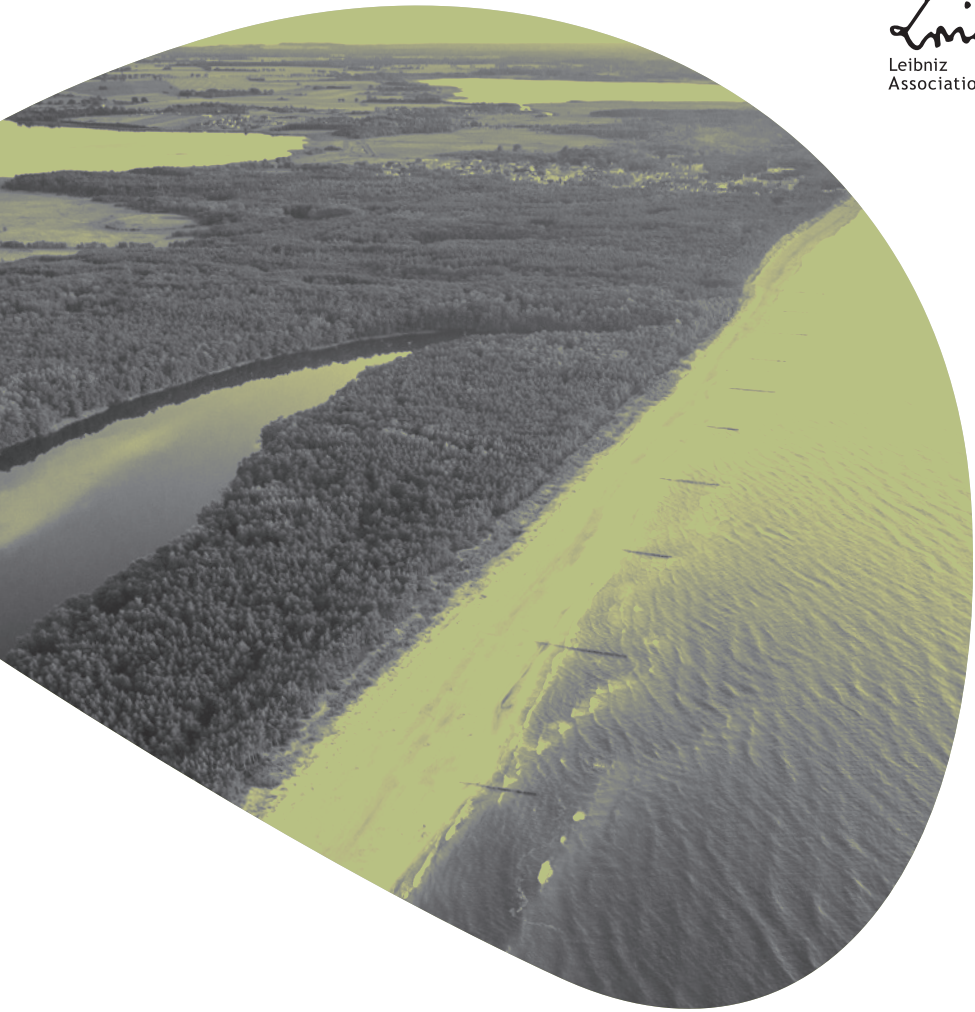




Environment and Sustainable Development

Section “Environmental Sciences”

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Introduction

The research conducted by the eight institutes within the Section “**Environmental Sciences**” is geared towards a better understanding of the Earth system integrated observation, in each of the three areas hydrosphere, lithosphere and atmosphere as well as their interaction with the biosphere. Their work focuses on the interfaces at which these spheres most closely intertwine with the human society: in the troposphere, in coastal waters and shelf seas, inland waters, and areas of land used in agricultural systems. In a cross-sectional way, research into climate development and the effects of global change permeate nearly all institutes and thus plays a major common role within the section.

