Environmental indicators

Restructured and Extended
Bavarian Environmental Indicator System

Bavarian Environment Agency

Augsburg, 2006 – ISBN 3-936385-97-1

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Proposed citation format: Bavarian Environment Agency (Publisher): Bavarian Environmental Indicator System

Printing: Mediendesign Sporer, Augsburg

Printed on 100 % recycled paper

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Preface

This report, published by the Bavarian Environment Agency [LfU], presents the 2004 Environmental Indicator System for Bavaria.

The report was compiled jointly by the former Bavarian agencies for environmental protection and water management. In August 2005, these two agencies and the Bavarian Geological Survey merged to form today's Bavarian Environment Agency. This consolidation of activities will benefit future work on Bavaria's indicator system for the various environmental media, thus further promoting sustainability.

Currently, the demand for indicators can be seen most clearly within the context of the specification and implementation of the "sustainability" concept in the follow-up to Rio 1992 and Johannesburg 2002. Current examples are the "Sustainable development in Bavaria" programme of the Bavarian State Government and the sustainability strategy of the Federal Government ("Perspectives for Germany").

If long-term, environmentally friendly development is to be firmly embedded in social and political reality, environmental awareness with a cross-generational perspective must be constantly cultivated. A clear, meaningful set of indicators can contribute towards achieving this goal. It can be used to describe and evaluate time trends with respect to problems of especial urgency today. Climate change, declining biodiversity, noise pollution, high levels of land take and material inputs into ecosystems are examples of issues - some of them only gradual processes - that need to be addressed with the help of a proactive strategy across all political sectors.

Environmental indicators are a central component of this kind of strategy, as they simplify communication on current problems themselves and increase people's understanding for the implementation of necessary measures and the need for review of existing consumer patterns.

A further challenge lies in setting specific targets, achievement of which can be monitored and visualized with the help of the indicators. Environmental indicators thus lay down a path, direction and individual steps towards sustainability.

With the environmental indicators, the LfU is also making a professional contribution to current work in Federal/state committees. We have a new instrument for practical applications in our hands, whose potential uses range from environmental planning through medium-term environmental reporting to cross-state comparisons.

Precisely because the new "Environmental Indicator System for Bavaria" submitted today will require further work in the future, too, it is important that the discussions initiated with other federal states and the Federal Government should be continued. Developments on a European level must be carefully monitored and horizontal and vertical harmonisation of indicator systems targeted.

Augsburg, June 2006
Bavarian Environment Agency

Prof. Albert Göttle
President

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1 Introduction

1.1 Situation and objectives

Environmental indicators are parameters used for collecting, describing and assessing complex environmental circumstances or situations. The aim of systemizing and simplifying environmental data is to provide comprehensible and representative information on the state of the environment.

The need for the development of environmental indicators and their use as a modern instrument for environmental protection is therefore being voiced by environmental and political science. The Bavarian State Ministry of the Environment, Public Health and Consumer Protection [StMUGV] first produced an ***Environmental indicator system*** in 1998 within the context of Bavaria's Agenda 21 and in order to draw up an environmental report for the OECD.

The federal states, Federal Government and European Union, as well as local authorities and companies, recognize the benefits of environmental indicators for environmental reporting, environmental planning and public relations. In addition, indicator-based implementation of the ***sustainable development*** concept is urgently needed. Environmental protection has a recognizable backlog in this regard. Whereas economic and social concerns have traditionally (and successfully) been expressed in indicators such as gross domestic product, inflation rate, stock index, unemployment rate and per capita income, there are no similarly succinct indicators of environmental quality. This also increases the importance of environmental indicators with a view to further follow-up action to the Johannesburg World Summit.

Like other agencies within the StMUGV, the Bavarian Environmental Protection Agency [LfU] has a multitude of ***environmentally relevant raw data*** at its disposal, which has been systematically gathered, some of it over many years, using measurement networks and monitoring programs; it also has the relevant experience in evaluating such information. On the basis of this data expertise and its professional knowledge, and using available data from other departments, the LfU has taken on the task of developing environmental indicators.

Environmental indicators discussed in a working group involving state agencies and institutes from various federal states could also be included.

The setting of concrete ***environmental goals, or targets,*** may be undertaken along with the development of indicators, but is an opportunity and a difficult task at the same time. On one hand, quantified environmental targets in conjunction with environmental indicators open up the important application field of environmental planning, which has great political weight and social relevance. On the other hand, technically sound indicators are not available for all environmental targets. For validated environmental targets for which data has not yet been collected, it will be necessary to clarify whether the work involved in data collection is practicable.

1.2 Functions

Four basic indicator functions are decisive for the requirements and selection criteria upon which indicator development was based:

<u>Analysis</u>: Indicators help to identify those problems that need to be addressed urgently. They reveal undesirable developments at an early stage (signal and warning function). This function is already fulfilled by a selection of specific, problem-oriented indicators. It will, however, not be particularly effective until regular analysis of the indicators, involving assessment of magnitude, trend and, possibly, also the degree to which goals are achieved, takes place.

<u>Planning</u>: Indicators assist environmental policymakers in identifying the most important fields of action, support the integration of environmental policies into other policies and help specialists to agree on goals and set targets. They are thus also useful as a tool for selecting the necessary measures to achieve targets and improve the efficiency of environmental planning.

<u>Monitoring</u>: Through time series and the visualization of trends, where possible in connection with concrete environmental targets, indicators can be used for long-term monitoring of environmentally-friendly development. They clearly reveal where progress has been made, but also

show up negative trends. Indicators thus serve to evaluate environmental policy measures.

Communication: Plans and measures must be communicated in a clear, comprehensible manner in both political and social discussions. Indicators fulfil this task by reducing the complexity of difficult situations and developments. To be effective in practice, the indicators deployed within an indicator system must be limited to a manageable number. They will then contribute to improved information for citizens and will support environmental policy integration into other policy areas.

1.3 Framework and project team

To perform this cross-sectional task, the LfU drew up a draft conceptual framework. The first step was to commission the Technical University of Munich [TUM] to carry out a ***study*** involving the analysis and evaluation of existing environmental indicator systems, and thus to find a scientifically based, methodical approach to the task. A ***project team*** was set up at the same time so as to incorporate the core competence of the various specialists right from the start. This was to ensure the best possible preparation and constant monitoring of the indicator development process in the technical units. A complete cross-section of the LfU's specialists (air quality, climate, noise, waste, soil, radiation, nature, landscape, pollution and ecology, toxicology, genetic engineering) were included in the project team, as well as specialists from the Bavarian Water Management Agency [LfW]. Experiences were also exchanged with environmental authorities in other ***federal states***, and the results from other current indicator projects (e.g. FEST project) incorporated.

In accordance with the results of the TUM study, a procedure was chosen that is based primarily on existing data and indicators. In the final phase of indicator selection it was also possible to include indicators derived from concrete StMUGV environmental targets. This combined procedure is basically in line with a recommendation by the German Council of Environmental Advisors.

2 Worksteps and methods

2.1 Project procedure

At the end of 1999, StMUGV made funds available for the ***Research Project*** "Further development of the environmental indicator system for Bavaria – analysis and evaluation of existing approaches". The LfU supervised this study conducted by the Technical University of Munich [TUM]; the final report was submitted in November 2000. In July 2001, the StMUGV published it as Collected Materials (Materialien), Vol. 164. The results of the TUM study were used in developing the indicator system.

Together with Baden-Württemberg, Hesse and Thuringia, Bavaria commissioned the Protestant Institute for Interdisciplinary Research [FEST] to carry out the joint indicator project ***Indicators and Local Agenda 21***. Following preliminary selection at a workshop with experts and a practical test phase in 16 pilot municipalities, FEST suggested 24 sustainability indicators and drew up a practical guide. The federal states presented it jointly in Stuttgart in November 2000. The LfU then forwarded the handbook to the Bavarian municipalities, rural districts and regional governments to support the Agenda process. Experience and results gained from participation in the FEST project were taken into account.

The ***Environmental Indicators*** project team commenced work in the middle of 2000. It evaluated current information on indicator work in other federal states as well as the results of various expert symposia. The outcome was its decision to work out a 'matrix-structured system interrelating problem areas and causal sectors.' The DPSIR framework of the European Environment Agency (EEA) was used as a basis. So as to be able to recognize and describe these relationships, an "Environmental Sustainability Model" (ESM) was drawn up for the further indicator development process. The StMUGV and the various specialists involved were regularly informed about the team's work.

In February 2001, the LfU held a ***conference*** on "Making sustainability measurable – environmental sustainability indicators" together with the Protestant Academy of Tutzing, in which national and international expert speakers took part. At this conference, Dr. Schnappauf, Minister for the Environment, commissioned the LfU to develop an indicator system.

This job was performed in a pragmatic manner, also involving other state authorities. The indicator development process proved to be a dynamic one, in which both new scientific findings and requirements stemming from political and social discussions must be integrated in the future.

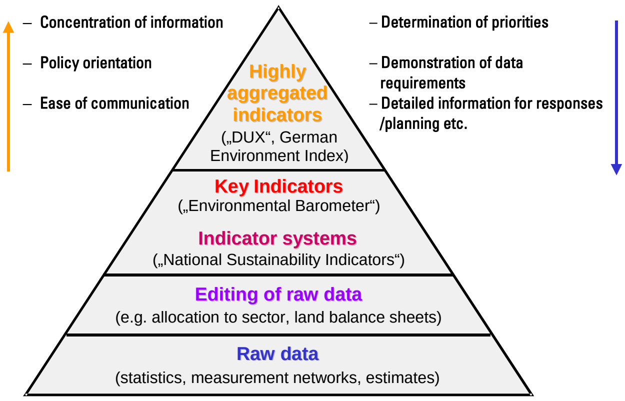
The LfW was constantly informed about the LfU's progress as from mid-2000 and was directly involved in the indicator-development project from May 2001 onwards. The Bavarian Geological Survey (GLA) was also asked to take part. The LfU and LfW specialists submitted proposals for environmental indicators from June 2001 onwards with the help of worksheets and the support of the project team. The process was coordinated at the LfU by the President's staff, the proposals concerning indicators discussed on a broad basis and the documentation produced jointly with the various specialists.

The concurrent exchange of information with other ***federal states*** was important. Core indicators were drawn up in discussions held within the context of the "Cross-State Core-Indicator Initiative" (LIKI). The last meeting took place in Hamburg on September 29th/30th 2004. These indicators served as the basis for development of joint Federal Government/federal state "environmentally specific sustainability indicators". A preliminary proposal was submitted by the Bavarian State Ministry of the Environment, Public Health and Consumer Protection [StMUGV] as early as the beginning of 2002. Following this, a broad-based, intensive discussion process was initiated, in which the "environmentally specific sustainability indicators", as decided by the Conference of Ministers for the Environment [UMK] in May 2004, were included.

This documentation is thus the result of an intensive coordination process within the Department for the Environment and alignment with other federal states. Progress reports were submitted, for example, at a workshop held by the Federal Government/state working group for Environmental Information Systems [BLAK-UIS][2] in Kiel/Flintbek in September 2001 and at a status seminar of the Lower Saxony Office for Ecology [NLÖ][3] in Hildesheim in February 2002.

2.2 Procedural approach

The choice and editing of environmentally relevant raw data and the development of environmental indicators via aggregation or selection processes is of great importance. These indicators give policy makers some orientation, helping them to pinpoint important fields of action, and give the public environmental information that is easier to understand.

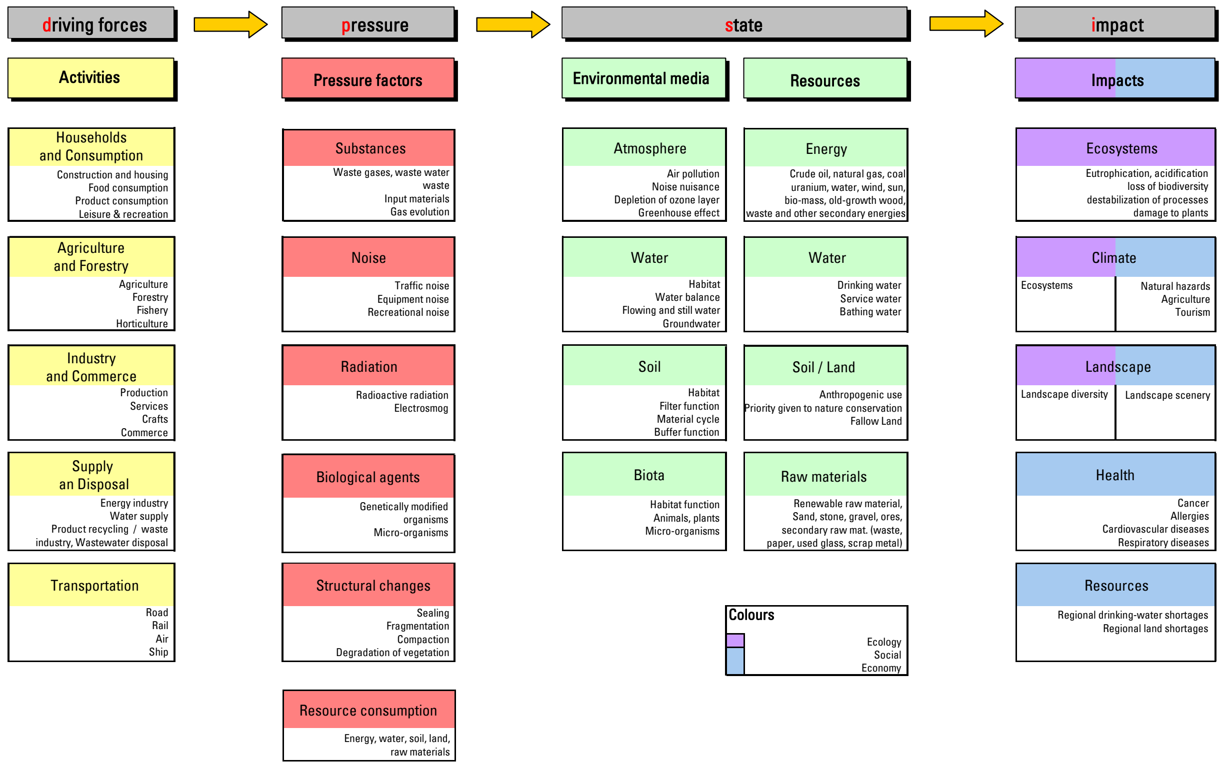


Indicators for environmental problems that fall under the remit of the LfU and the LfW are formed from existing indicator-relevant raw data by means of editing processes (e.g. allocation to sectors), selection and/or aggregation processes. As illustrated by the above information pyramid[4], this process is known as a ***bottom-up-process***. It was selected by LfU and LfW as being a particularly suitable method of indicator development for these agencies.

For further development of indicators in future, it will be necessary to include supplementary environmentally relevant raw data from external agencies such as the Bavarian Forest Institute [LWF] and the Bavarian State Research Centre for Agriculture [LfL]. If environmental goals are

[2] Bund-/Länder-Arbeitskreis Umweltinformationssysteme [Federal Government/state working group for Environmental Information Systems]
[3] Niedersächsisches Landesamt für Ökologie [Lower Saxony Office for Ecology]
[4] Adapted from the draft of a Strategic Environmental Policy Programme initiated in 1998 by the Federal Ministry for the Environment in the context of sustainable development in Germany

not yet available for all the environmental indicators developed via the bottom-up-process, identification of such goals should be investigated in the future. In the ***top-down-process,*** environmental goals for the relevant fields of action are among the first things to be produced, after which corresponding indicators are identified. Since environmental goals, especially measure-oriented environmental-action goals, are mainly discussed and deter mined in the political/social sector, this process can be largely realized at the ministerial level. It should, however, be borne in mind that expenditure of funds and adjustments to the data collection methodology may be necessary in order to obtain a data base for suitable environmental indicators. An intensive exchange of information between the StMUGV, LfU and LfW during the entire project and, above all, again in the ***final phase***, has made it possible to largely combine both procedural approaches.



2.3 Environmental sustainability model

Functional relationships (see 2.4) are important criteria for environmental indicators. Their clarification and description should serve to clearly reveal the links between causes and effects within the context of protected assets. Responsibility for relevant problems and preventive action can thus be allocated in accordance with the "polluter-pays" principle. The LfU project team has developed the "Environmental Sustainability Model"(ESM) for classifying indicators. It is described in detail in Appendix 1 of this report.

The ESM is based on the DPSIR framework developed by the European Environmental Agency (EEA) for the purpose of classifying indicators. The clearly structured ESM (sections, sub-sections, explanations) details and characterises the four DPSIR criteria[5], viz. *Driving forces*, *Pressures*, *State* und *Impact*,

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[5] *Driving- force indicators* show which human activities cause the relevant environmental pressures.

Pressure indicators describe which specific environmental pressures are caused by the various sectors.

State indicators describe environmental quality, i.e. the state of environmental media and natural resources, which is affected by pressure factors.

Impact indicators show the further effects and impacts of changes in environmental quality.

Response indicators measure the efforts by society (e.g. politicians, decision-makers in the relevant fields of action) to respond to the changes in environmental quality and the impacts thereof.

that are important for describing functional relationships. The ESM thus provides a detailed description of the cross-sectional character of the environmental pillar of sustainability, facilitates the identification of specialists that need to be involved and makes it possible to pinpoint the functional relationships between driving forces, pressures, changes in state and the impacts thereof (problems to be addressed). With respect to the development of ***sustainability indicators,*** the ESM is open to the economic and social dimensions. Links have already been created by the inclusion of "resources" and "human health".

2.4 Selection criteria

For the task of indicator development, the specialists were given predefined assessment and selection criteria which the project team had compiled on the basis of relevant research[6] on this subject and of the ideal requirements outlined in the "1994 Environmental Report" drawn up by the ***German Council of Environmental Advisors*** (published on March 8, 1994 in Bulletin 12/6995 of the German Parliament). These criteria permitted a logical and documented selection and assessment of indicators. The indicators described here are additionally structured according to the following scheme:

- Functional relationship -

With which of the problems to be addressed that are relevant to Bavaria does the indicator have a functional relationship, and how should this be shown in the ESM as a path and described in more detail? *Documentation*: description of the problems to be addressed, ESM assignment of the indicator, DPSIR classification, description of the functional relationships, limitations.

- Relevance -

How is the current relevance of an indicator describing specific problems applicable to the whole of Bavaria and/or certain regions of Bavaria assessed? *Documentation*: in-depth specialized data on problems that are temporally and spatially relevant to Bavaria.

- Data availability and data quality -

Are statistics for past or future time series already available for the indicator or can they be collected in the future with a reasonable degree of effort, or will they have to be collected in the future because of recent legal provisions? Is the quality of the available statistics sufficient to ensure the reproducibility, reliability and correct assessment of the results? Do the statistics permit regionalization within Bavaria? *Documentation*: data source, measurement method, frequency of collection, current availability, future availability, aggregation process, regionalisation.

- Environmental goals -

Can a link be established between the proposed indicator and an existing, quantified environmental goal for Bavaria? *Documentation:* Bavarian, German and EU targets for environmental quality and environmental action.

- Assessment reliability -

Can the trend to be described by the proposed indicator be assessed in a sufficiently targeted and professionally sound manner? *Documentation*: initial assessment of the proposed indicator on the basis of trend, level and, where applicable, environmental goal.

- Controllability-

Can the trend indicated by the proposed indicator be influenced and controlled by environmental policy measures?

- Communicability -

Does the proposed indicator largely fulfil the desired communication requirements?

[6] **FIS**: "Grundlagen für ein nationales Umweltindikatorensystem" – Fraunhofer Institute for Systems and Innovation Reseach; publ. in UBA-Texte 37/97 by the German Env. Agency [UBA], Berlin 1997

B/M: "Zukunftsfähiges Deutschland – Ein Beitrag zu einer global nachhaltigen Entwicklung" – Wuppertal Institute for Climate, Environment and Energy; Publishers: BUND/ MISEREOR, Basle 1996

TUM: "Weiterentwicklung des Umweltindikatorensystems für Bayern – Analyse und Bewertung bestehender Ansätze" – Chair for Water-Quality Control and Waste Management, Munich Technical University, November 2000

- Documentation -

Assessment of the indicator’s communication value for politicians and the general public.

- Compatibility-

Is the proposed indicator compatible with other indicators? *Documentation*: with which relevant indicators of other German states, the Cross-State Core-Indicator Initiative [LIKI] or the Federal Government is the indicator compatible on a European or municipal level?

3 Environmental indicators

The following environmental indicators serve to describe environmental quality in Bavaria and to designate causal environmental pressures and counteractive measures. They thus serve as the basis of various potential applications (see 4.1).

The creation of a harmonized core indicator set for the federal states has been further promoted in recent years by the work of the “Cross-State Core-Indicator Initiative” [LIKI] in cooperation with the Federal/state working party “Sustainable Development” [BLAK NE] and others. Short, pithy designations were proposed for the core indicators, and this has been taken into account wherever possible in this report .

The description of the indicators is based on the information received so far from the LfU and LfW specialists. For future work with environmental indicators in specific applications, the technical documentation, which, among other things, describes the collection, calculation and assessment principles underlying the indicators in an easy-to-understand manner, will require gradual sophistication. Target-group-oriented, application-specific adjustments to the description will be needed.

Each indicator is first presented in a summary slide with a short designation. The identification colour of the header (yellow-red-green-blue) symbolizes the indicator’s classification within the “Environmental Sustainability Model ” (see Appendix 1). Environmental goals were then included if they already have a firm political basis in Bavaria (e.g. Environmental Pact, goals of the state government) or a regulatory basis. The trends shown by the indicators are assessed. In order to make this assessment objective, a simple statistical trend analysis is carried out for a defined assessment period (mostly 10 years). Trends are only charted and evaluated if they reach a 10 % significance level. This means that, in the event of a trend actually being non-existent, the probability of the trend indicated being due purely to chance is 10 % at the most. The analysis process checks for a linear connection and does not make a detailed analysis of all possible functional dependencies. The not-too-strict significance level of 10 % was chosen so as to permit inclusion of other possible functional relationships in the “up- or downtrend” assessment.

