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# Development of Environmental Indicators for Monitoring of Genetically Modified Plants

by

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# Summary

In the last decade environmental monitoring is of increasing interest to provide politicians, stakeholders, decision-makers and the general public with information needed to design an adequate environment policy. Some experience is already gained in the field of technical and chemical based surveillance of environmental impacts and levels of pollutants. To observe the current state of the environment and to survey changes in environmental conditions, nowadays also the consideration of biotic aspects is required. A common approach for long-term monitoring is to design sets of indicators, thus various initiatives are preparing indicator based monitoring concepts.

One outstanding achievement in the international environmental debate was the adoption of Agenda 21 during the Earth Summit in Rio in 1992. The Agenda 21 is a comprehensive plan of action to be taken globally, nationally and locally by organisations of the United Nations System, Governments and Major Groups in every area of human impact on the environment. Chapter 40 of the Agenda 21 calls for the development of indicators for sustainable development. In particular, it requests governmental and non-governmental organisations at the national and international level to develop the concept of indicators of sustainable development in order to identify such indicators.
In response to the Agenda 21 the EU adopted the directive on Environmental Indicators and Green National Accounting (COM (94) 670 final) as a framework and a request for a further development of indicators.

Also in the field of biotechnology and genetic engineering an environmental surveillance is requested by the EU. With the adoption of the amended directive 90/220/EEC ‘on the deliberate release into the environment of genetically modified organisms’ (directive 2001/18/EC) in March 2001 a monitoring of the environmental effects of the release of genetically modified plants will be needed from 2002 onwards. Member states are requested to develop appropriate concepts to ensure a general surveillance for unanticipated adverse effects and, if necessary, case-specific monitoring focusing on adverse effects identified already.

Already during the last years the German Federal Environmental Agency initiated some basic research on monitoring of the deliberate release of genetically modified

plants. In 1999 two complementary approaches to prepare a monitoring concept were taken:
One research project took adverse effects of transgenic plants as a starting point. Within that project ‘Conceptual development of a long-term monitoring of genetically modified plants’ (FKZ 299 89 406), already identified effects, but also subsequent and potential effects are evaluated. The respective monitoring concept will be based on parameters.
As several environmental indicator sets were launched nationally and internationally in the past, the German Federal Environmental Agency decided to complete the bottom-up approach mentioned above with a top-down approach to assess, if already existing concepts could be adopted for a monitoring of genetically modified organisms. The aim of this study is to evaluate, if indicators of existing sets of indicators could also be used for an environmental monitoring of effects of the agricultural use of transgenic plants. It is to avoid to design a new set of indicators whilst others are available and potentially suitable.

The present study starts with some general considerations on the use of indicators for an environmental monitoring. The potential of indicators is examined as well as expectations in indicators are looked at.
Six international and five German proposals for environmental indicator sets are evaluated regarding their aims, their conceptual background and especially the proposed indicators.
The following indicator sets and concepts are evaluated:

- proposals of environmental indicators by the OECD
- proposals of indicators of sustainable development by the UN Commission on Sustainable Development
- proposals of indicators to assess Biological Diversity in the framework of the Convention on Biological Diversity
- proposals of Environmental Pressure Indicators and Environmental Headline-Indicators by the EU
- indicators used by the European Environmental Agency for the Environmental assessment report in 2000
- a proposal of Environmental Headline-Indicators by the European Environmental Bureau

- proposals of environmental state indicators for an economical and ecological national accounting in Germany (especially suggestions for an Ecological Area Sampling)
- points of the German concept for an integrated environmental monitoring (ökosystemare Umweltbeobachtung)
- a proposal of indicators for the assessment of agricultural impacts on the environment (UFOPLAN 297 81 139)
- a proposal of indicators by the Commission of Inquiry of the German Parliament 'Protection of Humans and the Environment' ('Schutz des Menschen und der Umwelt')
- indicators of sustainable development concerning bt-corn proposed within a risk dialogue by Novartis AG, Foundation Risk Dialogue (Stiftung Risikodialog, St. Gallen, Switzerland), Austrian Ecology Institute (Österreichisches Ökologie-Institut) and the Institute for Applied Ecology (Öko-Institut e. V.).

For the indicators suggested in these proposals and concepts it is assessed if they could serve as well as indicators for a monitoring of genetically modified plants. They are analysed regarding their potential suitability to reflect effects of the deliberate release of transgenic plants in agriculture. Besides the direct application it is evaluated if modifications or additions would be needed.

For some of the selected indicators a more detailed assessment is done. Taking 'pesticide use' as an example, the possible use and the capacity of the indicator are evaluated. Some additional suggestions for a practical adjustment are made. Further indicators are proposed.

To discuss this approach and the preliminary list of selected indicators with experts involved in the national and international indicator discussion a workshop was held in January 2001 in Berlin. The possible practical value of indicators already proposed was discussed as well as their expressiveness. To evaluate the actual possibilities to use indicators from other sets for a monitoring of transgenic plants or to integrate additional relevant indicators in existing systems an overview on international and national environmental indicator concepts was given.
This led to a discussion on the indicator approach as such and especially to a discussion on an indicator approach to monitor effects of genetically modified plants.

**Results:**

International suggestions for a monitoring have to work on themes with a world-wide relevance. Consequently international sets of environmental indicators have to be suitable to reflect effects in a broad range of various ecosystems and of very different agricultural systems and practice. Therefore they can not be adopted to every possible special issue but have to provide a general overview.

For several years a process of identification and implementation of environmental action targets is ongoing. For the abiotic sector agreements on targets are partly found and some action targets are implemented even legally. Based on clear and agreed environmental action targets the development of specific indicators is possible.
For several abiotic environmental phenomena a clear indication is feasible by few indicators, based on data, comparatively easy to sample.
On the other hand there is incomplete knowledge and data to establish trends for some other areas. Especially concerning biodiversity, habitats and landscape, the knowledge and measurement of impacts is still at a preliminary stage of research. International standards and agreed action targets are still under preparation. Besides others this is due to a very controversial, partly ethical debate on values and baselines.
To assess biotic aspects and trends within the biotic compound of the environment a broad set of indicators is needed to reflect the complex set of interactions and interdependence within biological systems.
The capacity of indicators to monitor trends in biodiversity was questioned during the workshop.

Presumably as a result of the uncertainties in designing a sound monitoring on biotic aspects, very often international sets of indicators are incomplete or claim problems to assess biotic aspects. Whilst for several years chemical and technical data are already sampled continuously for an environmental long-term monitoring, such an approach is still missing for a large-scale biological monitoring.
Just two of the German proposals under consideration, the Ecological Area Sampling (Ökologische Flächenstichprobe) and the concept for an integrated environmental monitoring (ökosystemare Umweltbeobachtung), suggest reporting systems to provide regular and reliable information on trends and states in the natural environment.

Sets of environmental indicators developed in the international context refer to issues already identified and accepted as problematic.
Biotechnology and genetic engineering are rather new technologies. There are several data and hints both from laboratory and field trials, that unintended effects could occur by the agricultural use of transgenic plants. But there is no exact and complete knowledge or documented experience on effects to expect by a large-scale release of genetically modified plants. Besides this lack in knowledge there is a deficiency in data, to be the basis for a development of relevant indicators. This situation may be one reason why all of the evaluated international sets of (environmental) indicators were drawn up regardless of possible effects by the agricultural use of transgenic plants.
As long as there is no particular development of indicators and as there are no suggestions for indicators reflecting possible effects of genetically modified plants, such information could possibly be provided by other indicators. Probably indicators drawn up in another context could be adopted for this additional purpose.

Is such a transfer an adequate means?
It should be held in mind that an ideal indicator is an indicator with a clear relation to a question to answer. It would be perfect, if an indicator could be integrated in an evident and certain relation between trigger and effect. For an adoption of an indicator for an additional purpose this ideal criteria remains the same.

Looking at indicators proposed for an environmental monitoring it is striking, that rarely aims, assessments done to select the indicators, the significance of a single indicator in a set of indicators or reference values are given. Given selection criteria are mainly pragmatic aspects. However, normally indicators are chosen following several criteria and aims – although they are not always presented in a transparent way.
For indicators, accompanied by selection criteria or even reference values, the question of transferability would be easy to assess.

If a limited set of indicators should represent several themes, a certain degree of aggregation cannot be avoided. Main purpose of such aggregations is to communicate detailed information to an audience that requires condensed, “simplified” information. During the process of aggregation some links or precise information may be lost. As a consequence indicators (and especially biological indicators) can not always be related to a specific cause. For such a clear relation between cause and effects there is often a need for additional information, especially as biological phenomena often can have diverse causes.

One aim of an indicator approach is an aggregation on the national level. Phenomena will be reflected as soon as they show a large-scale occurrence or a regional but massive appearance. The evidence of local or regional effects will be statistically ‘diluted’ if data are aggregated over vast areas. Simultaneously the number of possible reasons for the tracked effects is raising.

Indicators have to meet pragmatic criteria to be accepted. Indicators have to be simple, unambiguous, easy to assess and affordable with (very) limited means. Sets of indicators should be as small as possible which leads to high levels of aggregation. Indicators have to simplify complex circumstances and facts, as they aim at the description of general tendencies. This reduction to a simplified indicator is made regarding the specific needs the indicator originally is developed for. To adopt indicators to a new context it is necessary for each indicator to evaluate, if the reduction of a complex system to a single indicator is appropriate to the new context too.

Looking at ecosystems with their diverse interactions and interdependencies an aggregated indicator can hardly provide clear and unambiguous messages. Only a set of indicators may have the potential to reflect such complex systems in an adequate way. As a consequence each indicator has to have its exact and meaningful place and function in such a set. Thus sets of indicators can not be an accidental collection of indicators available.

The detailed examination of the sets of indicators mentioned above revealed 130 indicators possibly relevant to monitor effects of transgenic plants within agricultural systems. Several of the proposed indicators are very similar.

None of them has the potential to serve immediately as an indicator for a monitoring of transgenic plants. For such a monitoring a modification or specification of the indicators would be needed.

There are few indicators right to show direct effects of the use of transgenic plants. Mostly the indicators are suitable for a general assessment of impacts and trends. Partly they could provide essential background information to explain phenomena.

Some indicators (especially agri-environmental indicators, e.g. 'pesticide use') are more likely to contribute to an evaluation of some frequently promised positive impacts of the agricultural use of transgenic plants (e.g. reduction of pesticide use).

By using the indicators suggested up to now, no complete reflection of the ecological and environmental impact of the commercial use of transgenic plants in agriculture would be possible. Partly this is due to the lack of knowledge and subsequently the lack of indicators regarding biodiversity and biological phenomena. Most of the effects expected to be likely by the use of transgenic plants in agriculture are in the biological area. Consequently the very preliminary stage of the indicator discussion concerning biotic aspects has a remarkable impact on the process of developing indicators for monitoring effects of biotechnology and genetic engineering.
In addition a much broader set of indicators is required for the field of biodiversity than for others, which hampers the finding of an appropriate set of indicators and the building of a consensus on these indicators.

Up to now there are no proposed indicators suitable to monitor effects of transgenic plants in general but only to monitor effects of some species or of specific changes.
None of the indicators allows to associate beyond doubt an effect reflected by an indicator with a transgenic plant as the single possible cause. Thus there is always the need for additional information to try to assess if changes or variations in the indicator values are related to the release of genetically modified plants or to some other reasons.

Looking for implemented or at least widely accepted and agreed concepts of sets of environmental indicators it turns out that there are no such sets yet. As a consequence actually no already ongoing survey by indicators is available to be used for monitoring effects of genetically modified plants.
There are still several sets of (environmental) indicators under development and discussion, e.g. the environmental indicators of the OECD, indicators of sustainable development of the UN Commission on Sustainable Development, indicators to assess Biological Diversity in the framework of the Convention on Biological Diversity or environmental pressure indicators within the EU. As the development of these sets is ongoing, there may be the chance to integrate some additional aspects into this process. This may be one starting point for a monitoring of effects of the release of genetically modified organisms into the environment.

In addition, this open situation offers the opportunity to define the expectations towards a long-term monitoring of genetically modified plants, which also meets the requirements of a general surveillance as included in the new directive 2001/18/EC. It is to consider which of the expectations towards the monitoring should be met by an indicator approach.
Thereby it is to bear in mind, that indicators are a means to provide ‘easy’ information by the condensation of information, which implies a loss of detail.

For a development of new indicators it is to determine the case in question, the aim and the target group. Normally the starting point are effects. On the basis of a selection of data on these effects, indicators are derived, considering general action targets. As soon as indicators are defined, specific target values can be discussed. The basic criteria used for the selection during the whole process of developing indicators should be documented.
Sets or even systems of indicators help to describe general tendencies and should allow an (early) warning. However the possibilities for drawing conclusions on basic causes are limited. To provide information on complex interactions and situations it may be worthwhile to design a monitoring based on hypothesis and anticipated effects. It would be very welcome if these could be linked to indicators. But as indicators aims on a description of general tendencies and can not provide detailed information or even an analysis, an indicator approach can probably be only one part of a monitoring which should include aspects of a general and a case-specific surveillance (see other conceptual approaches mentioned above).

In the course of the workshop it occupied a large part of the discussion, which scale of a survey would be suitable.
There were many voices emphasising to start a monitoring by a regional, farm-scale census of data and to build indicators by data of representative farms. But a wide-ranging, detailed survey could probably only be put into practice for a test phase. It was named to be impossible to implement such a system on the long run in terms of limited means. On the other hand the idea was mentioned to impose the duty of data collection whenever a farmer cultivates transgenic plants.
Already now farmers are obliged to keep a record of their pesticide use for instance. But in accordance with the legislation in force (data protection) there are no possibilities to utilise those data for an analysis. To use these data, they have to be

anonymisated. This hinders finding relations between agronomic and environmental data.
As up to now farm-scale census approaches were limited to regional and temporary test projects and not part of nation-wide or international proposals for indicators no such proposals were evaluated within this study. But to develop a concept for monitoring impacts of the release of genetically modified plants in agriculture the consideration of those projects sounds useful.

Looking at farm-scale approaches during the workshop it was emphasised, that a monitoring of the use of transgenic plants in agriculture could not been done without considering the cultivation practice as a whole. The idea came up to implement a large-scale agricultural monitoring, covering all farmland area and not just to implement a specific monitoring of transgenic plants.
Regarding this suggestion it is to consider that by a 'traditional agricultural monitoring' not all possible effects of all transgenic plants could be covered. On the one hand there are plants with transgenic modifications leading to changes in agricultural practice (e.g. herbicide resistance). Those changes in agricultural practice could be reflected by an agricultural monitoring whilst ecological side effects can still stay undetected. On the other hand there are transgenic plants with an alteration of metabolic pathways or the capacity of producing new compounds. For such transgenic plants impacts on other organisms or the food-webs are expected. Those would not be reflected by a purely agricultural monitoring. A monitoring of ecological and biotic aspects would be needed in addition.
It is not to expect, that environmental effects of transgenic plants will be restricted to the area under cultivation. Consequently a corresponding ecological monitoring should cover a wider area.

The study reveals potential capacities and limits of an indicator approach for a monitoring of impacts of genetically modified plants used in agriculture.
At present none of those indicators included to the evaluated national and international proposals of sets of (environmental) indicators could be suggested for a direct adoption to monitor effects of transgenic plants.
For a future development of indicators as well as concerning the co-ordination with those bodies already involved in the development of environmental indicators, several starting points and clues are shown.

# 1 INTRODUCTION

Since the beginning of the Nineties we have seen the development of an increasing number of international concepts to create a basis for the assessment and evaluation of the environmental situation as a whole, going beyond existing mostly national environmental monitoring systems generally focusing on chemistry/technology, with the help of environmental indicator systems. These indicator systems pursue two objectives. On the one hand they are designed to identify the status quo also through comparisons between different states and on the other, to reflect developments taking place over time on a long-term basis. In the ideal scenario such indicators can indicate to what extent specific political stipulations and measures have a positive effect in terms of sustainable development or these indicators point to a need for action, thus forming the basis for decisions about measures designed to encourage and improve sustainable development.

In this context Agenda 21 is of outstanding importance; as the outcome of the Earth Summit held in Rio de Janeiro in 1992 it represents an international plan of action to deal with the challenges of the 21st century in terms of environmental and development policy. Agenda 21 calls for the development and usage of measured quantities and monitoring criteria to permit (environmental) developments to be examined as regards their sustainability.

Chapter 40 of Agenda 21 emphasises the importance of information for the process of sustainable development and particularly focuses on the availability of data and information and in this context on the development of indicators. These are to represent aggregated and qualified sets of data designed to indicate where the process of sustainable development should be oriented at a regional, national or international level as regards specific aspects or measures. It refers to the collection of data and analysis as a major shortcoming as only differentiated surveying, analysis and evaluation of data can form the basis for aggregation to one indicator to ensure that this indicator can ultimately help with the decision-making process. Here it is thus also a question of making up for any lack of information by the collection and analysis of data on the path towards sustainability.

In response to the agreed objectives and measures proposed in Agenda 21 the EU drew up the directive COM(94) 670 in 1994, laying down the outline conditions for the development of appropriate indicator proposals which are to be prepared and implemented by the member states following coordination throughout the EU.

The increasing usage of biotechnology and genetic engineering in environmentally relevant applications results in the need to include possible effects in the monitoring of environment developments and thus indicators for sustainable development. An initial step in this direction is to examine to what extent existing indicator systems or individual indicators already have the potential to reveal possible effects in their current form or are capable of doing so in future. In addition and in conjunction with such evaluation the question arises as to which monitoring parameters and data would have to be collected to provide in the long term sets of data to be used for the development of indicators and/or which would allow us to deduce possible causes from the indicator. Given the relative uncertainty as regards long-term ecological effects from the use of transgenic organisms on the environment and in view of complex influential factors which are not easy to simulate in experimental situations, the EU has laid down obligatory monitoring with amendment of the directive on the deliberate release of genetically modified organisms into the environment 90/220/EEC. Articles 13 and 20 of the amended directive 2001/18/EC published on 12 March 2001 for the cultivation of genetically modified plants (GMP) thus stipulate surveillance plans in order to ascertain and evaluate the effects on human health and the environment resulting from the use of such plants.

The project involved here is based at the interface between the preparations for a monitoring concept for genetically modified plants (see sect. 1.1) and the Agenda 21 process. The aim of the project is to act as a basis and incentive for discussion about indicators on the subject of biotechnology and genetic engineering in the framework of Agenda 21. It should be examined whether indicators from existing programmes can be used to develop a monitoring system for genetically modified plants or at least as a guideline for the development of indicators.

As the basis for this we will start by now taking a closer look at the term 'indicator' and the expectations associated with such indicators. The possibilities and limits for the development and use of indicators to elaborate a monitoring system for transgenic plants will also be discussed.

The study on the "Development of Environmental Indicators for Monitoring of Genetically Modified Plants" has included the following

- the preparation of a status quo report on the status of the discussion of environmental indicators which are relevant for the use of genetically modified plants in agriculture, and
- the systematisation and bundling of the existing indicators and objectives.

For this purpose the proposals und concepts initially available for environmental indicators of all relevant areas are examined and compared in relation to the indicators put forward there, but also with reference to the objectives of the concepts. This results in a compilation of indicators which are potentially relevant and suitable for the theme of biotechnology and genetic engineering as well as the monitoring of genetically modified plants.
The environmental and sustainability indicators selected are generally considered with regard to their meaningfulness in the context of biotechnology and genetic engineering, their significance and scope for interpretation with monitoring, their manageability and their practical suitability. This process involves the consideration of pragmatic and methodical aspects.

In Section 7 we use examples to take a closer look at indicators in terms of their suitability for the field of biotechnology and genetic engineering. Using the specific example of indicators relating to the theme 'Use of pesticides' (sect. 8) we analyse the possible usefulness of such indicators and take this as our basis for the further development of proposed indicators with specific reference to biotechnology and genetic engineering. The case study is then rounded off by a brief outlook regarding specific indicators for herbicide-tolerant and insect-resistant plants.

Interim results for the project were presented and discussed at the workshop on 'Environmental Indicators in National and International Indicator Concepts and Programmes' at the Federal Environmental Agency in Berlin on 16 January 2001. It was considered whether the indicators initially selected are adequate and meaningful for the field of biotechnology and genetic engineering, to what extent the indicator proposals already available are manageable in practical terms and what practical value they have to offer at the present time for the development of a monitoring system for transgenic crop plants.
On the basis of the overview of indicators drawn up the workshop considered whether such indicators or the use of indicators offer possibilities for the evaluation of

environmental situations, the identification of causal connections, the derivation of recommendations for action or even for use as a warning system.

The appendix contains the programme and the list of attendees at the workshop held on 16 January 2001. The contributions of the workshop have been included in this study. The considerations and results of the discussions held at the workshop are summarised in section 10.

## 1.1 CATEGORISATION OF STUDY IN ONGOING WORK ON MONITORING OF GENETICALLY MODIFIED PLANTS IN GERMANY

Given the gaps in knowledge still existing as regards the environmental effects from the commercial cultivation of genetically modified plants, the directive 2001/18/EC on the deliberate release of genetically modified organisms into the environment, which was amended in February 2001, provides for case-specific-monitoring in addition to general surveillance.

Against this background and in the context of the national and international considerations regarding comprehensive environmental monitoring outlined in section 1, the Federal Environmental Agency, Berlin, incorporated two research and development projects in particular in the 1999 Environmental Research Plan following the conclusion of initial work on the monitoring of transgenic plants[1]. These two projects were set up as complementary fundamental studies for monitoring in the field of biotechnology and genetic engineering and are based on the following complementary approaches:

The R&D project described here selected the 'top-down' approach by examining existing proposals und concepts from the field of environmental indicators which might be of use. The second project pursued a 'bottom-up' approach as regards the possible environmental effects of transgenic crop plants. This interdisciplinary alliance project[2] was begun in December 1999 with the aim of developing a concept for the (long-term) monitoring of genetically modified plants.

Under the project hypotheses regarding effects were developed and supported with corresponding parameters on the basis of known potential effects of transgenic plants derived from the ecological relationship structure for four crop plants by way of example until the preparation of an initial interim report (April 2001). An analysis of research projects on safety accompanying release was carried out in parallel as regards the methodology used. Another emphasis during the initial phase of this project was the evaluation of monitoring programmes set up by the Federal Government of Germany and the Länder regarding the parameters used for the long-

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[1] *Including: FEA texts 77/98: Monitoring von Umweltwirkungen gentechnisch veränderter Pflanzen (GVP) – Dokumentation eines Fachgespräches des Umweltbundesamtes am 04. und 05. Juni 1998.*
*FEA/Texts 52/99: Neemann, G. & Scherwaß, R.: Materialien für ein Konzept zum Monitoring von Umweltwirkungen gentechnisch veränderter Pflanzen.*

[2] *Pilot project for monitoring of genetically modified pflants (R&D 299 89 406)*

term monitoring of transgenic crop plants. In addition, the project also includes GIS-aided work for the processing and visualisation of area-specific data to ensure the integration of specialist data and position information on transgenic plants.

In the second phase of the project the parameters derived from the hypotheses regarding effects are prioritised. They are also supported with a range of methodical instruments. The various parts of the project are brought together to form a monitoring concept and supplemented with proposals for regional case-specific implementation.

With this conceptual technique on the one hand and the more analytical R&D project described in this study a two-pronged approach is being used to move towards a monitoring system in the field of biotechnology and genetic engineering .

In parallel with these activities in the framework of the 1999 Environmental Research Plan we should also consider further approaches from the research work on safety accompanying release being performed by various bodies and from model projects on monitoring for the development of a monitoring system for transgenic crop plants. This includes for example:

- 'Model projects for the monitoring of genetically modified plants as the first step towards application-related implementation of the monitoring concept' as cooperation projects carried out by individual Federal states under the overall control of the Länder and the Federal Environmental Agency
- Considerations of the study group of the Federal Government of Germany and the Länder 'Monitoring of the Environmental Effects of Genetically Modified Plants'
- Research projects in the framework of the BMBF key area 'Research into Safety and Monitoring'
- Considerations of study group 'Monitoring during Cultivation' under the overall control of the BBA
- Other research projects performed at university level.

# 2 INDICATOR – DEFINITION OF TERM

As various terms such as 'data', 'measured quantities', 'variables', 'parameters', 'indices' and 'indicators' are used in the discussion involving environmental surveillance and monitoring, these terms should be defined here first and the indicator term in question developed for the purpose of clarification.

The terms '**data'** and **'measured quantities'** are generally understood to refer to clear impartial variables describing a state (raw data) which can be directly surveyed. This context also includes 'variables' despite the different usage in some cases. Defined as a "variable quantity" (DUDEN 1990), the term **'variable'** is more an abstract generic term; for example, the specific measured quantity of 10° C may belong to the variables of 'temperature'. Variables thus also stand for directly measurable states.

A **'parameter'** is defined by the DUDEN (1990) as "an identifying quantity in technical processes etc. used to define the structure, performance of a machine, system, tool or similar". And if this definition has to be extended at least beyond the field of technology/craftsmanship in the context of this project, it becomes clear that parameters are still direct measurable quantities, which are however already aimed at a definition, i.e. the portrayal or description of a state.

Although the usage of the term **'indicator'** is often vague (JESSEL 1998), it can be clearly defined as pointing to or representing something else which is supposed to provide information about complex interrelations in the form of easily understood data (FUE 1997).

According to Langenscheidt's Fremdwörterbuch (AOL 2000) an indicator is a "sign, circumstance or feature which acts as an indicator for something which cannot be directly seen" or a "fact from which a phenomenon can be concluded". The DUDEN (1990) also describes indicators as circumstances or features which serve as (evidential) signs or indications of something else. FÜLLGRAFF & REICHE (1992) describe an indicator as "a characteristic quantity which can be used to describe and formalise actual and required states of a system. Environmental indicators serve to describe and identify quality states of the environment and form the basis for comparative environment reporting."