This section profile includes the following key areas of research:

- In the hydrosphere: **Coastal waters and shelf seas, inland waters and groundwater**
- In the atmosphere: **Aerosols and aerosol-cloud interactions**
- In the lithosphere: **Agricultural systems**
- As a cross-sectional task: **Research into climate development and effects of global change**

The institutes conduct their research on the basis of both **field observations as well as laboratory and modelling work**, some of those also on large scales. Long-term observations of living and non-living matter along all space-time scales identifies fundamental patterns and allows documenting global change and its consequences. The research in the Section “Environmental Sciences” takes a **multidisciplinary approach** and also draws on expertise in the social sciences and economics. In doing so, solutions can be sought that make it possible to sustainably utilise and protect the Earth system and manage competing usage types. **Models and scenarios** that the section’s institutes generate as a result of their work constitute a basis for recommending actions and innovative solution strategies to policy-makers and society.

Key research areas within the Section “Environmental Sciences”

The hydrosphere

Seas and oceans

Among the section’s key research areas are **coastal waters and shelf seas**, the marine areas with the greatest biological productivity. At the same time, this is where human impact on the oceans and human dependence on the sea are greatest. Coastal waters and shelf seas are put to many uses: fishing and aquaculture, shipping, energy generation, tourism, waste disposal, transport routes and settlement areas. Insights into the resilience of coastal waters must therefore be increased, and strategies for **integrated management** be developed.

Coastal waters are under strain from **excessive fertilisation, oxygen depletion, loss of biodiversity**, and a constant influx of dissolved and solid pollutants from land surfaces. Examples of such pollutants include pharmaceuticals, sunscreen, pesticides and microplastics. Insufficient research has thus far been conducted into the effects of these substances on food chains. When organisms that play an important role in interlinked food chains are harmed, they might be no longer able to fulfil their function within the ecosystem. The **services of these ecosystems** and their benefit for humankind are then diminished or disappear entirely.



Oxygen-deprived zones are increasing on a global scale. They are most commonly found in coastal waters and shelf seas, where an excess of nutrients accelerates oxygen depletion. Rising temperatures due to climate change will speed up this development. Understanding and measuring the **microbial activities** controlling these processes represent a key part of the marine research conducted within the section. It is essential to understand the nitrogen and phosphorus cycle in order to counteract the effects of excess nutrients in coastal waters.

At the interface **between land and sea**, coastal erosion and rising sea levels endanger the local people, their settlements and their groundwater supply. In order to minimise the damage and enable people to adapt, it is important to understand these processes and their dynamics.

The Section “Environmental Sciences” examines coastal waters and their usage in all climate regions. Yet particular emphasis is placed on Germany’s “local seas”, the **North Sea and the Baltic Sea**, as well as on **tropical waters**, for which data sets are particularly fragmented. Food production in tropical coastal waters through fishing and aquaculture is also drastically gaining in importance. Sustainable utilisation of these waters can only be ensured if governance systems and their efficacy are examined.



Inland waters and groundwater

Inland waters, i.e. rivers, lakes, ponds, wetlands and groundwater, provide crucial ecosystem services, including the provision of drinking water, fisheries and aquaculture, tourism and several regulatory functions such as preventing floods. Manifold human use-induced pressures affect inland waters and jeopardize their structure and functioning, and the ecosystem services they provide. Droughts, floods, fish kills and toxic algal blooms are consequences that directly affect our society.

How will our inland waters react to human-induced global change, including urbanization, intensive agriculture and climate warming? These and similar questions can only be answered by studying the **structure, functioning and interrelationships of inland waters across spatial and temporal scales**, and different levels of organization – from the population to the ecosystem level. Here, one of the central questions is how the fundamental controlling factors are influenced by various forms of use and stressors, and how freshwater systems respond to societal changes and management. Another key question concerns the effects of the loss of species and habitat diversity on the resistance and resilience of inland waters and their ecosystem services. Inland waters are closely linked with agricultural areas, cities and coastal waters via groundwater, artificial watering systems, and river networks. They therefore play an important role as an interface between terrestrial systems and the sea.



The grand challenges inland waters face demand an encompassing approach, integrating insights at different levels of ecological organization, spatial and temporal scales. Integration with societal drivers similarly is important, reflected in a **strongly developed science-society interface** in the section.



The atmosphere

With respect to the atmosphere, the Section “Environmental Sciences” specialises in the study of the **troposphere**. This is where the exchange between the atmosphere and the oceans and continents takes place. The troposphere provides the “air for life”, and is endangered by emissions from industrial production, transport and the burning of fossil fuels.