The following classification of environmental indicators is based primarily on the “problems to be addressed” as presented in the ESM (see Appendix 1). The indicators have been assigned to the categories with which they have the strongest functional relationship. Many indicators, however, have additional relationships with other problems that are referred to in greater detail in the description of the respective indicator.

Appendix 2 provides an overview of the environmental indicators that are subject of this report and shows the extent to which the indicators adopted by the Conference of Ministers for the Environment in the context of “sustainable development” can already be implemented in Bavaria.

Nature and landscape

Problems to be addressed: loss of landscape and biological diversity, impairment of natural scenery and ecological processes – (see ESM, section on "Landscape")

01. Land for Nature Conservation Goals
02. Environmental Farming
03. Species Endangerment
04. Representative Species

Ecosystems

Problems to be addressed: impairment *of ecosystems, eutrophication, acidification, accumulation of persistent substances – (see ESM, section on "Ecosystems")*

05. Quality of Treated Waste Water
06. Fertiliser Use
07. Acid and Nitrogen Input
08. Heavy Metal Input
09. Water Quality
10. Nitrate in Groundwater

Climate and health

Problems to be addressed: anthropogenic climate changes with impacts on ecosystems, economic sectors, health; impairment of and risks for human health from pollutants, noise, radiation - (see ESM, sections on "Climate" and "Health")

11. Carbon Dioxide Emissions
12. Air Quality Index
13. Road Traffic Noise
14. Total Noise Pollution in Residential Areas

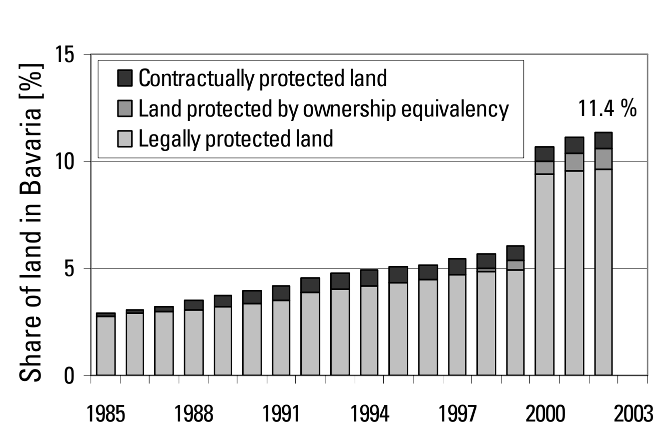
Resources

Problems to be addressed: resource shortages with economic, ecological and social impacts (sustainability) – (see ESM, section on "Resources")

15. Land Take
16. Energy Consumption
17. Waste and Recycling
18. Hazardous Waste
19. Contaminated Sites
20. Environmental Management

Nature and landscape

Land for Nature Conservation Goals



Problems to be addressed

- Loss of species and biotic communities
- Loss of ecological processes and functions
- Vegetation degradation
- Habitat fragmentation

Regionalisation

Yes, down to district level

Documentation

Bavarian Environmental Protection Agency [LfU], annually; data for partial criteria not yet available; allocation of Natura 2000 sites to the year 2000 (one-off land increase, no comparable growth expected in future);
need for improvement (GIS, data storage, quality)

Assessment

- Land share has seen a steady increase since 1985, which is a positive trend;
- Legally protected land dominates, with an annual increase of approx. 0.15%. The year 2000 witnessed a jump (Natura 2000 sites).

SHARE OF LAND IN BAVARIA FOR NATURE CONSERVATION GOALS - [%]

Problems to be addressed: Protected areas as provided for under the Bavarian Nature Conservation Act [BayNatSchG] are a traditional legal instrument for land conservation and are intended to preserve biodiversity and ecological processes. More recently, additional conservation measures have been implemented in the form of contractually protected areas and areas protected by ownership equivalency.

All of these conservation measures seek to reduce or prevent pollution – especially structural and chemicals pollution, such as soil degradation or fertilizer use – of the environmental media biota, water and soil in the protected areas. They routinely give nature conservation preference over anthropogenic use (e.g. farming) in these areas.

Definition: The indicator consists of 3 partial indicators. The land shares in Bavaria accounted for by each of these indicators are added together and shown as the relative share (in %) of the total land area in Bavaria.

The partial indicator *“legally protected land”* consists of nature reserves, national parks, natural forest reserves, Natura 2000 sites, “13d” areas as provided for under Article 13d of the BayNatSchG, landscape components, natural monuments in the form of land, and regional-planning priority zones.

The partial indicator “*land protected by ownership equivalency”* covers land recorded in the ecological land register maintained by the Bavarian Environmental Protection Agency [LfU] (land purchased with the support of the Bavarian State Ministry for the Environment, Health and Consumer Protection [StMUGV] and/or the Bavarian nature conservation fund, land belonging to nature conservation associations, land made available through rural development processes in Bavaria, buffer zones and land bordering riverbanks and lakeshores).

The partial indicator *"contractually protected land"* covers land subsidised by way of the contract-based conservation project [VNP], by hardship compensation and, probably from 2004 onwards, land on which measures as defined in the Bavarian regulations governing rural conservation and wildlife reserves [LNPR] have been subsidised.

***Functional relationship*:** The indicator falls under the ESM category *Activities*. It particularly concerns the sections *Agriculture and Forestry / Transportation / Households and Consumption*. As in the DPSIR classification, this is a *response indicator*.

The protective measures are directed against many environmental pressure factors, such as structural changes and material inputs, and include bans on ploughing, road building or other construction work, bans on drainage or ditch-digging, and reductions in pesticide and fertilizer use. Such measures help to preserve extensive areas of valuable natural countryside and ecosystems, along with the existing diversity of species and their habitats. In the core zones of national parks, for instance, ecological processes remain largely undisturbed.

Documentation: Statistics have been available for nature reserves and national parks since 1984, and are being continued by the Bavarian Environmental Protection Agency [LfU]. Natura 2000 sites are documented in digital form at the LfU. Habitat maps and "13d" areas identifiable from them are likewise documented in digital form at the LfU (from 1985-1995 all, and, for some districts, after 1996 as well). The documentation for the other partial indicators is still heterogeneous and requires improvement. Sufficiently comprehensive data on *"land protected by ownership equivalency"* is anticipated for 2004. Continuous series of statistics for *"contractually protected land"* have been available since 1983. The digitization of these areas is planned. It is currently not yet possible to merge the statistics for *"land protected by ownership equivalency"*, *"contractually protected land"* and *"legally protected land"*.

Environmental goals: The indicator relates to the following goals listed under Article 1(2) of the BayNatSchG and in the Bavarian Agenda:

- Protection of plant and animal species
- Preservation and growth of biodiversity

Assessment: The land share for nature conservation goals has seen a steady increase since 1985, with *"legally protected land"* dominating the upward trend. This showed a continuous increase until 1999 and then witnessed a pronounced jump in 2000 with the addition of the Natura 2000 sites. In total, *"legally protected land"* accounts for approximately 9.6 % of the land. The *"land secured by ownership equivalency"* is estimated to account for just 1.0 % at present. *"Contractually protected land"* has increased slightly since 1996. Its share is currently about 0.8 %

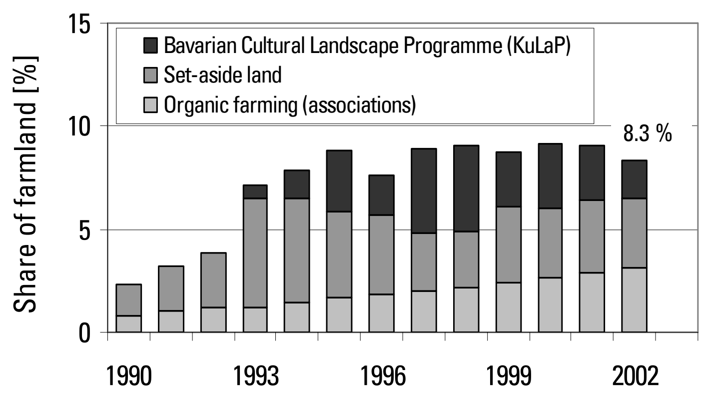
Future work: The indicator does not take the quality of the land into account, for example with regard to the species inventory, fulfilment of objectives identified in protected-area legislation or Natura 2000 management plans, or to 13d-status. Because of the unclear delimitation of "13d" land on biotope maps, it is currently difficult to determine the extent of overlap with other legally protected areas. GIS treatment of all land categories would help here and permit combination of the three partial indicators *"legally protected land"*, *"land protected by ownership equivalency"* and *"contractually protected land"*. This would prevent the double counts that sometimes occur at present.

Regionalisation: The data upon which the indicator is based permits regionalisation of the indicator down to district level.

Cross-state compatibility: In the interests of Germany-wide comparability, the LIKI[1] Initiative suggests the use of selected, strictly protected nature conservation areas as defined in Germany's Federal Nature Conservation Act [BNatSchG] (nature reserves, and core and maintenance zones in national parks and biosphere reserves) as core indicator. These have been used here, together with additional areas important in Bavaria for meeting nature conservation goals.

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Environmental Farming



Problems to be addressed

- Loss of species and biotic communities
- Structural changes to soil / water
- Accumulation of persistent substances in soil / life forms

Regionalisation

Yes, but very difficult for organic farming

Documentation

Bavarian State Ministry for Agriculture and Forestry [StMLF], annually;
organic farming: land certified by one of the organic farming associations recognized in Bavaria; in future, it will also be possible to monitor land farmed according to the requirements of the EC Regulation on the Organic Production of Agricultural Products.

Assessment

- Strong fluctuations in Bavarian cultural landscape programme [KuLaP] and set-aside land, to some extent a result of market forces
- Constant increase in organically farmed land, which is a positive trend

SHARE OF FARMLAND UNDER ENVIRONMENTAL MANAGEMENT - [%]

Problems to be addressed: Biodiversity in species and biotic communities is threatened by a constant and broad intensification of agriculture. Persistent substances used (e.g. heavy metals) are distributed ubiquitously and accumulate with time in the soil and in life forms, thus enabling them to enter the food chain. Eutrophication of waters impacts on aquatic habitats. Excessively high nitrate content in drinking water, which is caused by nitrogen input from fertilization, can impair human health. The use of genetically modified plants may involve unpredictable risks, particularly for biodiversity.

Ecologically sound farming methods can mitigate many environmental pressures.

Definition: The indicator shows the share (in %) of farmland under environmental management.

The following forms of land management have been included:

- *Organic farming* (as defined by the associations recognized in Bavaria),
- *Bavarian cultural landscape program [KuLaP]*; the following selected project components:
  - No fertilizers or pesticides,
  - Extensive use of meadowland by sheep or goats,
  - Mowing-date regulations,
  - Mowing of steep slopes, herding,
  - Long-term provision of areas for agri-environmental purposes,
  - Conversion of arable land into grassland (since 2001),
  - Environmental use of arable land in water-sensitive areas (since 2001).
- *Set-aside land* (except for renewable raw materials).

***Functional relationship*:** The indicator falls under the ESM category *Activities / Agriculture and Forestry.* As in the DPSIR classification, it is a *response indicator.*

The environmental land-management forms assessed by the indicator reduce many environmental pressures. A decrease in *chemicals input* from pesticides and mineral fertilizers lowers the pollution level in *soil, water and biota*, helping to stabilize and improve the condition of the environmental media and to reduce the impact on ecosystems and health. Environmentally sound farming methods avoid detrimental *structural changes* to soil, water and vegetation, thus enhancing the habitat of numerous species and biotic communities. This has positive consequences for biodiversity and landscape diversity.

Documentation: All the data for this indicator is collected centrally at the Bavarian State Ministry for Agriculture and Forestry [StMLF] and revised annually. Continuation of this procedure is possible.
The quality of data on *organic farming* is very good as the farms are subjected to several different inspections conducted by a number of inspectorates. Statistics have been available since 1973. The hectare figures are based on field maps and land registers, i.e. their accuracy is determined by the accuracy of the 1:5,000 maps. Quality assurance is the responsibility of the organic farming associations “Bioland”, “Naturland”, “Demeter Bayern” and “Biokreis Ostbayern” and the inspection authorities provided for under the EC Regulation on the Organic Production of Agricultural Products.

The boundaries of areas farmed in accordance with the *KuLaP* project and of *set-aside land* are usually defined in line with the land-register surveys, which are based on 1:5,000 field maps. The local agricultural boards monitor implementation of the *KuLaP* project components. Missing *KuLaP* statistics are a result of changes in the regulations.

Environmental goals: The indicator relates to the following goals listed under Article 1(2) of the Bavarian Nature Conservation Act [BayNatSchG] and in the Bavarian Agenda 21:

- protection of the historical diversity of species
- preservation of biodiversity,
- preservation and development of cultural landscapes in Bavaria,
- preservation of the uniqueness and diversity of Bavaria’s landscape units.

Assessment: Assessment of the indicator only began in 1993, as suitable *KuLaP* statistics were not available earlier. Statistical trend analysis always refers to the past 10 years, and this will remain so in future.
On the whole, there is no clearly discernible trend. *Organically farmed land* shows a steady increase. *KuLaP* and *set-aside land*, on the other hand, is subject to strong fluctuations caused partly by market forces in the agricultural sector.

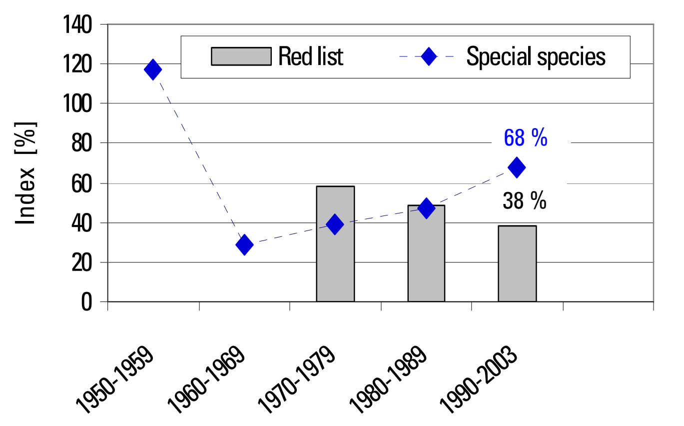
Future work: It is planned to include the quality of the land in terms of species inventory and the fulfilment of nature-conservation aims. There are also plans to include environmentally managed forested land.

***Regionalisation*:** Regionalisation is always possible for *KuLaP* and *set-aside land.* The data on *organic farming*, however, can be regionalised only with great difficulty.

Cross-state compatibility: In the interests of Germany-wide comparability, the LIKI[1] Initiative suggests the use of “organic farming” (as defined in EC Regulation 2092/91 on the Organic Production of Agricultural Products) as a core indicator. The Bavarian indicator is based on the stricter criteria set by the associations recognized in Bavaria, and takes additional areas into account that are important specifically in Bavaria for environmentally sound agriculture. Statistics in line with EC Regulation 2092/91 have been available for Bavaria since 1994 (e.g. 2002: 3.5 %).

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Species Endangerment



Problems to be addressed

Loss of species and biotic communities

Regionalisation

No, only a Bavaria-wide indicator makes sense

Documentation

- Red list (plants/animals): Bavarian Environmental Protection Agency [LfU], approx. every ten years at present; shorter intervals planned for selected groups
- Special animal and plant species: LfU, for some species annually
- Need for improvement: broader monitoring of “special species”

Assessment

- The share of endangered species on the “red list” is increasing.
- The situation for “special species” is improving due to the protective measures implemented.

RED-LIST SPECIES AND POPULATION TRENDS FOR SPECIAL PLANT AND ANIMAL SPECIES - [INDEX]

Problems to be addressed: The endangerment of species and biotic-community diversity is a global problem that can be traced back – at least in part – to the 19th century. The whole of Germany, including Bavaria, has witnessed a reduction in numbers, right down to the point of extinction, in those species that react sensitively to environmental changes or require large and complex habitats. Species that had adjusted to strong natural influences on their habitats, or to extensively used habitats characterized by man-made changes, have likewise suffered a reduction in numbers. There has also been a large-area loss of individual species characteristic of specific habitats (impoverishment of biocoenoses).

Definition: The indicator consists of two partial indicators: the partial indicator “red list species” shows the results of a review of Bavaria’s red-listed plant and animal species. It shows the share (in %) of non-endangered species of higher plants, vertebrates, molluscs, ants, locusts and dragonflies. No quantitative target value has yet been set for this partial indicator.

The partial indicator “special animal and plant species” describes a population figure for animal and plant species in relation to the target value of 100 % [index] in the reference year 2010. Depending on the species in question, the figure reflects a) the total population of that species in Bavaria b) its abundance in selected test areas, or c) a grid frequency, i.e. the ratio of the number of grid units (e.g. on a topographic map) populated by the species compared to the number of all the grid units in Bavaria. Thirty-three species were selected from a pool of over 60 species for which either a species support program exists in Bavaria or which are listed in Appendix II of the FFH [Flora-Fauna-Habitat] guidelines. This approach thus takes species-support-programmes and FFH-species aspects into account as well as the various types of habitat relevant in Bavaria; in addition, it covers the whole of Bavaria. Species selection is limited to those species for which information can be collected with reasonable effort and for which Bavaria has a special responsibility. To start with, seventeen species have been included. The target value was determined following structured surveys conducted by experts using the Delphi technique (birds) and interviews with individual species experts (other species).

Functional relationship: The indicator falls under the ESM category *Environmental media / biota.* As in the DPSIR classification, it is a *state indicator*.

Endangered plant and animal species react to changes in habitat factors that are defined primarily by specific habitat and landscape characteristics. Such changes in the environmental media *soil*, *water* and *biota*, which have habitat functions, can be traced back firstly to phenomena caused by *chemical* pollution (e.g. eutrophication). Habitat impairment is due secondly to s*tructural changes* (e.g. intensification of green-land use, disuse of bedding pastures and neglected grassland, groundwater drawdown in wetlands, and fragmentation) as well as disturbances (e.g. traffic and recreational noise). The environmental pressures mentioned here are caused predominantly by *agriculture and forestry*, *transportation* and *households*.

Documentation: The "red lists" are currently compiled under the management of the Bavarian Environmental Protection Agency [LfU] at intervals of approximately 10 years. Shorter periods for selected groups are planned. The LfU has commissioned monitoring projects for several of the "special species", and annual data will become available for some these. A partial re-orientation and expansion of these investigations will be necessary for the formation of a conclusive indicator.

Environmental goals: Both partial indicators – "red list species" and "special animal and plant species" – relate to the following goals listed in the Bavarian Nature Conservation Act [BayNatSchG] and the Bavarian Agenda 21:

- Protection of plant and animal species,
- Preservation of biodiversity.

Assessment: The "red lists" clearly reflect the mostly negative trend for species over the past decades. This partial indicator illustrates the trend as a reduction in the share of non-endangered species (corresponding to an increase in the share of endangered species). An improvement in the situation of "special species" is evident, which is probably mainly due to the protective measures introduced. For some species, however, the various attempts to improve the population are masked by other factors (e.g. eutrophication, climate).

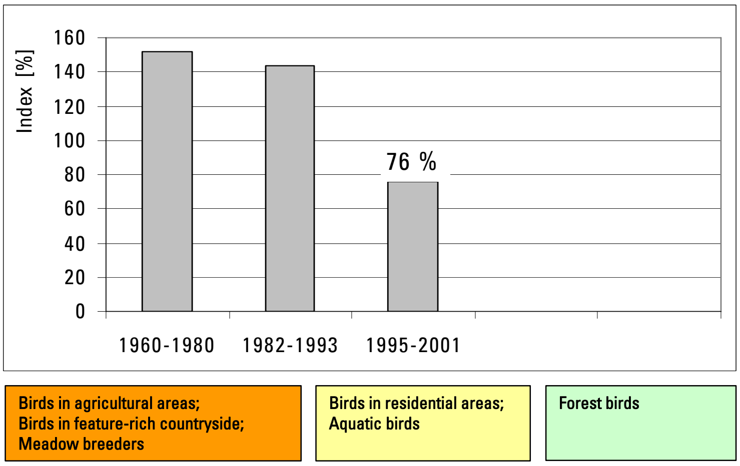
Future work: Detailed surveys are required for 16 additional species in order to make the "special species" partial indicator more informative.

Regionalisation: As regional "red lists" are only available for very few groups of animals and plants, and the endangered species come from a basket of species from various parts of Bavaria with different types of habitat, only a Bavaria-wide assessment makes sense.

Cross-state compatibility: An indicator of this type has not yet been suggested by the LIKI[1] Initiative. However, for animal and plant species that are already endangered, the "species endangerment" indicator is an important addition to the core environmental indicator "representative species". The red list is used in a comparable form in all other German states.

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Representative Species



Problems to be addressed

- Loss of species and ecosystems
- Degradation of ecosystems
- Accumulation of persistent substances

Regionalisation

May be possible for landscape units

Documentation

- Bavarian Environmental Protection Agency [LfU], some data annually since 1979
- Need for improvement: expansion of the indicator-related monitoring programme

Assessment

- The average population density of birds in non-protected areas has decreased by about half since the start of the 1960s
- This does not apply to forest birds, where numbers have remained stable or have increased (green); however, there has been a pronounced decrease in the numbers of birds in agricultural areas (red)

SPECIES DIVERSITY IN NON-PROTECTED LANDSCAPES – POPULATION TRENDS FOR REPRESENTATIVE BIRD SPECIES - [INDEX]

Problems to be addressed: Species diversity in non-protected areas is threatened by a continuous, large-area increase in anthropogenic land use. This includes the creation of water bodies, interference with vegetation, soil degradation and other structural changes, as well as the intensification of agriculture. The ecologically toxic effect of substances also impairs species diversity.