For example, an indicator could be a species of plant or animal which can be correlated so closely with certain environmental factors that its presence in a certain

area points to specific environmental conditions. Indicators often greatly simplify the complexity of reality (SCHILLING 1999).
The phenomenon suggested by an indicator which is often complex and not directly measurable is known as an **'indicant'** (GERMAN COUNCIL ON ENVIRONMENTAL QUALITY 1998, SCHILLING 1999).
To portray situations or developments in their entirety more than one indicator is often selected. In this regard RADERMACHER et al. (1998) have commented that in such cases it is generally better to speak of 'sets' of indicators than indicator 'systems' as the structure in many indicator concepts tends to have more in common with a set than a system.

Various differentiations can be carried out within these indicators, some of which are mentioned below.
RADERMACHER et al. (1998) point out that there is a "difference between descriptive and normative indicators. While descriptive indicators express a fact only in quantitative or qualitative terms and at most imply an idea of better or worse, normative indicators – for example, as required by the German Council on Environmental Quality (GCEQ) – already show an explicit reference to environmental policy objectives on the creation of indicators through the comparison between actual and required values." The discussion on sustainability frequently calls for normative indicators. However, the prerequisite for their creation is the existence of accepted target values. According to RADERMACHER et al. (1998) indicators of sustainability can only be normative indicators by definition.
BARKMANN (2000) too considers that indicators of sustainable development must always be normative. In his view, the at least latent association with planning in the context of sustainable development already results in a normative "loading" of each set of indicators through selection of the indicators. BARKMANN (2000) however considers accepted target values as being desirable, albeit not a condition for normative indicators. Nevertheless, the use of indicators for sustainable development should always be seen in association with systematic evaluation or decision-making.
PEARCE (in OECD 1999b) distinguishes indicators of sustainability from environmental indicators by stating that indicators of sustainability should be primarily future-oriented while environmental indicators are oriented towards the future and the past.
When developing concepts for future monitoring of transgenic crop plants the focus currently falls on reflecting the changes which have already occurred at the time of consideration. The indicators to be developed for the field of biotechnology and

genetic engineering and the monitoring of genetically modified plants should however comply with the criteria for environmental indicators, i.e. be oriented towards both the future and the past.

Irrespective of the issue regarding normative or (merely) descriptive indicators there are other possibilities for differentiation depending on what is shown by such indicators. Here a distinction is often made between indicators involving classification, state of the environment/state (direct), pressures (indirect) and reactions or goals resp. evaluation indicators (GEIER et al. 1999, ECKERT et al. 1999, JESSEL 1998). JESSEL (1998) points out that the classification into various indicator categories allows us to distinguish between the different purpose of the indication.

Certain environmental indicator programmes make use of the so-called Pressure-State-Response (P-S-R) model that was developed by the Canadian Anthony Friend in the Seventies. The Pressure-State-Response approach (P-S-R) firstly offers a comprehensive framework for the integration of the types of indicators used in all countries (WALZ et al. 1997). Secondly, it allows the indicators to be divided up into the categories of 'Pressure Indicators', 'State Indicators' and 'Response Indicators', which pertain to various interrelated questions. However, the Pressure-State Response approach does not mean that, depending on the field of environmental impact, the state indicators are directly related to the pressure indicators and the response indicators directly to the state indicators. In other words, cause/effect relationships do not exist automatically!

Meanwhile a modified form of categorisation is often used, whereby the pressure indicators are replaced by driving force indicators, with the boundary between pressure and driving force being blurred. With driving force indicators there is greater emphasis on the causes of changes than with the pressure indicators (OECD 2000a).

On the basis of the D-S-R or P-S-R models use is generally made of the 'Driving force-Pressure-State-Impact-Response model' particularly by EU organisations; this adopts the otherwise customary categories of D, P, S and R but extends the model to include 'Impact Indicators' and utilises D and P as two different special cases in parallel to describe underlying economic trends more accurately.

Here 'driving forces' are fundamental factors which influence a large number of relevant variables. 'Pressure' indicators on the other hand describe factors which (may) directly cause environmental problems. They can be influenced more quickly and directly than driving forces. An example of driving forces would be 'industrial production overall' while 'toxic emissions' could be a typical 'pressure' indicator. 'Impact' indicators represent the effects on the state of the environment. Between 'impact' and 'state' indicators there are cause-effect relationships. However, such direct correlations cannot be demonstrated in the D-P-S-I-R model in its entirety as for the P-S-R model. The categories 'State' and 'Response' indicators correspond to those in the models described above (EU Commission & EUROSTAT 1999).

While indicators are generally supported with directly measurable figures or states, indices are often combinations or aggregations of several indicators to form a single value and constructs to establish relationships (GRAY & WIEDEMANN 1996). Often such indices can only be specified as dimensionless figures (WALZ et al. 1997). At the top of an 'aggregation pyramid' there is ultimately a single highly aggregated value (RADERMACHER et al. 1998). RADERMACHER et al. (1998) however note that this procedure does not seem entirely convincing from the viewpoint of general statistical methodology and indices do not represent a higher aggregation level than indicators.

Often indicators are also registered directly as aggregating indicators, i.e. already summarising information. GRAY & WIEDEMANN (1996) compare aggregated indicators to a kind of "holy grail" of indicators and ask us to consider that there is disagreement about the value and validity of such indicators. They see the main problems with aggregation as the loss of information, the need for value judgements and the loss of transparency. They thus come to the conclusion that the value of aggregated indicators greatly depends on the purpose for which they are used and also their portrayal and explanation.

With aggregating indicators it should therefore be remembered that the gradual aggregation of the initial data requires decisions to be taken at every level regarding selection of the variables to be taken into account and how they are associated, thus increasing the number of subjective decisions taken at each level of aggregation (SCHILLING 1999). The weightings already included can no longer be seen from the (numerical) values which are ultimately specified for the indicators (FUE 1997).

The degree of aggregation or condensation should be selected depending on the purpose of the indicators (COENEN 2000). High aggregation levels may be appropriate for indicators which are to 'simply' show the state of a phenomenon in a condensed form, for example, the Gross National Product or the price index. Greater condensation also frequently seems necessary where politics is concerned. This is in contrast to scientific analyses, as they offer a more differentiated breakdown of results.

For this reason a high aggregation level does not seem advisable in the context of the monitoring of transgenic plants either.

However, it should not be forgotten that any selection of indicators represents an initial step towards aggregation, with all indicators which are not selected being given the weighting factor 'zero'.

## 3 WHAT SHOULD AND WHAT CAN INDICATORS DO?

Expectations on ideal indicators (UNEP/CBD/SBSTTA/5/12, Eckert et al. 1999, FUE 1997, Stöcker 1981, OECD 1999a, b, UN 1996):

- provide politicians and the general public with information on the status quo (description of current state) as well as changes and trends over time series and help us to understand the linkages between causes and effects
- bundle comprehensive multilayered information which is often not easily grasped and so present complex facts in a simplified way (aggregation and reduction of complexity) to ultimately provide clear, simple and quantifying information
- react as soon as possible to changes in time and/or place series and reflect these
- show prompt and exact reactions to disturbances or changes in clear cause-effect linkages and thus act as a pointer for the causes of developments
- make current states comparable with objectives in historical and regional terms
- allow situational comparisons to also be made between countries
- are based on an analytically sound foundation
- relate to a specific question and not just to available data
- are simple
- are user-oriented
- are easily understandable for the target group and also plausible for the general public
- are meaningful and easy to interpret
- can be registered in quantitative terms
- can be surveyed on a large or even comprehensive scale but at the same time provide for individual adaptation to chronological and spatial circumstances in the environment
- are based on available and reproducible data, or data which can be collected easily, at reasonable cost and without undue effort at regular intervals with reliable and consistent methods (in verified empirical data and time series)
- are scientifically plausible, scientifically and technically tenable and verified
- back up controversial political debate with clear information and help politicians respond to developments
- provide for communication about complex linkages
- are an instrument for the evaluation and optimisation of political action
- provide for consensus

- are adequate in terms of goals and oriented towards environmental policy objectives
- have an ecological significance for problem areas and play a role in public debate
- quantify potential risks, function as an alarm or early warning system and are able to signal undesirable developments
- provide for monitoring and evaluation of the state of the environment and environmental pressures as the basis for adequate plans of action
- allow us to make comprehensible qualitative evaluations of environmental strategy and situations.

There is probably no indicator that fulfils all these ideal requirements, particularly given that some requirements contradict each other. In addition, it is seldom possible to select one or just a few indicators in consensus (RADERMACHER et al. 1998).

For complex phenomena there are virtually no individual indicators which reflect all aspects of the topic in question. The public desire for a small number of clear-cut indicators is thwarted by the complexity of the environment.
A wide spectrum of many indicators may be necessary and in many cases, it is only possible to assess each individual indicator in the context of the others (GRAY & WIEDEMANN 1996). As regards the efforts to minimise the number of indicators for pragmatic reasons this means that this objective should be not rated more highly than the striving to obtain a meaningful conclusion at all with the help of the indicators.
Ultimately both the indicators themselves and the number of indicators should be subject to criteria which comply with the objectives pursued with the indicators. For example, where the requirement is to portray possible cause-effect relationships, it is comprehensive indicator systems that are needed, tending to conflict with the call for greatly limited effort and the public's demand for a clear overview of the environmental situation (SCHILLING 1999).
Whether cause-effect relationships in the context of the monitoring of genetically modified plants can be portrayed at all using indicators or whether descriptive monitoring models (see research project footnote 2, sect.1.1) should be preferred is discussed in Section 10.

Even when indicators can be placed in a cause-effect context, it should be borne in mind that the ecological linkages and the interactions between man and the

environment are far more complex than are assumed and can be shown in models (SCHILLING 1999).
Furthermore, biological indicators are generally dependent indicators. Changes with dependent indicators do not normally allow us to make direct conclusions about causes as they may be due to a number of reasons. One example of dependent indicators is organisms. This is particularly apparent in the case of birds. They are frequently the secondary consumers of higher trophic levels and very mobile creatures. This means that they often react without any possibility of directly recognising linkages to a combination and interaction of multiple, individual, parallel, possibly synergetic factors, which cannot be differentiated merely by observing the indicators. They can accumulate various impacts over time and areas. In such a case changes on the basis of indicators can only be registered after a large number of factors have come into play (KUSHLAN 1993).
Indicators can be suitable or unsuitable to characterise what we want to describe. On the other hand, they are never "true/correct" or "wrong" (FUE 1997).

Indicators should not only have analytical but also synoptic qualities above all: they should enable us to obtain information through summarisation (FUE 1997). This also means that indicators are not a substitute for exact diagnoses or studies and only allow us to draw conclusions about states, at best signalling undesirable developments (FEDERAL ENVIRONMENTAL AGENCY 1998).
Indicators always veer between remaining understandable on the one hand and revealing linkages on the other (FUE 1997).
For this reason it is necessary to specify before developing indicators which criteria the indicators to be selected should satisfy and what purpose they are to serve. The establishment of a small number of simple subject-specific environmental indicators which provide for consensus, are politically applicable, generally understandable, and reduce the complexity while still portraying causes as complex linkages, possibly as an early warning system, is an impossible goal.

Besides the necessity of defining the purpose planned with implementation of a system or set of indicators, each indicator system is generally based either explicitly or implicitly on a defined objective specifying the direction in which reality is to change (FUE 1997) or, in some cases, there are objectives and evaluations differing in terms of content, particularly in the case of vaguely formulated goals depending on the standpoint.

It should be remembered when discussing indicators in general and in particular normative indicators and their objectives that the definition of objectives is a decision which lays down values and standards for which consensus does not necessarily exist. One major difficulty with the determination of indicators is that a definition of objectives does not always take place or that the discussion does not involve all stakeholders. Normative fundamental decisions which are taken at several stages in the development process, should be rendered transparent, just like practical and theoretical considerations (FUE 1997).

Besides the necessity of determining and defining clear-cut criteria for the selection of indicators it should be specified for every indicator how reliable, well founded and certain it is and under what conditions the collection of reliable data records is possible. However, it is not only the soundness of the initial data that should be assessed but also, where appropriate, for the link between the raw data and the indicator, to allow us to assess how reliably and with what level of validity the indicator reflects the initial data. In addition, it should also be ascertained how reliable the collection of data is and independent of the technical surveying options (GRAY & WIEDEMANN 1996).

Going beyond the considerations regarding the underlying data structure and normative aspects for the selection of the indicators, an appropriate reference system should be laid down beforehand for each indicator for the derivation of indicators relevant in terms of policy and decision-making. In the case of normative indicators this involves a fundamental point of reference (= baseline) such as the current status or a historical optimum (definition once again guided by value judgements), as well as target value – or at least a definition of the orientation of objectives. This definition of objectives can take a positive form as a desired concept to be achieved (= target) or a negative form as a limiting value or threshold. In such a case the selected indicator could even function as an early warning system if appropriate structures have been created, at least for analysis but also for a response (STADLER 2000), and if the indicator is based on an adequate and appropriate analysis of the facts. Besides determining the limits of the tolerance ranges, ranking within the tolerance ranges is also a possibility.

When indicators are incorporated in a quantifiable system of objectives, a comparison can be made between the actual state and a required state or a desired direction of

development. Here it should be assessed whether there has been improvement or deterioration in a state.
In addition, it should always be known in what regard the indicators can be at all meaningful and consequently, what data for an indicator permit statements to be made. For example, the occurrence of a waterfowl in wetlands indicates that the region is suitable for waterfowl at least to a certain degree; however, the absence of such birds cannot be interpreted as a lack of suitability of the region as birds may also stay away for other reasons (KUSHLAN 1993).

Whenever evaluation is discussed, it should always be remembered that "the definition of the objective, the selection which empirically definable features are chosen as indicators, the setting of weighting factors which are not empirically definable [are] normative fundamental decisions, which ultimately cannot only be substantiated scientifically and pragmatically but also have to be justified politically." (FUE 1997) In particular, the assessment of which changes in ecosystems are seen as harmful cannot just be performed on a scientific basis as the science of ecology merely describes states of changes in states (SUKOPP & SUKOPP 1997). Evaluation should also be based on stipulations based on ethics and social politics regarding land use and nature conservation.

Regarding indicators it should also be borne in mind in the framework of this R&D project that both the field of biotechnology and genetic engineering and the assessment which scenarios describe developments that are to be viewed as negative or are sustainable, are influenced by the respective fixing of normative values. However, this is often not spelled out when considering the field of biotechnology and genetic engineering. Instead, a general attempt is made to conduct an dispassionate, purely scientific discussion without bearing in mind that every starting point for ideas and research in natural science is always based on and influenced by normative values.

In this R&D project we initially take a purely descriptive approach by extracting a list of potentially relevant indicators from existing proposals for indicators.

For a set or system of indicators which is also used to derive evaluations, it should also be ascertained for the individual indicators, besides defining the backgrounds and possibilities regarding statements, what relation exists between the indicators. Are they all equal or are there some offering a higher statement potential or some which can only state or indicate something in conjunction with the others? In addition, it should be ensured that several indicators do not point to the same phenomenon in different ways as this aspect would then be over represented.

For the basic selection of indicators for a set / system of indicators, clear, specific and comprehensible criteria should be laid down depending on the purpose of the set / system of indicators. These criteria should also be weighted to define in advance which criterion has priority if there is any doubt when they point in different directions for individual indicators as regards the suitability rating.

Criteria for the selection of indicators may be taken from the maximum catalogue of requirements described above, according to the objective for the set of indicators. Here the criteria can be classified into groups such as scientific, functional, user-specific and practical criteria.

The large number of different - in some cases conflicting - possible expectations on indicators and criteria for indicators means that the selection of the criteria laid down for indicators depends on political stipulations. For this reason transparency is also required in this context.

# 4 ANALYSIS OF EXISTING (ENVIRONMENTAL) INDICATOR CONCEPTS AND PROGRAMMES REGARDING THEIR USEFULNESS FOR THE FIELD OF BIOTECHNOLOGY AND GENETIC ENGINEERING AND THE MONITORING OF GENETICALLY MODIFIED PLANTS

First of all we would like to describe the programmes evaluated. For each programme we have compiled the indicators specified in the programme which might be suitable for the examination of transgenic useful plants. They are listed in **bold** in the following tables. Where only excerpts from a more extensive list of indicators are presented, the respective full list of indicators from the programmes can be found in the appendix (Tab. 25 – 36). In section 6 there is an overview of all indicators from the evaluated programmes proposed under this R&D project for the context of biotechnology and genetic engineering.

The potentially relevant indicators which might serve as guidelines for monitoring effects from the cultivation of transgenic plants were selected from the evaluated indicator proposals and programmes without any focus on genetic engineering.
The **selection criterion** was as follows: content-related overlapping of an indicant suggested by an indicator with the possible effects of genetically modified plants.
As regards the selection of indicators it should be taken into account that this was carried out against the background of the current level of knowledge and hypotheses for the effects of genetically modified plants. Other indicators, which did not seem relevant when preparing this study, might thus become of interest at a later date and in the light of further experience with transgenic plants.

All details which were available in the literature have been specified for the selected indicators possibly relevant to genetic engineering. Where the following compilations do not include information on exact definitions, methodology / frequency / site of data collection etc., the corresponding details were not available in the literature evaluated.

## 4.1 OECD

**STARTING POINT, BASIC CONCEPT AND OBJECTIVES OF RELEVANT INDICATOR SET PROPOSALS OF THE OECD**

At the end of the Eighties considerations were already being made about ecological developments and the possibility of their investigation at the Organisation for Economic Cooperation and Development (OECD), currently numbering 29 members, in particular European as well as some Asiatic, Central and North American industrial states and fast-developing nations. The presentation of a provisional set of environmental indicators in 1991 was followed in 1993 by the publication of an initial core set of environmental indicators, which were to be used to examine to what extent stipulations and obligations relating to environmental policy were really being observed by the member states (OECD 1993, OECD 1999a). Since 1994 the latest data has been regularly published on this set of environmental indicators, for which revised versions dating from 1994 and 1998 are available. However, a large amount of measured data for the indicators proposed by the OECD will only become available in the medium to long term (WALZ et al. 1997).

In the meantime the OECD is working on a system of agri-environmental indicators going beyond the general environmental indicators. Here it has been ensured that these agri-environmental indicators are in line not only with the environmental indicators of the OECD but also with other sets of indicators simultaneously developed by international organisations or individual member states of the OECD (OECD 1999a).

The agri-environmental indicators of the OECD are designed, although this explicitly and intentionally does not involve indicators of sustainability, to help monitor and evaluate the development of international agriculture in terms of the sustainability principle (FEDERAL ENVIRONMENT MINISTRY 2000a).

These indicators should be capable of providing information on the state and trends of the environment and natural resources with reference to agricultural activities in order to arrive at a better understanding of the linkages between agricultural and environmental issues. They should act as an instrument for the monitoring and evaluation of the respective policy areas and help to provide the political decision-makers with a data framework for further processes in the direction of environmentally friendly agriculture (FEDERAL ENVIRONMENT MINISTRY 2000a). The indicators should also enable us to make predictions and help to throw light on the aspects involving economics, the environment and social components of sustainable agriculture (OECD 2000a).

It is considered necessary here to put special emphasis on the analytical background and the practicability of the indicators regarding measurability so we are more able to ultimately interpret the trends revealed by the indicators (OECD 2000a).

For its general set of environmental indicators the OECD uses the Pressure-State-Response (PSR) model (see sect. 2), in addition to allocating the indicators to environmental problem areas.

For its agri-environmental indicators which are still under development the OECD applies the Driving Force-State-Response (D-S-R) approach as the driving force indicators focus on the causes of change in environmental conditions and the interaction between agriculture and the environment (OECD 2000a). With the D-S-R approach for the OECD's agri-environmental indicators the individual categories are associated with the following questions:

- "What is causing environmental conditions in agriculture to change, for example, changes in farm chemical input use (Driving forces)?
- What are the effects of agriculture on the environment, for example, the impacts on soil, water, air and natural habitats (State)?
- What actions are being taken to respond to the changes in the state of the environment, for example, by farmers, consumers, the food industry and governments, such as promoting sustainable agriculture by community based approaches (Response)?" (OECD 1999b, OECD 2000b)

The Pressure / Driving Forces-State-Response approaches applied to the OECD's sets of indicators frequently come under strong criticism as they are based on abstracting ecological linkages. However, in all fairness it must be pointed out that the OECD itself particularly states that the choice of indicators and their classification into the model categories should not obscure the fact that ecological linkages and the interactions between man and the environment are far more complex than can be shown in a simple Pressure-State-Response framework (OECD 1994: Environmental Indicators: OECD Core Set quoted according to WALZ et al. 1997). In addition, the approach is not aimed at revealing cause-effect chains in natural science but consciously accepts pragmatic reductions in complexity in order to fulfil the specific function of an indicator system regarding the provision of information, policy support and communications with the public. Other approaches involve comparable problems.

The agri-environmental indicators of the OECD were proposed in order to monitor and evaluate developments in agriculture at a global level. Here the indicators should have the following functions:

- provide information (for politicians and the general public) on the state and trends of the environment and natural resources with reference to agricultural activities and the effectiveness of political efforts to ensure sustainable agriculture
- improve the understanding of the linkages between agricultural and environmental issues, including the relationships between agricultural policy and the state of the environment
- identify and quantify the extent of the harmful and beneficial environmental impacts of agricultural policy and political measures
- provide an instrument to monitor and evaluate the respective policy areas
- help politicians to perceive the harmful and beneficial environmental impacts of agricultural policy and political measures and to identify the effective measures to achieve agricultural/environmental objectives
- provide a basis for decision-making as regards further developments towards environmentally friendly agriculture
- establish a basis for comparison between different states using a standardised methodology (FEDERAL ENVIRONMENT MINISTRY 2000a, OECD 1999a, OECD 1999b).

In addition to the OECD's proposals, consideration is also given to the further development and proposed national specification drafts of the general environmental indicators of the OECD. In 1997 WALZ et al. made proposals regarding the application of various approaches and in particular the OECD's approach to Germany. Here an attempt was made to focus more on ecological linkages than with the OECD approach and to make the selection and evaluation criteria more transparent.

**WHAT DOES THE OECD UNDERSTAND BY INDICATORS AND WHAT IS THEIR FUNCTION?**

According to the OECD (1993) an indicator can be defined in very general terms as a parameter or a value derived from parameters which provides information about a phenomenon. However the indicator has significance that extends beyond merely reflecting the data values of the parameters. Here indicators also have a synthetic function and are developed for a specific purpose. According to the OECD the main functions of indicators are as follows:

- to reduce a number of measurements and parameters which in their entirety would give an exact picture of a situation to a manageable scale. This results in a limited number of indicators, small enough to facilitate an overview but still sufficiently large to provide adequate information, with weighting problems increasing along with the level of aggregation.
- to simplify communications processes designed to put across the essence of the measurement results to users. Here it should be borne in mind that the simplification, summarisation and adaptation to user needs cannot automatically meet scientific demands to demonstrate cause-effect chains.

For the OECD (1993) indicators are thus one in a range of instruments used to describe and evaluate situations which nevertheless should be supplemented with further scientific and quantitative information.

Agri-environmental indicators in particular are indicators which show the impacts of agriculture on the environment, i.e. not the impacts of the environment on agriculture or food chains in the agricultural sector. They should not act as indicators of sustainability but as indicators measuring differences in quality and quantity, while nevertheless offering pointers on environmental aspects of sustainable agriculture (OECD 2000a).

In an ideal set of agri-environmental indicators in the D-S-R model the following requirements are made on indicators by the OECD (1999a, b), albeit in full awareness that it is of course not possible to satisfy all requirements (simultaneously):

- policy relevance and benefit for the target audience
  - should provide a representative picture of environmental conditions, pressures and society's response
  - offer assistance with response to environmental changes
  - are easily interpreted
  - reveal development tendencies over periods of time
  - react to environmental changes and the measures relating to same
  - offer a basis for international comparisons
  - be either national in scope or applicable to regional effects of national significance

  - have threshold or reference values which can be used for comparison so that users can assess the significance of the surveyed values
  - are more user and purpose-oriented than merely being based on data already available
  - focus on key issues
- sound analytical basis
  - define links between agricultural measures und environmental conditions
  - are able to explain an easily interpreted largely application-related linkage between agricultural and environmental issues
  - reveal trends and margins of fluctuation for the surveyed data
  - rest on a sound theoretical basis in both technical and scientific terms
  - are based on international standards and provide for international consensus as regards their value
  - permit linkage with economic models as well as prediction and information systems
- measurability
  - have an adequate data basis
  - are based on data collected nationwide, which if possible is already available in data series extending over many years
  - are available at a reasonable cost-benefit ratio
  - are based on data whose quality is well-known and which is adequately documented
  - are founded on a regular sound data surveying
- appropriate aggregation level.

In the framework of further development of the OECD proposals on environmental indicators and application to Germany WALZ et al. (1997) cite the following as evaluation options for the selection of indicators:

- ecological relevance to the problem area,
- quantifiability and availability of data,
- comprehensibility,
- status in public discussion.

In 1999 the OECD already observed that in some cases there was pressure regarding agri-environmental indicators at international level to slim down the wide spectrum of proposed indicators to just a handful or even one or two synthetic indicators (OECD

1999b). The OECD however considers the loss of information resulting from aggregation of the indicators to be problematic where many scientific studies have underlined the need for precise information.

A decision seems to have initially been taken in favour of a more complex but more meaningful set of agri-environmental indicators.

#### INDICATORS PROPOSED IN OECD PROGRAMMES

Given the length of time the OECD has already devoted to indicators in the environmental sector and multiple specification, various proposals regarding environmental indicators are to be found in the context of the OECD alone.

The first "Core Set of Indicators for Environmental Performance Reviews" of the OECD (1993) relates to 14 different environmental themes. For the field biotechnology and genetic engineering the indicators relating to the theme 'biodiversity and landscape' are of interest (Tab. 1).