Whereas air pollution within the European Union has been reduced considerably in recent years, it is the growing megacities in emerging countries, in particular, that suffer from smog, which causes health problems for millions of people. The efficacy of national and international measures for combating air pollution and protecting the climate can only be assessed when we understand the **chemical and physical relationships within tropospheric multiphase systems**. The recording of **air pollutants** in highly impacted regions also provides relevant information for the public health system.

Alongside the stresses imposed on the troposphere by pollutants, the section above all studies its **role in climate processes**. **Aerosols, clouds and their effect on Earth’s radiation budget and water cycle** remain the largest uncertainties in climate models. How do these short-lived, highly variable atmospheric components influence the state of the Earth system in regional and global terms? And what role do human influences play in this highly complex network of effects? With the leading German centres of competence for tropospheric aerosols and clouds, and for Earth system analysis and climate effects, the Leibniz Association is perfectly equipped to address these questions.



The lithosphere

With respect to the lithosphere, the Section “Environmental Sciences” specialises in the study of the **agricultural systems**. Competing demands on agricultural systems often lead to complex social challenges. Environmental researchers study the causes and interactions to develop potential solutions.

The demand for food and animal feed as well as biogenic raw materials for industrial and energy applications is growing globally. Yet it is necessary to protect natural resources and ecosystem services by means of sustainable production methods. As future production opportunities will depend on whether we manage to develop adequate **adaptation strategies**, it is vital to assess the effects of global change on agricultural systems. At the same time, agricultural production is also a **source of greenhouse gases**, and these emissions have to be reduced.

The Section “Environmental Sciences” examines how agricultural production can be realised in a sustainable way through approaches such as sustainable intensification, agroecology and organic farming with particular emphasis on the diversification of production systems. The institutes pay particular attention to research approaches at the **intersection between biological, technical and social and economic systems**. Based on the **analyses, modelling and evaluation of bioeconomic production systems**, new technologies and management strategies are developed. Researchers are increasingly using new methods of processing and analy-



sing extensive data sets (Big Data), for example to better assess the spatial heterogeneity of site conditions and the implications for sustainable management strategies.

The section's researchers also analyse **fundamental processes in agricultural landscapes**, the effects of various kinds of land use, and the resulting **land-use conflicts**. Among others, their research aims to find the most efficient ways to manage natural resources and to utilise nutrients, and to optimally adapt the use of organic nutrients to specific site conditions. They further improve research methods to assess processes and relationships in agricultural landscapes across different scales.

Based on this the section's researchers give **advice and recommendations to policy makers and society** for regulating the various demands on agricultural systems and landscapes and on their sustainable development.



Cross-sectional theme: research into climate development and climate impacts

The Section “Environmental Sciences” plays a key role in researching **climate impacts**. The research is not limited to the subsystems comprising the hydrosphere, lithosphere and atmosphere, but instead takes a cross-system, global approach in observing the Earth.

Earth as a system is subject to constant changes in planetary framework conditions. Since the Industrial Revolution at the latest, and especially since the second half of the twentieth century, these changes have been overshadowed by the consequences of massive human interference with the Earth’s system. This takes many forms, including urbanization, pollution, global impacts on biogeochemistry, land-use change and biodiversity loss. **Climate change** represents an overarching aspect of **global change** that impacts both societal as ecological systems at all levels of organization.

The central challenge faced by climate researchers is to study and predict when, where, for which endpoints and with which amplitude the consequences of climate change will occur. This analysis is conducted at both the regional and global level. The research at the global level aims to record the so-called **planetary boundaries** and use these to develop recommendations in support of necessary political and social measures. A prominent example of this is the **2°C warming goal**. Observation at the regional level is necessary in order to develop strategies for adapting to inevitable climate impacts. These tasks demand increasingly complex models. They are intended to close knowledge gaps in our understanding of the climate system, and supply information in ever greater spatial resolution.

Alongside the well-established areas of climate research such as agriculture and hydrology, there is currently an increased focus on the healthcare sector, but also on secondary effects such as conflicts and migration. The question as to what **political tools** are available in order to achieve each internationally agreed and nationally applied climate protection target, and how these tools differ in their efficacy, gives rise to fresh challenges.