Definition: The indicator describes population trends for 61 selected bird species in a variety of habitats by way of an index. Examples include the middle spotted woodpecker for forests, the skylark for farmland, the greater whitethroat for feature-rich landscapes, the common redstart for residential areas, the whinchat for grassland and the great crested grebe for water bodies. To start with, structured surveys were carried out by experts using the Delphi method[1]. A target population was determined for each bird species for the selected reference year 2010. When numbers counted at the present time or at an earlier date are compared with the target population, an index (expressed in per cent) is obtained for each bird species. The index shown as indicator is the arithmetic mean of the individual indices.

Functional relationship: The indicator falls under the ESM category *Environmental media / biota*. As in the DPSIR classification, it is a *state indicator*.

It describes the reaction of species in non-protected areas to various environmental pressures. The bird species selected for the indicator react to changes in habitat factors, which are primarily defined by the specific character-

[1] Standard method used in empirical social research

istics of the habitat and landscape. Such changes in the environmental media *soil, water* and *biota,* which have habitat functions, can be traced back firstly to *structural changes* (e.g. intensive use of green land, fragmentation). Habitat impairment is due secondly to *chemical pollution* (e.g. pesticides, persistent substances with ecologically toxic effects). The environmental pressures mentioned here are caused predominantly by *transportation*, *agriculture*, *forestry* and *households* (construction of settlements, recreational activities).

Documentation: The indicator is currently based on the evaluation of comprehensive literature on breeding-bird population densities in Bavaria. Plans exist to standardize the indicator to a greater extent in future by including additional survey areas.

Environmental goals: The indicator relates to the qualitative goals “no further deterioration” and “increasing populations”, which derive from the environmental goals specified in the Bavarian Nature Conservation Act [BayNatSchG] and the Bavarian Agenda 21 “protection of plant and animal species” and “preservation of biodiversity”.

Evaluation: The population density of bird species representative of the various habitats has decreased by approximately half since the beginning of the 1960s, with the index for the period 1995-2001 at approximately 76 %. Different trends are apparent for different habitats. Whereas the numbers of forest birds have remained constant or even increased slightly (green box), the numbers of aquatic birds and birds in residential areas have either remained constant or show a slightly downward trend (yellow box). Birds in agricultural areas and feature-rich countryside, along with meadow breeders, mostly show a pronounced or slight decrease in numbers (red box).

Further development: The location of additional survey areas must be defined for this indicator.

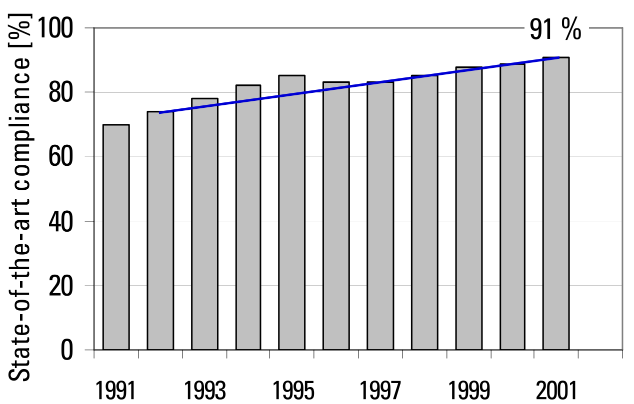
Regionalisation: Assessment of the indicator on a landscape-unit basis is conceivable, provided there is an adequate number of survey areas in the region concerned.

Cross-state compatibility: The LIKI[2] Initiative recommends “representative species” as a core indicator. In the interests of Germany-wide comparability, joint work has been done by the Bavarian Environmental Protection Agency [LfU] and other organizations to harmonise the methodology. Plans provide for state-specific selection of the species to be monitored.

[2] Cross-State Core-Indicator Initiative as per September 30, 2004

Ecosystems

Quality of Treated Wastewater



Problems to be addressed

- Impairment of aquatic ecosystems due to pollutant input
- Eutrophication and acidification
- Accumulation of persistent substances
- Pollution of bathing water

Regionalisation

- Very good regionalisation is possible, right down to administrative units and river basins in Bavaria.

Documentation

Bavarian Water Management Agency [LfW], annually

Assessment

- The efficiency of wastewater treatment plants in Bavaria (state- of-the-art compliance) is high. The trend is positive.
- Existing facilities must be maintained at their high performance level. Those few that are not state-of-the-art must be expanded and upgraded.

WASTEWATER DISCHARGES INTO SURFACE WATERS – STATE-OF-THE-ART COMPLIANCE AS REQUIRED BY § 7a OF THE FEDERAL WATER ACT [WHG] AND THE WASTEWATER ORDINANCE [AbwV] - [%]

Problems to be addressed: The habitat functions of water bodies are impaired by pollutant inputs from point and diffuse sources. These lead, for instance, to oxygen depletion, eutrophication and acidification processes, or have ecotoxicological effects on living organisms. The impacts on aquatic ecosystems include species displacement and loss of biodiversity. Toxic and persistent substances in discharges from industry and commerce can accumulate in water compartments (e.g. sediments) and in the food chain, thus impacting on aquatic ecosystems and human health. Microbial pollution puts limitations on the use of water for bathing.

Definition: The indicator is a measure of the extent to which point-source discharges from urban wastewater treatment plants and (as from 2005) direct discharges from industry and commerce into water bodies meet the state-of the-art requirements set forth under § 7a of the Federal Water Act [WHG]. All the parameters in the Waste Water Ordinance [AbwV] that are relevant to the particular discharge are taken into account. The indicator is determined as the quotient of the sum of the positive ratings and the total number of parameters evaluated for the discharge in question, and is expressed as a percentage [%]. It is measured annually.

***Functional relationship*:** The indicator falls under the ESM category *Activities / Supply and Disposal / Wastewater disposal*. As in the DPSIR classification, this is a *driving-force indicator* that reflects the effectiveness of policy measures.

Wastewater discharges, usually from urban wastewater treatment plants and direct-discharge trades and industries, are an important measurable variable in a pollutant analysis. The level of state-of-the-art compliance is a measure of the pollutants discharged into surface waters and is thus the all-important criterion for further reduction in pollutant inputs. It hence forms the basis for added improvement in the quality of water bodies (also in terms of the targets set forth in the EU Water Framework Directive).

The nutrients nitrogen and phosphorus are to some extent a cause for concern, and this issue needs to be addressed. Inputs of hazardous substances, heavy metals generally and organic compounds likewise need to be reduced.

Documentation: The source data is in the central database at the Bavarian Water Management Agency [LfW]. This data has been available for urban wastewater treatment plants for over 10 years. Although figures are also available for industry and commerce, systematic evaluation has so far been impossible due to incomplete reference data (pollutant-load requirements). As from 2005, the new wastewater/emissions program “UDIS-BY”, an element of the water industry’s internal data sharing system “INFO-Was”, will permit collection of the missing data.

The chart illustrates the situation for urban discharges only. The indicator will include all discharges for the first time in 2005.

By virtue of the ongoing updates procured through official monitoring of wastewater discharges by the local water authorities (which provides the basis for the levying of statutory water and wastewater charges) and the regular spot-checks or comparative evaluations by the Bavarian Water Management Agency [LfW], the data pool is of high quality and is very up-to-date.

Environmental goals: Wastewater discharges into water bodies are subject to a statutory permit. For a permit to be granted, at least the state-of-the-art requirements set forth in § 7 a of the WHG must be fulfilled. These are specified in detail in the AbwV and its annexes. Requirements from relevant EU directives have been included in this legislation (e.g. Urban Waste Water Treatment Directive 91/271/EEC, the “dangerous substances” Directive 76/464/EEC and its daughter directives, and the Integrated Environmental Pollution Prevention and Control [IPPC] Directive 96/61/EC).

In addition to discharge-quality targets, the EU Directives also contain time targets for fulfilment of these requirements. The Urban Waste Water Treatment Directive sets December 31, 1998 as the target for sensitive areas and December 31, 2005 for all treatment plants with an EW treatment capacity of 2000 and above. These deadlines have been met. Full implementation of the IPPC is envisaged for the relevant treatment plants by 2007, and will be effected in Bavaria as of October, 2007 by way of the Bavarian IPPC ordinance. The indicator serves to document the extent to which point-source emissions have been reduced.

Assessment: The efficiency of waste-water treatment plants in Bavaria is high, and the trend is positive. Existing facilities must be maintained at their high performance level. Those few that are not state-of-the-art must be expanded and upgraded.

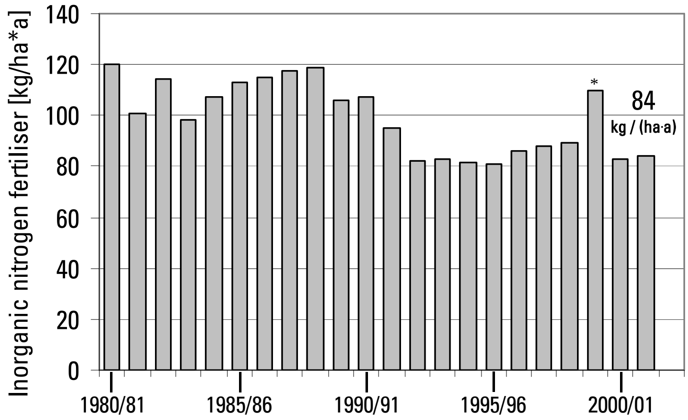
Future work: It might make sense to take the permit requirements (some of which are stricter than in the AbwV) of the individual discharger into account, or value creation / gross national product.

Regionalisation: The database is differentiated according to administrative units (e.g. regional governments, rural districts) and river basins in Bavaria, and is thus highly regionalised.

Cross-state compatibility: The LIKI[1] Initiative does not list this indicator as a core indicator.

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Fertiliser Use



Problems to be addressed

- Impairment of aquatic ecosystems due to chemicals input
- Eutrophication
- Drinking water quality

Regionalisation

Existing documentation does not permit regional differentiation.

Documentation

Bavarian State Ministry for Agriculture and Forestry [StMLF], annually

(Agricultural Report published every 2 years)

Assessment

- The use of mineral nitrogen fertilisers decreased markedly from 1988/89 to 1992/93.
- For the last 10 years there has been no discernible trend. The figure appears to be stagnant at approx. 80-85 kg/ha/a.
- *) Additional fertilisation to compensate for high precipitation

USE OF MINERAL NITROGEN FERTILISERS IN AGRICULTURE - [kg/ha/a]

Problems to be addressed: The habitat functions of water bodies are impaired by nutrient inputs. This eutrophication has impacts on aquatic ecosystems, e.g. species displacement and loss of biodiversity.

Most drinking water in Bavaria comes from groundwater. As human health could be impaired by excessively high nitrate levels[1] in drinking water, the water is closely monitored and numerous measures are implemented to guarantee compliance with statutory quality standards (see German Drinking Water Ordinance).

Definition: The indicator shows the average annual use of mineral nitrogen fertilisers in Bavaria, expressed as kg per hectare of farmland for the crop year in question [kg/ha/a].

***Functional relationship*:** Fertiliser use falls under the ESM category *Pressure Factors / Materials / Input materials*. As in the DPSIR classification, this is a *pressure indicator*.

Mineral nitrogen fertilisers are used in farming. The amount of fertiliser used is a measure of the intensity of agricultural activities. Excessive use of fertiliser by farmers causes it to enter surface waters – either by direct runoff or via the groundwater – where it can lead to eutrophication processes. On account of the transportation effect of water, impacts may also be felt far away (e.g. in lakes or the sea).

[1] Nitrate can be converted in the body into nitrite, which poses a danger especially to infants. Nitrite also promotes the formation of nitrosamines, which are suspected of having carcinogenic and mutagenic effects.

Documentation: Statistics have been available since 1938 and are published in the Agricultural Report by the Bavarian State Ministry for Agriculture and Forestry [StMLF]). The data quality is good and the form of presentation will be continued. The chart shows the figures for the last 20 years.

Environmental goals: A concrete target has not been set. The technical goal is continued reduction.

Assessment: Mineral fertiliser use decreased substantially from 1988/89 to 1992/93, both in terms of absolute quantities and in terms of the amount used per hectare of farmland. It now appears stagnant at approximately 80-85 kg/ha, with no discernible trend. The assessment is based on the trend shown over the last 10 years.

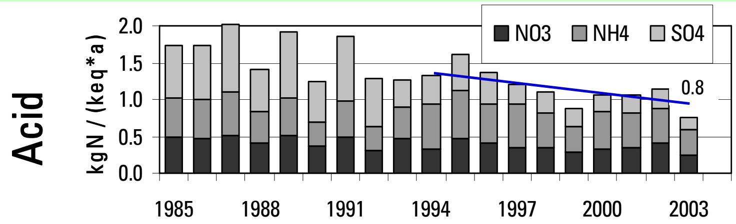
Future work: The potential emission of nitrogen compounds from farmland to the groundwater could prove a more target-relevant, response-related and communicable indicator, especially as nitrogen-fertilisation records are obligatory for all farm holdings. It will probably take a few years to obtain Bavaria-wide data that is sufficiently accurate to permit calculation of the "*nitrogen excess per hectare of farmland*". Until such time as this new indicator can be assessed reliably enough, the existing indicator "*fertiliser use*" will remain in use.

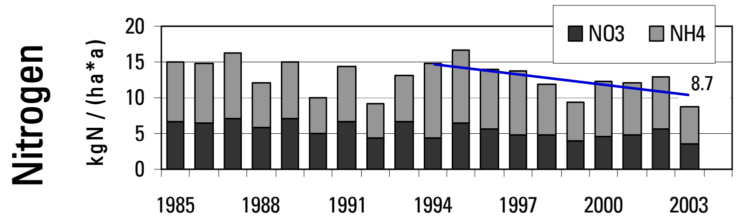
Regionalisation: The existing documentation (Agricultural Report) does not permit any regional differentiation for the indicator. However, regional assessments may be possible following introduction of the "nitrogen excess" indicator.

Cross-state compatibility: The indicator is used in international indicator systems (EU, OECD). The LIKI[2] Initiative favours "nitrogen excess" as an indicator and recommends further work on this indicator.

[2] Cross-State Core-Indicator Initiative as per September 30, 2004

Acid and Nitrogen Input





NO_3 | NH_4 SO_4

Problems to be addressed

Eutrophication and acidification

Regionalisation

Large-area regionalisation only (NW, NE, central, SW and SE Bavaria)

Documentation

Bavarian Environmental Protection Agency [LfU], annually

Assessment

- Acid and nitrogen input has decreased significantly over the past 10 years; the same applies to NH_4 and SO_4; no discernible trend for NO_3
- Official pollution limits are still being exceeded.
- Additional emission-reducing measures are needed.

ACID AND NITROGEN INPUT TO SEMI-NATURAL UNFORESTED ECOSYSTEMS FROM THE ATMOSPHERE [keq/ha/a] AND [kg N/ha/a]

Problems to be addressed: An excessive supply of nutrient and acid-forming substances leads to changes in chemical and biological soil parameters. These changes influence the vegetation and can cause changes in nitrogen and acid-sensitive ecosystems.

Definition: The indicator describes nitrogen and acid input to semi-natural unforested areas. *Nitrogen input* [kg N/ha/a)] comprises nitrogen in the form of nitrate (NO_3) and ammonium (NH_4), which are soluble in the collected rainwater. *Acid input* is determined via the amounts of dissolved sulphate (SO_4), ammonium and nitrate, calculated as the potential acid input from wet deposition and expressed as keq/ha/a; base cations that mitigate acidity are not taken into account. The term "deposition" as used here refers to the wet and dry deposition that can be measured in open, bulk collectors. It thus represents only part of the total deposition, since moist precipitation (e.g. fog) and some of the dry deposition (e.g. airborne dust) are not included. The mean annual totals are currently based on data from 9 semi-natural unforested locations.

Functional relationship: The indicator falls under the ESM categories *Environmental media / Soil* and *Water*. As in the DPSIR classification, this is a *status indicator*. It describes substance inputs from the atmosphere to these media. The inputs are influenced by *pressure factors in the form of waste gases and input materials (e.g. nitrogen oxides, sulphur dioxide, liquid manure, fertilizers)*, which mainly originate from *agricultural, industrial and transportation activities. Impacts* are eutrophication and acidification of *ecosystems.* The process of eutrophication is attributable to ammonium and nitrate inputs. Ammonium is formed from ammonia that is released, for example, as a consequence of animal husbandry (liquid manure). Nitrate is formed in the atmosphere from nitrogen oxides emitted from various sources, primarily motorized traffic; it also enters the atmospheric circulation as a result of soil erosion processes following the spreading of fertiliser. Eutrophication causes plants that are competitive only in locations with a low nutrient level to be displaced by nitrofilous species. Biotopes such as neglected grasslands and wetlands, with their unique plant and animal communities and their water and climate protection functions, are endangered. The acidifying components are sulphate, ammonium and nitrate. Sulphur dioxide, a precursor of sulphate, originates mainly from the combustion of fossil fuels. The detrimental changes to the soil that result from acidification affect the soil's chemical properties and its micro-fauna. Existing vegetation is damaged and the impacts resemble those of eutrophication.

Documentation: Deposition data is collected annually by the Bavarian Environmental Protection Agency [LfU] at monitoring stations that are part of a Bavaria-wide network.

Environmental goals: The reduction targets are based on the "critical loads approach" used by the German Environmental Agency [UBA] and the UN-ECE. Critical loads are the maximum pollutant loads that ecosystems can tolerate without being damaged. For unforested areas in Bavaria, they are mainly between 5 and 10 kg N/ha/a (in a few locations below 5 kg N/ha/a) and 0.5 keq acid/ha/a (in some locations, below). The most important target at present is to reduce total inputs to below 10 kg N/ha/a and 0.5 keq/ha/a; the long-term target is an input of less than 5 kg N/ha/a and a further reduction in acid input. Reduction in the pollutant loads caused by the partial deposition described here to below these limits is a minimum requirement only.

Assessment: Assessment is based on the critical load values and the 10-year input trend. Data collected earlier has not been included in the trend analysis. This permits continuous adjustment of the trend to reflect the latest developments, thus making it possible to monitor the effectiveness of environmental policy measures. The individual trends for ammonium, nitrate and sulphate inputs are evident from the entries in the red, yellow and green boxes. The red box signalizes an upward trend, the green box a downward trend and the yellow box an indiscernible trend.

During the 10-year period under review (1994–2003), both acid and nitrogen inputs fell significantly but still exceed the above-mentioned limits. This downward trend is attributable predominantly to SO_4 and (to a lesser extent) also NH_4. NO_3, by contrast, shows no discernible trend.. Measures to further reduce emissions are necessary .

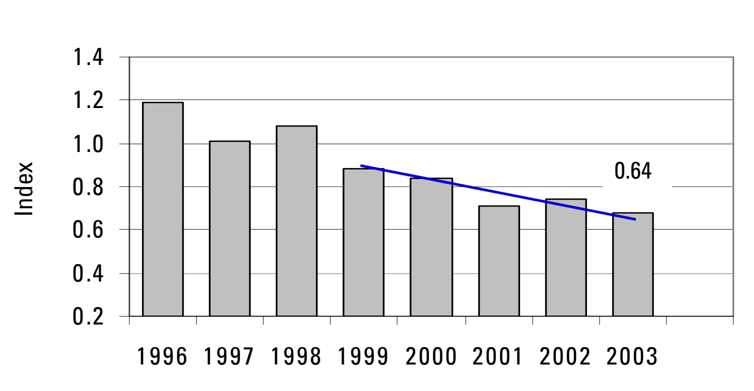
Future work: The target figures originate from the literature and from maps of Bavaria. Surveys of sensitive ecosystems and the determination of their critical loads should be completed. The annual totals are currently based on 9 LfU measuring locations; these should be compared with data from other authorities (e.g. the Bavarian Water Management Agency [LfW]) and amended where necessary. Pollution of forest ecosystems must be included in the indicator; to this end, deposition data must also be collected for the tree population.

Regionalisation: Regionalisation of the information is currently only possible on a large-area basis (NW, NE, central, SW and SE Bavaria). A denser network of monitoring stations would permit a higher degree of regionalisation.

Cross-state compatibility: The LIKI[1] Initiative has voiced a need for a Germany-wide core indicator to monitor the problems of eutrophication and acidification. It suggests "acid and nitrogen input" as indicator. This should be used as a basis for further activities, which should also incorporate the UBA's critical loads approach.

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Heavy Metal Input



Al Cd Co Cr Cu Fe Mn Ni Pb Ti Zn

As Sb V

Problems to be addressed

- Input and accumulation of persistent substances in water, soil and biota
- Risks to ecosystems and human health

Regionalisation

Large-area regionalisation only (NW, NE, central, SW and SE Bavaria)

Documentation

Bavarian Environmental Protection Agency [LfU], annually

Assessment

- The heavy metal index has decreased significantly over the past 5 years.
- The indices for As, Sb and V are decreasing (green), while the other pollutants currently show no discernible trend (yellow); no single index is increasing (red).

HEAVY METAL INPUT INTO SEMI-NATURAL UNFORESTED ECOSYSTEMS FROM THE ATMOSPHERE - [INDEX]

Problems to be addressed: As only persistent substances accumulate permanently in the environment and spread ubiquitously, persistence is a focal criterion for assessing the ecotoxicity of substances (preventive measures).