Tab. 1: Indicators for the field of biodiversity and landscape from the OECD's first set of environmental indicators from 1993

| | **Environmental indicator** (OECD 1993) | **Availability/ Measurability (s-m-l)** [3] |
|---|---|---|
| *Environmental pressures*: | | |
| | **Habitat alteration and conversion of land from its natural state** | l |
| | **Land use changes** | s |
| | **Introduction of new genetic material and species** | l |
| *Environmental conditions/state:* | | |
| | **Threatened or extinct species as a share of known species** | s |
| *Societal responses*: | | |
| | **Protected areas as a percentage of total area by ecosystem type** | s/l |
| | **Protected species as a percentage of threatened species** | m/l |

In the proposal elaborated in 1997 for the further development of the OECD proposals on environmental indicators and application to Germany (WALZ et al. 1997) the following areas were selected for a German system of environmental indicators: greenhouse effect, ozone depletion, eutrophication, acidification, toxic contamination, environmental impacts in urban regions, biological diversity - landscape protection, waste, water resources and surface water quality, forest resources, fish resources, soil resources, radiation exposure, general indicators. Table 2 contains the selection of the proposals of WALZ et al. (1997) considered to be relevant to the field of biotechnology and genetic engineering.

[3] *s-m-l: swift/immediate, medium-term, long-term*

Tab. 2: Indicators from the 1997 proposal for the further development of the OECD proposals on environmental indicators and application to Germany potentially relevant to the field of biotechnology and genetic engineering (WALZ et al. 1997).
Under the proposed response indicators there are no identifiable content-specific references to effects of transgenic plants, this being the reason why the relevant column has been omitted here.
Table 25 in the appendix reproduces the proposals of WALZ et al. (1997) in full.

| | **Pressure** | **State** |
|---|---|---|
| ***Environmental sphere***: | | |
| *Toxic contamination* | - **Overall indicator Soil**<br>- **Aggregated indicator PPA[4] Soil** | - **Overall indicator Water**<br>- **Aggregated indicator PPA, NMVOC[5] and ubiquitous substances Water** |
| *Biological diversity/ Landscape protection* | | - **Proportion of endangered/extinct species of animals and plants**<br>- **Proportion of endangered biotopes**<br>- **Development of stock of guiding indicators for ecosystem changes (e.g. characteristic bird species) (long-term)** |
| *Water resources and quality of surface water* | | - **Pollution of groundwater/drinking water with plant protective agents (medium-term)** |
| *Soil resources* | | - **Erosion, risk of erosion (related to whole of Germany)** |

Although the OECD wants to apply the approach of the D-S-R model which is slightly different from the P-S-R model specifically to the agri-environmental indicators, the OECD's agricultural environmental indicator proposals are not divided up into Driving forces, State and Response indicators.

In overall terms however, it should be borne in mind for the agri-environmental indicators that the OECD has only submitted preliminary proposals to date. On the grounds that it was too early to develop a definitive set of indicators, the workshop held in York (GB) in 1998 concentrated on conceptional and methodical aspects (OECD 1999b). Nevertheless, the list of agri-environmental indicators proposed at the York workshop (OECD 1999b; cf Tab. 3) represents the most specific proposal made by the OECD to date as regards the fields of biodiversity, habitats and landscape.

Table 26 in the appendix lists all the OECD agri-environmental indicators recommended by the OECD after the York workshop going beyond these areas.

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[4] *PPA: plant protective agent*

[5] *NMVOC: non methane volatile organic compounds*

Tab. 3: Full list of indicators for 'Biodiversity, Wildlife Habitat and Landscape' from the list of agri-environmental indicators of the OECD (1999b)
Indicators potentially relevant to the field of biotechnology and genetic engineering are shown in **bold**

| | Biodiversity | Wildlife Habitat | Landscape | Pesticide Use |
|---|---|---|---|---|
| | | | | |
| short-term develop-ment | - **Genetic diversity of domesticated livestock and crops**<br>**1. Change in the sum of all recognised and utilised varieties of domesticated livestock and crops**<br>**2. Change in the share of different livestock and crop varieties in the total population or in total livestock and crop production**<br>- Wildlife species diversity related to agriculture<br>- A. Quality<br>1. Appropriate key species indicators for each agro-ecosystem<br>2. Key threatening processes that can damage agricultural production activity<br>3. Proportion of semi-natural and uncultivated natural habitats on agricultural land | - **Intensively farmed agricultural habitats**<br>**- The share of each crop in the agricultural area**<br>- Semi-natural agricultural habitats<br>- The share of the agricultural area covered by semi-natural agricultural habitats<br>- Uncultivated natural habitats<br>- Area of wetland transformed into agricultural area<br>- Area of aquatic ecosystems transformed into agricultural area<br>- Area of natural forest transformed into agricultural area<br>- Area of agricultural re-converted into aquatic ecosystems | - Land characteristics of agricultural landscape<br>**1. Natural features, covering, for example, the land's slope, elevation, soil type, etc**<br>2. Environmental appearance, including the landscape ecosystems and habitat types<br>**- Land type features including changes in agricultural land use and land cover type**<br>- Cultural features of agricultural landscape<br>Key indicative cultural features<br>- Management functions of agricultural landscape<br>The share of agricultural land under public and private commitment to landscape maintenance and enhancement | - **Index of pesticide use (active ingredi-ents**) |

| | | | | |
|---|---|---|---|---|
| | - B. Quantity<br>**4. The extent of changes in the agricultural area and type of land cover (this indicator would draw from the wildlife habitat and land use/cover indicators) (Method of calculation and interpretation p. 84, OECD 1999b)** | | | |
| Medium- and long-term develop-ment | - **Change in numbers of endangered species related to agro-ecosystems**<br>- **Impacts on biodiversity of different farm practices and systems**<br>- Effects on biodiversity caused by off-farm soil sediment flow | - Habitat heterogeneity (average size of habitats)<br>- Habitat variability (number of habitat types per monitoring area)<br>- **Impacts on habitat of different farm practices and systems** | - (Developing system of) landscape typologies<br>- Monetary valuation of societal landscape preferences (from public surveys) | - Pesticide use efficiency (Technical and economic)<br>- Pesticide risk indicators |

Where the use of pesticides is concerned (right-hand column), it should be borne in mind that under the OECD proposals data is only to be collected nationwide while in order to monitor genetically modified plants it may be necessary to collect data per line, change in characteristics or possibly even with a field reference.

At the York workshop the themes listed in Table 4 were also cited as regards agricultural management. Although they may be considered as relevant indicators, they are not included in this form in the final recommended list of indicators (OECD 1999b).

Tab. 4: Themes which were discussed at the OECD's York workshop and which include indicators potentially relevant to biotechnology and genetic engineering but are not mentioned in the OECD's recommended list of indicators with the definitions specified here (OECD 1999b)

| | Definitions |
|---|---|
| *Pest management* | Use of non-chemical pest control methods<br>(use of integrated pest management) |
| *Soil and land management* | Use of reduced and zero-tillage and other best land management practices including crop rotations |

For the impact of agriculture on natural habitats indicators have already been discussed although not yet finally specified. The discussion includes the following:

- "fragmentation of habitats both in the agro-ecosystem and 'natural' habitats
- length of the 'contact zone' between agricultural and non-agricultural lands" (OECD 1999a)

In April 2000 the agri-environmental indicators of the OECD were debated once again in Paris. Excerpts from the proposals discussed there are shown in Table 5.

Tab. 5: Indicators from the OECD's agri-environmental indicator proposal (2000a) potentially relevant to the field of biotechnology and genetic engineering (excerpt from complete table, s. appendix, Tab. 27)

| **Indicator group** | **Agri-environmental indicators** |
|---|---|
| 1. Agriculture in the broader Economic, Social and Environmental Context | |
| 1.1 Contextual information and indicators | |
| ▪ Land use | |
| | - **Agricultural land use (types of use: agriculture, grassland, wetland, forestry)** |
| 1.2 Farm Financial resources | |
| 2. Farm Management and the Environment | |
| 2.1 Farm Management | |
| ▪ Whole farm management | |
| | - **Environmental whole farm management plan** |
| | - **Organic farming** |
| ▪ Nutrient management | |
| | - **Soil tests** |
| ▪ Pest management | |
| | - **Use of non-chemical pest control methods** |

| | |
|---|---|
| | - **Use of integrated pest management** |
| ▪ Soil and land management | |
| | - **Land management practices** |
| 3. Use of Farm Inputs and natural Resources | |
| 3.1 Nutrient use | |
| ▪ Nitrogen balance | |
| ▪ Pesticide use | |
| ▪ Pesticide risk | |
| ▪ Water use intensity | |
| ▪ Water use efficiency | |
| | - **Water use technical efficiency** |
| | - **Water use economic efficiency** |
| ▪ Water stress | |
| 4. Environmental Impacts of Agriculture | |
| 4.1 Soil Quality | |
| 4.2 Water Quality | |
| 4.3 Land Conservation | |
| 4.4 Greenhouse gases | |
| 4.5 Biodiversity | |
| ▪ Genetic diversity | |
| ▪ Species diversity | |
| | - **Wildlife species** |
| | - **Non-native species** |
| 4.6 Wildlife Habitats | |
| ▪ Intensively-farmed agricultural habitats | |
| ▪ Semi-natural agricultural habitats | |
| ▪ Uncultivated natural and man-made habitats | |
| ▪ Habitat matrix | |
| 4.7 Landscape | |
| ▪ Physical appearance and structure of landscape | |
| | - **Physical elements, environmental features and land use patterns** |
| | - **Man-made objects (cultural features)** |
| | - **Landscape typologies** |
| ▪ Landscape management | |
| ▪ Landscape costs and benefits (values) | |

One key problem for the development indicators is to determine a timeframe for reference. By taking 1985 as its basis the OECD arrived at a politically pragmatic definition (THYSSEN 2001).

**POSSIBILITIES FOR THE USE OF OECD INDICATORS IN THE FRAMEWORK OF MONITORING FOR GENETICALLY MODIFIED PLANTS**

One frequent restriction on indicator proposals in international concepts to which the OECD generally also cedes, is the selection of indicators according to the availability of data already collected. Such a restriction may make it impossible to reflect new developments which have not yet been considered. Although we should approve the limitation to indicators for which data can be collected according to the call for pragmatic limitation, this does not apply to the major reduction regarding data already surveyed.

This may also be due to the fact that the process of selecting indicators of the OECD and the selection criteria ultimately used are not very transparent (WALZ et al. 1997), something which in turn may make application to another sector more difficult.

Besides the difficulties with evaluation already described in section 3 many problems are predominantly associated with the huge number of different interactions and multicausal, synergetic and also indirect relationships found in ecosystems. They can be barely encompassed in a single system. It should be borne in mind that the Pressure-State-Response approach - just like the D-S-R approach - does not claim to reflect the diverse causal relationships between 'pressure and 'state' (WALZ et al. 1997). In addition, the OECD points out that although the Pressure-State Response model can highlight existing relationships, it however also encourages us to expect simple linear linkages and thus obscures our view for more complex linkages between effects (OECD 1993).

It is thus especially problematic to deduce appropriate indicators for the field of biodiversity. We quote WALZ et al. (1997): " ... [One] problem which cannot be easily integrated in the system is biodiversity. Here the problem lies in the fact that a reduction in the diversity of species cannot be attributed to a small number of influential factors but is the result of environmental impacts in virtually all problem areas. Here the difficulty arises from the fact that although the effect is clearly delineated and represents a separate problem area, the relevant environmental

impacts (Pressure) are extremely diverse and encompass different problem areas. This results in extensive overlapping with the pressures of other problem areas. This can ultimately be attributed to the circumstance that by combining landscape protection and biodiversity in a single problem area we run the risk of over interpretation of the cause-effect linkages between landscape interventions and biodiversity and pushing the linkages between other environmental impacts and biodiversity too far into the background.
Difficulties should also be expected with a procedure which aims to break up the subarea of 'biological diversity' and allocate it to the individual environmental impacts in the other problem areas: nor it is then possible to allocate an overall effect such as reduction in the diversity of species to a single influential factor."
In addition, there is the problem of insufficient knowledge of this complex field (OECD 2000a). The areas of biodiversity and landscape protection thus belong to the fields with the largest gaps in terms of objectives and the most imprecise indicators (WALZ et al. 1997). However, for biotechnology and genetic engineering the applicability of indicators to be developed would be conceivable from this very context.

Another problem is the fact that the OECD indicators are collected at a national level. However, it is particularly in the context of biotechnology and genetic engineering that some data are probably only of use with a regional reference as otherwise an average is established for example over many different landscape areas or habitats, thus failing to reflect regional effects.
As long as transgenic plants are not grown on a large scale, no proper application can be made of nationally aggregating indicators.

It remains to be seen what will be the OECD's final list of indicators as the compilations produced to date still show wide divergence, and there is no definitive proposal from the OECD regarding agri-environmental indicators (OECD 2000b). However, this is more interesting for the monitoring of genetically modified plants than the OECD's comparatively more general set of environmental indicators (see Tab. 1 in comparison to Tab. 3 und 5).

A general problem of indicators in the agricultural-environmental context which is not specific to genetic engineering is that relationships, for example between agricultural activities and the environment, are often not only complex but also site-specific and non-linear (OECD 1999a). Impacts can be initially absorbed without effects but possibly lower the reaction threshold. Impacts can be accumulated in some cases and only have an effect over time. In addition effects may only bring about gradual shifts in some cases (OECD 1999a). Such problems will also occur in the context of biotechnology and genetic engineering.

### 4.1.1 Further Development of OECD's Proposals for Agricultural Environmental Indicators

Now that proposals for indicators have been put forward by the OECD as an international organisation, the individual countries are now examining what form national implementation or specification can take. As regards the OECD's agri-environmental indicators this process is being carried out in Germany with the involvement of the Federal Environment Ministry and the Federal Agency for Consumer Protection, Food and Agriculture at the Institute for Organic Farming and Institute for Agricultural Policy, Department of Market Research and Economic Sociology of the University of Bonn for Habitats, Biodiversity, Landscape, Water Quality, Water Utilisation and Consumption, Soil Quality and Climate/Greenhouse Gases (Environmental Research Plan project "Indicators for a National Monitoring of the Environmental Impacts of Agricultural Production"; FKZ 200 12 118) as well as at the Institute for Economics, Agricultural Structure and Rural Areas of the Federal Research Institute for Agriculture (FAL-BAL) for General Indicators, Financial and Social Indicators, Plant Protective Agents: Usage and Risk, Nutrients/Use of Fertilisers, Land Conservation and Farm Management (project: Agri-environmental Indicators at International and Regional Level: Status of Research and Implementation-oriented Further Development).
At the beginning of 2001 the following indicators came under discussion regarding the subject of 'Farm Management' at the FAL-BAL, each of which could be considered differentiated according to transgenic and non-transgenic crops and type of crops (BERGSCHMIDT 2001):

- fertiliser utilisation,
- nutrient balances (N, P),
- supply of nutrients to soil,
- utilisation of plant protective agents (differentiated according to active substances),
- applications of plant protective agents (number/hectare),
- land cover and
- diversity of crop species.

To implement farm-level indicators for the evaluation of the environmental effects of transgenic crop plants the following was proposed by BERGSCHMIDT (2001) during the project workshop held in January 2001:

- general information (e.g. survey of land use)
  - proportion of land used for agriculture on which genetically modified plants are cultivated (differentiated according to individual crops)
  - proportion of genetically modified plants in entire production volume (differentiated according individual crops)
- operational indicators (trials network, special surveys)
- specific studies, for example
  - outcrossing to wild species and useful plants
  - species impoverishment (arable weeds and soil micro-organisms) due to one-sided use of herbicides
  - species impoverishment among soil micro-organisms and insects for example due to persistence of Bt toxins in soil.

During the workshop it was emphasised that the surveys for these indicators should be available at a farm level and plot-specific. This could result in a close correlation between effects impacting on the environment and the action of the polluter. In addition, this could provide for the evaluation of environmental effects specific to different cultivation systems, something which might be beneficial when assessing agri-environmental measures and policies.

In January 2001 proposals were available from the University of Bonn to make the agricultural environmental indicator proposals of the OECD more specific regarding the subjects of biodiversity, biotope and habitat function and landscape (WETTERICH 2001):

**A. Biodiversity:**

1. Genetic diversity of working animals and useful plants

    1.1 Number of species and breeds or types

    | | | |
    |---|---|---|
    | Animals: | Species: | no indicator |
    | | Breeds: | no indicator, only portrayal of actual situation |
    | Plants: | Species: | number of species in Species Index to Seed Act |
    | | Types: | number of licensed types of useful plants |

    1.2 Distribution of species and breeds or types

    | | | |
    |---|---|---|
    | Animals: | Species: | population of species of agricultural working animals |
    | | Breeds: | breakdown of herd book animals into 3 most common endangered/indigenous/foreign breeds |
    | Plants: | Species: | extent of cultivation for 3 or 5 most common species (crop/vegetables); poss. diversity index |
    | | Types: | extent of proliferation for 3 or 5 most common types per species |

    1.3 Breeding techniques: extent of use of artificial insemination, embryo transfer, hybrid breeding, cloning, genetic engineering, … for animals and plants

    1.4 Breeder structure

    Animals: number of officially recognised breeding organisations per animal species

    Plants: Number of breeding operations per plant species

    1.5 Support measures

    Animals: Support ownership and raising of endangered breeds of working animals

2. Diversity of wildlife species

    2.1 Population distribution and number of wildlife species (beneficial organisms, direct or indirect relation to agriculture)

    2.2 Population distribution and number of non-indigenous species, presenting a hazard to agricultural production or agricultural ecosystems

**B. Biotope and habitat function:**

1. Intensively farmed agricultural habitats

    1.1 Crop species relationship

    1.2 Proportion of ecologically managed area

2. Semi-natural agricultural habitats

Proportion of 'semi-natural' agricultural habitats

3. Natural and anthropogenic non-managed habitats

3.1 Conversion of wetlands and aquatic ecosystems to agricultural use

3.2 Conversion of 'natural' woodland to agricultural use

4. Habitat matrix

**C. Landscape**

1. Landscape appearance

1.1 Landscape elements and use of land

1.1.1 Landscape elements (esp. habitats and ecosystems)

1.1.2 Land usage patterns (land utilisation, cultivation patterns and systems)

1.2 Anthropogenic-cultural landscape elements

Key landscape elements in agricultural areas, manmade (hedged earthbanks, arable terraces,...)

2. Landscape maintenance

Proportion of land under public and private landscape maintenance programmes

3. Costs and benefit to landscape

3.1 Costs of agricultural landscape maintenance

3.2 Social estimation of landscape

## 4.2 EU INITIATIVES

### 4.2.1 'European System of Environmental Pressure Indicators' in the Framework of the 'TEPI' Project: Towards Environmental Pressure Indicators for the EU; Project commissioned by EUROSTAT

(sole sources: EU Commission & EUROSTAT 1999: A European System of Environmental Pressure Indicators; http://e-m-a-i-l.nu/tepi/)

**STARTING POINT, BASIC CONCEPT AND OBJECTIVES OF 'TEPI' PROJECT**

At the request of the EU Commission and under the direction of EUROSTAT work is currently underway on a EU-wide system of environmental pressure indicators in the framework of an alliance project involving various institutions from the EU[6], (project name: Towards Environmental Pressure Indicators for the EU, or TEPI for short). Such a system was put forward in 1994 by the EU Commission to the European Council and the European Parliament in the framework of the "Directions for the EU on Environmental Indicators and Green National Accounting" (COM (94) 670 final, 21.12.94) to back up the Fifth Environmental Action Programme after the Fifth Environmental Action Programme called for the integration of environmental issues in all other policy fields. At the meeting of the European Council held in Cardiff in June 1998 this was stressed once again (so-called 'Cardiff Process'), also calling for the development of indicators to monitor progress.

The aim of the EU-wide system of environmental pressure indicators being developed under the 'TEPI' project is a comprehensive description of the key human activities with negative environmental relevance. With 6 priority pressure indicators for each environmentally relevant policy field the decision-makers and the general public in all member states of the EU (currently numbering 15) are to be provided with the most important information for the design and monitoring of an adequate EU environmental policy. The system of indicators is thus meant to also act as an instrument for strategic planning in relation to various areas of the economy, such as agriculture. Ten areas were adopted from the key themes of the Fifth Environmental Action Programme as environmentally relevant policy fields so that a total of 60 indicators are to be put forward.

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[6] *TAU Consultora Ambiental, Spain; E*M*A*I*L, Netherlands; Öko-Institut e. V., Darmstadt branch; Germany, DHI, Denmark*

The objective is to derive ten indices or 'headline indicators' from the 60 indicators to help politicians with decision-making.
The main reason for condensing the indicators down to ten headline indicators is the wish of the general public for information about the state of the environment in the form of a manageable set of indicators which is generally understandable.

For the EU environmental pressure indicators the 'Driving Force-Pressure-State-Impact-Response Model' is being used (see sect.2).

The ten key policy fields which have been adopted for the 'TEPI' indicator project from the themes of the EU's Fifth Environmental Action Programme are as follows:

- Air Pollution (AP)
- Climate Change (CC)
- Loss of Biodiversity (LB)
- Marine Environment & Coastal Zones (ME)
- Ozone Layer Depletion (OD)
- Resource Depletion (RD)
- Dispersion of Toxic Substances (TX)
- Urban Environmental problems (UP)
- Waste (WA)
- Water Pollution & Water Resources (WP)

Where the monitoring of genetically modified plants is concerned, the themes of 'Loss of Biodiversity' (LB), 'Distribution of Toxic Substances' (TX) and 'Water Pollution & Water Resources' (WP) might in particular represent potentially relevant policy fields. (The abbreviations AP, CC, etc. were assigned to the individual policy fields by the Scientific Advisory Group' (SAG). They have been cited here to facilitate the identification of these themes in the 'TEPI' concept.)

The theme 'Loss of Biodiversity' addresses the theme which is probably also seen as the most complicated and controversial policy field under the 'TEPI' project. While in other areas such as air pollution pressures can be shown relatively easily by a small number of indicators, this is far more difficult for the complex subject of biodiversity loss. A much more comprehensive set of indicators is required for the field of biodiversity loss if we are to cater for the highly complex natural diversity involved and to make up for the many gaps in knowledge still existing as regards the impacts of agriculture on natural habitats. It is assumed at present that perfect proposals cannot be expected for this complex subject in the near future.

To ensure that the EU environmental pressure indicator system meets with wide acceptance and is plausible, the attempt was made to select the most comprehensive and objective approach possible. To this end 60 indicators have now been selected from a much larger number of proposals on the basis of suggestions made by around 2300 acknowledged European scientific experts according to a complex and elucidated quality evaluation system for the individual indicators. The applied criteria were as follows: policy relevance, soundness and logical deduction/direct relation between indicator and problem as well as responsiveness and comparability over time and space. In addition, a quality rating is given for every indicator selected. Of the systems compared in the present study the existing draft concept offers in overall terms the clearest description of the theoretical general considerations taken as a basis as regards quality assurance of the concept and the indicators.

It should nevertheless be borne in mind that precisely defined criteria and standards are only applied to selection of the indicators. This does not mean that the indicators are supported with ratings and standards. The objective of the EU environmental pressure indicators thus initially represents pure collection of data without the setting of standards or any evaluation reference.

**WHAT DOES THE EU SYSTEM OF ENVIRONMENTAL PRESSURE INDICATORS UNDERSTAND BY INDICATORS AND WHAT IS THEIR PURPOSE?**

Indicators in the framework of the EU environmental pressure indicator system should be understood as 'summaries' (corresponding to text résumés) of a complex reality. They should enable decision-makers to deal with such complex reality more easily. They are also aimed at lay people who are looking for a quick overview of the basic developments without requiring further interpretation. Here indicators should also send 'correct messages' without further explanation.

To be accepted by the various players in the environmental policy sector environmental pressure indicators must be as neutral as possible in terms of values. They should:

- support controversial political debates with non-controversial but relevant information
- make complex political debates more transparent.

Further criteria for such neutral indicators are:

- Highly aggregated indicators or indices should be available as data for people who are involved in debate but do not (want to) deal with all the details
- Value elements must be clearly separated from objective data
- Indicators are not necessarily tools in themselves; to be useful, they must be presented within their original framework and linked to socio-economic statistics;
- The indicator system must be sufficiently detailed to cover all aspects of the political debate.
- The indicator system should be adapted to the structure of the existing debate and not try to create a better structure

(Possibly) irreconcilable contradictions are already apparent in this small number of criteria: for example, indicators are to send 'correct messages' without further explanation, versus: indicators must be linked to socio-economic statistics; indicators should be summaries, but cover all aspects of the debate.

It remains to be seen which criteria will ultimately be designated as relevant when the project on the EU environmental pressure indicator system is concluded.

#### PROPOSED INDICATORS IN 'TEPI' PROJECT

When considering the proposed indicators (s. Tab. 6) it should be borne in mind that the 'TEPI' project has not yet been concluded.