Inextricably linked with these climate protection targets is the research conducted into the **energy transition** in Germany. The Section “Environmental Sciences” here focuses on issues surrounding the use of geothermal energy and biomass. The institutes also support the common

global tasks of recording sources of, and reductions in, the global greenhouse gas cycle, estimating negative ecological, social and economic effects of climate change, and identifying opportunities for altering the course of climate change.

In order to reconstruct the development of climatic and environmental conditions in the past, the section evaluates **natural archives**, especially ones collected from lakes and oceans. Here, researchers draw on sediment, calcareous sinter and ice-core archives for periods dating back thousands and millions of years, as well as observational data from the last two centuries. Using this information, they are able to measure natural variations in order to distinguish between natural and anthropogenic changes. The archives also provide insights into long-term trends and abrupt regime changes. Both strands of this information are vital to assess changes.

Dating techniques and the identification of climate and environmental indicators or proxies – are important methodologies in decoding the archives and correctly cataloguing their age. Both approaches are further developed within the section. The primary focus is on data relating to developments during the Quaternary, the most recent period in Earth's history, with particular emphasis on the last 10,000 years, the so-called Holocene. The **long-term data from the observation programmes** conducted by all the section's institutes reach back several decades. Pooling and jointly analysing this data in order to identify interactions is set to become a key future task.



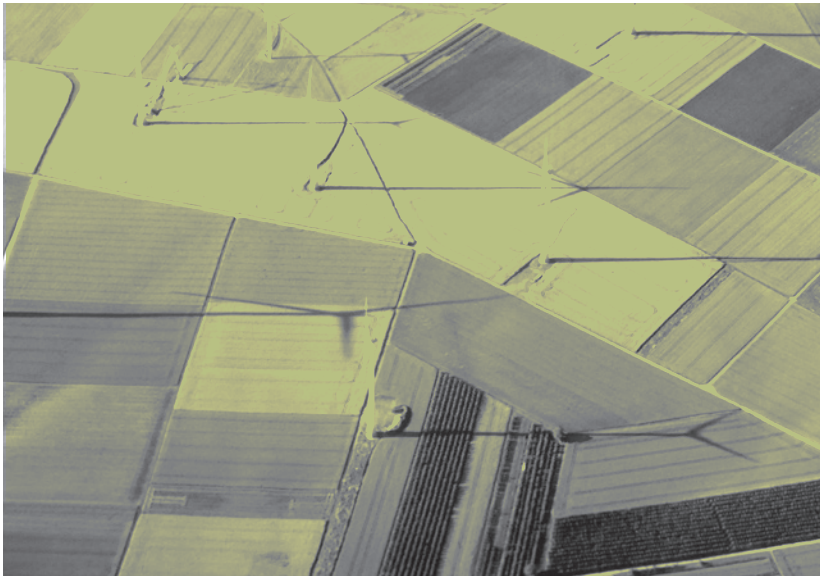
Collaborations

The institutes in the Section “Environmental Sciences” maintain intensive cross-sectional **collaborations within the Leibniz Association**. They are active members of the Leibniz Research Network “Earth & Societies”, “Biodiversity”, “Knowledge for Sustainable Development”, “Green Nutrition – Healthy Society”, “Mathematical Modeling and Simulation”, “Spatial Knowledge for Society and Environment”, the Leibniz Research Alliance “INFECTIONS in an Urbanizing World – Humans, Animals, Environments”, the Leibniz Strategy Forum “Sustainable Agri-Food Systems” and the Leibniz ScienceCampus Leipzig “Smoke and Bioaerosols in Climate Change”. They are also actively involved in the Leibniz Labs “Systemic Sustainability” and “Pandemic Preparedness”.



Additional environment-related challenges can be tackled with selected policy tools developed within the Leibniz Institute of Ecological Urban and Regional Development. Planning-related, governance-orientated, economic and legal instruments for controlling sustainable land management play an important role in the research of this institute. This forges a direct connection between the environmental sciences and the research of the Section “Economics, Social Sciences, Spatial Research”.

As a candidate for a future membership in the Leibniz Association, the Research Institute for Farm Animal Biology is a permanent guest in the Section “Environmental Sciences”. It investigates animal husbandry as a key element in the water-soil-plant-animal-food/residues value chain. The institute’s guest status within the Section “Environmental Sciences” ensures that the potential of livestock research can be used within environmental research specifically on agricultural areas and agricultural systems with regard to optimising ecologically sustainable production (reducing resource usage and limiting emissions).