Definition: A substance is persistent if it resists all degradation processes or is eliminated only very slowly or not at all from the natural material cycles. Persistent substances can be divided into two groups: persistent organic pollutants (POPs) and metals, including certain compounds. The metal input to the environment can be determined with relatively simple methods but there are no comparable methods available for POPs. For this reason, the indicator is currently limited to metals. The index is the arithmetic mean of the indices for the individual elements, calculated from the input threshold values (upper statistical limit of background content) for the metals Al, As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, Sb, Ti, V, Zn. The baseline used to calculate the indices for the individual elements is the mean threshold value for the element in question over the five-year period 1996-2000 (Index = 1). The database comprises values for total atmospheric deposition (wet and in the form of dust measured in µg/m²d with a Bergerhoff gauge conforming to the VDI[1] dust-monitoring standard 2119/2), measured in open spaces that are not directly affected by emissions. The results are therefore transferable to semi-natural unforested ecosystems.

Functional relationship. The indicator falls under the ESM categories *Environmental media / Water*, *Soil* and *Biota*. As in the DPSIR classification, this is a *state indicator*. The indicator is influenced by the *pressure factor*

[1] Association of German Engineers

"pollutants in waste-gas emissions". These are released into the environment by various *activities* in *industry* and *commerce*, *supply and disposal*, *transportation* and *households*. Combustion processes and abrasion (e.g. brake linings) are often the cause. Metal emissions enter the atmosphere in metallic form, as chemical compounds or, in some cases (mercury), as gas. They are usually bound to aerosols, and are transported away from the emission source over a distance determined by particle size. Sedimentation and wet precipitation lead to the deposition of metals and to accumulation in terrestrial and aquatic habitats. The metals can accumulate in biotic matrices and disrupt physiological processes. The impacts are effects on ecosystems. Risks to human health may arise via the food chain.

Documentation: Data is collected by the Bavarian Environmental Protection Agency [LfU] at long-term pollution-input monitoring stations. The 6 monitoring stations in Bavaria reflect the "background" pollution for the region in question. Data is collected every 4 weeks and summarized annually.

Environmental goals: Quantified environmental goals in the sense of ecological pollution limits, e.g. according to the Critical Loads and Levels approach, do not yet exist. This approach is currently under discussion at the German Environmental Agency [UBA] (see UBA-FB 297 73-011). With regard to possible ecotoxicological pollutant interactions and the long-term effects thereof (prevention measures conceivable), the goal here is to avoid an increase in the heavy metal index. The current background pollution levels are not known to have any acutely harmful effects.

Assessment: Assessment is currently based on the input trend for the last 5 years, as data for a 10-year trend is not yet available. Data collected earlier will still be presented in future but will not be included in the trend analysis. This will permit continuous adjustment of the trend to reflect the latest developments, thus making it possible to monitor the effectiveness of environmental policy measures. The temporal trends shown by the indices for the individual elements are evident from the entries in the red, yellow and green boxes: red = individual trend rising, yellow = no discernible trend, green = individual trend falling. The assessment is altogether positive, since the overall index falls significantly. The individual indices for As, V and Sb show a downward trend. The remaining heavy metals currently show no discernible trend (yellow). No single index is rising (red).

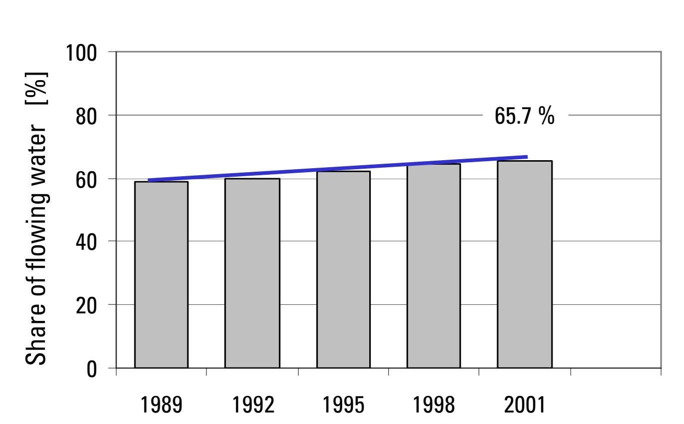
Future work: In future, POPs as well as metals should be included in the index. The index should additionally be extended to include indices on forest ecosystems, thus taking into account the special precipitation and accumulation conditions that prevail in these ecosystems. POPs input to managed land, too, (silviculture and agriculture, e.g. pesticide use, mineral fertilisers containing heavy metals) is of substantial importance for ecosystems and human health. Partial indicators need to be developed specifically for these inputs.

Regionalisation: Regionalisation of the information is currently only possible on a large-area basis (NW, NE, central, SW and SE Bavaria). A denser network of monitoring stations would permit a higher degree of regionalisation.

Cross-state compatibility: The LIKI[2] Initiative has voiced a need for a cross-state "heavy metal input" core indicator. The indicator described here should be used as a basis for further work.

[2] Cross-State Core-Indicator Initiative as per September 30, 2004

Water Quality



Problems to be addressed

- Impairment of ecosystems through pollutant input and waste heat
- Eutrophication and acidification

Regionalisation

Yes, by class of water (see assessment)

Documentation

Bavarian Water Management Agency [LfW], annually

Assessment

- The share of flowing water in quality class II or better continues to rise in Bavaria: in 2001, it was almost two thirds; in 1973, it was only 50 per cent.
- Quality classes I and I-II dominate in Alpine and Alpine foothill areas, the Bavarian Forest and the Franconian Forest, class II south of the river Danube and east of the river Regnitz and class II-III in the Keuper region west of the Regnitz.

BIOLOGICAL WATER QUALITY (SAPROBIC STATUS, MACROINVERTEBRATES) – SHARE OF FLOWING WATER WITH WATER QUALITY CLASSES "UNPOLLUTED" TO "MODERATELY POLLUTED" - [%]

***Problems to be addressed**:* The habitat functions of water bodies are impaired by pollutant inputs and waste heat. These lead especially to eutrophication processes and oxygen depletion, and may also have ecotoxicological effects on living organisms. The impacts on aquatic ecosystems include species displacement and loss of biodiversity.

Definition: The biological water quality (assessed according to the saprobic system) provides information on the quality status of flowing water, i.e. its pollution with biologically degradable organic substances. The occurrence of selected aquatic organisms is measured at the sampling sites. A saprobic index is then determined, which is based on the abundance of the existing species and specific saprobic scores. The index, together with the physiographic conditions, is used to allocate a quality class to the water. The classes range from I to IV, with three intermediate levels; there is thus a total of 7 quality classes. The graph shows the percentage of river/stream sections with quality classes I ("unpolluted to very slightly polluted"), I-II ("slightly polluted") and II ("moderately polluted"). The percentage share relates to the total length of the river/stream network.

***Functional relationship*:** Flowing-water quality falls under the ESM category *Environmental media / Water / Flowing Water*. As in the DPSIR classification, this is a *state indicator*. The quality status of the water is influenced by inputs of degradable organic substances, waste water and waste heat. Inputs to flowing water are caused by a wide variety of anthropogenic activities. Discharges from urban or industrial wastewater treatment plants are a typical example. Relevant waste-heat input is caused, for example, by the cooling processes used in the energy industry. Nutrients enter flowing water from both point and diffuse sources.

Documentation: Biological water-quality assessments are carried out annually at the ± 100 principal monitoring sites of Bavaria's "water-quality-status" monitoring network. These assessments are supplemented at intervals of several years by biological mapping, which also encompasses smaller rivers and streams. Data has been collected since about 1970 - since 1989 every three years – and is shown in the "saprobic-status" water-quality map.

Environmental goals: The primary goal is an increase in the share of flowing water in quality classes I, I-II or II (unpolluted to slightly polluted, slightly polluted and moderately polluted) from one survey to the next. The progress is documented every three years in Bavaria's water-quality map.

Assessment: The share of Bavaria's flowing-water network in quality class II or better has risen continuously since 1973. In 2001 it was 65.7 %, compared with only 50 % in 1973. Indicator assessment is based on the change in quality status as measured throughout Bavaria every three years.

Future work: "*Water quality*" is a traditional sustainability indicator that is easily communicated. Today, it reflects a drop in the need for action because targets have largely been met. The substantial improvements in waste-water treatment have resulted in a pronounced drop in the organic pollutant load in much of Bavaria's flowing water. As a result, other factors that influence water quality often play a greater role. For instance, diffuse-source water pollution, especially by nutrients, has increased in importance for the assessment of water quality. The increase in nutrient content above natural levels, i.e. eutrophication, leads to an increase in plant growth; sluggish water is particularly affected by this. In order to monitor the nutrient situation in flowing water, the trophic status has therefore been assessed – by means of suitable plant indicators – for a number of years as well. The "trophic status" could also be used as an indicator.

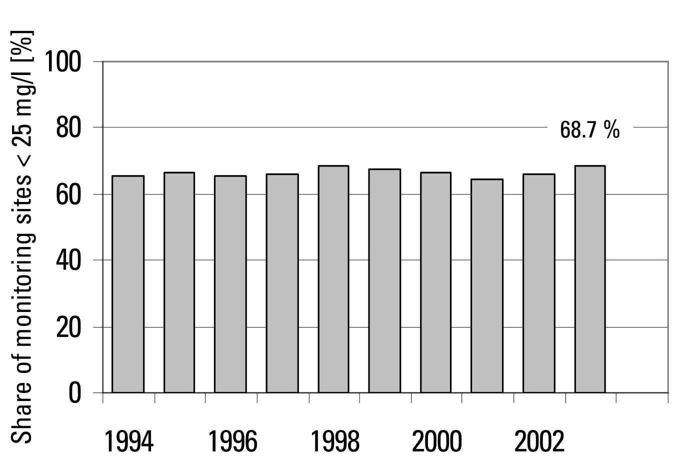
The ecological and chemical status of flowing water pursuant to EU-WFD may in future serve as target-oriented and easily communicable indicators, but initial assessment as provided for in the WFD is not anticipated before 2006. The condition of the ecosystem "surface water" comprises biological, physico-chemical and hydromorphological components.

Regionalisation: The indicator can be regionalised by class of water. The share of flowing water in quality class I or I-II is particularly high in Alpine and Alpine-foothill regions, as well as in Bavaria's forested highlands (Bavarian and Franconian forests and the Spessart area). Quality class II dominates south of the river Danube and east of the river Regnitz. By contrast, quality class II-III (critical pollution levels) dominates in the often sluggish waters of the dry Keuper region west of the Regnitz.

Cross-state compatibility: The LIKI[1] Initiative has suggested "water quality" as a core indicator. The data collection process has been agreed by all the Federal states, thus permitting cross-state comparisons despite methodical differences.

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Nitrate in Groundwater



Problems to be addressed

- Impairment of aquatic ecosystems due to nutrient input
- Eutrophication
- Drinking water quality

Regionalisation

Yes, for example, according to climate, soil conditions and land use (see Assessment)

Documentation

Bavarian Water Management Agency [LfW], annually

Assessment

- No discernible trend during the assessment period (10 years)
- The rainy south, with its extensive grassland farming, is less affected than Northern Bavaria, which has light, shallow soils.

NITRATE IN GROUNDWATER - SHARE OF EEA- NETWORK MONITORING SITES WITH NO_3 < 25 g/l [%]

Problems to be addressed: The habitat functions of water bodies are impaired by nutrient input. This eutrophication has impacts on aquatic ecosystems, e.g. species displacement and loss of biodiversity.

Most drinking water in Bavaria comes from groundwater. As human health could be impaired by excessively high nitrate levels[1] in drinking water, the water is closely monitored and numerous measures are implemented to guarantee compliance with statutory quality standards (see the German Drinking Water Ordinance). Low levels of precipitation are detrimental because nitrates in the groundwater are only slightly diluted. The situation is exacerbated by light or shallow soils. Northern Bavaria is thus more strongly affected than the rainy south, with its extensive grassland farming. No region, however, is completely free of nitrate pollution.

Definition: The EEA monitoring network (EEA: *E*uropean *E*nvironmental *A*gency) includes some of the monitoring sites within the Bavarian groundwater-quality monitoring network. The chart shows the percentage share of a group of 147 of these sites, for which nitrate has been measured annually for over 10 years, with a mean nitrate content below 25 mg/l.

Functional relationship: Nitrate pollution of groundwater falls under the ESM category *Environmental media / Water / Groundwater.*

[1] Nitrate can be converted in the body into nitrite, which poses a danger especially to infants. Nitrite also promotes the formation of nitrosamines, which are suspected of having carcinogenic and mutagenic effects.

As in the DPSIR classification, this is a *state indicator.*

In addition to release following the ploughing of grassland, land clearing and deforestation, excessively high nitrate levels in the groundwater are caused by material input, particularly from agricultural land use (e.g. nitrogen fertilisers). Aerated groundwater that is close to the surface usually has a natural nitrate content of 10 to 15 mg per litre. Nitrate contents above 25 mg per litre are a definite indication of strong anthropogenic influence. The *nitrate load in the groundwater* is thus an indicator for anthropogenic influences on the groundwater.

Groundwater nitrate can also enter the surface water, where it can lead to eutrophication processes. On account of the transportation effect of water, impacts may also be felt far away (e.g. in lakes or the sea).

Documentation: Data is usually collected twice yearly by the local water boards, and reliable data will remain available in future.

Environmental goals: Strong anthropogenic influence must be assumed as from nitrate levels of 25 mg per litre of groundwater. The environmental goal in this case is a substantial reduction in groundwater nitrate content.

Assessment: Assessment takes the form of a ten-year trend analysis. Since nitrate levels are strongly affected by annual differences in groundwater renewal, an informative trend is only obtained when changes are pronounced and long-term. The share of monitoring sites with nitrate levels of less than 25 mg/l is ± 67 %.

Future work: For groundwater, state indicators such as nitrate pollution are necessary in order to document long-term system trends. However, because groundwater responds slowly, such indicators are unsuitable if the causes are to be controlled as soon as possible. To this end, pressure indicators (see fertiliser use) must be used in addition.

During the next few years, it should be possible to develop a "nitrogen excess per hectare of farmland" indicator based on the records that farm holdings are now obliged to keep.

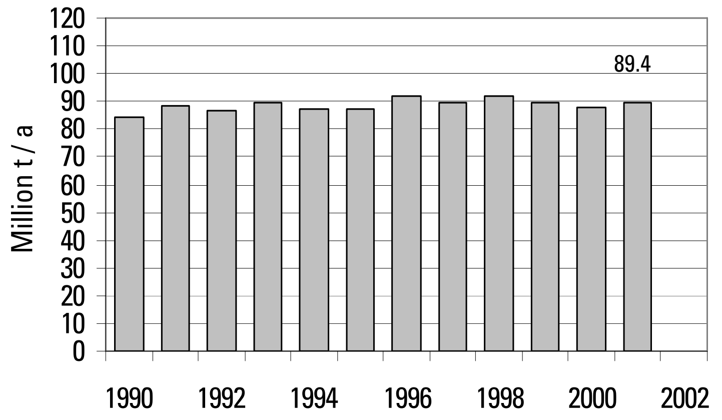
Regionalisation: The indicator can be regionalised according to climate, soil conditions and land use.

Cross-state compatibility: The LIKI[2] Initiative has suggested "groundwater nitrate content" as a core indicator. In the interests of Germany-wide comparability, the EEA monitoring sites have been agreed as data-collection sites. As an additional component, the indicator will include the share of monitoring sites with a mean nitrate content below 50 mg/l.

[2] Cross-State Core-Indicator Initiative as per September 30, 2004

Climate and health

Carbon Dioxide Emissions



Problems to be addressed

Anthropogenic climate changes with impacts on ecosystems and economic sectors

Regionalisation

Currently impossible due to lack of data, but desirable in principle

Documentation

Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology [StMWVT], annually

Assessment

- No discernible trend during the assessment period
- Additional preventive measures are necessary.

ENERGY-RELATED CARBON DIOXIDE EMISSIONS [MILLION T /A]

Problems to be addressed: The anthropogenic greenhouse effect is a global problem with regional causes and impacts. On account of the rise in concentrations of the 6 greenhouse gases (CO_2, CH_4, N_2O, H-fluorohydrocarbons, fluorohydrocarbons and SF_6) in the atmosphere, temperature increases between 1.4 and 5.8 K by the year 2100, a rise in sea level between 10 and 90 cm, a change in global and regional precipitation and an increase in extreme weather events are forecast[1]. These climate changes impact on ecosystems as well as society and the economy.

Definition: Annual energy-related CO_2 emissions in Bavaria are calculated from the energy consumption data by means of specific CO_2 emission factors. The clearly documented (source-based) calculation process is carried out in the manner agreed by the cross-state “energy calculations” working group. The CO_2 emission factors are defined for the individual fuels by the German Environmental Protection Agency and are applicable throughout Germany.

***Functional relationship*:** CO_2 emissions fall under the ESM category *Pressure factors / Materials / Waste gases.* As in the DPSIR classification, this is a *pressure indicator.*

The amount of CO_2 emitted annually in Bavaria accounts for less than 0.5 % of global CO_2 emissions; hence there is no quantifiable connection with the problem of climate change. As a result, it is not possible to draw any conclusions about actual climate changes from increasing or decreasing CO_2 emissions in Bavaria. On a global scale, however, energy-related

[1] 3rd Progress Report by the “Intergovernmental Panel on Climate Change” (IPCC), 2001

CO_2 emissions account for more than 50 % of the anthropogenic greenhouse gas emissions. In Bavaria, the figure is around 87 %, indicating the key role played by carbon dioxide. CO_2 emissions must be reduced in Bavaria for preventive reasons. Bavarian CO_2 emissions originate from the following sectors: transportation (37 %), households and small consumers (33 %), energy producers (18 %) and industry (12 %)[2].

Documentation: Energy-related CO_2 emissions are calculated by the Bavarian State Office for Statistics and Data Processing [LfStaD] from the energy consumption data, using specific CO_2 emission factors. The consumption data is collected by the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology [StMWVT]. High-quality CO_2-emissions data is thus available annually from the LfStaD, and reliable data will remain available in future.

Environmental goals: In its climate-protection strategy paper, the Bavarian government adopted the target of reducing CO_2 emissions to 80 million t/a by the year 2010.

The United Nations Framework Convention on Climate Change (UNFCCC) was signed in 1992 at the Rio "Earth Summit". The UNFCCC environmental quality goal is stabilisation of greenhouse gases at a level that prevents disturbance of the climate system. In 1995, the German government set the national climate-protection goal of reducing CO_2 emissions by 25 % (compared to 1990) by the year 2005. On the basis of the 1997 Kyoto protocol and "burden sharing" among EU Member States, Germany is obliged to curb greenhouse-gas emissions (Kyoto gases) by 21 % (compared to 1990) by the end of the period 2008 – 2012.

Assessment: Assessment takes the form of a ten-year trend analysis. CO_2 emissions show no discernible trend during the assessment period. Recognizable fluctuations are mainly caused by weather influences, fluctuations in energy prices and in the economy, and the associated variations in energy consumption by individual sectors. To achieve the Bavarian target of 80 million t/a by 2010, further measures for curbing CO_2 emissions are necessary.

Future work: As an alternative to the annual statistics on CO_2 emissions, other indicator systems express annual greenhouse-gas emissions (CO_2, CH_4, N_2O, H-fluorohydrocarbons, fluorohydrocarbons and SF_6) in CO_2 equivalents. The documentation for these emissions does not currently allow the formation of a Germany-wide environmental indicator. In Bavaria, however, where carbon dioxide accounts for 87 % of these gases and hence plays a key role, CO_2 emissions currently suffice as a pressure indicator for the anthropogenic greenhouse effect.

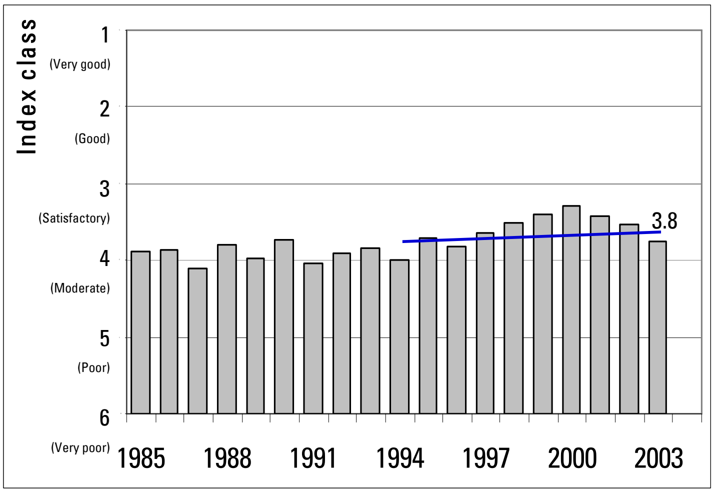
Regionalisation: Although desirable in principle, regionalisation is currently impossible due to a lack of available data.

Cross-state compatibility: The LIKI[3] Initiative has suggested "carbon dioxide emissions" as a core indicator. To permit cross-state comparability, an adjustment mechanism to reflect the different numbers of inhabitants is planned.

[2] Bavarian Energy Report 2001/2002, The Bavarian Ministry for Economic Affairs, Infrastructure, Transportation and Technology

[3] Cross-State Core-Indicator Initiative as per September 30, 2004

Air Quality Index



Problems to be addressed

- Impairment of health; short-term effects of air pollutants NO_2, SO_2, CO, O_3 and PM_{10}
- Impairment of ecosystems; eutrophication, acidification, ground-level ozone

Regionalisation

Yes, by conurbations and rural regions

Documentation

Bavarian Environmental Protection Agency [LfU], annually

Assessment

- Slight improvement in air quality during the assessment period (10 years) with regard to short-term effects
- At this point in time, class 3 (satisfactory) and class 4 (moderate) dominate.

SHORT-TERM AIR QUALITY INDEX FOR AIR POLLUTANTS NO_2, SO_2, CO, O_3, AND PM_{10} - [INDEX CLASS]

Problems to be addressed: Even the short-term effects of elevated concentrations of the indexed air pollutants can lead to impairment of human health. The transport of the pollutants NO_2, SO_2 to sensitive, semi-natural habitats and their deposition there causes acidification and eutrophication processes, which can have negative impacts on the ecosystems.