Tab. 6: Indicators of the 'TEPI' project potentially relevant to the field of biotechnology and genetic engineering
(an overview of all 'Environmental Pressure Indicators' of the project can be found in Tab. 28 in the appendix)

| SAG Code | Pressure Indicators | Unit of Measurement |
|---|---|---|
| ***Loss of Biodiversity*** | | |
| LB-3 | **Agricultural intensity: area used for intensive arable land** | % of total arable land<br>*updated version:*<br>% of the total area of the country |
| LB-6 | **Changes in traditional (extensive) land-use practice**<br>Definition: 'Changes in traditional high value farming practices resulting in homogenisation of land use and loss of habitat and species diversity' | number of different habitat types per rural holding |
| LB-8 | **Pesticide use on land**<br>*The indicator on pesticides use is of minor reliability and has a low predictive capacity if no additional information on toxicity and environmental behaviour of the used active ingredients (like bioaccumulation and persistence) is added in it. The technical coefficients proposed for pesticides are: toxicity classification of active ingredients used, bio-accumulation of active ingredients used, persistence of active ingredients used*<br>*(this indicator is probably not included in the set of between 60 - 80 environmental pressure indicators)* | tonnes/hectare per habitat type |
| LB-7 | **Increase in cultivation of hybrid cultivars**<br>*This indicator is linked to the indicator originally proposed by the SAG* " Loss of genetic resources - non-utilisation of available crop species and varieties"<br>(this indicator is probably not included in the set of between 60 - 80 environmental pressure indicators) | Ratio between area cultivated with 'traditional' cultivars and area cultivated with hybrid cultivars |
| ***Dispersion of Toxic Substances*** | | |
| TX-1 | **Consumption of pesticides by agriculture** | tonnes (of active ingredients?)/year |
| TX-3 | Toxic chemical consumption by economic activity (D67/548/EC)<br>*updated version:*<br>**Consumption of toxic chemicals** | tonnes/year |
| ***Water Pollution and Water Resources*** | | |
| WP-3 | **(total quantity) Pesticides (by type – herbicides, fungicides etc) used per year (per hectare?) of utilised agricultural area / on agricultural land** | toxicity equivalents/hectare |

**POSSIBILITIES FOR THE USE OF 'TEPI' INDICATORS FOR MONITORING GENETICALLY MODIFIED PLANTS**

The EU environmental pressure indicators are to be mainly based on existing data records. The data position thus greatly depends on what data has already been and is being collected in the individual member states. Data often only provide information on changes when they can be considered in comparison with data from previous years. However, long data series are frequently not available.

Given the attempt to reflect all environmental impacts in a system of 60 EU environmental pressure indicators and to only select six indicators per policy field, the number and thus partly also the spectrum of what can be shown is subject to a pragmatic reduction. In addition, this objective can only be achieved with a relatively high level of aggregation. A system of indicators in conjunction with the monitoring of genetically modified plants should however be able to provide more detailed information and not just highlight certain aspects.

### 4.2.2 EEA (1999): Environmental Signals

[sole source: EEA (1999) Environmental signals 2000, Environmental assessment report no 6, (Nov. 1999);
http://themes.eea.eu.int/binary/s/signals2000.pdf]

**STARTING POINT, BASIC CONCEPT AND OBJECTIVES OF EEA INDICATORS**

The role of the European Environment Agency (EEA) based at Copenhagen is to provide the European Community and member states with objective, reliable and comparable information at a European level. This should offer the Community and the member states a basis for decision-making for introducing the necessary environmental protection measures, for evaluating action taken and for informing the general public about the state of the environment. Together with many research institutions and national organisations in Europe and the 'European Topic Centres' the EEA forms a Europe-wide environmental data and monitoring network, the European Environment Information and Observation Network/EIONET.

With the help of EIONET EEA continuously collects data on so-called 'indicator fact sheets'. This set of 'indicator fact sheets' has undergone steady expansion to date.

With 'Environmental Signals 2000' the EEA presented an initial report to the EU on the state of the environment based on indicators in November 1999. It is intended to provide information about progress in certain policy areas. The EEA however does not want to call the current collection of indicators 'the EEA set of environmental indicators'! The two main criteria for the selection of indicators in this initial report were policy relevance and adequate data from a sufficiently large number of member countries.

The plan is to report about the state of the environment every three years, changing the focus each time. In the long term it wants to draw up a constantly usable acknowledged set of indicators for efficient reporting about the state of the European environment.

The EEA has made a key contribution to the development of the D-P-S-I-R model (see sect. 2). Its strategy development and reporting is based on this model. However, this does not mean that the EEA is already using indicators for every category in each report on the state of the environment.

As regards the subject of 'Agriculture and the Environment', for which overlapping with the field of biotechnology and genetic engineering could be most readily expected (see Tab. 7), it is pointed out that consideration of the reporting options are still at an early stage.

**EEA INDICATORS IN REPORT 'ENVIRONMENTAL SIGNALS 2000' FROM NOVEMBER 1999**

Tab. 7: Indicators used for agriculture by the EEA in 1999 for the report on the state of the environment 'Environmental Signals 2000'
Indicators potentially relevant to the field of biotechnology and genetic engineering are shown in **bold**

| **Indicator** | **Classification acc. to D-P-S-I-R** |
|---|---|
| | |
| **Eco-efficiency in agriculture** | Pressure |
| Livestock numbers | Driving force |
| **Fertiliser consumption per hectare** | Driving force |
| **Irrigated land** | Driving force |
| **Pesticide consumption per hectare** | Driving force |
| **Area with organic farming** | Response |

**POSSIBILITIES FOR THE USE OF EEA INDICATORS FOR MONITORING GENETICALLY MODIFIED PLANTS**

The reports issued by the EEA do not represent a fixed set of indicators which is regularly collected and constantly published. However, these reports are based on the continuously compiled data of the 'indicator fact sheets'. If there are to be indicators on biotechnology and genetic engineering in the future, the EU-wide data of the 'indicator fact sheets' could probably by partially used to support the indicators with data.

### 4.2.3 EPRG 'Expert group', EU Commission and EEA: Environmental Headline Indicators

[Sources: BUITENKAMP 1999; www.eeb.org; www.gencat.es/mediamb/bioind/1050.htm: paper by Bernt Rondell (Environmental Assessment Department, Swedish Environmental Protection Agency/ SEPA) at Expert Meeting held on 6-7 December 1999 in Stockholm, Sweden; HÖNERBACH, pers. communication 2001]

The EU's Environmental Policy Review Group/EPRG was set up to monitor implementation of the Cardiff Process for the integration of environmental concerns in all policy areas. This body, which meets at regular intervals, consists of representatives from environmental authorities and environmental ministries within the European Community.

An 'Expert Group on Indicators' appointed by the EPRG plays an advisory role as regards the various sets of integration indicators. However, this body is above all engaged in developing the environmental headline indicators for the DG Environment of the EU Commission. The DG Environment has been assisted with the 'headline indicators' by the EEA and EUROSTAT.

The proposal on 'headline' indicators evaluated here was the result of coordination between the DG Environment, the EPRG Expert Group on Indicators, the EEA and EUROSTAT. It was submitted to the European Council at the prime ministers' meeting in Helsinki in December 1999 and was scheduled to be approved at their meeting in Gothenburg in 2001. It contains a small number of highly aggregated indicators on 11 themes.

This limited set of headline indicators is aimed at presenting a general picture of the trends in key environmental areas. It is emphasised that the proposals only represent a first component for a larger set of indicators (EU COMMISSION & EEA 2000).

Tab. 8: 'Headline indicators' proposed to date by the EU in the field of 'Nature and biodiversity' (EU COMMISSION & EEA 2000)

| **Issue** | **Key policy objective** | **Current indicator** | **Proposal for ideal indicators in medium – long term** |
|---|---|---|---|
| **Nature & bio-diversity** | Protection of bio-diversity for future generations (Communication of the Commission on bio-diversity) | Designated 'Special Protection Areas (SPAs)' according to the Birds Directive (as part of the NATURA 2000 network) | Bio-diversity index based on the variety of<br>- species,<br>- genes and<br>- habitats/ecosystems/ landscapes<br>An indicator based on evaluation of trends in conservation status of key species and habitats e.g. those listed in Habitats and Birds Directives as well as more common species which are particularly sensitive to changes in land use |

Potential overlapping of these 'headline indicators' with effects of transgenic plants only exists in the field of 'Nature and biodiversity'. For this reason only this complex is shown in Table 8 (full list of proposals in Table 29, appendix).

The 'current indicator' proposed here regarding the area allocation of bird protection areas according to the EU Bird Protection Directive is not applicable in the field of biotechnology and genetic engineering.

The possible significance and usability of the 'ideal indicator' depends on index formation. However a reference to a member state or EU level is basically not likely to be small enough in terms of scale.

The EU COMMISSION (2000) also points out that headline indicators should "only be used for the purpose for which they are intended – namely, to inform the public about certain general trends in the relationship between agriculture and the environment. When offering such a limited set of indicators it should therefore always be pointed out that no full picture of this relationship is provided."
This means that, due to their orientation, these indicators are not suitable when considering effects with a single causal relation.

## 4.3 EEB 1999: Ten Benchmarks for Environmental Policy Integration - EEB Position Paper on Targets, Indicators and Timetables, tabled for the Helsinki Summit

[sole source: BUITENKAMP 1999; www.eeb.org]

**Starting Point, Basic Concept and Objectives of EEB Proposals**

The European Environmental Bureau (EEB) was founded in 1974 by non-governmental organisations from the environmental sector. It was founded on the conviction that the environmental und nature conservation policy of the EU has a high status which is not always reflected in the joint political action of the member states. A clear representation of interests and support for environmental policy and objectives oriented towards sustainability thus seemed necessary.

In the year 2000 the European Environmental Bureau numbered 130 member organisations in 24 countries. Besides its work focusing on sustainability it also ensures a smooth exchange of information between the member organisations and also in contact with Brussels and, where appropriate, coordination between all parties in terms of content.

At the Millennium Summit held in Helsinki at the beginning of September 1999 (Helsinki Millennium Summit) the EEB provided the heads of state of the EU member states with a document proposing ten 'benchmarks' (reference variables, orientation points or also sustainability objectives) to take environmental policy into consideration. According to the EEB these ten 'benchmarks' to ensure a sustainable orientation of environmental and economic policy should be accompanied by clear-cut indicators and timetables to assess the extent of the shifts necessary and monitor the changes occurring.

The EEB is already putting forward initial indicators for these benchmarks, and this is why we have also considered this approach here even if it is not yet a concept supported by the government.

**What does the EEB understand by Indicators and What is their Function?**

The EEB emphasises that prior to the selection of indicators it should be clearly defined at what target group the indicators are to be aimed. The target groups range from political decision-makers to environmental experts. It is important to focus on the right issues to take into consideration all key aspects for detailed analyses and political decisions or their evaluation.

For each theme the indicators must clarify the sector-specific questions as well as reflecting the specific contributions and impacts on other themes associated with this sector. However, the EEB also emphasises that it should always be remembered that indicators never tell the whole story and always need to be accompanied by more elaborate reporting.

The EEB attributes a special function to the 'headline indicators'. 'Headline' indicators should give politicians the most important facts and inform the general public. At the same time they are symbols for the overall environmental impact of the economy. The regular presentation and discussion of a set of headline indicators is designed to increase political pressure for action.

The EEB also sees the indicators it has proposed as fulfilling this function of 'headlines', which raise public awareness of key issues. Given that headlines cannot tell the whole story, the EEB expects this to at least spark off new debate and possibly also set new priorities. At this point further information is necessary to shed light on the underlying causes and trends. For this reason work is to continue on a set of around 100 indicators to provide more detailed information.

**EEB INDICATORS**

The EEB proposes ten benchmarks each with one associated indicator (see Tab. 30, appendix). Here the indicators for the fields of biodiversity and agriculture should be singled out (see Tab. 9) as no further overlapping with the theme of biotechnology and genetic engineering is seen.

Tab. 9: Indicators potentially relevant to the field of biotechnology and genetic engineering among the indicators for the EEB's 'benchmarks'

| Benchmark | Indicator |
|---|---|
| | |
| Biodiversity | **Biodiversity index based on genetic and habitat variety (has yet to be developed), Target: A halt to habitat decline and the extinction of species in the EU** |
| Agriculture | **Pesticide usage (tonnes of active ingredients weighted according to human and ecotoxicity) Target: No use of pesticides that are not allowed for organic farming by 2020** |

Over and above these 'headline' indicators the EEB emphasises, undoubtedly with a view to a more comprehensive and detailed set of indicators, that special attention should be paid to the extent of the release of genetically modified organisms in the environment and their use in agriculture. Another key indicator is the land area used for agriculture and in particular the percentage of biologically farmed land according to the EEB

The EEB is thus the only international institution to make proposals which give consideration to ecological farming and the use of genetic engineering in agricultural production.

**POSSIBILITIES FOR THE USE OF EEB INDICATORS FOR MONITORING GENETICALLY MODIFIED PLANTS**

To date the EEB has proposed 'headline' indicators which are only capable of highlighting aspects of a theme. Such indicators are suitable for stimulating debate and drawing attention to specific situations. However, to back up this process further information and data are required to shed light on possible causes and trends for developments observed.

The indicator of pesticide consumption proposed for the field of agriculture is entirely relevant for the use of transgenic plants in agriculture and could be operationalised with adequate data surveying. However, this calls for precise stipulations and criteria for data collection (see also section 8).

## 4.4 UN-CSD – UN COMMISSION ON SUSTAINABLE DEVELOPMENT

**STARTING POINT, BASIC CONCEPT AND OBJECTIVES OF UN CSD PROGRAMME**

Chapter 40 of Agenda 21 calls for the elaboration of indicators for sustainable development in order to describe the direction taken by developments. This would ascertain whether processes are taking place in line with the objectives of Agenda 21. Paragraph 40.6 calls not only on the individual states but also international organisations and NGOs to develop a concept for sustainability indicators and to define the relevant indicators. However, this demand only concerns the states who adopted Agenda 21. Agenda 21 is not a document binding under international law, unlike the Convention On Biological Diversity (CBD) for example, which has entered into force.

The UN Commission on Sustainable Development (UN CSD) is authorised to monitor and force forward realisation of the recommendations of Agenda 21 to ensure the implementation of the key points of Agenda 21 (WWF 1994). Since April 1995 the UN CSD has thus been engaged in elaborating indicators for sustainable development. Based on the OECD's proposals (FUE 1997) the work concept of the UN CSD encompasses the entire spectrum of social, economic and environmental aspects of sustainable development.

It intentionally selected the 'Driving Force-State Response model' and not the 'Pressure-State Response model' in order to not only use the State and Response indicators, but also the Driving Force indicators in place of the Pressure indicators; the Driving Force indicators are meant to provide a clearer picture of activities, processes and patterns which may impact on sustainable development.

In 1996 the UN CSD published its initial considerations and results on sustainability indicators which already included a catalogue of 130 indicators. The selection process for the indicators is not described in the literature. However, background information on classification and also the methodology of data collection and further definitions of the indicators is given for almost all indicators[7].

It is basically planned to reduce the proposed set of indicators from 130 to a smaller more manageable number of indicators.

It is hoped that the individual countries will utilise this proposal to select their own indicators with relevance for their national objectives and priorities and to put together their own (sets of) adequate indicators (UN 1996, OECD 1999b). The indicators proposed by the UN CSD are intended to help states with the decision-making process (UN 1996).

In 1997 a voluntary trial started in 22 states: the 130 indicators proposed by the CSD were to be supported with available data and examined in terms of their practical implementability as well as political relevance and significance (FEDERAL ENVIRONMENT MINISTRY 2000b). In Europe these 'test countries' included also included Germany as well as Belgium, Finland, France, Austria, the United Kingdom and the Czech Republic.

In Germany the political coordination of testing the CSD sustainability indicators was the responsibility of the Federal Environment Ministry. An Interdepartmental Study Group (IMA) representing all ministries at a national level was set up to test the CSD indicators. Assistance with general organisation, data collection and processing as well as methodical-conceptional issues was provided by the Federal Environmental Agency and the Federal Statistical Office. In addition, scientists were consulted and a dialogue with various societal groups sought.

The prime aim of the test phase in Germany was to clarify what set of sustainability indicators would be suitable for a highly industrialised country such as Germany in order to reflect changes relating to sustainable development. When testing the CSD indicators in Germany it was thus a key question to what extent the proposed indicators are relevant to evaluating the sustainability of existing trends in Germany and whether the central priority problem fields of sustainable development have been covered in Germany (FEA homepage: www.umweltbundesamt.de/csd/ in May 2000).

[7] *Name, Brief Definition, Unit of Measurement, Chapter of Agenda 21, Type of Indicator, Purpose, Relevance to Sustainable/Unsustainable Development, Linkages to other Indicators, Targets, Underlying Definitions and Concepts, Measurement Methods, The Indicator in the DSR Framework, Limitations of the Indicator, Alternative Definitions, Data needed to compile the Indicator, Data aAvailability, Data Sources, Agencies involved in the Development of the Indicator, Further Information [References]*

With this approach the test phase in Germany also examined whether there are suitable indicators over and above the set of indicators proposed by the United Nations. The result of the German test phase was a national set of 218 sustainability indicators. The proposed result from Germany not only includes indicators for which data are already available but also indicators which are considered to be meaningful but are nevertheless not yet backed up by data series. For this set of almost 220 proposed indicators it is however now assumed that there will have to be a major reduction in the list of indicators to minimise effort/costs and improve the communications capacity (FEDERAL ENVIRONMENT MINISTRY 2000b).

The UN CSD sustainability indicators have not yet been finally decided. The last development in the UN CSD sustainability indicators process is that the indicators are not longer assigned to the Chapters of Agenda 21 and the D-S-R approach is not used any more. A list with 58 indicators will only be understood by the CSD as a recommendation which should offer the states a basis and aid for the development of their own national set of indicators (HÖNERBACH, pers. communication). The current draft indicators were to be submitted to the Commission of Sustainable Development (CSD) in April 2001 (FEDERAL ENVIRONMENT MINISTRY 2000b).

**WHAT DOES THE UN UNDERSTAND BY INDICATORS IN THE CSD PROGRAMME AND WHAT IS THEIR FUNCTION?**

The following selection criteria were applied for preparation of the set of indicators proposed by UN CSD to date:

- The frame of reference should be national, whereby individual states may consider greater regional differentiation to be necessary;
- It must be possible to assess progress towards sustainable development;
- The indicators should be clear and simple to ensure they are easily understandable;
- The indicator concept must be realisable with the capacities of the national governments (given their time, logistic, technical and other constraints);
- The indicators must be conceptually well-founded;
- While the number of indicators is restricted in number, data surveying should be unlimited in terms of time and the concept adaptable to future developments;
- All aspects of Agenda 21 and sustainable development should be taken into consideration;

- The concept should be representative of international consensus to the greatest possible extent;
- The indicators must be based on data which are readily available or can be made available at a reasonable costs-benefit ratio, are adequately documented, of known quality and are updated at regular intervals (UN: http://www.un.org/esa/sustdev/program.htm; in May 2000).

For the German test phase the following general criteria were applied for Germany in addition to the content-specific criteria regarding suitability, with varying levels of the consideration being given to the former (see Tab. 10).

Tab. 10: Weighting of selection criteria for the German CSD indicator process

| Ideal requirements on indicators | **Priority selection criteria for German CSD indicator process** |
|---|---|
| Linkage to Agenda 21 (model of sustainable development) | **+** |
| Easy to understand | **+** |
| Providing an overview | **+** |
| Sensitivity of indicators to changes in timescale | **+** |
| Availability in terms of data / time series | **+/-** |
| Procurement of data without undue effort | **+** |
| International compatibility | **-** |
| Consideration of interaction between environment, economy and social aspects | **-** |
| Flexibility/openness of conceptional framework (DSR approach etc.) | **-** |
| Consistency of different subareas | **-** |

Source: FEA, Internet: www.umweltbundesamt.de/csd/ in March 2000

In the context of the UN CSD indicators the FEDERAL ENVIRONMENT MINISTRY (2000b) is discussing that the function of both environmental indicators and indicators for sustainable development is to provide information and examine how objectives set by society are achieved. In the view of the ministry indicators have a descriptive character, describing developments taking place over time afterwards, i.e. in general they are not variables for prognosis. Indicators only have a warning function when they are normative indicators which stand in direct relation to targets or scales of values (FEDERAL ENVIRONMENT MINISTRY 2000b).

### PROPOSED INDICATORS IN CSD PROGRAMME

As to date the only selection criterion for indicators developed from another context was a possible overlapping with the field of biotechnology and genetic engineering, the overlap range was extremely extensive here.

Proposed indicators and their classification according to the D-S-R model (UN 1996):

Table 11 shows the selected indicators which are potentially relevant to the field of biotechnology and genetic engineering, classified according to the D-S-R categories. In Table 23 in the appendix these indicators are supported with additional background information (Definition, Unit of measurement). Table 31 in the appendix contains all UN CSD sustainability indicators from 1996.

The following indicators include some indicators which are undoubtedly only conceivable for very extreme effect scenarios (Life expectancy at birth) and are more applicable from health than environmental aspects. They have been initially included for the sake of completeness although they are not considered further in the following compilations as this study focuses on environmental indicators. Nor do the following compilations include Response indicators only portraying the existence or absence of research programmes, regulations or stipulations for the implementation of studies into environmental compatibility.

Tab. 11: UN-CSD sustainability indicators from 1996 potentially relevant to the field of biotechnology and genetic engineering

| Chapters of Agenda 21 | Indicators | | |
|---|---|---|---|
| | **Driving Force Indicators** | **State Indicators** | **Response Indicators** |
| Category: Social | | | |
| Chapter 6: Protecting and promoting human health | - | **- Life expectancy at birth<br>- Adequate birth weight<br>- Infant mortality rate<br>- Maternal mortality rate<br>- Nutritional status of children** | **- Proportion of potentially hazardous chemicals monitored in food** |
| Category: Environmental: | | | |
| Chapter 14: Promoting sustainable agriculture and rural development | **- Use of agricultural pesticides<br>- Use of fertilisers** | - | - |
| Chapter 15: Conservation of biological diversity | - | **- Threatened species as a percent of total native species** | - |
| Chapter 16: Environmentally sound management of biotechnology | - | - | **- R&D expenditure for biotechnology<br>- Existence of national biosafety regulations or guidelines** |
| Category: Institutional | | | |
| Chapter 8: Integrating environment and development in decision-making | - | - | **- Sustainable development strategies<br>- Mandated environmental Impact Assessment** |
| Chapter 40: Information for decision-making | - | - | **- Programmes for national environmental statistics** |

Proposed UN indicators with changes in German test phase:

The following Table 12 is an excerpt from the document published by the FEDERAL ENVIRONMENT MINISTRY (2000b). It contains the indicators already listed in Table 11 as well as the new indicators proposed in the publication of the FEDERAL ENVIRONMENT

MINISTRY (2000b), which can be categorised as relevant to the field of biotechnology and genetic engineering.

Tab. 12: Indicators selected in the German test phase of the UN CSD sustainability indicator proposal from 1996, which are considered as potentially relevant to the field of biotechnology and genetic engineering
(indicators deleted here from Table 11 were eliminated in the German test phase)
(* : added in German test phase; °: new indicators in German test phase)
(An overview of all UN CSD sustainability indicators of the German test phase can be found in Tab. 32 in the appendix)

| **Chapters of Agenda 21** | **Indicators** | | |
|---|---|---|---|
| | **Driving Force Indicators** | **State Indicators** | **Response Indicators** |
| Category: Social | | | |
| Chapter 6: Protecting and promoting human health | - | **- Life expectancy at birth *and at age of 60** | |
| ° Category: Economic | | | |
| °Chapter 4: Change in consumption patterns | **- °Market share of organic foodstuffs** | - | - |
| Category:Environmental | | | |
| °Chapter 18: Protection of quality and quantity of freshwater resources | - | **- °Contamination of groundwater with nitrate, plant protective agents, parameters relevant to acidification**<br>**- °Pollution of surface waters with plant protective agents** | - |
| °Chapter 10: Integrated approach for planning and management of soil resources | | **- Change in 'state of land'**<br>**- *Soil erosion** | |
| Chapter 14: Promoting sustainable agriculture and rural development | **- Use of plant protective agents**<br>**- *plant protective agent risk indicator**<br>**- Use of fertilisers** | - | **- °Share of land used for especially extensive farming**<br>**- ° Share of land used for organic farming** |

| | | | |
|---|---|---|---|
| Chapter 15: Conservation of biological diversity | - | - **Threatened (*and extinct animal and plant) species as a percent of total indigenous species**<br>- **°Share of endangered indigenous crop plant types in the respective total number**<br>- **°Share of endangered and extinct biotopes in total number of biotope types occurring**<br>- **°Index for ecosystem changes (e.g. characteristic bird species)** | - **° Share of land used for integrated farming** |
| Chapter 16: Environmentally sound management of biotechnology | - | - | - **R&D expenditure for biotechnology**<br>  - ***risk and safety research**<br>- **Existence of national regulations or guidelines for biological safety**<br>- **°Labelling of genetically modified products and procedures / those free of genetic engineering** |

Even where the indicators have been assigned to topics in tables 11, 12 and 23, the authors emphasise that many indicators may not only be relevant to the subjects specified but also to other chapters and themes (FEDERAL ENVIRONMENT MINISTRY 2000b).

Other approaches associated with the development of UN CSD sustainability indicators

At the second meeting of the CSD held in New York in May 1994 the World Wide Fund for Nature (WWF) drew up the so-called 'New York Catalogue' with sustainability indicators. This set of indicators is supposed to measure sustainability both at a national and international level. With the help of the proposed indicators it should be possible to identify the state of a specific country in relation to the objective of 'sustainable development' and to also make a comparison between countries. The WWF's list of indicators contains 80 indicators from ten areas. Table 13 shows the WWF's sustainability indicators from the theme 'Land use, forests and diversity of species' considered to be relevant to the field of biotechnology and genetic engineering (1994). For the other nine areas no relevance could be identified for any indicator in the context discussed here (areas and indicators are listed in Table 33 in the appendix).

Tab. 13: Sustainability indicators potentially relevant to the field of biotechnology and genetic engineering from the WWF proposal (1994) in the context of the CSD for the area 'Land use, forests and diversity of species'

| **Indicator** | **Unit of measurement** |
|---|---|
| | |
| **Red List species** | Total and as a % of all indigenous species |
| **Soil erosion of agriculturally productive land and other areas** | Total area in km², in tonnes of soil and as a % of relevant soils |
| **Land area under agricultural use** | as a % of land |
| **Use of fertilisers and pesticides** | per capita and in kg per hectare of productive land |

In the context of the CSD indicators we should also like to mention a German project that is under preparation with reference to the CSD process although it is not in direct association with it. In September 2000 under an R&D project the Federal Environmental Agency, Berlin commissioned the development of a set of 60 to 80 key indicators based on existing data, which in their entirety are intended to be used for reporting on sustainability at a national level. Similar projects are underway in Great Britain or Finland. The project also includes structural considerations as well as the preparation of methodology sheets. An initial draft for a national set of sustainability indicators is scheduled for April 2001, followed by completion of the project in May 2002. As soon as this concept has been developed, it should also be evaluated in terms of its relevance to the field of biotechnology and genetic engineering and the monitoring of genetically modified plants.

