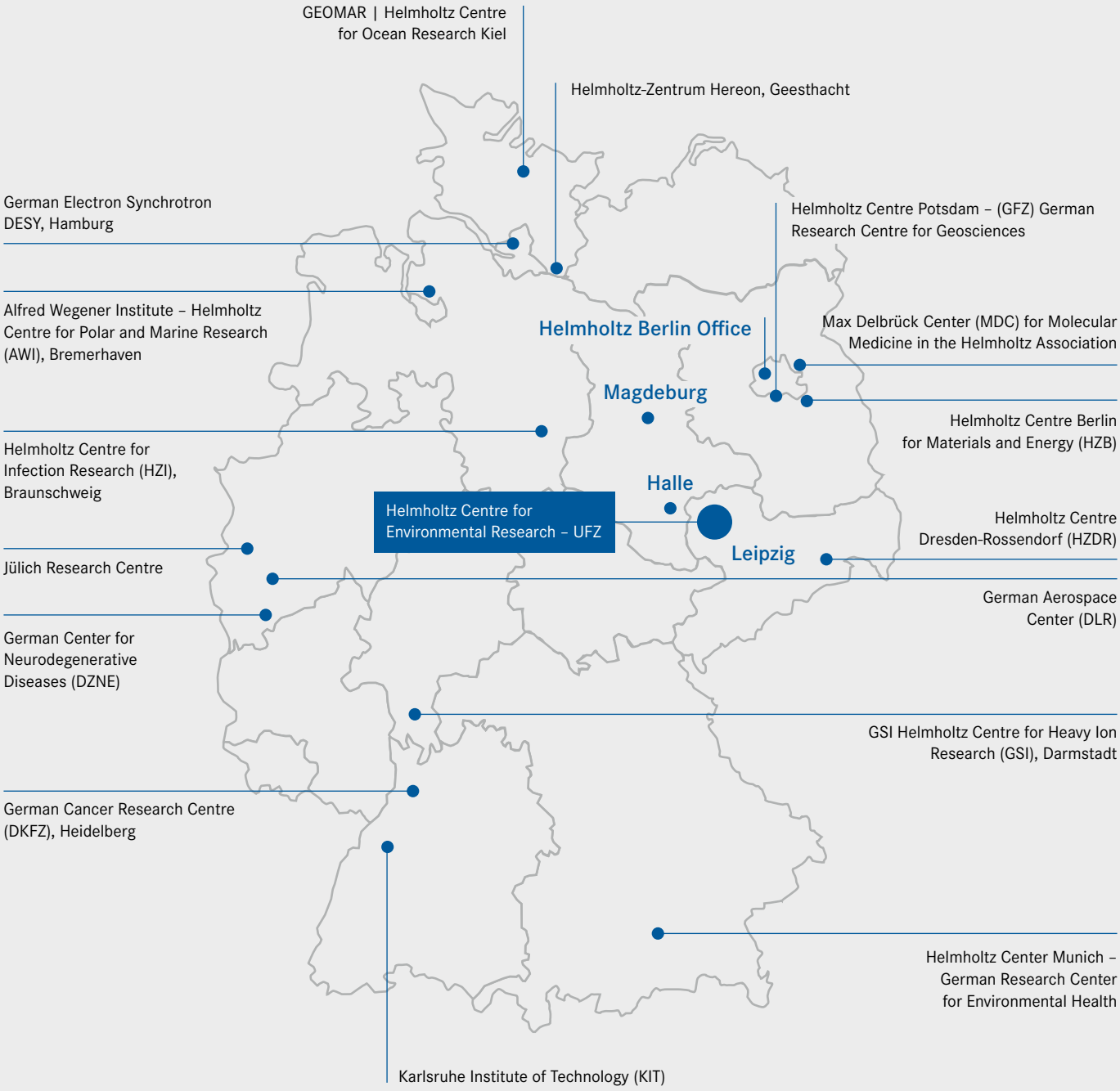
Behind the name

There are good reasons why the Helmholtz Association bears the name of Hermann von Helmholtz, one of the greatest natural scientists of the 19th century. Hermann von Helmholtz stands for the whole diversity of scientific research with an orientation towards technological practice. He was one of the last true universal scholars. Helmholtz reflected a natural science which spanned the fields of medicine, physics and chemistry. His ground-breaking research work and developments combined theory, experiment and practical application. Helmholtz founded the Physikalisch-Technische Reichsanstalt (PTR) and served as its first president. The PTR was the world's first scientific research centre outside the university sector and so counts as a predecessor to the Helmholtz Association.

www.helmholtz.de

The Helmholtz Centres

18 scientific-technical and biological-medical research centres have united themselves to form the Helmholtz Association. With about 44,000 employees and an annual budget of € 5,8 billion, the Helmholtz Association is Germany's largest scientific organisation.



HELMHOLTZ
Centre for Environmental Research

FACTS AND FIGURES

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Magdeburg / 39114 / Brückstraße 3a / Germany

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(Core funding, third-party funds
and research contracts)

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5 % The Free State of Saxony
5 % The State of Saxony-Anhalt

www.ufz.de

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For reasons of sustainability, only a small new edition of the UFZ Strategy 2025+ brochure was printed. It is available online as an e-paper and for download: www.ufz.de/imagebroschuere

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