Definition: The short-term air quality index (AQI) is an aggregated indicator based on individual measurements for the following air pollutants: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), ozone (O_3) and the PM_{10} fraction of airborne dust. The pollutant concentrations measured at selected stationery monitoring stations are grouped daily into one of 6 index classes based on the school grading system. The index classes for each of the 5 air pollutants are based on epidemiological and toxicological studies as well as the EU limits specified in the daughter directives of the Air Quality Framework Directive 96/62/EC. The short-term air quality index is defined as the highest index value assigned to any one of the individual pollutants. The annual average of the daily air quality indices determined according to this method serves as the environmental indicator.

***Functional relationship*:** The air quality index falls under the ESM category *Environmental media / Atmosphere / Air pollution.* As in the DPSIR classification, this is a *state indicator.*

The indicator is influenced by the incidence of the air pollutants NO_2, SO_2, CO, O_3 and PM_{10}. The air quality in rural areas, conurbations and cities is determined by different pollutants. Urban areas with heavy traffic are affected by high levels of nitrogen dioxide and airborne dust from vehicle emissions. In rural areas with little traffic, by contrast, it is primarily ozone levels that determine the air quality. The main sources of the pollutants included in the air quality index are road traffic, domestic heating systems, industry, power plants and co-generation stations. Quantified information on the shares of the indexed pollutants emitted by individual sectors in Bavaria is available from the emissions register. In 1996, traffic was the cause of 75 % of the NOx emissions and 41 % of the PM_{10} emissions.

Documentation: Data is collected by the Bavarian Environmental Protection Agency [LfU] by means of the Bavarian Air Quality Monitoring System. It is made available on a daily basis, and an annual average is determined as indicator. It has been possible to create time series since 1985.

Environmental goals: The specialist view is that additional air pollution abatement measures should, in the long term, improve the Bavarian air quality index. The Federal Government's target of reducing NO_x emissions by 60 %, SO_2 emissions by 90 % and VOC emissions by 69 % (compared with 1990 levels) by the year 2010 underscores this assumption.

Assessment: Assessment takes the form of a trend analysis for the last 10 years. In terms of the short time effects[1] of the relevant pollutants, a slight improvement in air quality in Bavaria is evident. The data underlying this trend is especially indicative of traffic-related pollution (e.g. PM_{10}) in city centres. Annual fluctuations are due primarily to meteorological influences on summer ozone levels and variations in PM_{10} pollution. At the present time, the daily air quality index is mostly in classes 3 (satisfactory) and 4 (moderate). Further measures are necessary to improve the air quality (see air pollution abatement planning).

Regionalisation: Regionalisation is theoretically possible. Since the air quality index in rural areas is affected by different pollutants than in densely populated areas, statistics could be regionalised accordingly.

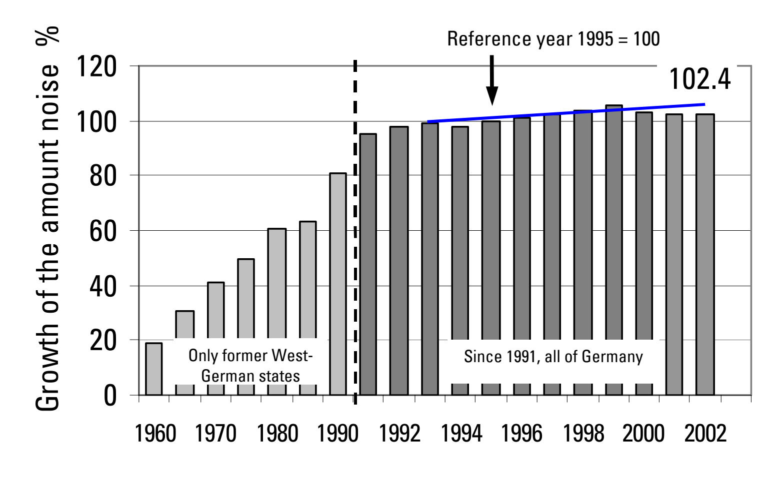
Future work: A long-term air quality index is planned in addition to the short-term AQI. The long-term AQI will focus on the long-term impacts of the air pollutants nitrogen dioxide, sulphur dioxide, carbon monoxide, ozone and the PM_{10} fraction of airborne dust, and also of the carcinogenic air pollutants diesel soot and benzene.

Cross-state compatibility: The LIKI[2] Initiative favours an aggregate core indicator to describe air quality (air quality index), which takes the relevant air pollutants into account. Useful existing approaches are currently being discussed in pollution control committees.

[1] Long-term effects: see section "Future work"

[2] Cross-State Core-Indicator Initiative as per September 30, 2004

Road Traffic Noise



Problems to be addressed

Impairment of health by noise

Regionalisation

The data currently in use applies to the whole of Germany; regionalisation will be possible as from 2007, when the EU "ambient noise" directive is implemented.

Documentation

German Federal Ministry of Transport and Guideline RLS-90, annually

Assessment

- Five-fold noise increase since 1960; increase in road traffic noise during the assessment period (10 years) still significant; highest level to date in 1999; slightly lower figures in the three subsequent years
- Headline indicator

GROWTH IN ROAD-TRAFFIC-RELATED NOISE POLLUTION - [%]

Problems to be addressed: The individual need for mobility and the transport requirements of commercial activities have led to a constant rise in traffic volume over the past few decades, especially in road traffic, and hence to a constant increase in noise pollution. The resulting noise burden for the population is accompanied by physical reactions, in particular stress reactions, which can cause long-term health damage.

Throughout Germany, road traffic is by far the main cause of noise pollution as a whole. These noise emissions affect the whole of Bavaria, and like elsewhere, they are spread much more evenly than other noise sources. Accordingly, the noise pollution will not decrease unless road traffic noise is reduced. This means that an indicator for road-traffic noise is highly suitable for reflecting the change in noise burden on the population in their residential areas, and that it may be viewed as a leading or headline indicator.

Definition: The outdoor noise burden depends on the average emission patterns of the vehicles E_i and on the total distance they drive G_i. To obtain the indicator, these two variables are multiplied. The relative energetic noise level B_i (compared with the year 1995 = 100 %) can be described as follows for year i:.

$$B_i = \frac{E_i}{E_{1995}} \cdot \frac{G_i}{G_{1995}} \cdot 100\ \%$$

The total distance travelled in Germany, G_i, can be looked up in billions of kilometres for the year i in the Federal traffic ministry's paperback "Traffic in Figures." This reliable data source has been published since 1960. Vehicle noise emissions are defined by the German Guideline RLS-90 (previous version RLS-81) on the basis of the emission level $L_{m,E}$ (which reflects the average emission patterns) as $E_i = 10^{0.1(Lm,E)i}$, where $(L_{m,E})_i$ is the $L_{m,E}$ for the year i. So far, there has been no change in the RLS-90 emission level $L_{m,E}$. Given the rising traffic volume, reducing E_i is the all-important technical opportunity to curb noise pollution.

Functional relationship: The indicator falls under the ESM category *Pressure Factors / Noise.* As in the DPSIR classification, this is a *pressure indicator.*

It describes the noise pollution caused by road traffic and is the headline indicator for the protected concept of "peace". People conceive sound as noise when they are consciously or unconsciously disturbed by it. Both humans and animals can be affected in the areas where they live and during rest/sleep periods. The deleterious effects of noise increase with growing levels, and the proportion of people who feel disturbed or are objectively burdened by the noise rises. The impairment of sleep is particularly damaging. Stress reactions occur and the risk of cardiovascular diseases increases.

Documentation: The indicator is characterised by good data quality. The total distance travelled each year can be looked up in the Federal traffic ministry's paperback "Traffic in Figures." This reliable data source has been published since 1960. Vehicle noise emissions are defined by the German Guideline RLS-90 (previous version RLS-81) on the basis of the emission level $L_{m,E}$, which reflects the average emission patterns. In Bavaria, G_1 data on road traffic volume is not available. However, the Federal data is currently sufficient for analysing trends in Bavaria. The data is updated annually.

Environmental goals: To achieve a long-term reduction in the total noise pollution for the population in residential areas to 65 dB(A) or less during the day and 55 dB(A) or less at night, and to preserve and extend quiet areas with noise levels of 50 dB(A) and less during the day, a trend reversal and a reduction in road traffic noise are necessary.

Assessment: Road traffic noise pollution is more than 5 times higher today than it was in 1960. An analysis of the trend over the past ten years provides an up-to-date assessment. As is evident from the chart, the increase in noise over this period remains significant. The highest level to date (105.8 %) was reached in 1999. Effective technical measures can be implemented to curb noise, starting with reductions in tyre and engine noise. To this end, all state-of-the-art solutions must be exploited. Potential still exists here.

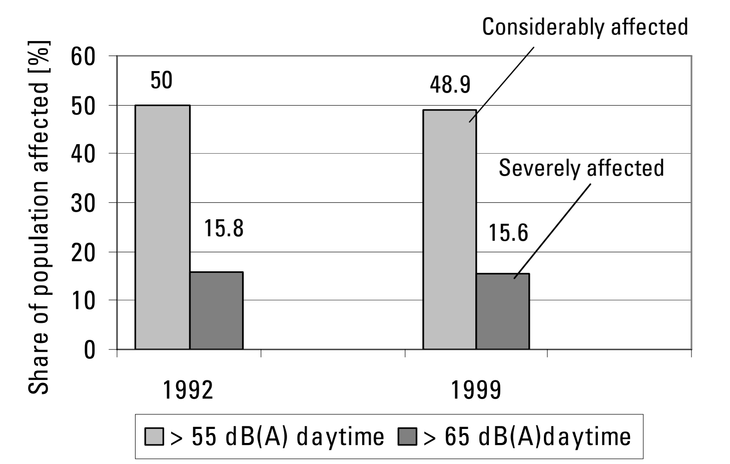
Future work: A need for additional activity here is currently not anticipated.

Regionalisation: Regionalisation within Bavaria will only be possible as from 2007, when the EU "ambient noise" directive is implemented.

Cross-state compatibility: The LIKI[1] Initiative considers the development of a coordinated state indicator for the issue of noise to be necessary. At the present time, documentation still poses a problem. The Bavarian indicator system uses the response-oriented pressure indicator described here, for which a database exists, together with the indicator "total noise pollution in residential areas" (a state indicator). A comparison with other German states is impossible due to their lack of raw data for creating such indicators..

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Total Noise Pollution in Residential Areas



Problems to be addressed

Impairment of health by noise

Regionalisation

The data currently in use applies to the whole of Germany; regionalisation will be possible as from 2007, when the EU "ambient noise" directive is implemented.

Documentation

German Federal Environmental Agency; additional surveys are planned, including collection of hitherto unavailable night-time data.

Assessment

- Noise pollution was already very high in 1992 and had decreased only slightly by 1999.
- Additional noise-reduction measures are necessary.
- Base indicator

SHARE OF THE POPULATION IN WHOSE RESIDENTIAL AREA THE OVERALL OUTDOOR NOISE LEVEL EXCEEDS 55 / 65 dB(A) DURING THE DAY - [%]

Problems to be addressed: According to the European Commission's Green Paper on future noise policy, published in Brussels in 1996, numerous studies have come to the conclusion that during the day, approximately 20 % of the Union's population or close on 80 million people suffer from intolerably high noise levels above 65 dB(A). Some 50 % of the Union's population are exposed to daytime noise levels above 55 dB(A). These noise levels are considered by most people to be at least annoying, lead to serious sleep disturbances, and are feared to have adverse effects on the cardiovascular system and on physical and mental well-being.

The European Commission's Green Paper and the special report "Environment and health: judging the risks correctly", published by the German Council of Environmental Advisors in August, 1999 set target levels of 55 dB(A) for the day and 45 dB(A) for the night. These levels are in keeping with the guiding principle of sustainable development and serve to promote preventive action against the damaging environmental impacts caused by noise. If they are exceeded, the requirements for healthy living conditions are no longer fulfilled. However, lower noise levels can still have negative impacts. The threshold for annoyance reactions is 50 to 55 dB(A) during the day, while noise-related sleep disturbance can occur at mean indoor levels as low as 25 to 35 dB(A).

Definition: The indicator shows the share of the population in Germany in whose residential area the recommended outdoor noise limit is exceeded. The higher daytime noise level of 65 dB(A) shows the share of people exposed to intolerably high noise levels and hence describes only a partial aspect of the noise impact. The lower daytime level of 55 dB(A) shows the share of the population that is considerably affected by noise.

***Functional relationship*:** The indicator falls under the ESM category *Environmental Media / Atmosphere / Disturbance of the peace*. As in the DPSIR classification, this is a *state indicator* .

Especially in cities and conurbations, noise pollution caused by road traffic, industry and commerce and leisure activities is the most serious local environmental problem. Noise pollution by air traffic is highly relevant in the vicinity of airports and in areas used for military flights.

Documentation: The data originates from the German Federal Environmental Agency [UBA]. In the follow-up to the Federal government's CSD report[1] and to recent research, the UBA has commissioned a new model with which noise pollution in residential areas will be calculated in future.

Environmental goals: A permanent decrease in noise pollution to daytime levels of 65 dB(A) or less and night-time levels of 55 dB(A) or less is targeted for 2010, as well as the preservation and extension of quiet areas with daytime levels of 50 dB(A) and less.

As formulated in the European Commission's Green Paper, the aim of future noise protection policies is that nobody should be exposed to noise levels that endanger his/her health or quality of life. In detail, the objectives set forth in Annex 1 of the Green Paper are as follows:

- The population should on no account be exposed to levels above 65 dB(A); a level of 85 dB(A) should never be exceeded.
- For the share of the population that is already exposed to levels between 55 dB(A) and 65 dB(A), any deterioration must be prevented.
- For the share of the population that is exposed to levels below 55 dB(A), any increase in this level must be prevented.

Assessment: The noise pollution for the population was already very high in 1992 and was only very slightly less in 1999. Approximately half of the population is exposed to a considerable daytime noise burden. The share of the population exposed to a high daytime burden is approximately 16 %. There is a clear need for further noise reduction measures.

Future work: Whether or not it makes sense for Bavaria to conduct its own surveys will need to be reviewed. For the purpose of data collection, the noise abatement plans as provided for under § 47a of Germany's Federal Ambient Pollution Control Act [BImSchG] and the implementation of the EU "ambient noise" directive could be useful. The indicator should be extended to include night-time noise levels in order to take health impairment by noise during this period into account.

Regionalisation: Regionalisation within Bavaria will only be possible as from 2007, when data as required by the above-mentioned EU directive must be available.

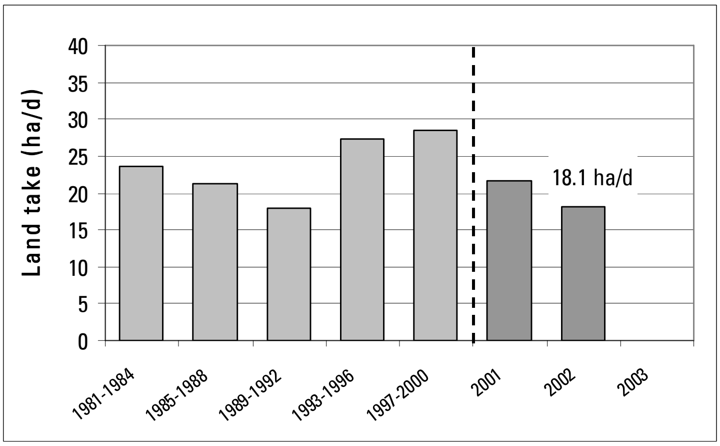
Cross-state compatibility: The LIKI[2] Initiative considers the development of a coordinated state indicator for the issue of noise to be necessary. The Bavarian indicator system uses the "total noise pollution in residential areas" indicator described here, together with the pressure indicator "road traffic noise". However, a comparison with other German states on the basis of Federal data is not possible.

[1] CSD-D (2000): "Erprobung der CSD-Nachhaltigkeits-indikatoren in Deutschland" [Testing of the CSD Sustainability Indicators in Germany], Publisher: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Berlin 2000

[2] Cross-State Core-Indicator Initiative as per September 30, 2004
[2]

Resources

Land Take



Problems to be addressed

- Loss of soil resources
- Structural changes that impact on the landscape, species, habitats, and ecological relationships and processes
- Traffic-related pressures

Regionalisation

Yes, down to municipal level

Documentation

Bavarian State Office for Statistics and Data Processing [LfStaD];
until 2000: every four years;
since 2001: annually

Assessment

- The graph shows a rise in land take between 1993 and 2000, followed by a decrease in 2001 and 2002.
- With annual data collection, trends will be easier to spot in future.

LAND TAKE FOR SETTLEMENT PROJECTS AND TRANSPORT INFRASTRUCTURE - [ha/d]

Problems to be addressed: Important soil functions such as habitat function, filter and buffer functions or retention capacity are impaired or even destroyed by structural changes caused by land take (e.g. sealing, compacting). These structural changes also have a negative impact on important uses of the soil, such as its natural yield potential. Since ecological relationships and processes are habitat-bound, they are increasingly being lost as land is taken for development projects and transportation infrastructure.

Definition: The indicator shows the land take (rezoning of open spaces) for settlements and transport infrastructure (S+T) in hectares per day [ha/d]. It includes built-over areas and utility areas for the buildings (*built and unbuilt surface area*), business zones that are mainly used by industry and commerce (excluding land uptake by the extractive industry) *(business zones excluding the extractive industry)* *recreational areas* (such as sports fields), *cemeteries* and land used for road, rail and air traffic *(transport infrastructure areas).*

***Functional relationship*:** The indicator falls under the ESM category *Activities* and includes all sectors thereof (*households and consumption, agriculture and forestry, industry and commerce, supply and disposal, transportation*). As in the DPSIR classification, this is a *driving-force* indicator.

In Bavaria, agricultural land decreased by 4.0 % between 1981 and 1997. During this period, land use for transport infrastructure increased by 11.3 % while built and unbuilt surface area increased by 33.6 %. The comparatively sharp increase in built and unbuilt surface area reflects the rapid expansion of settlement areas. It is particularly indicative of the increased construction of detached and semi-detached houses in suburban areas. As of December 31, 2001, S+T in Bavaria accounted for 742,304 ha or 10.5 % of the total surface area (the figure for Germany as a whole is 12.4 %). Built and unbuilt surface areas account for more than 50 % of the S+T area.

Land take has impacts on the soil, which cause the aforementioned *structural changes*. These changes impair important soil functions, such as habitat and filter functions. The consumption of limited *soil and land resources* by S+T creates competition for the remaining open spaces. The direct impacts of this are soil degradation, impairment of the habitat function and also regional shortages of land for certain uses. Furthermore, urban sprawl automatically leads to an increase in individual motor-vehicle traffic and thus to additional *pressure factors* such as air pollution and noise.

Documentation: Chronological data dating back to 1981 can be extracted from the statistical yearbooks published by the Bavarian State Office for Statistics and Data Processing [LfStaD]. Even more detailed data is contained in the statistical reports published by the LfStaD – these classify acreage in Bavaria by type of use. Throughout Germany, data is collected and published every 4 years. Following an amendment to the Agricultural Statistics Act, the LfStaD is now authorized to determine and publish land take by S+T on an annual basis. Data on the remaining forms of use (e.g. agricultural land, wooded areas, expanses of water) are still collected at 4-year intervals. As a result of the yearly updates possible since 2001, the indicator can now be assessed much more reliably.

Environmental goals: At Federal level, the aim is to reduce land take from the 1997 figure of 120 ha/d to 30 ha/d by 2020. Bavaria is targeting a further reduction in the land-take figure of 28.4 ha/d recorded for the period 1997 – 2000.

Assessment: The chart shows a sharp increase in land take between 1993 and 2000, followed by a decrease in 2001 and 2002. Annual data collection will make it easier to recognize trends in future.

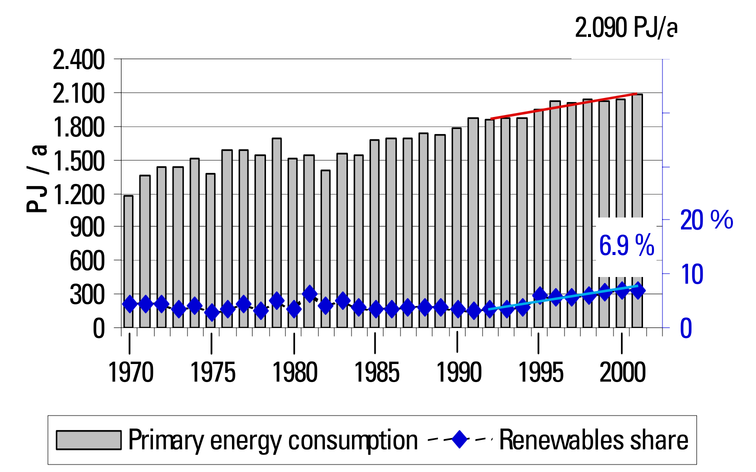
Future work: The indicator does not reflect qualitative changes to the soil functions (state). The loss or impairment of soil functions such as water-retention capacity or filter function due to sealing could be described by a “sealed-surfaces” state indicator. Indicators that include soil quality still have to be developed.

Regionalisation: Because land surveys are decentralized in Bavaria, the indicator is available down to municipal level.

Cross-state compatibility: The LIKI[1] Initiative has recommended “land take” as a core indicator. Comparisons with data from other Federal states is possible because data collection is standardized throughout Germany. For comparative purposes, statistics must be standardized to a suitable reference variable (e.g. population). The S+T share of the total surface area of the individual states must also be taken into account.