### POSSIBILITIES FOR THE USE OF UN CSD INDICATORS FOR MONITORING GENETICALLY MODIFIED PLANTS

Once again, only national overall data are to be made available for the CSD's sustainability indicators. No data on a local scale would thus be available, let alone with a field reference.

As in the case of the other proposals the applicability of the UN CSD indicators initially depends on implementation of the concept and the final list of indicators. As implementation of the UN CSD proposals has to be voluntary, it is by no means assured. Nevertheless, there are unmistakable efforts towards implementation, especially from Germany, so that it is proposals or a concept based on the UN CSD proposals which are most likely to possibly have a future.

Strong criticism has come from the Forum Umwelt & Entwicklung as regards the existing indicator proposals and in particular, the concept of the CSD: "The CSD does not offer any definition of objectives for the indicators it has proposed. However, indicators only make sense if they refer to a goal: they should indicate how far we are from this goal. When developing indicators compatible with the future we must thus be able to understand what the objective of compatibility with the future means in terms of the individual indicators." (FUE 1997)

Whether this shortcoming would be problematic in the context of monitoring genetically modified plants or whether a separate (new) target reference would have to be established in this other context at all events is not initially a topic for discussion.

In addition, the lack of clear logical relationships within the D-S-R model also comes in for criticism (FUE 1997). Such links providing for causal relationships would undoubtedly also be desirable in the field of biotechnology and genetic engineering – however, whether they are applicable from a system of sustainability indicators which does not involve the field of biotechnology and genetic engineering would have to be examined using a specific example.

## 4.5 CBD – Convention on Biological Diversity

**Starting Point, Basic Concept And Objectives Of CBD Indicator Programme**

Initiated by the United Nations Environment Programme (UNEP) the Convention on Biological Diversity (CBD)[8] was adopted at the Rio summit in 1992 and came into force in December 1993.

At a CBD Brainstorming Meeting on Scientific Assessment held in Oslo in November 1999 it was observed that our knowledge on biodiversity and its positive contributions is overall full of gaps while on the other hand the 'resource' of biodiversity is clearly subject to pressures (UNEP/CBD/COP/5/INF/1).

The basis for the indicator process as regards the CBD includes inter alia article 7 of the convention which urges the Parties to the Convention to

- ascertain and monitor the elements of biodiversity which are of particular importance for the conservation and sustainable use of biological diversity,
- to identify processes and activities which (possibly) have adverse effects on biodiversity (Stadler 2001).

Article 26 of the Convention calls on the individual states party to the Convention to submit reports on their measures for implementation of the Convention. This should also include the efficiency of the measures. Paragraph 2 of Decision III/10 of the Third Conference of the Parties (UNEP/CBD/COP/3-Decision) calls on all countries involved to incorporate in their national reports a core set of biodiversity indicators which reflects the situation in various ecosystems.

Indicators under the CBD are intended to help with implementation of the Convention. Indicators are meant to portray the current status in terms of biodiversity, possible pressures and the changes forecast. Policy-related indicators should identify the effectiveness of the measures taken to achieve the objectives of the Convention or reveal shortcomings in action (Stadler 2000).

For a time very intensive work was carried out on the indicator proposals in the context of the CBD. In the meantime however, the level of interest in this theme has fallen (see below).

To back up implementation of the Convention on Biodiversity the Biodiversity Action Network (BIONET) organised the 'Biodiversity Indicators and Targets Initiative' (BITI).

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[8] *The text of the Convention and all official documents quoted below regarding the Convention are available under www.biodiv.org.*

The first step of this initiative was the 6th Session of the Global Biodiversity Forum (GBF) on biodiversity indicators in April 1997. Here the discussion not only focused on indicators but also on options for the implementation of indicator concepts and goals. The results were incorporated in the CBD process (BIONET & IUCN 1997; SWEDISH SCIENTIFIC COUNCIL ON BIODIVERSITY 1999).

The conference not only put forward proposals regarding further practical steps towards indicators but also developed recommendations regarding a core set of biodiversity indicators which should be applicable at a global level and collected at a national level. This set of indicators should in future be available to the CBD partners as a basis for their reports on implementation of the CBD (BIONET & IUCN 1997).

The 6th GBF concluded inter alia (BIONET & IUCN 1997) that

- indicators can first and foremost only be specific to individual states and should be incorporated in the national biodiversity strategies and action plans;
- there is a close link between objectives and indicators: indicators must be selected with regard to objectives as they are an important instrument for measuring progress. To measure progress a perspective regarding the direction of such progress is required, something which calls for objectives;
- the preindustrial state or state in 1993 (time when the CBD came into force) can be proposed as the 'baseline' or reference point for the CBD.

The 6th GBF also proposed incorporation of the biodiversity indicators in the P-S-R model (BIONET & IUCN 1997) and recommended collecting information in a global database and in the long term, aggregating various indicators to form a Natural Capital Index (STADLER 2001).

Given the extensive content-related overlapping the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), which makes recommendations to the Conference of the Parties, clearly based its proposal for a core set of biodiversity indicators on the proposals of the 6th GBF in terms of content two years later (see below; s. Tab. 14). These indicators are to be used by the states party to the Convention as a framework for the definition of their own country-specific biodiversity and response indicators and integrated in the local and national monitoring programmes. Here attention should initially focus on State and Pressure indicators, with Response indicators being added later on as regards the objectives of the Convention (UNEP/CBD/SBSTTA/5/12).

In their report on the Fifth SBSTTA Meeting for the Conference of the Parties (COP-5) in Nairobi the SBSTTA emphasised the necessity of continuing the indicator process very swiftly (UNEP/CBD/COP/5/3). In May 2000 it was decided in Nairobi (COP-5) as regards monitoring and indicators (Decision V/7) that

- principles should be developed for designing national-level monitoring programmes and indicators,
- a core set of available and potential indicators should be drawn up,
- regional cooperation in the field of indicators is to be encouraged,
- given that the capacities of many countries are limited for the consistent monitoring of indicators, indicators should be developed incrementally based on national priorities (UNEP/CBD/COP/5/23).

The General Secretariat is to submit a report on the current status of the debate regarding indicators at the 6th Conference of the Parties to be held in the Netherlands in 2002. The General Secretary is to draw up a list of principles for the development of national monitoring programmes and indicators in consultation with the Parties to the Convention and other organisations as well as the Roster of Experts and to select standard questions and put together a list of existing or potential indicators which can be used by the Parties to the Convention to comply with their obligations regarding national reporting or for regional/global overviews (STADLER 2001).

No significant progress was thus made in Nairobi in terms of the indicators (STADLER 2000).

Recently the CBD has seen a shift in the discussion from quantitative indicators, which are applicable at a global level and would have provided for area-based comparisons, towards the development of local, regional or national indicator systems.

This development seems to find its justification among other things in the fact that states which are already trying out or implementing concepts would have to adapt their systems to make them compatible with international proposals. In addition, there is a problem for definition of the indicators in that determination of the associated reference system which, despite being essential, has as yet hardly taken place. Initially there needs to be the definition of objectives as positive targets or as limiting values or thresholds to be avoided as well as baselines for the level of biodiversity (STADLER 2000): "..., the specific formulation of the political objectives on the other hand is a complex process, calling for debate in the whole of society regarding the necessary, desired and acceptable implementation of the goals of the Convention, which culminates in political decisions. The establishment of such consensus is the basic prerequisite for the development of national strategies, with appropriate indicators then being used to evaluate their implementation and effectiveness. Germany too is still in the middle of the process of establishing goals. Only when clear-cut political

stipulations exist can we take further steps on this basis for the development of internationally applicable indicators."
The SBSTTA (UNEP/CBD/SBSTTA/5/12) sees politicians as being obliged to define goal ranges and questions (targets) as well as measurable objectives, whereupon the associated variables could be specified by scientists.

As justification for reducing the goal of a 'universal core set of indicators' originally contemplated to a national or regional level it is stated that there cannot be universal, global indicators. It is nevertheless also obvious that some states party to the Convention have shied away from the possibility of comparison as regards their efforts. In addition, reservations regarding the cost of such activities and available resources may also play a role in general terms.

**WHAT DOES THE CBD UNDERSTAND BY INDICATORS AND WHAT IS THEIR FUNCTION?**

In the view of the attendees at the 6th Session of the GBF (held with regard to the CBD indicators, see above) 'indicators' differ from 'statistical values' through their relation to reference values or goals. For example, the total number of species could already be used as a reference value when establishing the total number of endemic species in country X. The indicator would thus be: 'total number of endemic species in country X in relation to the total number of species' (BIONET & IUCN 1997).
According to the GBF biodiversity indicators point towards development tendencies and the state of the biological resources and stress factors for biodiversity. Indicators also document the progress made towards objectives and are generally expressed as quantitative variables. However, they are not always capable of portraying fundamental changes or cause-effect linkages. The CBD indicators in particular could reveal national developments or act as pointers to suitable measures (BIONET & IUCN 1997).
In conjunction with the CBD, indicators thus have the function of providing quantified information, bringing about a reduction in complexity and raising public awareness of relevant changes in biodiversity. In addition, national measures can be compared and evaluated using these indicators (STADLER 2000).
In the context of the CBD it was originally planned to introduce another index in the long term which would cater for ecological concerns, in addition to the standard economic und social indices (e.g. Gross National Product), to evaluate political action (STADLER 2000).

Objectives of biodiversity indicators are as follows according to the SBSTTA (UNEP/CBD/SBSTTA/5/12):

- Identification and monitoring of nationwide trends and threats/harm to nature
- Help with finding solutions to national or regional problems
- Highlighting of national, regional and global needs with reference to the Convention On Biological Diversity
- Management of resources
- Creation of opportunities for comparisons between states
- Creation of incentives for certain states
- Provision of information for overviews, depiction of trends, analyses and reviewing impact of action taken
- Setting the course for an approach based on ecosystems when using concepts for biodiversity.

At the 6th Session of the Global Biodiversity Forum (GBF) on biodiversity indicators criteria for indicators und sets of indicators were also put forward and differentiated (BIONET & IUCN 1997):

Criteria for a global set of indicators in its entirety:

- Presentation of a representative picture of changes in biodiversity
- Portrayal of the consequences of the main causes for changes in biodiversity
- Portrayal of the effectiveness of action undertaken in the framework of the CBD
- Small number of indicators.

Criteria for global biodiversity indicators:

- Quantitative data (from the past and current data) should be available or capable of being reconstructed
- Relevance for policy and ecosystems
- Sensitivity to human activities
- Suitable for monitoring using precise and affordable methodology
- Stability so that regular natural fluctuations are not mistaken for changes in trends
- Usable for at least 10 to 20 years
- Easy to understand.

Criteria for state-related biodiversity criteria:

- Information to be quantified
- Information to be simplified
- User-friendly
- Policy-related
- Relating to specific objectives
- Scientifically tenable
- Reflecting changes
- Easy to understand
- Based on information which can be realistically monitored with limited resources.

In addition the SBSTTA (UNEP/CBD/SBSTTA/5/12) would like to apply the following criteria for a universal core set of indicators, to be monitored by all states:

- Reaction to changes in space and/or time
- Reference to socio-economic aspects/developments.

**PROPOSED INDICATORS IN CBD PROCESS**

Tab. 14: Biodiversity indicators potentially relevant to the field of biotechnology and genetic engineering from preparatory documents for SBSTTA-5

| Indicator | Data Sets | Methods | Comments by SBSTTA |
|---|---|---|---|
| State Indicator; Ecosystem Quality; Species | | | |
| **Change in abundance and/or distribution of a selected core set of species** | Wide area, transect, sample results | Surveys and monitoring programs depending on the species involved | Can provide information on ecological changes and early warning signals regarding ecosystem processes. Species in the set to be included based on country-specific conditions (e.g. rare etc.) |
| **Threatened species**<br>**- % of total species or certain taxonomic groups**<br>**- % endemic species threatened**<br>**- Threatened species in protected areas** | Endangered and threatened species data sets | Surveys and monitoring | Indicate species for which most urgent actions are needed |
| State Indicator; Ecosystem Quality; Genetics | | | |
| **- Replacement of indigenous crops**<br>**- Replacement of land races with few imported ones** | Allelic diversity, karyotype variants | Morphological analysis, offspring parent regression, DNA sequencing, electrophoresis, karyotypic analysis | Will provide information on inbreeding depression, out-breeding rate, rate of genetic drift, genetic flow, etc. |
| Pressure and response indicators | | | |
| **Changes in proportion of commercial species** | National statistics, commercial production records, records by community groups | Record keeping and monitoring of selected data | |
| **Alien/invasive species**<br>**- % habitat colonized by invasive species**<br>**- % protected areas colonized by invasive species** | Surveys, transects or sample results, patrol reports or reports from local communities | Monitoring of trends in distribution | |

We should point out once again that the indicators listed in Table 14 do not originate from an official list of proposals but are contained in a preparatory document which was drawn up by the Secretariat of the Convention in preparation for SBSTTA-5 (UNEP/CBD/SBSTTA/5/12) (Full list of proposals can be found in Table 34 in the appendix). The proposals were not incorporated in the recommendations made to the Conference of the Parties so that there are no official indicator proposals in the context of the CBD.

At the 6th Session of the Global Biodiversity Forum (GBF) on biodiversity indicators objectives were already put forward for the individual articles of the CBD, with indicators being allocated to same in some cases. Here the direct linkage of objectives with indicators in particular is of interest.
The publication accompanying the 6th Session of the GBF (BIONET & IUCN 1997) involves proposals made by the GBF. No final list of proposals for the CBD has yet become available. The next meeting of the SBSTTA (SBSTTA-7, Montreal) scheduled for November 2001 will however once again deal with the subject of indicators according to current plans (STADLER 2001, pers. communication).

The GBF's indicator proposals were not seen to contain any proposals potentially relevant to biotechnology and genetic engineering which go beyond the other concepts evaluated here. For this reason we have not listed any of the proposals made by the GBF.
Besides specific objectives and indicators 'biodiversity indicator categories' are also defined by the GBF. This involves themes which might be clarified by biodiversity indicators. In the context of biotechnology and genetic engineering the following subjects seem of interest:

- agriculture: farming structure, practice and land use (e.g. livestock, use of fertilisers)
- use of atmospheric resources
- use of soil resources
- use of water resources
- water abstraction/use of pesticides
- number of introduced species and genomes
- erosion/loss of genetic diversity patrimony
- land use
- degree of connectivity of food webs

- species diversity
- recorded species present
- change in number and composition of species over time
- genetic diversity
- in situ genetic resources: medicinal plants, wild ancestors of domestic varieties

(BIONET & IUCN 1997).

As regards potentially interesting or important themes the SBSTTA (UNEP/CBD/SBSTTA/5/12) points out that genetic diversity outside the context of agrobiodiversity should be a subject for research in future.

### Possibilities for The Use of CBD indicators for monitoring Genetically Modified Plants

Given the formal decisions of COP-5 (see above) it seems that the debate surrounding indicators has no priority in the context of the CBD at the present time. It is thus difficult to say how further development in terms of the CBD biodiversity indicators will progress. At present no implementation of the set of indicators proposed to date is in sight.

If indicators are to be used for implementation of the CBD at a later date, these indicators will portray existing states on a national scale. If no data surveys and analyses are planned at a regional level, changes in states would probably only be reflected in the statistics when the phenomena occur on a large scale or over a wide area.

Whether some of the proposed indicators can be used in the field of biotechnology and genetic engineering depends, as for other programmes, on the sensitivity of the set of indicators to such technological developments and data monitoring and analysis which is geared in this regard.

The proposed State indicators for ecosystem quality and genetics could acquire special relevance when not only the indicators themselves but also the underlying data are considered (see Tab. 14).

## 4.6 State of the Environment Indicators in the Framework of Green National Accounting (GNA)

**Starting Point, Basic Concept and Objectives of Green National Accounting and in particular Ecological Area Sampling**

Since publication of the 1990 report drawn up by the German Council on Environmental Quality (German Council on Environmental Quality 1990) there has been consensus that a nationwide system should be set up for the purpose of ecological, i.e. integrated environmental monitoring (incl. surveying, description of biodiversity) (Hoffmann-Kroll et al. 1998). The German Council on Environmental Quality calls for 'General Ecological Environmental Monitoring', which should:

- ensure sector-based environmental monitoring
- register not only structural but also functional changes in ecosystems
- provide for the early detection of environmental changes and
- permit statements to be made regarding future developments in the state of the environment (Schönthaler 2001).

Against this background we have seen the development of considerations regarding the establishment of Green National Accounting (GNA), similar to national accounting, which links socio-economic and ecological characteristic quantities and puts economic statistics into the necessary relation with environmental statistics. Such 'ecological accounting' is intended to reflect interaction between the environment and the economy with regard to the model of sustainable development and portray the value and capacity of the natural environment (Hoffmann-Kroll et al. 1998, Radermacher et al. 1998).

This has given rise to the objective of developing an operationalised and realisable indicator system for a systematic, consistent and descriptive overall picture of the state of the environment. This descriptive reporting system (stocktaking/inventory, methodology in line with official statistics) without normative stipulations or any direct reference to environmental quality objectives or specific problems should permit spatial structuring to take account of different nature sites or localised conditions, going beyond the national picture (Radermacher et al. 1998, Hoffmann-Kroll et al. 1997). According to Schilling (1999) the aim of establishing Green National Accounting (GNA) was to develop highly aggregating indicators which can be used to describe the state the environment in its entirety and on the basis of the ecosystem concept.

The GNA indicator system sees itself as a system of state indicators relating to the 'state' of the 'Pressure-State Response' approach and is designed to supplement approaches based on the OECD concept at a national level, extending them in terms of quality, as regards the 'state of the environment' (RADERMACHER et al. 1998).
Under GNA the quality of the environment is considered in the context of three questions:

- What is the situation regarding the functionality of ecosystems? (functionality indicators)
- What is the level of contamination for landscapes and ecosystems with substances? (substance indicators analysed from environmental monitoring data)
- What is the structure of landscapes and ecosystems? (structure indicators, new data on the 'physical structure' are collected under the Ecological Area Sampling programme)

These three questions and different sources of data make it necessary to break indicators down into three areas: functionality indicators, substance indicators and structure indicators (HOFFMANN-KROLL et al. 1997). Proposals for an operationalised set of functionality indicators, which are particularly significant regarding the aspect of non problem-specific precautionary care of the environment, were submitted in autumn 2000 (BARKMANN et al. 2001, STBA/FFU/ÖZK (in prep.).
The demonstration in particular of structures in the representative biotopes/ecosystems[9] of Germany is to take place in the form of sampling as total coverage is not possible (RADERMACHER et al. 1998). For GNA and in particular EAS, Germany was divided up into six main ecosystem types and 20 site types, in line with the procedure used for the British Countryside Survey on the basis of abiotic variables which do not change over time. These are space types which are characterised by being as homogenous and natural as possible (RADERMACHER et al. 1998, FEDERAL STATISTICAL OFFICE & FEDERAL AGENCY FOR NATURE CONSERVATION 2000). In overall terms the British Countryside Survey provided the basic model for Ecological Area Sampling (DRÖSCHMEISTER 2001).

Structure indicators under GNA –Ecological Area Sampling (EAS)

Ecological Area Sampling (EAS) is a procedure designed for regular monitoring of the 'normal landscape', i.e. intensively farmed landscapes in particular outside protected areas (BÜRGER & DRÖSCHMEISTER 2001, DRÖSCHMEISTER 2001). For Ecological Area

[9] *The subdivision 'Biotope' is used in GNA to represent the term 'Ecosystem'.*

Sampling new concepts and indicators have been developed for the 'physical structure', in other words, for externally visible characteristics as there has been a lack of nationally standardised comparable data collected on biodiversity. The indicators developed for Ecological Area Sampling are meant to directly describe biodiversity and, according to HOFFMANN-KROLL et al. (1998), also quantify the most important influencing quantities on biodiversity.

Primary data are to register structural features of landscapes and ecosystems as well as changes occurring to them over time. This nationally standardised random sampling over permanent observation areas should provide area balances and portray the diversity of habitats and species (HOFFMANN-KROLL et al. 1998). With Ecological Area Sampling it should be possible to make representative statements regarding the state and changes in the landscape and nature for around 90% of the territory of the Federal Republic of Germany with the exception of urban areas (BÜRGER & DRÖSCHMEISTER 2001).

With Ecological Area Sampling biodiversity is considered in relation to biotopes and the animals and plants occupying them as well as changes over time, however only in terms of biotope and species. Genetic diversity is not examined under Ecological Area Sampling as it was not classed as a priority and was thus subject to the pragmatic selection criterion of cost (HOFFMANN-KROLL et al. 1998).

Ecological Area Sampling is organised into two levels:

Level I (biotope structural level) records and describes landscape and biotope quality with the help of structural features meaningful in terms of indicators. Here the focus is on data relating to distribution and areas as well as biotope characteristics. The ecological landscape data for the biotope types observed are collected at the various site types in Germany by the evaluation of aerial views and site inspections.

To supplement and particularise the description of landscape and biotope quality from the first level in various usage areas, ecological data for the quality of biotope types should be collected by means of selected surveys on the species stock and diversity of species at level II (species level). The results from 800 sampling units each covering 1 $km^2$ can be projected onto the biotope types per site type for Germany or be made available for selected questions relating to nature protection (FEDERAL STATISTICAL OFFICE & FEDERAL AGENCY FOR NATURE CONSERVATION 2000, BÜRGER & DRÖSCHMEISTER 2001, DRÖSCHMEISTER 2001).

Objectives and functions of EAS are as follows: (HOFFMANN-KROLL et al. 1998; RADERMACHER et al. 1998, BÜRGER & DRÖSCHMEISTER 2001, DRÖSCHMEISTER 2001):

- monitoring and provision of required basic data on the physical structure and its analysis in the form of national area balances und indicators,
- regular information and reporting for the policy area,
- fulfilment of prerequisites for systematic, representative, nationally standardised surveying of data on the physical structure which is carried out at regular intervals without undue effort,
- enable reporting to be performed (also for international reporting obligations) about stock and changes in areas of biotope types as well as selected species and species groups of flora and fauna with reference to biotope types,
- submission of nationally sound and robust data on the spread and quality of biotope types also outside nature reserves and thus supporting policy action aimed towards nature protection,
- portrayal of area-specific changes in biodiversity in Germany,
- provision of a basic instrument for representative ecological environmental monitoring at a national level,
- measurability of successes and failures in field of nature conservation and environmental policy (review of results) at a national level by allowing extent of changes to be identified,
- creation of a basis for comparison as regards various area protection measures to demonstrate for example the effectiveness of large-scale nature conservation projects undertaken by the Federal Government in comparison with the state of the landscape as a whole.

Following the development of an EAS concept a practical trial has already taken place in agriculturally farmed areas of Brandenburg, Berlin and Thuringia (HOFFMANN-KROLL et al. 1998).

Substance indicators under GNA

The data for substance indicators are to be generated from existing sets of data from environmental monitoring. Here GNA is thus limited to secondary statistical analyses (HOFFMANN-KROLL et al. 1998).

Under GNA there may be problems with performance regarding the substance indicators as to date the majority of the data collected through environmental monitoring is not related to biotope types. For existing surveys the biotope types of the survey sites would thus have to be additionally determined (except for substance indicators on groundwater and atmosphere). There would nevertheless also be the possibility of intersecting surveyed substance data with a biotope reference by means of interpolation. This can however only succeed if sufficient amounts of data have been collected in a dense network. Problems result in the case of categories which are not sharply delineated such as air and water (RADERMACHER et al. 1998).

Functionality indicators under GNA

Besides substance and structural (EAS) indicators functionality indicators are also provided for GNA. These however are still under development since we are breaking new ground in scientific terms when registering functionality and are still faced with deficits in operationalisation (RADERMACHER et al. 1998).

Now that initial work has been performed on functionality indicators under GNA, the INDECO project is a continuation of this project and is being carried out by the University of Kiel on behalf of the BMBF. The aim of the INDECO project is to offer an overall picture of the state of the environment in Germany with a concise overview and to report about this in a generally understandable form that is effective for the general public.

Fundamental studies including conceptional considerations for selection of a set of indicators for ecosystem functionality within GNA have been available for some time (MÜLLER 1996 & 1998). By the 'functionality of ecosystems' BARKMANN et al. (2001) understand an ecological description of processes and structures which allows the claims of society as regards usage to be fulfilled.

Functionality indicators are therefore "characteristic quantities describing the internal functioning of complex ecological acceptors of human action such as ecosystems or water catchment areas. The indicant of functionality to be monitored is the effect structure from the biotope und biocenosis in terms of preservation or improvement of the efficiency of the balance of nature." (MÜLLER 1998)

For the proposals regarding functionality indicators in the context of GNA special emphasis was given to the development of indicators which relate to the guideline of 'Ecological Integrity' (see MÜLLER 1996). Ecological Integrity should be seen as a guideline for risk provision in ecosystems. A diverse range of uncertainties involving society and natural science preclude comprehensive protection of the natural foundations of life. The remaining risks which basically cannot be identified are best confronted by encouraging/protecting the dynamic ability for self-organisation of ecological systems, according to BARKMANN (2001) and BARKMANN et al. (2001). Various theories of ecosystem research have been used to obtain suitable indicators for the ability of self-organisation (MÜLLER 1998, BARKMANN et al. 2001). It has been possible to back up a simplified set of indicators with data using information from ecosystems research (BARKMANN pers. communication 2001).

To date possible effects of the large-scale cultivation of genetically modified plants have not been given special consideration in the work underway on functionality indicators. However, the problems involving unforeseeable environmental impacts are taken into consideration by the functionality indicators for ecosystem risk provision in a fundamental albeit non-specific way.