Future prospects

Over the coming years, Earth-system research will focus on both system-specific processes and predictions as well as on the interfaces between the major subsystems, in order to better record the **processes at the system boundaries** and the **cross-boundary flow of materials and energy**. Future scenarios are to be developed using refined concepts and integrated models at all scales. These can help society to recognise and counter the impacts of climate change and the increasing human pressures on the environment.

In collaboration with the social and political sciences, the intention is to develop effective political and legal tools through which measures can be implemented to defend against pending dangers and damages. To this end, the section's institutes engage in excellent science-society interfaces.

A successful, **evidence-based environmental policy** requires not only validated information and concepts, but also effective communication structures. These structures should create direct channels between data generators, knowledge generators and political stakeholders without generating dependencies. This also requires new participative concepts, which are being developed in collaboration with the social, political and communication sciences.

On the global level, specific structures and procedures must be developed with which the implementation of the United Nation's Sustainable Development Goals (SDG) can be effectively observed and evaluated.

The Leibniz Association's Section "Environmental Sciences" is above all focused on the following **environmental objectives and their inter-actions**:

- Achieving food security and improved nutrition for all, promoting sustainable agriculture (Goal 2: Zero hunger).
- Ensuring the availability and sustainable management of clean water and sanitary facilities for all (Goal 6: Clean water and sanitation).
- Ensuring access to affordable, reliable, sustainable and modern energy for all (Goal 7: Affordable and clean energy).
- Taking urgent measures to combat climate change and its effects (Goal 13: Climate action).

- Preserve marine and inland water biological diversity and the sustainably use of marine and inland water resources for sustainable development (Goal 14: Life below water).
- Protect, restore and foster the sustainable use of terrestrial ecosystems, for example forests; combat desertification; halt and reverse land degradation; and halt the loss of biological diversity on land (Goal 15: Life on land).



Section “Environmental Sciences” in Figures

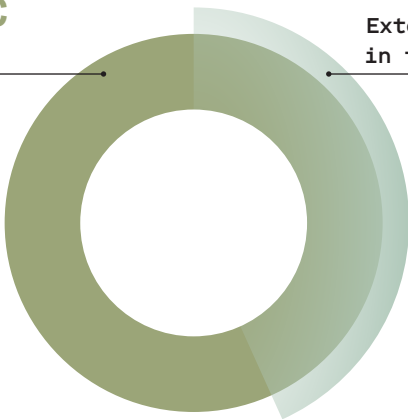
Last Update: December 2024

218 Mio €

Budget in total

94 Mio €

External funding
in total



1.123 | 51 %

Women in total



2.218

Staff in total

Section “Environmental Sciences” in Figures

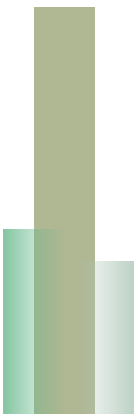
Last Update: December 2024

1.354

Researchers in total

614 | 45 %

Female researchers



503 | 37 %

International
researchers

353

Doctoral researchers
in total

187 | 53 %

Female doctoral
researchers



177

Researchers
in executive
positions in total

64 | 36 %

Female researchers
in executive positions



8 Leibniz Institutes of the Section “Environmental Sciences”



BERLIN

- **IGB** Leibniz-Institut für Gewässerökologie und Binnenfischerei, Berlin

BRANDENBURG

- **ATB** Leibniz-Institut für Agrartechnik und Bioökonomie, Potsdam
- **IGZ** Leibniz-Institut für Gemüse- und Zierpflanzenbau, Großbeeren
- **PIK** Potsdam-Institut für Klimafolgenforschung
- **ZALF** Leibniz-Zentrum für Agrarlandschaftsforschung, Müncheberg

BREMEN

- **ZMT** Leibniz-Zentrum für Marine Tropenforschung, Bremen

MECKLENBURG-VORPOMMERN

- **IOW** Leibniz-Institut für Ostseeforschung Warnemünde

SACHSEN

- **TROPOS** Leibniz-Institut für Troposphärenforschung, Leipzig

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