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Energy Consumption



Problems to be addressed

- Resource consumption
- Climate changes
- Landscape impairment

Regionalisation

- Currently impossible (state of documentation)
- Desirable (see future energy-statistics legislation)

Documentation

Bavarian Ministry of Economic Affairs, Infra-structure, Transport and Technology [StMWIVT], annually

Assessment

- Constant increase in primary energy consumption; this increase is independent of environmental pollution trends.
- Marked increase in the share of renewable energies since 1995 (currently 6.9 % as measured by the efficiency method, which corresponds to approx. 11 % by the earlier substitution method)

PRIMARY ENERGY CONSUMPTION (PEC) - [PJ/a] AND SHARE OF RENEWABLE ENERGIES - [%]

Problems to be addressed: Continuously ex-cessive consumption of non-renewable forms of energy can lead to a shortage of resources. The energy-related release of carbon dioxide contributes to the anthropogenic greenhouse effect; energy-related air pollutants can lead to impairment of human health and ecosystems.

Definition: Primary energy consumption (PEC) is calculated by adding together the amount of fuel produced in Bavaria, the differ-ence between cross-border energy purchases and deliveries, and changes in stocks[1]. The indicator includes the following energy sources: fossil fuels (crude oil, mineral coal, lignite and natural gas), nuclear energy and renewable energy (biomass, wind and water power, waste, solar energy and geothermal and ambient heat). The share of renewable energies is determined according to the efficiency method, which is used throughout Germany.

***Functional relationship*:** Energy consumption falls under the ESM category *Activities*. All the sectors of this category contribute to the indica-tor. As in the DPSIR classification, this is a *driving-force* indicator.

Many pressure factors are associated with the PEC. These are caused by the energy sector, industry and commerce, households and trans-portation. Carbon dioxide is released during the combustion of fossil fuels (coal, oil, gas), lead-ing to an increase in the atmosphere's CO_2 content and hence contributing to the anthro-pogenic greenhouse effect. Energy-related air pollutants of particular relevance include NO_x, SO_x, CO and dust. These impair human health (e.g. respiratory diseases) to an extent that is

[1] Bavarian Energy Balance from April 7, 2004; The Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology

dependent on their concentrations. Deposition of NO_x and SO_x can lead to eutrophication and acidification of soils and water. These phenomena, in turn, can impact on ecosystems (e.g. forests). The harnessing of water power necessitates structural changes (e.g. barrage weirs), which impair the ecosystems in semi-natural watercourses and spoil the natural scenery.

On the basis of current energy consumption patterns, PEC can only be covered by global reserves of fossil fuels for a limited time, i.e. the non-renewable energy resources will become exhausted.

Documentation: The energy consumption data is collected annually by The Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology (StMWIVT). The data includes consumption both by the energy conversion sector and the final energy sectors. In the conversion sector and in industry it is collected by direct statistical methods (e.g. questionnaires). In the transport sector, by contrast, market research results are used in addition to statistics on energy supplies to transport operators as a database. For households and other consumers there is no data on actual energy consumption. For this sector, therefore, final energy consumption is equated with energy supply. The PEC figures are published annually by the StMWIVT. Database inaccuracies stemming from the collection methods have no significant effect on the indicator's accuracy. Statistics dating back to 1970 are available at the Bavarian Environmental Protection Agency [LfU].

Environmental goals: The Bavarian government adopted a comprehensive energy policy plan[2] in April 2004. Among the environmental goals cited in the plan, those of developing and promoting energy-saving measures and increasing the share of renewable energies to 8 – 9 % (efficiency method) relate to the indicator.

Assessment: The indicator is assessed on a 10-year-trend basis. From 1992, primary energy consumption has shown an upward trend. There has been a marked increase in the share of renewable energies over the same period.

Decoupling of primary energy consumption from environmental pollution began more than 20 years ago with the introduction of extensive emission-reduction measures in the energy sector (marked decrease in SO_x, for example). For the 10-year assessment period, this decoupling effect is particularly evident from the carbon dioxide emissions. Thanks to the drop in the share of CO_2-intensive fuels (e.g. coal and crude oil), the rise in energy-conversion efficiency (e.g. combined heat and power) and the increased share of renewables, (e.g. biomass), CO_2 emissions have not increased further despite a rising PEC.

Regionalisation: Although regionalisation of the information is desirable, it will not be possible in the foreseeable future on the basis of current energy statistics. This is a long-term goal based on future energy-statistics legislation.

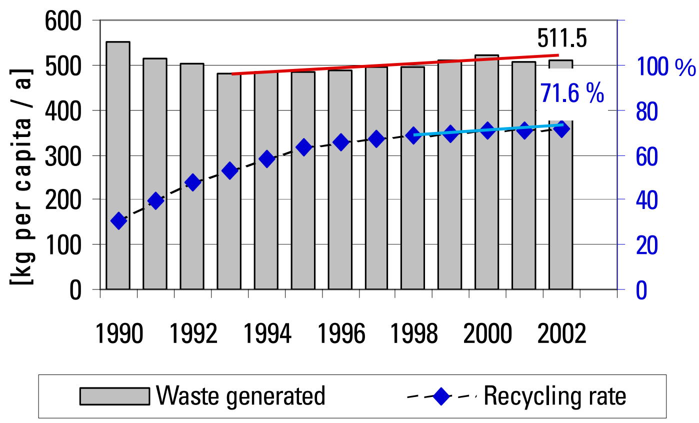
Future work: In future, the indicator will also reflect the shares of the individual regenerative energies, e.g. biomass, wind and water power, solar energy and geothermal and ambient heat.

Cross-state compatibility: The LIKI[3] has likewise recommended an "energy consumption" indicator comprising the two partial indicators "*primary energy consumption*" and "*share of renewables*". Comparisons with other Federal states are possible if statistics are standardized to a suitable reference variable (e.g. per inhabitant, GDP).

[2] prepared by the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology
[2] Bayerisches Staatsministerium für Wirtschaft, Verkehr und Technologie, „Gesamtkonzept Bayern zur Energiepolitik", April 2004 [The Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology, "Bavaria's Comprehensive Plan for Energy Policy", April 2004].

[3] Länder-Initiative Kern-Indikatoren (LIKI) [State Initiative Core Indicators] – Status as of September 30, 2044

Waste and Recycling



Problems to be addressed

- Consumption of raw materials and energy
- Release of substances with consequences for health and ecosystems

Regionalisation

Yes, by administrative districts and waste management agencies

Documentation

Bavarian Environmental Protection Agency [LfU], annually

Assessment

- Waste generated: slight increase during the past 9 years
- Recycling rate: following a sharp initial increase, the past few years saw only a slight annual increase; goals set in the Bavarian Environmental Pact and the waste management plan can be met.

GENERATION OF HOUSEHOLD WASTE AND HOUSEHOLD-TYPE COMMERCIAL WASTE - [kg per capita/a], AND RECYCLING RATE - [%]

Problems to be addressed: Continuously excessive resource consumption (e.g. raw materials, energy), the inefficient use of these resources in economic activities along with non-optimized material cycles can lead to resource shortages if the substitution or regeneration rate is too low. This is likely to impair economic, technological and social development for future generations. Waste contains mostly non-renewable resources in modified form. Energy resources are already consumed during product manufacture and trade. The consumption of non-renewable resources is a global problem with regional causes and impacts. Bavarian consumption does contribute to global shortages, but is low compared to worldwide consumption (e.g. 0.7 % of global crude-oil consumption); reductions in Bavarian consumption therefore do not permit any conclusions in respect of global resource conservation. In its 2000 Annual Report[1], the Duales System Deutschland AG forecasts that crude oil reserves will be exhausted by the end of this century[2]. Crude oil has been Bavaria’s most important primary energy source over the past thirty years[3]. An early shortage of crude oil would have substantial economic and social impacts on the whole of Bavaria.

Definition: Household waste and household-type commercial waste include the recoverable materials collected and sorted by the municipalities and Germany’s “Duales System” [DSD] as well as the residual waste left to the official waste management agencies (*entsorgungspflichtige*

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1 Published April 2001 in Cologne

2 “Der Grüne Punkt – Ressourcen, Reserven und Prognosen”. [(The green dot - resources, reserves and forecasts]

3 Bavarian energy report 1999/2000, published June 2000 in Munich by the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology

Körperschaften[4]). This residual waste includes residual waste from DSD processing. Recycled slags and scrap from thermal household-waste treatment and waste separated out from the DSD collections and from biological-waste collections are deducted to prevent double counts. This annually determined *waste generation* figure is set in relation to the number of inhabitants and expressed in [kg per capita/a]. *Recoverable materials* include glass, paper, metals, plastics, composites, green cut and biological waste, as well as recycled slag and "other recoverables". Residual waste comprises non-recyclable household and office waste, bulky waste, household-type commercial waste collected by the municipalities, and waste separated out from recoverables collections. The *recycling rate* is the quotient [%] obtained by dividing the quantity of recoverables (see list above) by the sum (less the double-count entities mentioned above) of the recoverable and the residual waste quantities generated by households.

***Functional relationship*: **The indicator falls under the ESM category *Activities.* It is influenced particularly by the Household and Consumption, Industry and Commerce and Supply and Disposal sectors. As in the DPSIR classification, this is a *driving-force* indicator. The recycling rate reflects the effectiveness of policy *measures.*

The main raw materials used to manufacture products that end up as waste after use are crude oil, wood, metals, non-metals and energy. The recycling of this waste into secondary raw materials (e.g. recycled paper, wood, glass and metals) and secondary energy sources helps to conserve resources. The production and transportation of products resulting in waste are associated with emissions to the environmental media; this applies likewise to disposal processes (recycling and removal).

Documentation: As provided for under Article 12 of the Bavarian Waste Management Act [BayAbfG], data on household waste quantities is collected annually by the official waste-management agencies. It contains information on the nature, origin and quantity of the waste generated, as well as the quantities recycled or otherwise disposed of. Figures have been available since 1990 and will be collected in future, too. The Bavarian Environmental Protection Agency [LfU] uses this data to produce the annual household-waste statistics on which the indicator is based.

Environmental goals: Waste prevention is firmly anchored as overriding principle in Article 3 of the EU Directive 75/442/EEC, in § 4 of the German Recycling Management and Waste Act [KrW-/AbfG] and in Article 1 of the BayAbfG. The Bavarian Ordinance pertaining to the Waste Management Plan (AbfPV) provides for a recycling rate of 73 % by 2009. In the Bavarian Environmental Pact (October 23, 2000), this target was adopted for as early as 2005.

Assessment: All in all, *waste generation* shows little change. The lowest figure (480.3 kg per capita/year) was recorded in 1993. Since then, a slight increase to 511.5 kg per capita/year has been observed, which is partly attributable to improved collection of recoverables such as green cut. The *recycling rate* initially increased very quickly. Since 1996, the rate of increase has been slower. However, at 71.6 %, the current rate is already high, and it is probable that the targets set in the Environmental Pact and in the AbfPV will be met.

Future work: It is considered particularly important that the indicator be expanded to include commercial waste and that the pressure factors be quantified.

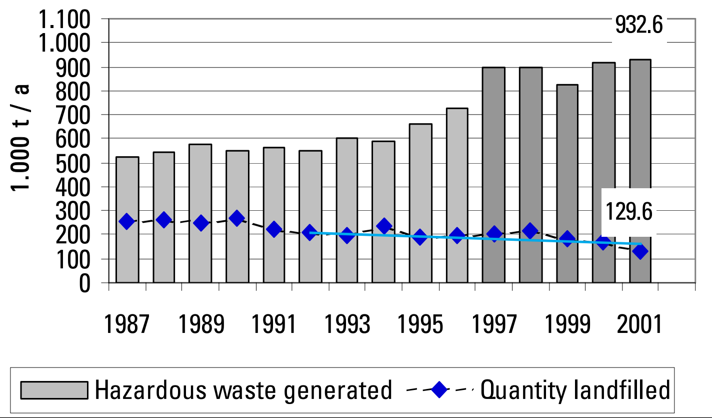
Regionalisation: Statistics on waste quantities and recycling rates are differentiated according to administrative regions and the official waste management agencies (rural and urban districts).

Cross-state compatibility: The LIKI[5] Initiative designates "waste and recycling" as a core indicator. On account of the very different waste statistics available across Germany, the most widely available partial indicators are selected for purposes of cross-state comparisons. Further harmonisation of the waste balances for settlements in the Federal states is a future goal.

[4] In Germany, it is a statutory duty to offer such waste to these agencies, and they must accept it.

[5] Cross-State Core-Indicator Initiative as per September 30, 2004

Hazardous Waste



Problems to be addressed

- Consumption of raw materials and energy
- Release of materials that impact on ecosystems and human health

Regionalisation

Possible, but additional data are necessary

Documentation

Bavarian Environmental Protection Agency [LfU], annually

Assessment

- Hazardous waste generated: the current state of documentation does not yet permit reliable assessment. There was an upward hazardous waste trend until 1996. From then on there has been no clearly discernible trend.
- Quantity landfilled: long-term downward trend.
(Reliable assessment is difficult, in part due to the use of hazardous waste as a pollutant sink)

HAZARDOUS WASTE GENERATED AND
QUANTITY LANDFILLED AT HAZARDOUS WASTE DUMPS - [1,000 t/a]

Problems to be addressed: Continuously excessive resource consumption (e.g. raw materials, energy), the inefficient use of these resources in economic activities along with non-optimized material cycles can lead to resource shortages if the substitution or regeneration rate is too low. Second to the resource aspect, hazardous waste must be assessed in terms of the relatively high potential pollutant risk it poses to the environment (compared to household waste). Hazardous waste that cannot be treated (further) by thermal or physico-chemical methods is landfilled. The amount landfilled is a measure of the materials removed from the economic cycle. Contrary to the sustainability principle, the landfilling, or dumping, of waste can shift waste issues to later generations. It also involves environmental risks in the form of new contaminated sites, and such risks are potentially difficult to calculate. Thanks to the high technical standards of hazardous waste landfills in Bavaria, pollutant release is hardly likely. The existing landfill capacity will suffice until 2010, and exploitation of the expansion potential will also provide sufficient medium-term capacity. However, since landfill space is limited, the quantities of waste disposed of in this way have high long-term relevance.

Definition: The *hazardous waste generation* indicator refers to the total amount of generated waste that is subject to special monitoring and that is disposed of (i.e. the quantity recycled plus the quantity landfilled, i.e. removed). It does not include contaminated high-volume mineral waste in the form of soil and rubble. This latter type of waste has no relevant connection with current waste management because it originates primarily from the rehabilitation of contaminated sites and the demolition of older buildings. The *quantity landfilled* indicator includes waste (generated in Bavaria) that is subject to special monitoring and is landfilled at special sites for hazardous waste as well as other waste that is not subject to special monitoring but that is landfilled at these sites because of its pollutant content. It does not refer to waste disposed of as pack in excavated mine stopes (not relevant to Bavaria) or waste disposed of on residential waste landfills during construction activities (not practiced in Bavaria).

***Functional relationship*:** The indicator falls under the ESM category *Activities*. The sections *Industry and Commerce* and *Supply and Disposal (life-cycle and waste management)* particularly influence the indicator. As in the DPSIR classification, this is a *driving-force* indicator.

Commerce and industry use up *resources* (raw materials and energy) when producing goods; the production processes also generate hazardous waste. Subjecting such waste to qualified, state-of-the-art material recycling rather than landfilling it is one way of conserving resources. The use of process heat generated by energetic recycling helps to conserve energy resources. The disposal of hazardous waste by means of recycling or landfilling can lead to the release of *substances.* These may impair the state of all environmental media and thus impact on ecosystems and health. Hazardous-waste dumps are safeguarded against such substance losses, although a very slight risk of pollutant release cannot be entirely ruled out.

Documentation: Data on *quantities of hazardous waste generated* is obtained as part of the statutory waste-accountability procedure. The *quantity landfilled* is taken from the annual records kept for each dump. The survey is conducted once yearly and is governed by statute. Amendments to the legislation have led to changes in data-collection methodology, so that no directly comparable databases are available over given periods of time. Future legislative amendments may have similar implications.

Environmental goals: Waste prevention and waste recycling are anchored as qualitative goals in EU Directive 75/442/EEC, in § 4 of the German Recycling Management and Waste Act [KrW-/AbfG] and in Article 1 of the Bavarian Waste Management Act [BayAbfG] and of the Bavarian Ordinance pertaining to the Waste Management Plan [AbfPV]. Quantified goals for hazardous waste generation are not available. The AbfPV stipulates that, where possible, (hazardous) waste be treated prior to being landfilled.

Assessment: It is difficult to clearly recognize an overall trend for the indicator *hazardous waste generated.* This is due, in part, to the aforementioned changes in the database (see documentation). The figures for *hazardous waste generated* rose between 1987 and 1996. In 1997, the database underlying the indicator was expanded by legislative amendments. This resulted in a sudden jump. Since then, there has been no clearly discernible trend. As from 2002, the database changed substantially once again due to further legislative amendments. The *q-uantity landfilled* shows a downward trend over the 10-year assessment period. The reasons for this vary and can only be analysed to a limited extent. Reliable assessment of the indicator is difficult, in part due to the use of hazardous waste as a pollutant sink.

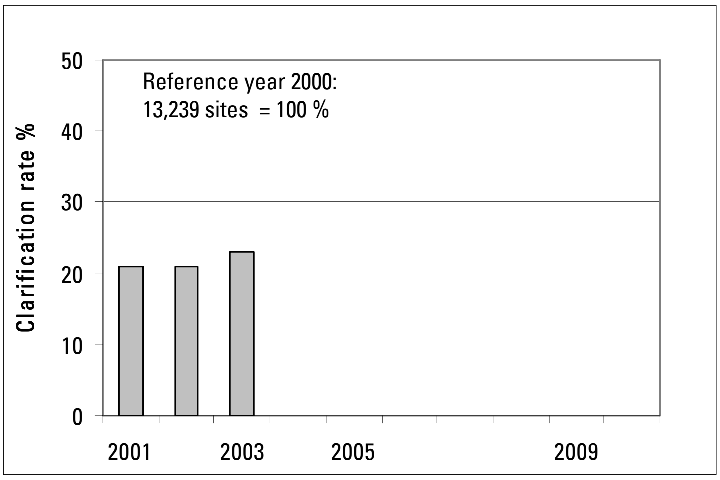
Future work: Quantification of resource consumption and substance release; review as to whether the recycling rate can be included in the indicator (to this end, objective definitions of recycling and removal, i.e. landfill, are needed); error analysis and drafting of assessment criteria; review as to whether a differentiated data collection method that is independent of the legal position would lead to a indicator that can be assessed reliably.

Regionalisation: Possible in theory. A broader-based and hence more time-consuming data collection system would be required.

Cross-state compatibility: The LIKI[1] Initiative has not recommended "hazardous waste" as a core indicator.

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Contaminated Sites



Problems to be addressed

- Unused land resources
- Intensified demand for uncontaminated land

Regionalisation

Yes, right down to municipal level

Documentation

District administrative authorities / Bavarian Environmental Protection Agency [LfU], annually. Assessment of the land register as required by Article 3 of the Bavarian Soil Protection Act [BayBodSchG]. Improved documentation since 2003, as required by new soil protection legislation (BayBodSchVwV)

Assessment

Documentation on sites with suspected contamination is comprehensive.

Effective measures are needed to clarify whether or not these sites are contaminated.

SHARE OF THE OVERALL NUMBER OF SITES WITH SUSPECTED CONTAMINATION THAT RECEIVED CLARIFIED CONTAMINATION STATUS IN 2000 – SUSPICION CLARIFICATION RATE - [%]

Problems to be addressed: The operation of industrial plant without or with little regard for environmental standards led to excessive pollutant release in the past. These pollutants accumulated with time in the soil and in groundwater, posing risks to ecosystems and human health. Rapid re-use of contaminated sites and sites suspected of being contaminated is often impossible because of the frequently unclarified status of the site (legal succession, the extent of the necessary investigations and remediation work, the costs involved and who will pay, the possible use of the land under planning law, etc.). These sites accordingly remain unused for lengthy periods of time and are not available as a land resource.
Solving the problem of contaminated sites has to do primarily with averting danger and permanently restoring the soil functions. Land recycling is a central component of an economic, ecological and urban renewal strategy; it must also be borne in mind that the general requirements for healthy living and working conditions and the safety of the residential population must be fulfilled.

Definition: The suspicion clarification rate is the ratio of the number of sites confirmed contaminated or uncontaminated to the total number of sites with suspected contamination (as of March 31, 2000) in Bavaria. Sites suspected of being contaminated are former dumping sites and former industrial sites suspected of harbouring harmful soil changes or other hazards for individuals or the general public. Sites with clarified contamination status are those for which the suspicion of contamination has been either ruled out or sufficiently confirmed.

Functional relationship**:** The indicator falls under the ESM category *Resources / Soil / Land*. It describes the re-use potential of the aggregated sites with suspected contamination in Bavaria at a certain time. Solving the problem of contaminated sites is a finite task, which, given the limited number of cases, can be accomplished in the foreseeable future at calculable cost. Only some of the sites suspected of being contaminated are ultimately confirmed as posing a hazard. As in the DPSIR classification, this is a *response* indicator.

Contaminated sites and sites suspected of being contaminated are sites that are currently not available for re-use or for a different use due to the presence of (possible) pollutants (e.g. heavy metals, organic substances). The impact of this is that the land requirement for settlement purposes must preferably be satisfied by available land that does not pose a contamination risk. As a result, there is intensified competition for the non-expandable resource *soil/land.*

Documentation: The Bavarian Environmental Protection Agency [LfU] has transferred the existing data stock from the contaminated-sites register previously managed pursuant to Article 27, Paragraph 2 of the Bavarian Waste and Existing-Contamination Act[BayAbfAlG] to the new register pursuant to Article 3 of the Bavarian Soil Protection Act [BayBodSchG]. The new register is based on the two Annexes to the Administrative Regulations for Implementation of the Bavarian Soil Protection and Contaminated-Sites Act [BayBodSchVwV]. As of March 31, 2000 there were 13,329 sites with suspected contamination recorded in the processing-priority categories (of that time) 1 to 6. All the relevant data is documented, from site identification through investigation – including allocation to one of the (now valid) processing-priority categories A, B or C and the processing stage reached – to deletion of the site from the register. The data transferred from the old register was supplemented, corrected and adjusted to the requirements of the new soil protection legislation by the district administrative authorities (KVB) (see Annex 2 of the BayBodSchVwV).