Potential overlapping with the field of biotechnology and genetic engineering (see Tab. 17) may result with the functionality indicators when for example genetically modified plants bring about physiological changes in ecosystems (water / substance / energy balance) which manifest themselves in a change in the level of self-organisation. Functionality indicators claim to reveal such effects. The highly aggregated indicators however only reflect the changes in the status quo, i.e. do not permit any definite conclusions to be drawn regarding individual causes. To conclude that transgenic plants are behind surveyed changes separate studies would have to be carried out if this is suspected.

**WHAT DOES GNA UNDERSTAND BY INDICATORS AND WHAT IS THEIR FUNCTION?**

In this project RADERMACHER et al. (1998) define indicators as "measured or calculated quantitative characteristics, i.e. which can be ultimately monitored and should permit statements to be made about the state and development of the environment as components of indicator systems geared to specific purposes."

Specifically for EAS the term indicator is not understood in the sense of bioindicators but as environmental indicators. Indicators should not be seen as pointers or signs but as follows: "indicators are understood to mean features and data ascertainable in the landscape with empirical methods, which can be used to indirectly determine and analyse aspects of the physical structure and processes impacting on same which cannot be monitored directly." According to EAS indicators are thus variables which are clearly measurable according to defined criteria and synonymous with parameters (FEDERAL STATISTICAL OFFICE & FEDERAL AGENCY FOR NATURE CONSERVATION 2000).

According to HOFFMANN-KROLL et al. (1998) indicators should directly describe biodiversity and quantify the key variables influencing biodiversity. To this end statistically meaningful data, which can be projected onto the total area of Germany, should be collected on a systematic and regular basis.

**PROPOSED INDICATORS IN GNA**

Indicator proposals for EAS/structures

For Ecological Area Sampling randomly distributed detailed vegetation surveys are planned in the selected biotope types on permanent observation areas. Species-related data is also to be collected for fauna. Surveys have been proposed for the following groups, although not every group is to be monitored in every biotope type: butterflies, dragonflies, grasshoppers, ground beetles, water molluscs, birds (RADERMACHER et al. 1998, [breakdown showing which species group is to be monitored in which biotope type group: p. 200]).

Qualifying the proposals for the monitoring of fauna we should note that the authors themselves point out that the survey set cited as a minimum programme from a technical viewpoint is unrealistic for reasons of effort (RADERMACHER et al. 1998). It is thus probable that if the EAS is implemented, only part of the proposed data will be collected.

The data collected in the field will be aggregated into indicators.

Table 15 from HOFFMANN-KROLL et al. (1998) uses the example of the biotope type Crops to illustrate how comprehensive data surveying should be for each biotope type under EAS. However, the data for the indicators ultimately cited for EAS (see Tab. 16) cannot be reproduced in the same detail used in field surveying.

Tab. 15: Structure indicators proposed under EAS for the biotope type Crops (full list)

| **Biotope quality** | **Indicators for vascular plants, mosses and lichens** | **Indicators for species group Ground beetles** |
|---|---|---|
| | Indicators referred to the size of the study unit ('per plot') | |
| | **For biotope types 'Cereals and root crops'** | **For biotope type 'Cereal crops'** |
| ▪ Soil character<br>▪ Border of field type<br>▪ Width of border of field<br>▪ Gradient of crop land<br>▪ Weed vegetation | ▪ Number of species<br>▪ Number of species in various vegetation layers<br>▪ Dominance relationships between species (structural diversity)<br>▪ Sociological behaviour groups (structural diversity, level of disturbance)<br>▪ Life form types of plants (structural diversity, level of disturbance)<br>▪ Structural features of leaves (structural diversity, effects of pollution)<br>▪ Total cover level of soil with vegetation (stability, productivity)<br>▪ Thickness of various vegetation layers (productivity)<br>▪ Number of vegetation layers (productivity)<br>▪ Cover level of soil with individual vegetation layers (productivity)<br>▪ Proportion of species with specific habitat requirements (strategy types)<br>▪ Ecological indicator values (nitrogen value, leanness indicator, moisture value, moisture indicator, continentality figure, reaction value)<br>▪ Proportion of crop-determined species (Hemerobiewert)<br>▪ Number of rare plant species<br>▪ Number of 'Red List' species | ▪ Number of species<br>▪ Dominance relationships betw. species (evenness)<br>▪ State of ecosystem due to ecological claim types<br>▪ Number of 'Red List species |

Tab. 16: Proposals on EAS structure indicators for GNA potentially relevant to the field of biotechnology and genetic engineering on (RADERMACHER et al. 1998, FEDERAL STATISTICAL OFFICE & FEDERAL AGENCY FOR NATURE CONSERVATION 2000, DRÖSCHMEISTER 2001).
Tables 35 a, b and c in the appendix show all proposals for EAS structure indicators for GNA put forward by RADERMACHER et al. (1998), FEDERAL STATISTICAL OFFICE & FEDERAL AGENCY FOR NATURE CONSERVATION (2000) and DRÖSCHMEISTER (2001).

| | | Indicator | | | Indicator |
|---|---|---|---|---|---|
| **Vegetation** | | **Share of endangered biotope types in all non-technical biotope types represented in Germany in %** | **Fauna** | | **Share of endangered wildlife vertebrate species (Red List species) in the total number of vertebrate species occurring in Germany in %** |
| | | **Share of endangered species of mosses (Red List species) in the total number of corresp. species occuring in Germany in %** | | | **Share of endangered wildlife mammal species (Red List species) in the total number of mammal species occuring in Germany in %** |
| | | **Share of endangered species of lichens (Red List species) in the total number of corresp. species occ. in Germany in %** | | | **Share of endangered reptile species (Red List species) in the total number of reptile species occurring in Germany in %** |
| | | **Share of endangered species of algae (Red List species) in the total number of corresp. species occ. in Germany in %** | | | **Share of endangered amphibian species (Red List species) in the total number of amphibian species occ. in Germany in %** |
| | | **Share of endangered species of fungi (Red List species) in the total number of corresp. species occ. in Germany in %** | | | **Share of endangered fish and Cyclostomata species (Red List species) in the total number of corresp. species occ. in Germany in %** |
| | **Vascular plants** | **Share of endangered wildlife species of ferns and flowering plants (Red List species) in the total number of corresp. species occ. in Germany in %** | | | **Share of endangered bird species (Red List species) in the total number of bird species occ. in Germany in %** |
| | | **Number of species per area unit** | | | |
| | | **Share/Number of rare plant species** | | **Example of breeding birds** | **Number of breeding pairs per area unit** |
| | | **Number of Red List species per plot** | | | **Abundance of selected species** |
| | | **Share of endangered plant species (cover)** | | | **Number of species per area unit** |
| | | **Occurrence of Red List species in biotope type** | | | **Number of rare species per area unit** |
| | | **Species population of plots in chronological development** | | | **Number of Red List species per area unit** |
| | | **Spectrum of strategy types** | | | **Number of breeding pairs of Red List species per area unit** |

The methods used for data surveying are described in a joint publication issued by the FEDERAL STATISTICAL OFFICE AND THE FEDERAL AGENCY FOR NATURE CONSERVATION (2000).

Indicator proposals for substances

From the field of substance indicators the following indicators are potentially relevant to the field of biotechnology and genetic engineering:

- use of plant protective agents (the existing basic data only include specific values for a small number of measuring points)
- use of fertilisers.

For the substance indicators an overall rating of the realisation chances was made using a scale from 1 to 6 (6 being the best possible result). The two indicators mentioned here scored 3 while many other indicators were given a better rating. The realisation chances of the above indicators potentially relevant to genetic engineering thus tend to be moderate to slight (RADERMACHER et al. 1998).

Indicator proposals for functionality

BARKMANN et al. (2001) have put forward indicators for the level of self organisation or the self-organisation ability of ecosystems which according to the latest knowledge could all be relevant with the exception of 'entropy production' when considering the effects of transgenic useful plants (see Tab. 17).

Tab. 17: Complete overview of the theoretical classification of the indicators selected by BARKMANN et al. (2001) for the level of self-organisation or the self-organisation ability of ecosystems

| Subject areas | Theoretical designation | Variables for quantification |
|---|---|---|
| **Ecological Thermodynamics** | **Exergy uptake**[10]<br>To what extent can the high-value energy introduced to the system be taken up by it? | Gross primary production,<br>Net primary production,<br>Leaf surface index |
| | Entropy production<br>To what extent can the entropy produced by the system be given off externally so that the system can preserve its level of order? | Entropy balance,<br>simplified entropy balance |
| **Organisation / Complexity** | **Level of organisation**<br>How large are the interactions between the system categories? | Organisation measures: e.g. *ascendency*,<br>highest trophic level in food web |
| | **Biotic / abiotic diversity**<br>How large are the biotic and abiotic diversity and thus the number of functional groups (categories) in the system? | Number of species according to functional groups (Gilden), heterogeneity index |
| **Substance-related basis of system development** | **Accumulation (pools)**<br>To what extent can the system compensate for fluctuations in the availability of energy, nutrients and water? | Intrabiotically stored nutrients, accumulation of energy/carbon accumulation in living and dead biomass |
| | **Nutrient losses**<br>Is the ecosystem organised so that a loss of important nutrients can be prevented? | Seepage,<br>atmospheric losses |
| **Ecophysiological efficiency** | **Biotic water utilisation**<br>How efficiently can the biotic elements of an ecosystem tap into the available water resources? | Transpiration per overall evaporation,<br>Transpiration per overground phytomass |
| | **Metabolic efficiency**<br>How efficiently can the biotic elements of an ecosystem obtain the available energy resources (biomass)? | Energy utilisation: respiration losses per biomass |

[10] *Exergy is a measure of the share of the total energy of a system which can be converted into mechanical work.*

**Possibilities for the Use of GNA Indicators for monitoring Genetically Modified Plants**

Ecological Area Sampling is to permit national data surveying for the natural stock without any reference to specific questions. To date this kind of survey has not taken place in Germany. Such data series might in particular show unexpected effects which possibly would not be revealed by problem-driven surveys. Such environmental survey data might therefore provide important additional background information for e.g. the 'general surveillance' according to the amendment of the EU directive on the deliberate release of genetically modified organisms into the environment (2001/18/EG).

However, at the present time it is not clear how and whether EAS can be implemented nationally in the form currently proposed.

A nationwide state report is to be prepared for EAS using statistically randomised areas. Although this would include changes in the mean, there would still be no direct access to potential conflict or risk sites. As EAS is aimed at making statements regarding the fundamental entirety of all plots or for selected subsets, there is no emphasis on statements regarding individual sampling sites/plots.

With its non question- or problem-driven approach EAS can only be used to establish that changes in a monitoring variable have occurred. However, these cannot be explained in causal terms or justified.

In addition, the surveying frequency for the indicators is measured in years, in intervals of up to five years. Data series would thus only be available after lengthy periods.

Of the indicators proposed for Ecological Area Sampling only a small number seem to be directly usable for monitoring transgenic crop plants (see Tab. 16). Nevertheless, a large quantity of the basic data surveyed for the indicators are also relevant to the monitoring of genetically modified plants.

It seems possible to extend the surveys under the EAS concept to specifically include biotechnology and genetic engineering with comparatively little effort. Which data should be added to the surveys is currently being considered under the R&D project mentioned in the first section (see footnote 2).

Radermacher et al. (1998) point out that the majority of the existing environmental indicator systems cannot fulfil their original claim to portray environmental problems or the state of the environment with just a few meaningful indicators, or only to an

inadequate extent, and that this limitation also applies to the proposals submitted for Ecological Area Sampling.
As regards Ecological Area Sampling it should nevertheless be borne in mind that one principle of development was, "to process the surveyed data comprehensibly as far as possible in the procedure and to apply indirect indication processes and evaluations to the data obtained only as the final step of analysis." (DRÖSCHMEISTER 2001) This principle can increase the levels of usability of the EAS indicators for other issues to a significant extent.

Given that it is probably only possible to differentiate at most according to extensive landscape types for the substance indicators under GNA, the reference to site types is lacking, something which may limit usage in the field of biotechnology and genetic engineering.

## 4.7 ECOSYSTEM ENVIRONMENTAL MONITORING

Ecosystem environmental monitoring also relates to the statements and recommendations made by the German Council on Environmental Quality, which extensively called for improvements to environmental monitoring in its 'Environmental Expert Opinion' of 1987 (GERMAN COUNCIL ON ENVIRONMENTAL QUALITY 1987) and in the special expert opinion 'General Ecological Monitoring of the Environment' of 1990 (GERMAN COUNCIL ON ENVIRONMENTAL QUALITY 1990).

The main aim of the R&D project 'Model-based Implementation and Specification of a Concept for Ecosystem Environmental Monitoring with the Example of the Rhön Multistate Biosphere Reserve' (on behalf of the Federal Environmental Agency and the Bavarian State Ministry for Regional Development and Environmental Affairs), which has been underway since 1997 and is scheduled to run until the middle of 2001, is to operationalise the high technical requirements of the German Council on Environmental Quality as regards the monitoring of changes in the functioning of ecosystems and the early detection of environmental changes. Here Ecosystem Environmental Monitoring is to be primarily based on the data collected in existing monitoring programmes and measuring networks (SCHÖNTHALER et al. 1997, SCHÖNTHALER pers. communication). The R&D project on Ecosystem Environmental Monitoring in the Rhön is thus extensively considering possibilities for harmonising the surveying of environmental data and extending data analysis (SCHÖNTHALER 2001).
Ecosystem environmental monitoring has been developed as a modular system which can be realised in individual steps through the implementation of individual components. These partial steps are aimed at successive harmonisation of the existing monitoring activities. The concept includes the following harmonisation components (SCHÖNTHALER et al. 1997, SCHÖNTHALER 2001, SCHÖNTHALER pers. communication):

- shared issues to which Ecosystem Environmental Monitoring should devote itself, with the data requirement being directly derived from their formulation (this work step consists of a 'problem-driven' and 'theoretical system-based' approach),
- joint set of parameters ('core data set'), for which integrated and ecosystem analyses are necessary,
- proposals for harmonised data surveying and quality assurance as well as

- a common analysis concept which provides for a pool of simple and more complex analysis methods.

In the framework of the 'problem-driven approach' the questions on Ecosystem Environmental Monitoring have been expressed in the form of ten general cause-effect hypotheses, which themselves have been differentiated into numerous subhypotheses. Their formulation is based on generally sufficiently known cause-effect linkages and the assumption of hypothetical development trends in the future. The internal structuring of the cause-effect hypotheses into causes, primary and secondary effects is closely allied to the P-S-R- or D-P-S-I-R model. This provides for an interface with other indicator systems under discussion at both a national and international level (SCHÖNTHALER 2001, SCHÖNTHALER pers. communication).

With view of the requirements on Ecological or Ecosystem Environmental Monitoring[11] formulated by the GCEQ (GERMAN COUNCIL ON ENVIRONMENTAL QUALITY 1990) the concept was not solely focused on the environmental problems currently considered to be relevant. Subtle changes in the structure and above all in the functioning of ecosystems should be monitored. For this reason the 'problem-driven approach' in the concept of Ecosystem Environmental Monitoring has also been combined with a 'theoretical system-based approach'. In the framework of this approach theories have been formulated on fundamental functional laws in ecosystems (e.g. on the productivity of systems and the unity of substance cycles). This approach highlights parameters which are probably key variables characterising the self-organisation ability of ecosystems. They should be given special consideration when analysing data, in particular when this involves variables which cannot at least be linked directly and spontaneously with environmental problems currently described. This procedure is allied with the expectation of being able to identify system and function changes in Ecosystem Environmental Monitoring at an early stage.

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[11] *The term 'Ecological Environmental Monitoring' as used by the GCEQ (1990) no longer corresponds to current linguistic usage.*

Indicators are also assigned to the ecosystem functions described under the theoretical system-based approach in the concept for Ecosystem Environmental Monitoring. With this step the project work is directly tying up with the ongoing monitoring being performed by INDECO (cf sect. 4.6), in whose framework highly aggregated indicators are to be formulated to describe the state of the environment (SCHÖNTHALER 2001, SCHÖNTHALER pers. communication).

To date the release of genetically modified organisms (GMO) has not been treated as a separate problem area under the concept of Ecosystem Environmental Monitoring. However, methodical and content-related interfaces to the subject of GMO have been suggested in conjunction with the handling of other problem areas, with the possibility of further differentiation (SCHÖNTHALER 2001, SCHÖNTHALER pers. communication).
As many possible cause-effect linkages for the cultivation of transgenic plants are being dealt with only now, and given the commercial cultivation of genetically modified plants unexpected effects on the balance of nature cannot be ruled out, the application of the theoretical system-based approach for Ecosystem Environmental Monitoring seems to be of interest for the development of a monitoring system for biotechnology and genetic engineering. This theoretical system-based approach can be a useful complement to conventional, more problem-oriented monitoring approaches.

Of the cause-effect hypotheses formulated in the framework of Ecosystem Environmental Monitoring hypothesis 2 for example is relevant to the cultivation of transgenic useful plants (SCHÖNTHALER 2001):

| | |
|---|---|
| Cause-effect hypothese 2 | Accumulation of toxic substances in terrestrial ecosystems and consequences for biocenoses |
| Cause | Use of plant protective agents (PPA) |
| Primary effect | Accumulation of PPA residues and/or their degradation products in the environmental media of air, soil and groundwater |
| Secondary effect | Accumulation of PPA residues and/or their degradation products in plant and animal organisms and their consequences for population development |

Other hypotheses provisionally formulated in the project may acquire relevance in terms of monitoring approaches for transgenic plants[12]. A final analysis of the interfaces between Ecosystem Environmental Monitoring and monitoring for biotechnology and genetic engineering can be made on completion of the R&D project on Ecosystem Environmental Monitoring with the example of the Rhön.

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[12] *See 3. Interim report re R&D project 'Model-based Implementation and Specification of a Concept for Ecosystem Environmental Monitoring with the Example of the Rhön Multistate Biosphere Reserve' (unpublished)*

## 4.8 Other Approaches not representing Completed Programmes or Concepts

### 4.8.1 Project for Development of Parameters and Criteria as Basis for Evaluation of Ecological Performance and Burdens of Agriculture – Indicator Systems

In 1998 the University of Bonn carried out a project for the development of parameters and criteria as a basis for the evaluation of ecological performance and burdens of agriculture on behalf of the Federal Environmental Agency, Berlin.

The aim of the project study (GEIER et al. 1999) was to derive a catalogue of indicators as a basis for evaluating ecological effects on agriculture.

The authors of the study point out that the call for indicators to be founded on ecological linkages should act as an important ideal benchmark for systems of environmental indicators, i.e. clear-cut effect linkages between the indicator and the environmental impact to be described. According to this stipulation the systematic definition and specification of agriculturally relevant environmental effects is a necessary prerequisite to establish a catalogue of indicators as the basis for the evaluation of ecological effects of agriculture (GEIER et al. 1999).

The authors also emphasise that indicator values require interpretation and that such interpretation is facilitated by reference values or thresholds. In their view, the extent of an environmental problem can only be identified by knowledge of the shortfall from the desired state. As regards such goal-oriented considerations reference is made to the expert opinion of the German Council on Environmental Quality, in which environmental quality targets are defined as scientifically justified desirable objectives for the state of the environment (GEIER et al. 1999).

Besides these basic considerations regarding the subject of indicators the study examines to what extent appropriate indicators are available and where changes and additions are required. In addition, new environmental indicators are proposed. Here it was established that only a small number of the proposed indicators are already covered by official environmental reporting.

The project considers a range of so-called environmental effect areas. Here it is observed that the situation for individual environmental effect areas is extremely heterogeneous. In particular for the area 'Species and biotope diversity' it is noted that

existing data is partly collected using different methods depending on the Federal state. One prime concern is thus considered to be standardisation of data collection.
In particular, the areas included in the study 'Species and biotope diversity', 'Diversity of crop plants and working animals' and 'Use of genetically modified organisms' are relevant to biotechnology and genetic engineering as well as the monitoring of genetically modified plants.
It should be stressed that this study, in contrast to all other examinations of environmental indicators made on a national or international scale, is the first to consider the use of genetically modified organisms as a possible environmental effect area. The authors expect difficulties with this field in as far as the fundamental data necessary to derive indicators is not available and there is a problem not only regarding a lack of data but also insufficient knowledge. For this reason the study specifies no indicators of its own for the complex over and above the considerations regarding the environmental effect area 'Use of genetically modified organisms' (GEIER et al. 1999).

In Table 18 the indicators potentially relevant to the field of biotechnology and genetic engineering have been compiled by area from the indicators proposed under the project for other environmental effect areas.

The project described here involves a study with proposals which does not include a concept awaiting implementation.

Tab. 18: Indicators potentially relevant to the field of biotechnology and genetic engineering, included in the project for the development of parameters and criteria as a basis for the evaluation of ecological performance and burdens of agriculture (excerpt from indicator proposals of GEIER et al. (1999), see tables 36 a and b in the appendix)

| Environmental effect area | Indicators | Authors' comments |
|---|---|---|
| Species and biotope diversity (biodiversity, biotope quality of agriculturally productive land) | Only state indicators potentially relevant to GMP:<br>• **Occurrence and number of rare and/or endangered grassland species or arable weeds and dependent small animal species directly or indirectly dependent on same (fields: insects such as ground beetles, hover flies)**<br>• **Occurrence and number of endangered and characteristic higher-order consumers (fields: partridge, quail, skylark)**<br>• **Population sizes of rare, endangered and/or characteristic species** | The effort involved in implementation is rather high and there is still a need for development and additional surveys. |
| Soil function<br>- introduction of toxic substances | • **State: results of waterworks regarding contamination of drinking water and groundwater measuring points with nitrate and PPA. PPA levels in surface waters. The results presented by the waterworks should quantify PPA contamination.**<br>• **Pressure: PPA use (quantity), N balance (as per PARCOM), area w/o PPA use, extent of permanently covered borders of bankland. (In addition same indicators in water protection areas.)** | Little effort involved, data procured by analysis of existing data<br><br>Little effort involved, but new surveys necessary in some cases<br><br>Currently no area-specific data available on PPA use |
| Diversity of crop plants and working animals | Almost no proposals as basis lacking:<br>• **State: overview of hazard levels and extent of working animals und crop plants**<br>• **Response: measures to conserve same** | |
| Use of genetically modified organisms | No proposals as basis lacking:<br>Pressure and State indicators cannot be shown at present.<br>Monitoring measures can be used as Response indicators. | |

### 4.8.2 Shaping the Industrial Society – Perspectives for Handling Flows of Substances and Materials, Report by Commission of Inquiry 'Protection of Mankind and the Environment' of the 12th German Bundestag

The role of the Commission of Inquiry ''Protection of Mankind and the Environment' appointed by the German Bundestag in 1992 was to develop proposals for sustainable development which could be implemented in the medium and long term. Objectives and indicators were put forward (see Tab. 19).

Tab. 19: Ecological objectives and indicators of the Commission of Inquiry (ENQUETE 1994) for the areas 'Structure of ecosystems', 'Functions of ecosystems' and 'Other factors' Indicators potentially relevant to the field of biotechnology and genetic engineering are shown in **bold** (objectives und indicators relating to the 'Health of man' were not relevant in their entirety)

| **Protection and structuring objectives** | **Evaluation criteria** | **Indicator/parameter**<br>**substance** | <br>**system-based** | **Evaluation Comparison with** |
|---|---|---|---|---|
| ***Structure of ecosystems*** | | | | |
| Abiotic | | | | |
| - Integrity of atmosphere / air | Air pollution / Photosmog<br>Hole in ozone layer | Hydrocarbon/ $NO_x$ concentration<br>ODP[13] value | Ozone concentration<br>Ozone depletion/yr. | Ozone limiting value<br>Natural ozone concentration |
| - Integrity of water<br>Surface<br>Groundwater | Eutrophication<br>Nitrification | Eutrophication-potential<br>Nitrate concentration | Drinking water contamination | Critical load drinking water limiting value (EU) |
| - Integrity of soil | Acidification<br>Heavy metal contamination<br>Soil erosion | Acidification potential<br>Heavy metal concentration | pH gradient<br>**Erosion**<br>Sealing | Critical load<br>Limiting value |

[13] *ODP = ozone-depleting potential*

| **Protection and structuring objectives** | **Evaluation criteria** | **Indicator/parameter** substance | **Indicator/parameter** system-based | **Evaluation Comparison with** |
|---|---|---|---|---|
| ***Structure of ecosystems*** | | | | |
| Biotic | | | | |
| - **Diversity of species/ gene pool** | **Species loss/ reduction in genetic diversity** | Species-specific ecotoxicity: $LD_{50}$[14] | **Reduction in DNA variance** | Natural range |
| - **Ecosystem stability / water** | **Disturbance of ecological balance** | Aquatic ecotoxicity: $LC_{50}$[15] **PEC value** | **Aquatic ecotoxicity: species shift / population dynamics** | PEC[16]/NEC[17] ratio natural site-specific stock |
| - **Ecosystem stability / soil** | **Disturbance of ecological balance** | **Terrestrial ecotoxicity: PEC value** | **Terrestrial ecotoxicity: changed microbe population** | PEC/NEC ratio natural site-specific microbe population |
| - **Ecosystem stability / veg. kingdom** | Changed growth zones | | **Regional species loss** | Natural vegetation |
| ***Functions of ecosystems*** | | | | |
| Abiotic | | | | |
| - Climate stability | Greenhouse effect | GWP[18] value | Temperature rise/ year | Ecologically compatible increase rate |
| Biotic | | | | |
| - Sustainable (production) function / water | Fish mortality | $LD_{50}$ | Reduced fish stock | Natural stock |
| - Sustainable (production) function / soil | Yield reduction | | Hectare yield/year | Normal yield |
| - Sustainable plant growth | Forest dieback | Pollution gas concentration ($SO_2$, $NO_x$, $O_3$) | Treetop thinning Needle loss Standing timber yield | Healthy timber stand Normal yield |
| - Recreation function of landscape | Loss of 'nature' | | | |
| ***Other factors*** | | | | |
| | Odours Noise | | | |
| -**Sparing of resources** | | **Persistence** | **Irreversibility** | |

As regards the above indicators it is questionable in many cases whether the relevant data can be collected.