Environmental goals: Clarification of the contamination status of 50 % of the suspect sites is targeted for 2010, and 100 % for 2020. (Targets set in March 31, 2000).

Assessment: Thanks to the extensive restructuring of the register and the data reorganization carried out by the 96 KVB, reliable assessment is anticipated as from 2003. The 2003 clarification rate of 23 % is based primarily on data-revision effects and should not be wrongly interpreted as an indication that targets will be met prematurely.

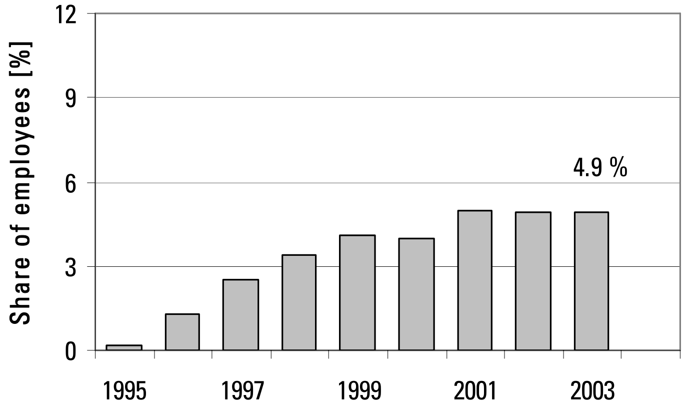
Future work: No need for additional activities is currently anticipated.

Regionalisation: By virtue of the way in which the register is structured – identification of suspect sites by local sub-district and plot number – the indicator is available right down to municipal level.

Cross-state compatibility: The LIKI[1] Initiative has not recommended the suspicion clarification rate as a core indicator.

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

Environmental Management



Problems to be addressed

- Consumption of raw materials
- Energy consumption
- Water consumption

Regionalisation

Yes, at regional administrative level

Documentation

Chambers of Commerce and Industry [IHK]; Bavarian State Office for Statistics and Data Processing [LfStaD], annually

Assessment

- Marked increase during the first few years
- Recent signs of stagnation due to a general preference for ISO 14001 over EMAS revalidation

SHARE OF EMPLOYEES IN BAVARIA IN EMAS-VALIDATED ORGANISATIONS - [%]

Problems to be addressed: Through the production of goods and services, the macro-economic supply sector has a substantial influence on the use of natural resources. The environmental impacts are twofold: firstly, inefficient resource utilization combined with inadequate substitution or regeneration rates causes regional and global resource shortages. The economic, social and ecological implications are primarily associated with risks for future generations. Secondly, decisions concerning the use of environmentally relevant input materials and production processes always contribute to pollution of the environmental media.

Definition: The indicator shows the share of employees in Bavaria that is employed in Bavarian EMAS organisations, minus self-employed persons and family members who work in the business. All organisations registered by the chambers of commerce and industry as participating in the Community eco-management and audit scheme [EMAS] are included. They are obliged to establish, implement, evaluate and publish an environmental management system, prove the continual improvement of their environmental performance and have this certified every 36 months by an external expert. The weighting according to the number of employees is geared to the goals pursued in the Bavarian Environmental Pact and is intended to allow for the different sizes of the organisations.

Functional relationship: The indicator falls under the ESM category *Activities / Agriculture and Forestry*, *Industry and Commerce*, *Supply and Disposal*. EMAS-validated organisations are found in all these sectors. The main focus is on “industry and commerce”. As in the DPSIR classification, this is a *response* indicator.

The in-house/in-plant use of resources (raw materials, water, power etc.) can be well-controlled by the organisation. Building on this fact, EMAS aims to improve stewardship over production inputs, i.e. by identification and remedying of unnecessary and inefficient consumption. Resource consumption is reduced and so are the pressures put on the environmental media. Since April 21, 2001, when the EMAS Regulation was revised to include indirect environmental impacts, pressure factors originating outside the organisation (e.g. customers and suppliers, along with their employees), have been included in the indicator. It thus reflects the extent to which awareness has been raised in the corporate sector for the topics of environmental protection and resource conservation.

Documentation: The employee data for EMAS organisations is collected by the chambers of commerce and industry, the official EMAS registration authorities. The publicly accessible EMAS register lists name and address of the organisation, the sector, registration number, registration date and place of registration. A link to the number of employees exists in so far as validation and registration require prior payment of a validation fee that depends on the number of employees. However, it is the number of employees at the time of initial validation that counts; this number is not corrected in line with subsequent fluctuations in employee numbers. By contrast, the figure for the total number of employees in Bavaria, as registered by the Bavarian State Office for Statistics and Data Processing (LfStaD), is always the latest figure.

Environmental goals: The share of employees in EMAS-validated organisations should increase continually and over the long-term. This requires that the organisations participate permanently in the system. Despite differences in indicator definition, this goal is in harmony with the requirements of the Bavarian Environmental Pact. Of the 1,757 EMAS-validated organisations in Germany, 371 are currently located in Bavaria (status as of January 28, 2004).

Assessment: EMAS participation, which initially witnessed a marked increase, is now showing signs of stagnation due to revalidation reservation and preference for the private-sector ISO norm. Participants consider the EMAS cost-benefit ratio to be unfavourable, a finding that has been addressed in the new EMAS Regulation. A particular aim was to emphasize the higher quality demanded by EMAS requirements in comparison to the ISO norm.

Future work: Compatibility of the EMAS indicator with the goal outlined in the Environmental Pact would be welcome. This is particularly relevant for the inclusion of other environmental management systems (primarily ISO 14001), for which, however, no data is currently available. The inclusion of “light versions” of environmental management systems, such as ECOPROFIT and QuH [environmental certification for the skilled trades], should also be investigated; however, the different quality of the various systems should be kept in mind.

Regionalisation: Differentiation of the indicator is possible at regional administrative level.

Cross-state compatibility: The LIKI[1] Initiative recommends “environmental management” as a cross-state core indicator and stresses the necessity of including ISO 14001. Comparison with other Federal states is possible.

[1] Cross-State Core-Indicator Initiative as per September 30, 2004

4 Prospects

4.1 Applications

The environmental indicators can be used in various applications. The experience thus gained must be taken into account during future work, i.e. when these indicators are refined for specific applications and hence for specific requirements and target groups.

Environmental planning: Environmental indicators are an important instrument for elaborating goals and monitoring target achievement within the framework of environmental planning. For example, the state government in Baden-Württemberg has formulated both qualitative and quantitative targets for individual environmental sectors in its environmental plan, and has named appropriate indicators for monitoring the achievement of these goals.

For Bavaria, the action programme for the Bavarian Agenda (see below) is of similar importance.

Policy integration: Environmental indicators can improve inter-ministerial communication on priority fields of action. The planning and embedding of environmental goals in Bavaria's various product policies (see Environmental Pact), in the same way as is provided for at EU level in the Cardiff process, could be envisaged as a task here. Additional, sector-specific environmental indicators (e.g. for the agricultural sector) but also indicators related to protected rights/assets (e.g. for the health sector) can be developed on the basis of the proposed set of core indicators. A health indicator system is currently being developed in Bavaria.

Sustainable development: The need for indicators with which the principle of "sustainable development" can be implemented was voiced back in 1992 in the Rio Agenda. An action programme based on Bavaria's Agenda 21 (which was adopted by the Bavarian government at the end of 1997) was drawn up for the 2002 global summit in Johannesburg. The action programme outlines goals and measures. The environmental indicators are intended as a basis for suitable control; as a first step, a link with the goals could be established.

The Federal Government's "national sustainability strategy" of 2002 already contains some environmental indicators. Commissioned by the Conference of Ministers for the Environment [UMK], the Federal Government/state working group for sustainable development [BLAK-NE] produced a list of "environmental sustainability indicators" based on the core indicators proposed by the Cross-State Core-Indicator Initiative [LIKI]. In its resolution of May 2004 the UMK approved these core indicators (see Appendix 2) and determined that they be given priority in future work on sustainable development. (www.blak-ne.de).

At European level, headline environmental indicators are used in the annual "synthesis report" on implementation of the EU sustainable-development strategy agreed in Gothenburg in 2001.

Environmental report: Current environmental reporting in Bavaria is both "compartmental" in nature (e.g. air hygiene annual report, Bavarian waste statement etc.) and also of cross-media nature (e.g. Bavaria Agenda progress report). The intention is to use the environmental indicators developed so far, together with published environmental goals, as an initial foundation for an indicator-based, integrated environmental reporting system (environmental report). Interesting approaches include the "German Environmental Data", the "Baden-Württemberg 2003 Environmental Data" or "The Environment in your Pocket", published by the British DEFRA.

Environmental information: Environmental indicators can also be used to provide easily understandable environmental information for the public. All forms of communication media are suitable, for example the Internet. Depending on the application and the target group in question, it could also be useful to develop a highly aggregated "Bavarian environmental index" based on a few selected key indicators (see environmental barometer), of a similar nature to the "German environmental index" [DUX] produced by the German Environmental Agency.

Cross-state comparison: Environmental indicators that are also used in other German states (core indicators) can be used for comparison purposes and for benchmarking. The prerequisite is whether, given the differences between the states, a comparison is at all purposeful and whether the indicators are sufficiently compatible. Current work being carried out by the state environmental protection agencies in the LIKI[1] Initiative can make a substantial contribution here. The European Environment Agency in Copenhagen provides annual information on important trends, with international comparisons, in its "Environmental Signals" report. This report is based on 37 core indicators available across Europe ("EEA core set of indicators"), which are subject to constant revision.

Economy: Through the development and application of specific environmental indicators for selected sectors of the economy, benchmarking /ranking can be used as an additional and innovative instrument for environmental protection.

4.2 Future work

The need for future work on environmental indicators is apparent from the limitations that have been described for the individual indicators and will be additionally defined by the practical experience gained from the various applications mentioned, some of which are future applications. Experience in the development and application of environmental indicators is currently being gathered at municipal, state, federal and European levels. Substantial impetus is expected here from the continued work of the Federal Government/state committees (e.g. LIKI), which are additionally involved in the (further) refinement of the core indicators adopted by the UMK in May 2004. The subject is also receiving increased attention from the scientific disciplines.

The set of indicators proposed here for Bavaria must accordingly be subjected to expert review at regular intervals. To this end, all the specialists involved are called upon to follow current developments. Topics currently attracting special attention include "landscape fragmentation", "contaminated breast milk", "electromagnetic fields" and "genetically modified plants".

In future, more emphasis must be put on environmental issues that fall under the remit of other Bavarian agencies. Such issues include "the condition of forests", "environmental farming" and "nitrogen excess". The relevant agencies (e.g. the Bavarian State Research Centre for Agriculture [LfL] and the Bavarian Forest Institute (LWF]) should be included. The current process of harmonising core indicators with other states and the Federal Government may require further involvement by specialists in the respective fields in order to resolve outstanding compatibility issues and to agree on the aggregation process (e.g. "air quality index", "waste and recycling"). Future progress will be documented in a continuation of this report.

[1] Cross-State Core-Indicator Initiative

Appendix

1. Environmental Sustainability Model (ESM)
2. Indicator Overview

Bavarian Environment Agency

Environmental Indicators
- Appendix 1 -

Environmental Sustainability Model (ESM)

In the project report entitled "Weiterentwicklung des Umweltindikatorensystems für Bayern" ["Further Development of the Environmental Indicator System for Bavaria"] (Report: November 2000), the DPSIR[1] model of the European Environment Agency is recommended as an up-to-date, suitable conceptual framework for the classification of indicators. This model is also recommended as an environmental indicator system for Bavaria, and its relevance was confirmed at the conference entitled "Ökologische Indikatoren der Nachhaltigkeit" [Environmental Indicators for Sustainable Development] at the Bavarian Environmental Protection Agency on February 15th and 16th, 2001.

The Project Team for Environmental Indicators has based its "Environmental Sustainability Model" (ESM) on the DPSIR model. It addresses the structure, details and characteristics of four DPSIR categories important for further work, viz. ***Driving forces, Pressure, State*** and ***Impact,*** in specific sections, sub-sections and explanations. The DPSIR category ***Response*** was not addressed, as responses can be initiated in all 4 categories and are not necessary for describing the causal relationships. Classification of selected indicators according to the DPSIR model remains unaffected.

The ESM is intended to provide ***assistance*** in the development of indicators, in cooperation with all the various specialists involved, during the following work steps:

- Description of the cross-sectional nature of the environmental pillar of sustainability, including a portrayal of cross-media relationships;
- Topic access and identification of specialists to be involved;
- Pinpointing of functional relationships between driving forces, pressures, changes in the state of the environment and the resulting impacts (problems to be addressed);
- Investigation of the problem-solving adequacy of the proposed indicators, and
- Structuring of environmental reports and indicator systems in line with user-/target-group requirements.

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[1]) *Driving forces:* driving-force indicators show which human activities produce the relevant environmental pressures. *Pressures*: pressure indicators express which specific environmental pressures are caused by the various sectors. *State:* state indicators describe environmental quality (environmental media and natural resources), which is affected by pressure factors. *Impact:* impact indicators show the further effects of changes in environmental media and resources. *Response:* response indicators measure the methods and extent of responses by society (politicians and decision-makers in the fields of action identified) to the environmental changes and the impacts thereof.

Activities (Driving forces)

Human activities serve to satisfy a wide variety of ***needs*** *and are thus the economic drivers that impact on natural resources on a daily basis. They do so through the use of resources and land. All human activities influence environmental media, and changes in the latter have both ecological impacts and economic and social consequences. A link with the sustainability dimensions can take place at this part of the ESM .*

Households and Consumption

Households exert a great deal of influence on needs- and requirements-driven demand for and consumption of products and services (e.g. foodstuffs, accommodation, mobility, leisure, recreation). Consumption is dependent on disposable income. It is, however, also dependent on the basic values and principles of the persons involved and thus on their lifestyle and environmental awareness, and is ultimately also a result of overall social trends. Activities associated with households and consumption have major impacts on the environment, e.g. through land use (settlement and transportation) or the release of substances in the form of waste, wastewater and gas emissions. Feedback effects on production sectors can be generated by changes in demand behaviour (e.g. ecologically produced foodstuffs, 3-litre car etc.). Consumer behaviour is thus an important key to sustainable development.

Agriculture and Forestry

Agriculture and forestry, including fishing and horticulture, are forms of soil and land use that include the production of biotic raw materials in ecological systems by using and controlling naturally occurring processes. For control purposes, substances such as fertilisers and pesticides are used, or plant cultivation methods that are also important for the food chain are used and further developed. In addition, certain technical measures, such as the use of agricultural machinery and the construction of drainage ditches or rural-development planning measures, cause structural changes in land and soil. These changes impact on natural resources, especially soil and water, the structures and functions of ecosystems and the networking of biotopes.

Industry and Commerce

With their products and services, industry and commerce (production, services, crafts and retail trade) represent the need- and demand-oriented supply side. A wide variety of resources (raw materials, energy, water etc.) are used, and land is taken for production sites. Industrial and commercial activities are directly responsible for a multitude of impacts (e.g. substances) on environmental media (e.g. atmosphere, water). Trade in products and services is closely interlinked with passenger and goods traffic (transportation).

Supply and Disposal

The economic sectors that ensure supplies, e.g. energy and water, and the disposal of wastewater and waste are subsumed under Supply and Disposal. Both fulfil infrastructure requirements for households, agriculture and forestry, as well as industry and commerce. They must satisfy the need for supply and disposal safety and efficiency as well as ecological requirements. The energy-supply industry uses resources and releases substances, e.g. into the atmosphere. The main environmental resource used for the water supply is water. Substances are also released within the context of waste and wastewater disposal. One important task in waste disposal is the recycling of waste into secondary raw materials and secondary energy sources (product life-cycle management) in order to conserve resources.

Transportation

The current steady growth in traffic volume is the result of private mobility requirements and the transportation requirements of all economic sectors. Traffic can be divided up into road, rail, air and ship traffic (modal split) and involves transport of both persons and goods. While households play a large role in passenger traffic as a result of journeys to and from work and changes in leisure behaviour, goods traffic is mainly due to commercial activities. Through its need for land and consumption of resources, the release of substances and growth of noise, transportation exerts a multitude of effects on all environmental media and resources, and thus impacts on ecosystems and landscape, climate, human health and raw-material supplies. Within the context of sustainable development, the far-reaching socio-economic aspects of transportation (e.g. consequences of accidents) must also be taken into account.

Pressure Factors (Pressure)

*Many **pressure factors** (pressures) result from human activities. In line with the polluter-pays principle, the qualitative and quantitative allocation of these factors to the individual sectors is important for developing indicators. Pressure factors lead to changes in the state of the environment, i.e. environmental media and resources.*

Substances

During human activities, substances are introduced into the environment as input materials that serve specific purposes (e.g. fertilisers, pesticides) or released within the context of disposal (e.g. via waste gases and wastewater). They change the composition of the environmental media, viz. air, water, soil and biota. These substances may be transported, accumulated, converted and mobilized in these media, and abstracted from them. Because of their substance-specific effects (e.g. toxic, eutrophic, acidic), the substances may influence humans (health), ecosystems and climate via these media.

Noise

People perceive sounds as noise when they are consciously or unconsciously disturbed by them. Humans and animals may be affected both in their living and sleeping areas. The harmful effects of noise become more severe with increasing volumes, and the share of people who feel disturbed or are objectively burdened increases. Impairment of sleep phases at night is particularly harmful. Noise is environmental pollution that can be experienced directly. According to all polls since the end of the 1950s, more than 50 % of people feel adversely affected by noise. Environmental noise has physical, psychological, social and economic effects on humans and also impacts on ecosystems by disturbing animals. Noise has increased primarily through road traffic and leisure-time activities.

Radiation

Radiation is the targeted spatial and temporal dissemination of energy in the form of waves and/or particles. We differentiate between ionising and non-ionising radiation. Ionising radiation (radioactive radiation) is produced both by natural and civilization-related sources. Natural sources include space (cosmic radiation) and natural radioactive materials (terrestrial radiation). Civilization-related sources are medical x-ray diagnostics, nuclear medicine, coal and nuclear power plants and the industrial use of radioactivity (e.g. non-destructive testing of materials with x-rays). Non-ionising radiation results both from natural sources, e.g. natural infrared or UV radiation, and also from artificial sources, e.g. radio waves or microwaves from the operation of transmission systems and cell phones. Ionising radiation may damage cellular tissue and alter genotypes. Non-ionising radiation may also cause damage to cellular tissue; the possibility of further health impairments is currently being investigated.

Biological Agents

Biological agents, e.g. pathogenic microorganisms, may also put pressures on environmental media. Bacteria and viruses in wastewater may pollute surface waters to such an extent that they can either no longer be used at all (e.g. for bathing) or only to a limited extent. Genetic engineering techniques can be used to recombine the genotype of organisms for a certain purpose and this effect may also be transferred beyond the species. Genetic engineering is employed all over the world today in all sectors dealing with organisms, e.g. in medicine, agriculture, food production and environmental protection. The negative effects of genetic engineering on health are the subject of discussion (e.g. triggering of allergies through proteins that have been altered using genetic engineering) or on ecosystems (e.g. uncontrolled spread of organisms that have been altered by genetic engineering).

Structural Changes

The economic uses of the resources soil/land can be divided up into settlement and transportation , agriculture and forestry, other economic and public uses (e.g. industry, commerce, supply and disposal facilities, recreational uses) and exploitation of raw-material deposits. All of these uses compete with one another. Bodies of water are likewise subject to structural changes through use of water for recreational purposes, fishing or the generation of energy, for instance, but also for waste-heat discharges, e.g. from thermal power stations. The needs of human beings are satisfied by the various forms of anthropogenic land use. These often cause irreversible structural changes in the ground (e.g. sealing and loss of soil, fragmentation of areas), in water bodies (e.g. straightening of watercourses, barrage weirs) and in habitats for animals and plants (e.g.

destruction of biotopes). Such changes, in turn, impair the natural functions of the environmental media as components of the ecosystem (e.g. filtration, buffering, substance conversion, habitat function) and as the basis of life.

Resource consumption

Human activities consume global and regional reserves of energy, water, soil/land and other raw materials. The available reserves of today's most important fuels, viz. crude oil, natural gas and coal, as well as minerals (e.g. ores) are just as limited as agriculturally productive, fertile land. Although global consumption of resources continues to rise along with rising population figures and living standards, a decoupling from economic growth has been possible in some sectors (e.g. energy consumption) thanks to increased efficiency. Use of resources must orient itself to the capacity for regeneration of renewable resources (e.g. water) and/or the replacement rate of non-renewable resources (e.g. fossil fuels). For the supply of drinking water, the quality of water resources and (as with land) regional availability are of particular importance. Like water, many plants and plant components (e.g. wood, vegetable oils etc.) can also be put to unlimited use as renewable raw materials or fuels if produced in an environmentally sound manner and used efficiently.