To date no further steps have been taken towards implementation.

*[14] $LD_{50}$ = lethal dose at which 50% of individuals die*
*[15] $LC_{50}$ = lethal concentration at which 50% of individuals die*
*[16] PEC = predicted environmental concentration*
*[17] NEC = no effect concentration*
*[18] GWP = greenhouse warming potential*

### 4.8.3 Proposals for Sustainability Indicators from a Risk Dialogue between Novartis AG, the Foundation Risk Dialogue, the Austrian Ecology Institute and the Institute for Applied Ecology

Between 1997 and 1999 representatives of Novartis AG, Basel, Novartis Germany GmbH, the Austrian Ecology Institute, Vienna, Institute for Applied Ecology, Freiburg and Foundation Risk Dialogue, St. Gallen have taken initial steps towards the development of sustainability indicators for genetically modified plants (see Tab. 20). Fundamental questions were what sustainability could mean in the field of agriculture and nutrition in specific cases and how sustainability can be evaluated and achieved (FOUNDATION RISK DIALOGUE 2000).

As a conflict in interests was expected in the dialogue, the Foundation Risk Dialogue was entrusted with the task of overseeing the process, supporting the dialogue in critical phases by regular reviews in terms of content and at the process level and preventing the dialogue from breaking down.

In the initial dialogue phase the parties involved agreed to discuss the question of sustainability using the specific example of genetically modified Bt corn produced by Novartis. It was to be considered whether this product could be evaluated as sustainable and what conditions should be satisfied in this regard (FOUNDATION RISK DIALOGUE 2000).

In the second phase the attempt was made to draw up a list of sustainability objectives on the basis of jointly selected sustainability studies. Using a ranking, a set of 17 objectives was chosen from a proposal of 47 sustainability objectives for the fields of economics, ecology and social aspects. The objectives were then regrouped and summarised into 13 higher-level objectives.

The process was aided by the PROSA method (Product Sustainability Assessment) of the Institute for Applied Ecology, which was used to put together and condense evaluation criteria in the fields of economics, ecology and sociology. However, the realisation soon followed that selection of the criteria and their weighting still depended on those values, interests and objectives which they had tried to "objectify". The dialogue dealing with the evaluation criteria for Bt corn thus also had to deal with conflicts and contradictions in interests. The ranking revealed the variations in weighting among the players: While all parties involved more or less agreed where the environment was concerned, there was wide divergence on the emphasis placed on economics and social aspects.

In the social field the representatives of Novartis for example considered sustainable development to depend on the objectives 'Reliable supply of food', 'Improvement of food quality' and 'Trust in authorities, science, industry (Novartis)'. The ecological research institutes on the other hand focused on the importance of the objectives 'Protection of consumer interests', 'Healthy food', 'Fair trading conditions' and 'Access for farmers and rural communities to genetic resources for foodstuffs' as the criteria for sustainable development. The emphasis in terms of economics showed similar divergence. Once again opinions differed as regards which economic objectives are important for sustainable development. The representatives of Novartis stressed importance of the objectives 'Boost shareholder value', 'Market leader/Full range' and 'Improve economic situation of farmers (returns, operating costs)'. The ecological research institutes on the other hand saw sustainable development as depending on the objectives 'Maintaining a healthy agricultural structure', 'Internalisation of costs' and 'Prevention of monopolisation' (FOUNDATION RISK DIALOGUE 2000).

The following sustainability objectives were drawn up.

Economics:

- Maintenance of a healthy agricultural structure
- Internalisation of external costs
- Boost shareholder value of Novartis
- Market leader/Full range
- Improve economic situation of farmers (returns, operating costs))

Social aspects:

- Reliable supply of food
- Improvement of food quality
- Protection of consumer interests
- Fair trading conditions
- Healthy food
- Trust in authorities, science, industry
- Access for farmers and rural communities to genetic resources for foodstuffs

Environment:

- Improve ecological balance (use of resources, emissions)
- Biological safety
- Maintain diversity of species, encourage natural processes/regions

It was originally planned to carry out the project in two stages: The first stage included content-related, theoretical and conceptional considerations, whose results were presented here (FOUNDATION RISK DIALOGUE 2000). This was to be followed by a practical trial to identify and check the results. To date this second stage has not be carried out due to the reluctance of one project partner.

Examination of the proposed indicators (see Tab. 20) shows that in some cases they cannot be supported with data in this form but first need to be made specific. This was planned for the second stage of the project, which however is not in sight at the present time.

The dialogue project described here does not involve a proposal for (environmental) indicators in general, but is a project that aimed at the development of sustainability indicators, especially for genetically modified plants using the example of Bt corn . For this reason the proposals from this dialogue project are not considered below together with other indicators offering potential relevance for the monitoring of effects from the use of biotechnology and genetic engineering.

Tab. 20: Objectives and sustainability indicators in the environmental field developed under the risk dialogue between Novartis AG, Foundation Risk Dialogue, the Austrian Ecology Institute and the Institute for Applied Ecology for transgenic Bt corn

| Objectives/themes | Indicators |
|---|---|
| **Improve eco-balance according to ISO standard (energy and land inputs, use of fertilisers and pesticides, air and water emissions, waste)** | ▪ **Typical eco-balance indicators including transport routes e.g.**<br>- **Use of pesticides per agricultural unit**<br>- **Toxicity of applied pesticides**<br>- **Use of nitrogen and phosphate-containing fertilisers per agricultural unit** |
| **Biological safety** | ▪ **Existence +stipulation criteria of national regulations or guidelines on biological safety**<br>▪ **Monitoring, review processes (time limit + checking)**<br>▪ **Population-dynamic effects and effects on biogeochemical cycles**<br>▪ **Effects on targeted and untargeted organisms**<br>▪ **Pathogen-host interrelations**<br>▪ **Predator – prey relationship**<br>▪ **Competition/displacement effects**<br>▪ **Interactions with abiotic environment**<br>▪ **Possibilities of survival, establishment and spread**<br>▪ **Tendency towards introgression**<br>▪ **Gene transfer to naturally occurring hybrid partners**<br>▪ **Horizontal gene transfer of recombinant genes to micro-organisms**<br>▪ **Phenotypical and genetic stability**<br>▪ **Pleiotropes and position effects**<br>▪ **Development of resistance/resistance management** |
| **Conserve diversity of species / Encourage natural processes / regions** | ▪ **Percentage of threatened species in total number of indigenous species**<br>▪ **Percentage of refuges**<br>▪ **Size of coherent biotopes without severance**<br>▪ **Mean natural evolution to anthropogenic species loss**<br>▪ **Implementation/existence of monitoring programmes**<br>▪ **Share of organic farming in total agricultural land**<br>▪ **Protection programmes/border of field protection**<br>▪ **Substance introduction/substance contamination** |
| **Subgoal**: soil protection | ▪ **Soil erosion (soil cover, crop rotation, mowing frequency, stocking rate, mechanical soil pressure)**<br>▪ **Soil fertility** |

# 5 UNEVALUATED (ENVIRONMENTAL) INDICATOR CONCEPTS AND PROGRAMMES

In 1997 **'land quality indicators'** were developed by the UNEP, UNDP, FAO and the World Bank. These relate to the situation in third-world countries in particular. The indicators focus on problems which have already cropped up and environmental aspects which have been currently been classed as priorities, this being the reason why they have not been included in this study. However, in terms of effects there may be overlapping with the effects of cultivating transgenic plants, for example in the field 'Species und biotope losses'.
In addition, the FAO and WHO have formulated very general objectives regarding agriculture, sustainable food safety or the creation of an environment beneficial to health. Corresponding indicators have not been put forward. For this reason the relevant texts and concepts have not been evaluated.

Indicators are also being developed by the **Scientific Committee on Problems of the Environment** (SCOPE) of the International Council of Scientific Unions (ICSU) in cooperation with the UNEP to scientifically supplement and substantiate the work being performed by the CSD (RADERMACHER et al. 1998). Here highly aggregated pressure indicators for environmental aspects of sustainability are being developed to support political decision-making at a national and international level (RADERMACHER et al. 1998, http://www.unep.ch/earthw/indicat.htm in July 2000, UNEP/CBD/COP/5/INF/1). According to WALZ et al. (1997) the SCOPE project on sustainability indicators suffers from conceptional problems. Due to the high level of aggregation this project is not considered further here.

At the initiative of the Federal Environment Ministry the **Environmental Barometer for Germany** is published at regular intervals. This involves one highly aggregating indicator for each key theme of environmental protection (SCHILLING 1999). Once again the Environmental Barometer for Germany is not considered further here due to its high level of aggregation.

At the end of the Eighties a regionally differentiated agricultural and environmental data system, the **RAUMIS** model system (Regionalised Agriculture and Environmental System), was developed at the University of Bonn on behalf of the BMELF for the differentiated portrayal of the economic linkages between effects in the agricultural sector and to consider interdependences between agriculture and the environment as a policy information system. RAUMIS contains 431 models, which each distinguish between 77 plant and 16 animal production processes. The model uses a weighted points system. This involves highly aggregated indicators with great simplification of the complex relationships, so that it does not seem possible to use it to portray effects in the field of biotechnology and genetic engineering[19].

**Other** approaches, proposals or concepts for (environmental) indicators:

- Regional Seas Program in the framework of the Mediterranean Action Plan (core set of 130 indicators for sustainability in the Mediterranean; developed by the Mediterranean Commission on Sustainable Development)
- World Resources Institute (WRI): list of 22 indicators for biodiversity in situ, ex situ and the diversity of domestic/working animals
- WWF: Living Planet Index (LPI): an indicator for changes in freshwater, forest and ocean ecosystems; measures the extent of biodiversity losses
- World Bank: environmental performance indicators (EPI), world development indicators (WDI)
- Global Environment Facility (GEF): developing programme-level indicators for GEF biodiversity programmes
- Global Environmental Monitoring System (GEMS): Global environmental monitoring system of the UNEP[20]
- WIEWS = World Information and Early Warning System of the FAO
- REPRO: method for economic analysis in ecological terms and evaluation of agricultural management systems, in particular as regards the flows of substances and energy[21]

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[19] *MEUDT, M. (1999): Implementation of Environmental Indicators in Policy Information System in Germany. Chapter 15. In: BROUWER, F. & CRABTREE, B. (eds.) Environmental Indicators and Agriculture Economics, McGill University, Ste. Anne de Bellevue, Quebec, Canada.*

[20] *UNEP (1990): A Survey of Environmental Monitoring and Information Management Programmes of International Organisations. HEM, Munich.*

[21] *DIEPENBROCK, W.; ROST, D. & HÜLSBERGEN, K.-J. (1999): Informationssystem 'Agrar-Umweltindikatoren' und Betriebs-Bilanzierungsmodell ‚REPRO‘. Research report commissioned by MELF of State of Saxony-Anhalt. Martin Luther University Halle-Wittenberg.*

- KUL: Critical environmental impacts on agriculture: procedure portraying environmental impacts of agricultural enterprises (at operating level) and reviewing them in terms of their environment compatibility[22]
- Forest damage survey LEVEL I
- ICP-Forests LEVEL II (UN, EU, states)
- Forest information with Remote Sensing[23]
- Soil state survey for forests (states)
- Monitoring Agriculture with Remote Sensing (MARS): Since 1988 the Statistical Office of the European Communities has been carrying out the MARS project for the quantitative assessment of agricultural usage (size, state, yield) in the member states. The objectives of the MARS project provide for an improvement in agricultural statistics with the help of remote sensing techniques (MARS-STAT) and - in the framework of the 1992 EU agricultural reform –the use of remote sensing data and methods to implement the agricultural policy measures of the EU (MARS-CAP)[24].

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[22] *Eckert, H. & Breitschuh, G. (1997): Kritische Umweltbelastungen Landwirtschaft (KUL): Ein Verfahren zur Erfassung und Bewertung landwirtschaftlicher Umweltwirkungen. In: Deutsche Bundesstiftung Umwelt / Diepenbrock, W.; Kaltschmitt, M.; Nieberg, H.; Reinhardt, G. (ed.): Umweltverträgliche Pflanzenproduktion – Indikatoren, Bilanzierungsansätze und ihre Einbindung in Ökobilanzen. Initiativen zum Umweltschutz 5, p. 185-195.*
*Eckert, H., Breitschuh, G., Sauerbeck, D. 1999: Kriterien umweltverträglicher Landbewirtschaftung (KUL) – ein Verfahren zur ökologischen Bewertung von Landwirtschaftsbetrieben, Agribiol. Res. 52,1 1999, p. 57-76*
[23] *FIRS [EU]: Regionalisation and Stratification of Forest Ecosystems for the whole of Europe and design of a System of Nomenclature for European Forest Mapping*
[24] *SPÖNEMANN, J. et al.: Möglichkeiten der Abgrenzung intensiver und extensiver Landnutzung mittels ERS-Radaraufnahmen in einem mitteleuropäischen Testgebiet. http://uggg-pc-s1.uni-geog.gwdg.de/kuf/pi_proj.htm*

# 6 INDICATORS PROPOSED FROM THE EVALUATED CONCEPTS AND STUDIES

Table 24 in the appendix summarises all indicators selected from the evaluated studies and concepts as being potentially relevant to the field of biotechnology and genetic engineering, listed according to subject. It is apparent that although many indicators are similar, they vary in terms of content formulation or precise designation.

Some indicators are listed under the heading 'Biotopes'. Here in particular endangered biotopes or changes in habitat are to be considered in general terms.

Many indicators refer to the species population. The indicator 'Threatened species' is repeated in a number of variations and specifications and should be considered in relation to different reference systems. In some cases individual species groups from fauna and flora are singled out, for example as characteristic species.

One special case at the species level is the separate examination of working animals and crop plants.

Closely associated with this are also proposals for genetic diversity in the species spectrum. Here the focus nevertheless does not solely fall on species which are utilised or influenced anthropogenically.

The programmes evaluated contain some indicators for the landscape, landscape structure and landscape utilisation. Besides the monitoring of changes attention is given to different forms of land use. A number of functionality indicators relating to the level of self-organisation or the self-organisation ability of ecosystems can be classified under the heading Landscape.

The heading Fertilisers and Plant Protective Agents is closely linked to agriculture. Many indicators are proposed in this regard and generally only differ in terms of their description and specification.

Where fertilisers and plant protective agents are concerned, there are also some proposals for the category of Water.

As regards efficiency indicators only indicators relating to the availability of water are relevant to the context we are considering here.

A surprisingly small number of indicators have been put forward for the category of soil to date. This probably reflects the extensive gaps in our knowledge persisting as regards the many processes in soils, as well as a lack of legal or binding agreements. The indicator proposals for erosion can also be included under the heading of soil.

There is also a group of indicators which does not involve environmental indicators in terms of portraying the environment but are indicators relating to measures or circumstances with possible effects on the environment.

For all the indicators proposed here we can now select indicators for use in the field of biotechnology and genetic engineering and for monitoring genetically modified plants. If however the criterion 'indicator for which the surveying of adequate data series is underway' is applied during the selection of appropriate indicators, none of the indicators proposed here will remain in the catalogue.

Some of the indicators listed from various programmes in Table 24 in the appendix are identical. It was thus advisable to select the most precisely formulated indicator. This pragmatic yet fundamental criterion was applied to Table 21. It contains the most precisely defined indicators particularly for themes for which there were many indicator proposals. This nevertheless does not mean that according to the existing definition and available description for each indicator the surveying of associated data would be possible or has already taken place.

Tab. 21: Compilation by theme of selected indicators potentially relevant to the field of biotechnology and genetic engineering which are defined most precisely (here: reduction of all selected indicators by omission of double entries)

| **Indicator** | **Project/Programme** |
|---|---|
| ▪ *Biotopes* | |
| Share of endangered und extinct biotopes in total number of occurring biotope types | FEM 2000b |
| Share of endangered biotope types in all non-technical biotope types represented in Germany in % | EAS |
| Protected areas as a percentage of total area by ecosystem type | OECD 1993 |
| Habitat alteration and conversion of land from its natural state | OECD 1993 |
| Fragmentation of habitats both in the agro-ecosystem and 'natural' habitats | OECD 1999a |
| Impacts on habitat of different farm practices and systems | OECD 1999b |
| Length of the "contact zone" between agricultural and non-agricultural lands | OECD 1999a |
| ▪ *Species population* | |
| Wildlife species | OECD 2000a |
| Threatened or extinct species as a share of known species | OECD 1993 |
| Threatened species<br>-% of total species or certain taxonomic groups<br>-% endemic species threatened<br>- threatened species in protected areas | CBD |
| Threatened (and extinct) species as a percent of total native species | FEM 2000b |
| Red List species (total and in % of all native species) | WWF 1994 |
| Change in numbers of endangered species related to agro-ecosystems | OECD 1999b |
| Protected species as a percentage of threatened species | OECD 1993 |
| Population sizes of rare, endangered and/or characteristic species | GEIER et al. 1999 |
| Share of endangered species of mosses, lichens, algae, fungi and wildlife ferns and flowering plants (Red List species) in the total number of corresp. species occurring in Germany in % | EAS |
| Share of endangered wildlife species: vertebrates, mammals, reptiles, amphibians, fish, Cyclostomata and birds (Red List species) in the total number of corresp. species occurring in Germany in % | EAS |
| Occurrence and number of rare and/or endangered grassland species or arable weeds and small animal species directly or indirectly dependent on same (fields: insects such as ground beetles, hover flies) | GEIER et al. 1999 |
| Wildlife species diversity related to agriculture: Appropriate key species indicators for each agro-ecosystem | OECD 1999b |
| Wildlife species diversity related to agriculture: The extent of changes in the agricultural area and type of land cover (this indicator would draw from the wildlife habitat and land use/cover indicators) (Method of calculation and interpretation p. 84, OECD 1999b) | OECD 1999b |
| Occurrence and number of endangered and characteristic higher-order consumers (fields: partridge, quail, skylark) | GEIER et al. 1999 |
| Number of species of vascular plants per area unit | EAS |
| Number of Red List species (vascular plants) per plot | EAS |
| Occurrence of Red List species (vascular plants) in biotope type | EAS |
| Species population (vascular plants) of plots in chronological development | EAS |
| Regional species loss / flora | Enquete 1994 |
| Biotic / abiotic diversity: How great is the biotic and abiotic diversity and thus the number of functional groups (categories) in the system? | BARKMANN et al. (2001) |

| Indicator | Project/Programme |
|---|---|
| Spectrum of strategy types (vascular plants) | EAS |
| Change in abundance and/or distribution of a selected core set of species | CBD |
| Stock development of guiding indicators for ecosystem changes (e.g. characteristic bird species) | WALZ et al. 1997 |
| Index for ecosystem changes (e.g. characteristic bird species) | FEM 2000b |
| Number of breeding pairs (breeding birds) per area unit | EAS |
| Abundance of selected species (breeding birds) | EAS |
| Number of species (breeding birds) per area unit | EAS |
| Number of rare species (breeding birds) per area unit | EAS |
| Number of Red List species (breeding birds) per area unit | EAS |
| Number of breeding pairs Red List species (breeding birds) per area unit | EAS |
| Alien/invasive species:<br>- % habitat colonized by invasive species<br>- % protected areas colonized by invasive species | CBD |
| Non-native species | OECD 2000a |
| ▪ *Working animals und crop plants* | |
| Measures to conserve working animals and crop plants | GEIER et al. 1999 |
| Overview of hazard levels and extent of working animals und crop plants | GEIER et al. 1999 |
| Share of endangered indigenous species of crop plants in respective total number | FEM 2000b |
| Changes in proportion of commercial species | CBD |
| Replacement of indigenous crops | CBD |
| Replacement of land races with few imported ones | CBD |
| Genetic diversity of domesticated livestock and crops: Change in the sum of all recognised and utilised varieties of domesticated livestock and crops | OECD 1999b |
| Genetic diversity of domesticated livestock and crops: Change in the share of different livestock and crop varieties in the total population or in total livestock and crop production | OECD 1999b |
| ▪ *Genetic diversity* | |
| Biodiversity index based on genetic and habitat variety (has yet to be developed) | EEB, EPRG |
| Genetic diversity | OECD 2000a |
| Reduction in DNA variance | ENQUETE 1994 |
| Introduction of new genetic material and species | OECD 1993 |
| Increase in cultivation of hybrid cultivars<br>(This indicator is linked to the indicator originally proposed by the SAG "Loss of genetic resources - non-utilisation of available crop species and varieties")<br>(this indicator is probably not included in the set of between 60 - 80 environmental pressure indicators) | TEPI project |
| ▪ *Landscape, landscape structure, land use* | |
| Landscape typologies | OECD 2000a |
| Land characteristics of agricultural landscape: Natural features, covering, for example, the land's slope, elevation, soil type, etc | OECD 1999b |
| Land characteristics of agricultural landscape: Land type features including changes in agricultural land use and land cover type | OECD 1999b |
| Land area under agricultural use (in % of land) | WWF 1994 |
| Agricultural land use (types of use: agriculture, grassland, wetlands, forestry) | OECD 2000a |
| Agricultural intensity: area used for intensive arable land | TEPI project |
| Intensively farmed agricultural habitats: The share of each crop in the agricultural area | OECD 1999b |

| Indicator | Project/Programme |
|---|---|
| Share of especially extensive land farming processes in land area | FEM 2000b |
| Share of integrated farming in land area | FEM 2000b |
| Share of ecological farming in land area | FEM 2000b |
| Environmental whole farm management plan | OECD 2000a |
| Impacts on biodiversity of different farm practices and systems | OECD 1999b |
| Changes in traditional (extensive) land-use practice<br>Definition: 'Changes in traditional high value farming practices resulting in homogenisation of land use and loss of habitat and species diversity' | TEPI project |
| Exergy uptake: To what extent can the high-value energy introduced to the system be taken up by it? | BARKMANN et al. (2001) |
| Level of organisation: How large are the interactions between the system categories? | BARKMANN et al. (2001) |
| Accumulation (pools): To what extent can the system compensate for fluctuations in the availability of energy, nutrients and water? | BARKMANN et al. (2001) |
| Nutrient losses: Is the ecosystem organised so that a loss of important nutrients can be prevented? | BARKMANN et al. (2001) |
| Metabolic efficiency: How efficiently can the biotic elements of an ecosystem obtain the available energy resources (biomass)? | BARKMANN et al. (2001) |
| ▪ *Fertiliser and plant protective agents* | |
| Use of fertilisers [metric tons of fertiliser nutrients per 10 $km^2$ of agricultural land] | UN 1996, FEM 2000b |
| Pesticide use [pesticide use in metric tons of active ingredients per 10 $km^2$ of agricultural land] | OECD 2000a, FEM 2000b, UN 1996 |
| (Total quantity) Pesticides (by type – herbicides, fungicides etc) used per year (per hectare?) of utilised agricultural area* / on agricultural land | TEPI project |
| PPA use (quantity), N balance (as per PARCOM), area w/o PPA use, extent of permanently covered borders of bankland. (In addition same indicators in water protection areas.) | GEIER et al. 1999 |
| Index of pesticide use (active ingredients) | OECD 1999b |
| Use of agricultural pesticides, plant protective agents risk indicator | FEM 2000b |
| Terrestrial ecotoxicity: PEC value[25] | ENQUETE 1994 |
| Terrestrial ecotoxicity: changed microbe population | ENQUETE 1994 |
| Toxic chemical consumption by economic activity (D67/548/EC)<br>- updated version: Consumption of toxic chemicals | TEPI project |
| Proportion of potentially hazardous chemicals monitored in food [%] | UN 1996 |
| Use of integrated pest management | OECD 1999b + 2000a |
| Use of non-chemical pest control methods | OECD 1999b + 2000a |
| Use of reduced and zero-tillage and other best land management practices including crop rotations | OECD 1999b |
| ▪ *Fertilisers and plant protective agents – water* | |
| Aggregated indicator PPA, NMVOC[26] and ubiquitous substances / water | WALZ et al. 1997 |
| Contamination of groundwater with nitrate, plant protective agents, parameters relevant to acidification | FEM 2000b |
| Results of waterworks regarding contamination of drinking water and groundwater measuring points with nitrate and PPA. PPA levels in surface waters. The results presented by the waterworks should quantify PPA | GEIER et al. 1999 |

[25] *PEC = predicted environmental concentration*

[26] *NMVOC=. non methane volatile organic compounds*

| Indicator | Project/Programme |
|---|---|
| Contamination | |
| Aquatic ecotoxicity: species shift / population dynamics | ENQUETE 1994 |
| Aquatic ecotoxicity: PEC value | ENQUETE 1994 |
| Contamination of surface waters with plant protective agents | FEM 2000b |
| ▪ *Water – efficiency* | |
| Eco-efficiency in agriculture | EEA |
| Water use / technical efficiency | OECD 2000a |
| Water use / economic efficiency | OECD 2000a |
| Biotic water utilisation: How efficiently can the biotic elements of an ecosystem tap into the available water resources? | BARKMANN et al. (2001) |
| Irrigated land | EEA |
| Water stress | OECD 2000a |
| ▪ *Soil* | |
| Soil tests | OECD 2000a |
| Soil quality (indicator group) | OECD 2000a |
| Nitrogen balance | OECD 2000a |
| ▪ *Erosion* | |
| Soil erosion of agriculturally productive land and other areas (total area in km², in tonnes of soil and in % of relevant soils) | WWF 1994 |
| ▪ *Measure indicators* | |
| R&D expenditure for biotechnology: risk and safety research | FEM 2000b |
| Labelling of genetically modified products and procedures or those free of genetic engineering | FEM 2000b |
| Market share of foodstuffs from organic farming | FEM 2000b |

Table 21 is still extremely comprehensive. Another pragmatic selection could be made by only considering indicators for which the monitoring of data would be possible using the available methodology and an acceptable deployment of resources according to the existing description and definition of indicators. However this would probably involve the loss of several themes of interest to the field of biotechnology and genetic engineering.