Environmental Media and **Resources** (State)

*It is useful to differentiate between environmental media and resources when describing the s**tate** of the environment. With environmental media, it is generally quality aspects of habitat functions and other natural functions that are the primary focus of interest (cf. air, water and land quality). Resources are material and energy reserves in the ecosystem as well as the limited land space available for further development. Within this context, the focus is on quantitative and economic aspects of use. The state of the environmental media – e**nvironmental quality** - and of resources is altered by the above pressure factors and may have to be assessed on a regional level (e.g. air quality in cities).*

Environmental Media

Atmosphere

The atmosphere is the mantle of air surrounding the earth. It consists of nitrogen, oxygen and trace gases, and is in direct contact with the hydrosphere, biosphere and pedosphere, so that an intensive exchange of substances takes place among these environmental media. The atmosphere is altered by all anthropogenic activities via the introduction of substances, with potential impacts on ecosystems, climate and human health (e.g. climate changes caused by trace elements in the atmosphere – "greenhouse effect", depletion of the ozone layer in the stratosphere – "hole in the ozone layer", substances with acidification effects – ammonia, nitrogen and sulfur dioxide, as well as health risks from certain air pollutants such as fine particulates, volatile organic compounds – "VOCs", persistent organic pollutants – "POPs", and ground-level ozone). In addition, the atmosphere serves as a carrier medium for sounds. Sounds affect ecosystems and human health in the form of "environmental noise".

Water

Water, in the form of fresh water and salt water, is the largest habitat and a prerequisite for life in all ecosystems on earth. It is essential for soil fertility. At the same time, groundwater is of great importance as a natural water reservoir. The interplay between precipitation, surface and groundwater regulates the water supply. The quality of the environmental medium water is impaired by the input of substances and microorganisms (e.g. foodstuffs, heavy metals, persistent organic compounds, POPs, active substances in medicines, bacteria, viruses etc.). This leads, for example, to the accumulation of pollutants in sediments and organisms, eutrophication or acidification with possible impacts on the ecosystem, and consequences for use. Water as a storage medium for warmth affects local and global climatic conditions.

Soil

Soils are three-dimensional layers of the earth's outer crust (pedosphere) that are characterized by soil-forming processes (pedogenesis) and constantly change as a result of such processes. The factors involved in pedogenesis include geology, climate, biotic communities, relief, humans and time. As far as its natural functions are concerned, soil is the basis of life for people, animals, plants and soil organisms; it is a component of ecosystems, especially with its water and nutrient cycles; as a medium for decomposition, balance and restoration it has filtering, buffering and substance-converting properties that make it especially important for groundwater protection. Harmful substances also enter drinking water and the food chain via the soil and may thus harm humans and other living beings. Structural changes, such as the compacting or wetting of soil, also interfere with its functions and the chain of natural processes.

Biota

Biota are all life forms in the environment (plants, animals, fungi etc.). They are the basic living components of ecosystems. Impacts on the environment are initially characterized by substance changes or changes in the behaviour of individual life forms, which may lead to individual damage. Because of the functional integration of biota in ecological systems, such damage may then trigger changes in the ecosystems. Biota must therefore be protected as an environmental medium as well as for reasons of their gene-pool function, for ethical reasons and, finally, for the well-being of humans. Despite their dependence on the functions of ecosystems, humans are not classed as biota, but are considered separately due to social and economic connections.

Resources

Energy

Humans use various energy sources for the production of the warmth they need (e.g. heating systems) or for the production of power (e.g. electricity) for all of their activities. An adequate energy supply is one of the most important prerequisites for economic activities today and an indispensable basis for the life of future generations, as well. Whereas the most commonly used fossil fuel sources, *viz.* crude oil, natural gas and coal, and also fissionable uranium, are exhaustible, solar and wind power, geothermal heat and biomass are renewable. Non-renewable energy sources should be used as economically as possible (energy efficiency), in keeping with the goal of sustainability. This is all the more necessary because crude oil serves as an important non-renewable raw material for the production of materials and because the use of fossil fuels plays an important role in climate change through the release of carbon dioxide. At the same time, increased efforts should be made to use renewable raw materials and secondary raw materials from waste recycling as substitutes for non-renewable energy sources.

Water

Only a very small share of the water on earth, i.e. fresh water, is suitable for use as drinking water and service water in food production, and for the irrigation of areas used for agriculture. In Bavaria, fresh water is obtained almost exclusively from groundwater and spring water. Service water used for hygienic purposes makes up the largest share of water consumed in households. Water is used in agriculture and horticulture for irrigation purposes as well as for the subsequent processing of food products. Industry and commerce also use large quantities of water for the production of other goods. It is used both as a solvent and as service and cooling water. The availability of water is thus an important criterion for location selection. Although Bavaria has an overall abundance of water, it also has regions where temporary shortages may occur. Water is therefore stored, and some water is diverted from the Alpine and Danube regions to the north, where there is less water. The input of substances to water during processes in which it is needed reduces its general usability. Hydropower, as a renewable energy source, plays a role in the energy supply (see Energy). Valuable foodstuffs are taken from the sea, inland lakes and rivers.

Soil/Land

The soil has many uses and is therefore an important resource. Loss and/or destruction of soil functions is dependent on the way in which the land is actually used (see Structural Changes). Competitive situations with respect to agricultural use or the conservation of ecosystems arise, for example, through the development of commercial facilities, settlement and transportation routes, or through the use of materials found in the ground as raw materials (ores, construction materials etc.). Soil pollution results from infrastructure-related phenomena such as settlements, industrial plant or transportation routes. Soils may lose their natural functions (e.g. filtering properties) or their economic functions (e.g. production of foodstuffs) as a result of excessive pollution and thus be lost as a resource. Loss of function may also be caused by excessive agricultural or forestry use resulting in structural changes to the soil such as ground compaction, wetting or erosion.

Raw Materials

A distinction can be made between mineral and renewable raw materials. Mineral raw materials are mined below or above ground, depending on the location of the deposits. Roughly, mineral raw materials can be categorized as energy-producing raw materials (see Energy), metal ores, stones and earth as well as other industrial minerals. The most important industrial raw materials include crude oil, coal, natural gas, sand and gravel, iron ore, limestone, bauxite, lignite, sulphur and phosphate. Renewable raw materials are plant and animal products from agriculture and forestry for commercial and industrial use in the non-food sector. Raw materials such as fibres, medicinal plants, wood, lignocellulose, oils, fats, starch etc. can be processed industrially to form products such as construction materials, paper, industrial starch etc. or used to generate heat and power (see Energy). Non-renewable raw materials should be used as economically as possible (raw material efficiency) in keeping with the goal of sustainability. At the same time, increased efforts should be made to use renewable raw materials and secondary raw materials from waste recycling as substitutes.

Impacts

Qualitative and quantitative changes to the state of the environment, i.e. to the environmental media and resources, may have ***impacts*** *on natural resources and human health. These may be so far-reaching that future generations can no longer live in a manner that meets their needs. A break-down of this section into the sub-sections ecosystems, climate, landscape, resources and health is proposed, as this allows fields of action to be included in which social and/or economic consequences also need to be taken into account, sometimes even to a major extent. Again, the links to the economic and social pillars of sustainability necessary for developing sustainability indicators can be established..*

Ecosystems

Ecosystems consist of biota and the media water, soil and atmosphere. They are characterized by the interactions of living organisms with one another and with their habitats. Every ecosystem has special structures and functions. Structures are determined as follows: physically, by spatial arrangement; chemically, by the quantity and distribution of inorganic and organic substances; biologically, by the nutritional levels of producers, consumers and decomposers, the range of life forms and variety of species. The functions of ecosystems are determined by the material life cycle, the associated flows of energy and also the relationships and interactions between the biota. Ecosystems are always open and, to a certain extent, capable of self-regulation, i.e. the ability to buffer disturbance through internal regulatory mechanisms such as predator-prey relationships, competition or symbiosis, and thus to retain a certain stability. More extensive anthropogenic changes to the environmental media may lead to unpredictable changes to the ecosystems and thus to the endangerment of natural resources.

Climate

The earth’s climate is characterized by meteorological parameters such as air temperature, humidity and pressure, precipitation, winds and solar radiation. It also incorporates spatial and temporal characteristics. The radiation balance on earth is a key climatic factor; it is influenced by the share of certain natural and anthropogenic greenhouse gases such as carbon dioxide and steam in the atmosphere. On the one hand, these gases keep the earth “warm” and are thus essential for our life forms, and on the other, the share of these gases is steadily increasing, e.g. through the use of fossil fuels. Climate changes such as the rise in global temperatures can already be observed and have been forecast for the future with the help of climate models. Current knowledge assumes a human contribution to these climate changes. Rapid changes in climate may, in particular, have far-reaching impacts on biota and ecosystems. In addition, there are social and economic impacts such as those on regional production of foodstuffs and renewable raw materials and the threat to people and property though natural disasters.

Landscape

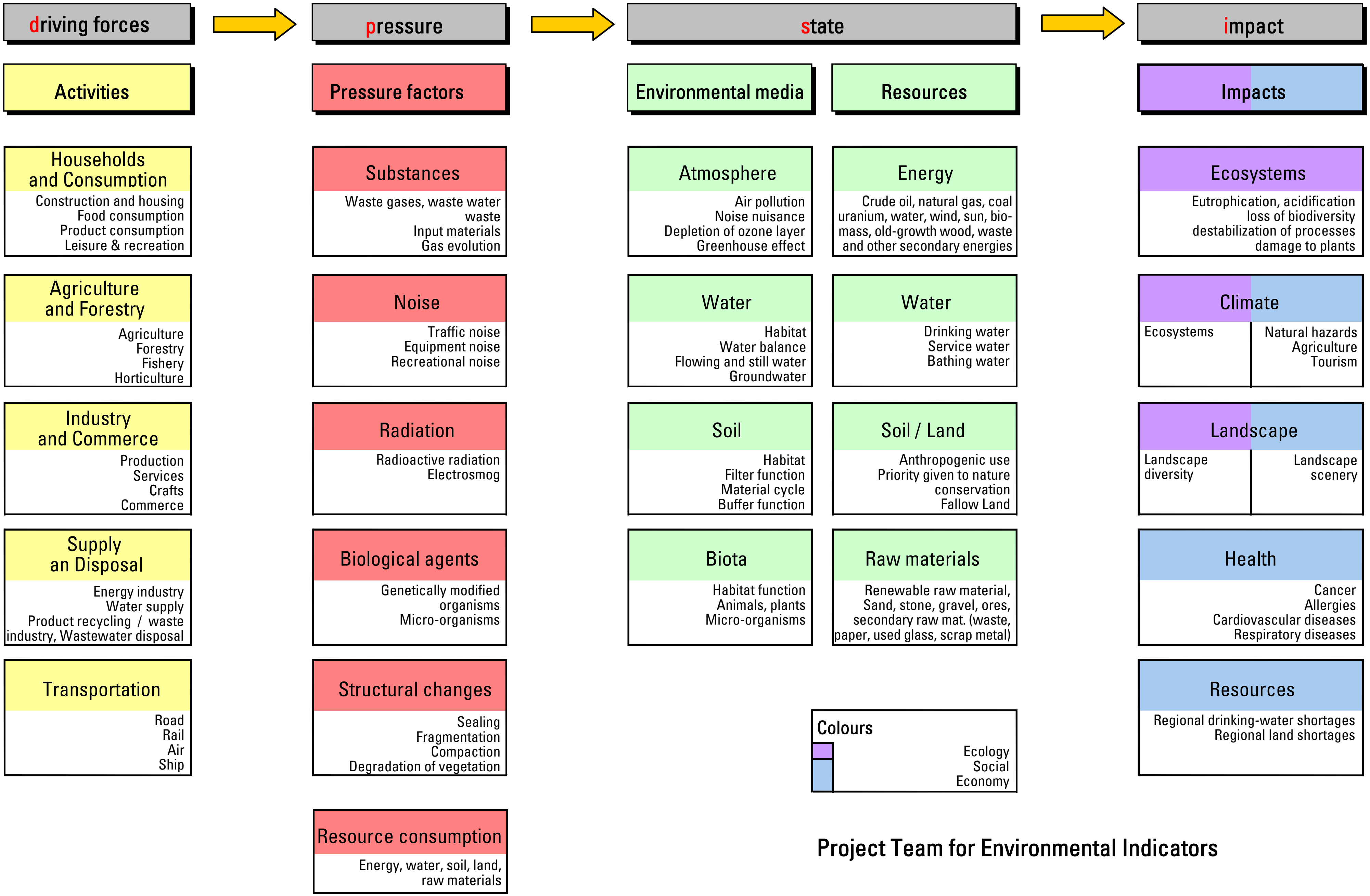
A landscape is a section of the earth's surface which, as a result of its features (landscape structure) and functional network (landscape balance), can be viewed as a unit, consists of a mosaic of various ecosystems and can be re-shaped by humans to a greater or lesser degree. A natural landscape is primarily characterized by natural or semi-natural ecosystems, whereas a cultural, man-made landscape is primarily characterized by cultivation- and settlement-related ecosystems. Under our socio-economic conditions, landscapes are thus usually systems in which natural characteristics, e.g. geology, biota, watercourses and climate, and man-made structures, such as transportation routes, settlement patterns and other land uses, overlap and influence one another. Changes to the landscape have an effect on ecosystems, quality of life for humans and economic aspects (e.g. agriculture, rural tourism).

Health

Health is a basic human need, defined as a state of complete physical, mental and social-well-being (World Health Organization – WHO). Besides genetic factors and individual lifestyles, environmental factors such as noise, radiation and chemicals also contribute to the occurrence of disease. Diseases connected with such environmental factors are cancer (skin, lung), allergies and respiratory diseases. Human health and high environmental quality are thus closely connected. Damage to health has substantial social and economic effects.

Resources

An economy that is committed to the principle of sustainability requires the most economical use of available resources possible, with such use being optimised with respect to competing potential uses. Energy reserves such as crude oil and natural gas, and other supplies of raw materials are distributed unevenly over the world and traded globally. Other resources, e.g. drinking water, renewable raw materials or renewable energy such as biomass, waterpower and wind, are, on the other hand, generally traded in regional markets. The use of soil and land is almost exclusively determined by local and regional decisions. Excessive resource consumption is likely to cause a shortage of raw materials unless technical progress, management systems and changes in behaviour are able to improve our stewardship over resources and provide substitutes for important raw materials. A shortage of resources could lead to major economic impacts (e.g. prices, costs) and social impacts (supply problems, unfair distribution) and thus to limited satisfaction of basic elementary needs. It must therefore be prevented through sustainable development.


driving forces
pressure
state
impact
Activities
Pressure factors
Environmental media
Resources
Impacts
Households and Consumption
Construction and housing
Food consumption
Product consumption
Leisure & recreation
Agriculture and Forestry
Agriculture
Forestry
Fishery
Horticulture
Industry and Commerce
Production
Services
Crafts
Commerce
Supply an Disposal
Energy industry
Water supply
Product recycling / waste industry, Wastewater disposal
Transportation
Road
Rail
Air
Ship
Substances
Waste gases, waste water
waste
Input materials
Gas evolution
Noise
Traffic noise
Equipment noise
Recreational noise
Radiation
Radioactive radiation
Electrosmog
Biological agents
Genetically modified organisms
Micro-organisms
Structural changes
Sealing
Fragmentation
Compaction
Degradation of vegetation
Resource consumption
Energy, water, soil, land, raw materials
Atmosphere
Air pollution
Noise nuisance
Depletion of ozone layer
Greenhouse effect
Water
Habitat
Water balance
Flowing and still water
Groundwater
Soil
Habitat
Filter function
Material cycle
Buffer function
Biota
Habitat function
Animals, plants
Micro-organisms
Energy
Crude oil, natural gas, coal uranium, water, wind, sun, bio-mass, old-growth wood, waste and other secondary energies
Water
Drinking water
Service water
Bathing water
Soil / Land
Anthropogenic use
Priority given to nature conservation
Fallow Land
Raw materials
Renewable raw material, Sand, stone, gravel, ores, secondary raw mat. (waste, paper, used glass, scrap metal)
Colours
Ecology
Social
Economy
Ecosystems
Eutrophication, acidification
loss of biodiversity
destabilization of processes
damage to plants
Climate
Ecosystems
Natural hazards
Agriculture
Tourism
Landscape
Landscape diversity
Landscape scenery
Health
Cancer
Allergies
Cardiovascular diseases
Respiratory diseases
Resources
Regional drinking-water shortages
Regional land shortages
Project Team for Environmental Indicators

Bavarian Environment Agency

Environmental Indicators
- Appendix 2 -

Indicator Overview

Nature and Landscape

No.	Indicator	UMK [1]
1	***Land for nature conservation goals*** [2] Share of land in Bavaria for nature conservation goals - [%]	***Nature conservation land*** (1)
2	***Environmental farming*** [2] Share of farmland under environmental management - [%]	***Ecological agriculture*** (1)
3	***Species endangerment*** Red list species and population trends for special plant and animal species - [Index]	-
4	***Representative species*** Species diversity in non-protected landscapes – population trends for representative bird species - [Index]	***Representative species*** (2)
Indicator is being created as part of the indicator-system development process, for example in the Federal/state environmental committees.		***Landscape fragmentation*** (3)
Indicator is primarily relevant on a local level and in the context of sustainable development; it is of less importance for a state-level environmental indicator system.		***Recreational areas in conurbations*** (1)

Ecosystems

No.	Indicator	UMK [1]
5	***Quality of treated wastewater*** Wastewater discharges into surface waters – state-of-the-art compliance as required by §7a of the Federal Water Act [WhG] and the Wastewater Ordinance [AbWV] - [%]	-
6	***Fertilizer use*** [3] Use of mineral nitrogen fertilizers in agriculture - [kg/ha/yr]	***Nitrogen excess*** (3)
7	***Acid and nitrogen input*** [4] Acid and nitrogen input to semi-natural unforested ecosystems from the atmosphere - [keq/ha/yr] and [kgN/ha/yr]	***Acid and nitrogen input*** (3)
8	***Heavy metal input*** [4] Heavy metal input to semi-natural unforested ecosystems from the atmosphere - [Index]	***Heavy metal input*** (3)

9	***Water quality*** Biological water quality (saprobic system) – share of flowing water with quality classes "unpolluted" to "moderately polluted" - [%]	***Water quality*** (1)
10	***Nitrate in groundwater*** Share of EEA-network monitoring sites with $NO_3 < 25$ mg/l - [%]	***Nitrate content of groundwater*** (1)
	Indicator is being created as part of a future, interdisciplinary development process	***Condition of forests*** (1)

Climate and Health

No.	Indicator	UMK [1]
11	***Carbon dioxide emissions*** Energy-related carbon dioxide emissions - [million t/a]	***Carbon dioxide emissions*** (1)
	This additional indicator is relevant in the context of sustainable development because of the focus there on "environmentally friendly mobility"; for a state-level environmental indicator system, "carbon dioxide emissions" (see No. 11) are sufficient.	***Carbon dioxide emissions from transportation*** (1)
12	***Air quality index*** [5] Short-term air quality index for air pollutants NO_2, SO_2, CO, O_3, and PM_{10} - [Index class]	***Air quality*** (1)
13	***Road traffic noise*** Growth in road-traffic-related noise pollution - [%]	-
14	***Total noise pollution in residential areas*** [6] Share of the population in whose residential area the overall outdoor noise level exceeds 55 / 65 dB(A) during the day - [%]	***Noise pollution*** (3)
	Indicator is relevant in the context of sustainable development because of the focus there on "environmentally friendly mobility".	***Goods transportation service*** (2)
	Indicator is currently being created as part of the indicator-system development process by expert committees at Federal/state level.	***Pollution of breast milk*** (3)

Resources

No.	Indicator	UMK [1]
15	***Land take*** Land taken for settlement and transportation purposes - [ha/d]	***Land take*** (1)
16	***Energy consumption*** Primary energy consumption (PEC) - [PJ/a] and share of renewable energy sources - [%]	***Energy consumption*** (1)
	Indicator is relevant in the context of sustainable development because of the focus there on "climate protection and energy policy" and because of its connection with the economic index "gross national product"; in a state-level environmental indicator system, "energy consumption" (see No. 16) is sufficient.	***Energy productivity*** (1)
	Indicator is relevant in the context of sustainable development because of the focus there on "resource use"; in a state-level environmental indicator system, "energy consumption" (see No. 16) is sufficient.	***Final energy consumption by private households and small users*** (1)
17	***Waste and recycling*** Generation of household waste and household-type commercial waste - [kg per capita/yr] and recycling rate - [%]	***Waste and recycling*** (1)

Indicator is relevant in the context of sustainable development because of the focus there on "resource use" and because of its connection with the economic index "gross national product"; it is of less importance for a state-level environmental indicator system.		***Raw materials productivity*** (1)
18	***Hazardous waste*** Hazardous waste generated and amount landfilled at hazardous waste dumps - [1,000 t/a]	-
19	***Contaminated sites*** Share of the total number of sites with suspected contamination that received clarified contamination status, reference year 2000 – suspicion clarification rate [%]	-
20	***Environmental management*** [7] Share of employees in Bavaria that is employed in EMAS-validated organisations - [%]	***Environmental management*** (EMAS: 1 / ISO 14.000: 3)

The figures given in brackets for the "environmental sustainability indicators" adopted by the Conference of Ministers for the Environment [UMK] evaluate the cross-state/Federal feasibility level of the indicators according to a classification system adapted from the "Federal/state working group on sustainable development" (BLAK NE) as follows:

Level **1**: Indicator is already feasible
Level **2**: Indicator is feasible; individual technical, methodical or data-related aspects still need to be clarified
Level **3**: Indicator is of technical importance but not yet ready for application; substantial efforts are necessary

Explanations:

1) Core indicator adopted at the 62nd Conference of Ministers for the Environment [UMK]) on May 6th and 7th, 2004 in Bad Wildungen / see www.blak-ne.de

2 As core indicator, but expanded to include components specific to Bavaria

3) Feasible alternative; to be replaced as soon as core indicator "excess nitrogen" is available.

4) Indicator is the basis for current nationwide development work on the core indicator; will be replaced in so far as is then necessary

5) Alternative to core indicator with individual air pollutants; will be replaced as soon as aggregated air quality index is available as core indicator

6) Feasible alternative to core indicator; will be replaced as soon as a core indicator "noise" is available

7) Currently limited to EMAS organisations; to be expanded as soon as ISO 14,000 data is available as per core indicator