To avoid this it is necessary to initially develop selection or weighting criteria.

When considering existing concepts (sect. 4) in the context of the requirements made on indicators and sets of indicators (sect. 3) it can be seen that there is often wide divergence between requirement and reality regarding basic conceptional considerations and clarity of objectives / scales of values and the criteria applied.

A number of general aspects apply to the overall selection of indicators from existing indicator proposals to portray the impact from the use of genetically modified plants:

- There are only few indicators which have the potential to directly demonstrate consequences of the release of genetically modified plants.
- Additionally however there are many indicators under discussion which could become relevant when observed effects are to be understood or explained. Such 'auxiliary indicators' and their underlying data may be required to reveal or rule out linkages.
- For all proposed indicators it seems important that background information is available for the areas on which the data records relating to the indicators have been surveyed.
- Surveys using comparable areas seem essential particularly when attempting to link change in an indicator value over time with a possible cause as only then it is possible to reduce causes to one or two with effects which may otherwise be due to multiple causes.
- None of the indicators proposed to date by itself allows us to draw a conclusion regarding a direct linkage between a possible change in the indicator value and the cultivation of genetically modified plants as the sole possible cause without involving other statistical data.
- Most indicators only become significant in direct comparison with a meaningful value, i.e. with the parallel monitoring of a 'zero value' or the previous determination of a 'baseline'.
- Many indicators are only suitable for considering the potential effects of certain new gene constructs, specific changes in characteristics or special lines and species. They are thus unsuitable in general terms and at all events when considering effects of the cultivation of all transgenic plants.

The following section contains a further synopsis and evaluation of the selected indicators.

# 7 SYNOPSIS AND EVALUATION OF SELECTED INDICATORS[27]

The indicators listed in Table 21 can be divided up into 7 categories: 1) Endangered wild species/Natural biotopes; 2) Endangered working animal and useful plant species; 3) Change in land use; 4) Plant protection agents and fertilisers; 5) Water; 6) Soil and 7) Miscellaneous.

Most indicators were selected for Category 1, i.e. for the surveillance of biodiversity in natural habitats. For agro-ecologically relevant objectives few indicators exist to date. The actual aim of the associated agro-ecologically relevant indicators, such as the use of pesticides and fertilisers or changes in land use, is often to monitor impacts on the balance of nature.

To be suitable for the field of biotechnology and genetic engineering and the monitoring of genetically modified organisms most if not all indicators require modification or particularisation.

See below for a comment regarding the listed indicators in terms of specific categories:

### Category 1A) – Endangered biotopes

With some of the listed indicators it is difficult to differentiate this from the category 'Land use' as the distinction is not clear-cut. The relevance of the biotope indicators for the context selected in this study can thus be discussed in common with each other (see comments re Category 3).

### Category 1B) – Endangered wild species

The following indicators have the greatest relevance in terms of agriculture:

'Occurrence and number of rare and/or endangered grassland species or arable weeds and small animal species directly or indirectly dependent on same (in fields: insects und bird species such as quail, partridge, skylark)' (2 very similar aggregated indicators from GEIER et al. 1999).

'Wildlife species diversity related to agriculture: Appropriate key species indicators for each agro-ecosystem' (OECD 1999b)

'Wildlife species diversity related to agriculture: the extent of changes in the agricultural area and type of land cover' (OECD 1999b)

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[27] *Contribution by Angelika Hilbeck & Matthias S. Meier, EcoStrat GmbH, Zurich*

In some cases these indicators are dealt with in the scenarios (sect. 8), i.e. when considering possible indicators on the basis of the risk potential of existing transgenic useful plants (see bird and/or insect species, as well as characteristic or endangered species).

Three indicators with similar content are immediately noticeable. They might be suitable as an aggregated and particularised indicator for the field of biotechnology and genetic engineering:

'Change in abundance and/or distribution of a selected core set of species' (CBD)

'Development of stock of guiding indicators for ecosystem changes (e.g. characteristic bird species)' (WALZ et al. 1997)

'Index for ecosystem changes (e.g. characteristic bird species)' (FEM 2000b)

The prerequisite is that individual or a core set of relevant bird species can be identified as dependent final consumers of certain arable flora for example to act as a measured quantity for monitoring. This could be used to develop a guiding indicator which quickly reveals specific ecosystem changes, e.g. the disappearance of certain plant species. Depending on the level of detail used for monitoring this could be carried out for specific regions or landscape types and allow us to draw conclusions as regards the fragmentation of habitats and biotope changes.

We should like to add the following fundamental remark here: To ensure sensitive and swift monitoring of environmental changes it would be advisable if insects could serve as the characteristic species, either instead of or in addition to bird species. Insects have a faster succession of generations, are far more localised in terms of their requirements and generally occur, although not always (if an endangered species), in much larger numbers.

### Category 2) Endangered useful plants and animals

As the initial intention is to focus on the portrayal of effects of transgenic crop plants in the near future, working animals have not been taken into consideration here.

*Basic considerations regarding diversity*

It is of fundamental importance to initially establish a clear-cut definition for the term 'diversity deserving protection'. It should be clarified for example how an increasing diversity of transgenic types (lines) is to be evaluated. In this case the diversity would be based on differences in individual transgenes in an otherwise genetically identical context. Other scenarios could result if for example two or three transferred gene constructs resulted in morphological differences including reproduction barriers to the parent species. If these were considered as new species, the genetic 'diversity' would only be based on the number of transgenes in an otherwise genetically identical context. The possibility of genetic engineering contributing to an increase in biodiversity has already been expressed by scientists (WITCOMBE 1999, STEWART et al. 2000), in particular as regards the expiry of patents on gene constructs. It is thus expected that such constructs will be crossed into various types as 'universal genes'. It is therefore necessary to decide what diversity of useful plants is to be monitored and what is considered as deserving protection.

*Comments regarding listed indicators*

The indicators for endangered useful plants listed in Table 21 relate to diversity of species on the one hand and to genetic diversity on the other. There is overlapping between diversity of species and genetic diversity but they are not necessarily identical (see 'Basic considerations regarding diversity'). Given the fact that in Central Europe almost all land races have already been replaced by hybrids or other high-yield types, the following indicators from the catalogue presented might be the most relevant in terms of **diversity of species**:

'Share of endangered indigenous crop plant types in the respective total number' (FEM 2000b)
'Changes in proportion of commercial species' (CBD)

The first indicator involves monitoring to what extent indigenous crop plant types (i.e. in the widest sense also including land races or types which are grown rarely and in the non-commercial sector) are replaced by high-performances types, and to what extent this contributes to the further displacement of indigenous types. The second indicator deals with the displacement of commercially farmed crop plant species. The monitoring of transgenic crop plants should look at both possibilities. That reservations about the displacement of types und species are justified is shown in a recent article in

Cropchoice News[28], stating that US cotton farmers have increasing difficulties in buying non-transgenic cotton seed although the transgenic types do not offer the required yield for certain planters.

**Genetic diversity**

Four indicators have been basically developed which could be supported up with data regarding the monitoring of transgenic crop plants.

'Genetic diversity' (OECD 2000a)

'Reduction in DNA variance' (ENQUETE 1994)

'Introduction of new genetic material and species' (OECD 1993)

'Increase in cultivation of hybrid cultivars' (TEPI project)

The indicator 'Genetic diversity' is very unclear without further background information and particularisation. It is easier to establish the content of the other three indicators.

## Category 3) Land use

Indicators describing changes in land use in conjunction with transgenic crop plants may become increasingly important as one of the future prospects of genetically engineered changes in plants is the introduction of characteristics to allow plants to grow at sites which have been inadequate to date. The aim is to grow plants for example on acidic, saline or dry soils, something which may entail a radical change in land use. Possible consequences may be further destruction of the habitats of endangered plant and animal species or also changes in the water balance of the landscape. To identify and ward off undesirable ecological developments to protect nature and biodiversity in good time, the effects of the cultivation of transgenic useful plants on land use should form part of the monitoring programme.

Of the indicators listed some are similar in nature or could be derived from each other with appropriate monitoring of the measured quantities. For those which are less relevant separate indicators for land characterisation are considered as for this data for one indicator on changes in land use can be simultaneously included.

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[28] *CROPCHOICE NEWS, 18 January 2001: Delta and Pine Land seeds account for 84 percent of the cotton varieties, and Stoneville controls the other 16 percent, says Jim Worstell, Ph.D., quoting from U.S. Department of Agriculture figures. Of that seed, more than 99 percent is genetically modified.*
*"In some regions, no non-GMO seed is offered for sale," he says. "Farmers in our region recognize the poorer seed quality and even lower yields of GMO varieties, but they have been convinced by Monsanto advertising that they have to have the GMO genes."*

Indicators such as 'Land area under intensive use', 'Integrated production' or 'Organic farming' are basically measured quantities which could be aggregated into one indicator for transgenic crop plants. It would be desirable to differentiate in which production systems genetically modified plants are mainly used: integrated, extensive or intensive production?

'Impact on biodiversity of different farm practices and systems' (OECD 1999b)

For this indicator there is overlapping with the indicators in Category 2, so that it has already been partly covered there.

'Changes in traditional extensive land-use practice' (TEPI project)

This indicator does not play an important role in Germany and the EU as there is nowadays virtually no traditional land use relevant in terms of ecology, economics and the physiology of nutrition. This indicator could however also be taken into consideration on a localised basis in Germany or in certain countries of Southern Europe, and above all with the eastward expansion of the EU.

### Category 4) Use of plant protective agents and fertilisers

The subject of plant protective agents (PPA) is examined in detail in section 8. Fertilisers are considered under the indicators in Category 5) as regards their relevance, for example to nitrate leaching.

### Category 5) Water quality

The monitoring of plant protective agents and nitrate as well as metabolites or other residues of agricultural chemicals in surface and groundwater is essential (see sect. 8.1). This seems to be sole category in which the indicators developed to date can be used without change for the context of biotechnology and genetic engineering. Here three indicators are the most important, also covering the other indicators of this topic listed in Table 21 to a wide extent:

'The contamination of ground and surface water with plant protective agents or their metabolites (which may possibly be even more dangerous than the active substance itself [comment made by EcoStrat]) and the constituents of fertilisers (nitrates, phosphates, etc.)' (GEIER et al. 1999; FEM 2000b)

'Water utilisation efficiency (ecological, technical and economical)' (OECD 2000a; EEA)

'Irrigated land' (EEA)

The last indicator may fall under water efficiency as well as changes in land use where this involves shifts in agricultural practice in terms of intensification or extensification.

The detection of agricultural chemicals in ground and surface water must be followed by ecotoxicological analysis, or the reverse procedure can possibly also be applied if this proves to be more cost-effective, namely that the above pollution is subjected to ecotoxicological testing. In some cases organisms which are known to be extremely sensitive to certain substances (e.g. Daphniae for pesticides) may provide a more exact, or at least equally reliable and indeed more cost-effective result than complex analyses.

'Aquatic ecotoxicity (impact on aquatic organisms, population dynamics etc.)' (ENQUETE 1994)

This indicator would show an indirect effect of genetically modified plants, namely the increase or decrease in the utilisation of agricultural chemicals resulting from the use of transgenic useful plants (see sect. 8).

For the field of biotechnology and genetic engineering we should however develop additional indicators which may demonstrate a direct impact of genetically modified plants. Many transgenic plants will form new types of proteins which under natural circumstances do not get into ground or surface water in this form. We still know very little about the behaviour and transport or co-transport processes of proteins and DNA in soils. Both will have to be investigated anew each time. It would thus be advisable if, for example, the presence and concentration of transgenic DNA and the corresponding newly formed proteins were investigated both in surface and groundwater. Here too the detection of these substances should be followed by ecotoxicological studies with relevant aquatic organisms. In addition, a possible horizontal gene transfer with aquatic micro-organisms needs to be clarified. However, the protocols and test organisms have to be redeveloped as the procedures established for the ecotoxicological clarification of agricultural chemicals are not suitable for DNA and proteins. Most agricultural chemicals, for example pesticides, are low-molecular frequently inorganic compounds. Here short-term effects and contact toxicity play a key role (esp. in the case of volatile substances). Their mechanism of action is fundamentally different to that of proteins, which are generally high-molecular very complex organic compounds. Meaningful test protocols must take into account the different exposure times / type of relevant exposed organisms.

## Category 6) Soil

Here more or less the same applies as for Category 5) Water. All indicators listed for this field are of interest although they do not show all direct impacts of transgenic crop plants.

'Soil tests' and 'Soil quality' (OECD 2000a)

Depending on the content of these tests they may also show specific effects of transgenic crop plants, for example the impact of formed toxins.

'Microbial activity levels' (functionality indicator proposed by MÜLLER 1996 & 1998 for GNA, which is however no longer included in current lists of proposals)

This indicator may well show direct impacts of a transgenic crop plant and probably represents the most suitable measured quantities which can be surveyed in the framework of monitoring transgenic crop plants. It is however no longer included in current lists of proposals for functionality indicators.

As we only know little about the ecosystem of soil, it is recommended developing indicators which monitor the impact of transgenic crop plants in terms of functions such as soil respiration (i.e. gas exchange = $CO_2$, methane or above production) or degradation rates of organic material. In comparison with Category 5) Water appropriate methods still have to be developed for specific monitoring of transgenic crop plants.

## Category 7) Miscellaneous

This category includes economic indicators which, although of interest for environmental monitoring, are only indirectly relevant. Depending on how far specific environmental monitoring of transgenic crop plants is taken in the future, the following indicators should at least be applied:

'R&D expenditure for biotechnology : risk and biosafety research' (FEM 2000b)

'Labelling of genetically modified products and procedures or those free of genetic engineering' (FEM 2000b)

'Market share of foodstuffs from organic farming' (FEM 2000b)

The last indicator should be extended to include the market share of transgenic crop plants for reasons of comparability.

# 8 Case Example 'Use of Pesticides' – Explanations and Suggestions for Creation of an Indicator from Existing Proposals [29]

## 8.1 Justification for Selection of Indicator 'Use of Pesticides'

Many of the indicator lists which have been analysed in this study (see section 4), do not just relate to the agricultural sector. For monitoring in the field of biotechnology and genetic engineering it would also be insufficient to limit our considerations solely to land directly used for agriculture.

One of the few indicators with specific application for monitoring in the agricultural sector is the 'Use of pesticides' (OECD 1999, UN 1996, FEM 2000, EEA 1999). This indicator is highly significant as the use of pesticides results in major impairment of the environment (also going beyond the agricultural sector) (e.g. groundwater contamination by pesticides and their residues) which can/could only be rectified at high cost and with complex programmes. The use of pesticides in agriculture comes in for criticism, and the prime objective for sustainable agriculture is seen as reducing the levels used to a major extent. In this regard the genetic engineering sector is also promoting usage of the transgenic useful plants now licensed for commercial farming and justifying the development of such plants. A reduction in the use of plant protective agents is quoted as an outstanding 'ecological' characteristic for both transgenic herbicide-tolerant and insect-resistant plants. This means that this indicator is not only an environmentally relevant measured quantity but also an instrument for measuring success. To clarify the diverse aspects or one or more indicators for the use of pesticides there now follows a discussion of the use of pesticides on transgenic crops in the USA on the one hand and a description of scenarios on the other hand to indicate which additional impact areas or indicators might also be involved.

[29] *Contribution by Angelika Hilbeck & Matthias S. Meier, EcoStrat GmbH, Zurich*

## 8.2 Overview of Controversy regarding Development in Use of Pesticides in the USA

### 8.2.1 Development in Use of Herbicides on Transgenic Herbicide-tolerant Soya and Cotton

In 1999 transgenic glyphosate-tolerant soya beans of the type 'Roundup Ready' were grown on half of the land used for the cultivation of soya beans in the USA (BENBROOK 1999). Farmers who produced 'Roundup Ready' soya in 1998 consumed two to five times more herbicide (measured as the quantity applied per field area) than farmers who planted non-transgenic soya. However, we cannot conclude an increase in the use of herbicide in the cultivation of soya merely from this development as the measured quantity of herbicide per field area is inadequate in this regard. Some herbicides are effective at low quantities applied per area while a larger quantity is required for others. More detailed glyphosate consumption figures for 1999 nevertheless indicate that there has been an increase in glyphosate consumption for transgenic soya crops (BENBROOK 1999). A possible reason for this might be the development of tolerance to glyphosate among certain weed species or a change in weed species composition in favour of glyphosate-tolerant species (cf. scenarios). The development of resistance is an insidious process and frequently manifests itself by the fact that ever-increasing application quantities or spray frequencies have to be used to attain the required control effect.

Nor do figures for the use of herbicides on cotton allow us to draw definitive conclusions either. Data from US agricultural statistics do not show any correlation between the cultivation of transgenic cotton and changes in the use of herbicides and insecticides (THALMANN & KÜNG 2000). The use of glyphosate in particular has also increased in the cotton farming sector. It is not possible to say for sure whether more harmful herbicides are being replaced by less harmful herbicides on the basis of the available data (THALMANN & KÜNG 2000).

### 8.2.2 Development in Use of Insecticides on Transgenic Insect-resistant Plants (Bt plants)

An analysis performed by the American Environmental Protection Agency (EPA) regarding the ecological and economic benefits of transgenic Bt plants put the reduction in the use of insecticides at 30% to combat the European corn borer following the cultivation of Bt corn since 1995 (EPA 2000). That this estimate is at least worthy of discussion is evident from the report of BENBROOK (2000a) and the subsequent debate between GIANESSI (2000) and BENBROOK (2000b+c).

In his examination of the EPA analysis BENBROOK (2000a) comes to the conclusion that in 1999 there was a 26% increase in the area treated with insecticide to combat the European corn borer (in relation to the total area used to farm corn) in comparison with 1995. He arrives at this result by distributing the insecticides applied to corn during these years to the target organisms in a different way. The EPA proceeded from the assumption that 50% of spray applications with Chlorpyrifos and Methyl Parathion – two insecticides which account for a large part of the insecticide controlling 'pests' in corn – targeted the European corn borer and 50% other 'pests'. BENBROOK on the other hand, relying on industrial and academic data, assumed that only 25% of both insecticides were used to combat the European corn borer. Since 1995 the use of the two insecticides has each fallen by around 30%. If the European corn borer is weighted at 50% as one of the organisms targeted by these two insecticides (assumption of EPA), the reduction in the controlling the European corn borer with these two insecticides is weighted more heavily than is the case with BENBROOK'S 25%.

In his criticism of BENBROOK'S analysis (2000a) GIANESSI (2000) does not deal with the issue described above. On the other hand, GIANESSI criticises the allocation of other insecticides from which BENBROOK assumed in his report that they are used to control the European corn borer. BENBROOK (2000c) dealt with most of the criticisms expressed by GIANESSI in a second analysis and recalculated the area treated with insecticide to combat the European corn borer. In his second calculation he still arrived at an increase of 19% between 1995 and 1999.

BENBROOK explained this increase on the one hand by the raised awareness of farmers that the European corn borer is a phytophagous insect that may bring about extensive losses in harvests. However, the circumstance that the European corn borer only causes significant financial prejudice every 3 to 5 years has not penetrated the consciousness of farmers. Many farmers who do not farm Bt corn now seem to control the European corn borer with chemical insecticides every year, something which they did not do prior to the licensing of Bt corn (BENBROOK 2000a). On the other hand the widespread control of the European corn borer has probably resulted in a change in the composition of the organisms not targeted and/or natural opponents (cf. scenarios), something which has possibly made it necessary to use additional insecticides to combat 'secondary pests' (BENBROOK 2000a). This would also explain why the total quantity of all insecticides applied to corn since 1995 has not fallen but risen slightly.

### 8.2.3 Résumé

Whether transgenic herbicide and insect-resistant plants actually result in a reduction in the use of pesticides and to what extent we are clearly unable to say for sure at the present time. Consequently we cannot come to a final conclusion as regards profitability for the use of Bt corn. In their report GIANESSI & CARPENTER (1999) observed that in 1997 the US corn farmers earned approx. US$ 72 million from the cultivation of transgenic Bt corn calculated for the entire nation while the following year (1998) they suffered a loss of approx. US$ 26 million using a cultivation area three times the size of the previous year's. Due to the increased corn harvests with Bt corn the corn prices plunged to a historic low.

A key factor for the increase or fall in the use of insecticides is undoubtedly the manner in which transgenic plants are integrated in a cultivation system. From the above examples it is clear that a ten years' field experience is necessary (probably even more) to make an ecological and economic assessment for the introduction of new technology such as green genetic engineering without any coordinated review of results. If a reliable evaluation based on sound data is to be made more quickly, cultivation must be accompanied by extensive coordinated monitoring.

## 8.3 SCENARIOS

Possible consequences of a large-scale repeated cultivation of transgenic herbicide-tolerant or insect-resistant plants should be shown in individual 'scenarios'. Here special attention is given to the development in the use of pesticides to also demonstrate their complexity. It becomes apparent that, to achieve an actual reduction in the use of pesticides, the cultivation of crop plants by no means becomes simpler through the use of transgenic herbicide-tolerant and insect-resistant plants but requires at least the same amount of expertise and instinctive skill from the farmer as for example with integrated or organic farming methods.

### 8.3.1 Herbicide-tolerant Plants

Total herbicides (= non-selective herbicides) have been applied in arable farming with conventional crop plants before sowing to remove the weeds before emergence of the crop plant seed on the field. The application of such herbicides after emergence has not been possible to date as this would have also affected the crop plant. With genetically engineered tolerance, for example to glufosinate, it becomes possible to spray this total herbicide during the entire vegetation period of the crop plant.

**Scenario 1: Species shift, development of resistance and effects on associated organisms**

In transgenic herbicide-tolerant crops the use of the corresponding total herbicide show an increase. This is possibly carried out in several spray applications, particularly at the early growth stage of the crop plants and if necessary later on as well. The use of selective herbicides after emergence is thus no longer required. Selective herbicides only remove specific individual weeds or classes of weeds (generally those resulting in the greatest financial losses). Weeds not affected by the selective herbicide remain standing and can thus prevent or hinder the occurrence of other weed species.

In transgenic herbicide-tolerant crops the exclusive use of total herbicides temporarily removes the entire weed vegetation. With repeated large-scale applications to various crops this may result in two phenomena: firstly, the weed species may develop tolerances to the total herbicide. Secondly, there may be a shift in the weed species towards species which are from the outset more tolerant to total herbicides. Both will result in an increase in the herbicide consumption in the long term. At least there are already initial field indications for the second of the two phenomena.

Glyphosate-tolerant weeds have already started spreading in the USA among transgenic crops of 'Roundup Ready' soya and 'Roundup Ready' cotton (soya or cotton with genetically engineered glyphosate tolerance) (www.biotech-info.net/weed_shift.html). This 'new' composition of weed species can only now be controlled with a mixture of herbicides or alternative methods.

A further implication associated with post-emergence applications of total herbicides is possibly an increase in the herbicide spray drift. Depending on the time at which the post-emergence application takes place, the crop in question may already be relatively high, at all events however higher than in the previous pre-emergence application when no crop plant stock is present. This means that the spraying bar has to be set higher, something which increases the risk of drift with just a light wind. Increased herbicide drift may cause sensitive plant species to be affected in adjacent ecological compensation areas, such as the borders of fields, "Buntbrachen"[30] and hedges.

A shift and reduction in species in the arable flora may not only have an adverse effect on Segetal species but also the associated fauna such as insects and birds (BERGER et al. 2000). It is thus feared in England that certain species of birds, which feed on the seeds from weeds and are already considered as endangered in terms of their populations due to the extensive destruction of their fodder plants, are threatened further by the large-scale use of total herbicides. This has been demonstrated, for example in model simulations carried out by WATKINSON et al. (2000) (see also comments of FIRBANK & FORCELLA 2000 in this regard).

*[30] Buntbrachen: creation of stocks rich in wild flowers on disused land and borders of fields; measure proposed in the context of the agro-environmental measures of the Federal Government of Germany and the Länder as part of the plans drawn up by the Länder for the development of rural areas for the period 2000 - 2006 (second pillar of Common Agricultural Policy)*

**Scenario 2: Effects on soil fertility and associated organisms**

The cultivation of transgenic herbicide-tolerant crop plants and the use of a total herbicide may make it possible to dispense with tillage measures to control weed (ploughing, shallow tillage, etc.), something which can be basically seen as a positive step as biological soil processes can take place with less disturbance. For this purpose an initial spray application is required shortly before or after sowing. Other spray applications are carried out depending on the extent of the weed vegetation occurring after the last spray application, above all in the early growth phase of the crop plants.

Dispensing with tillage measures may have a positive effect on the soil functions as soil compaction and erosion are reduced (EDWARDS et al. 2000). The fact that the soil is not turned over improves the habitat conditions of ground beetles and other beneficial organisms. The habitat improvement for ground beetles may however be limited by the increased use of herbicides as, for example, ground beetles avoid fields treated with herbicide (EDWARDS et al. 2000). Dispensing with tillage measures also brings about a change in the composition of the soil micro-organisms, involving above all a shift from bacteria to fungi (EDWARDS et al. 2000). This effect might possibly be intensified by the use of herbicides as herbicides also have an antibiotic effect in some cases. One sign for this is the greater susceptibility of crop plants treated with herbicides to fungus disease at the emergence stage (CHRISPEELS & SADAVA 1994). The use of transgenic herbicide-tolerant plants may thus call for higher levels of fungicides.

**Scenario 3: Development of multitolerant crop weed plants and outcrossing to related crop weeds**

Seeds of crop plants which remain on the field after harvesting (loss) may compete with other crop plants during subsequent cultivations and themselves become weeds. Where the loss originates from a herbicide-tolerant crop plant, it can no longer be controlled in a subsequent cultivation with the herbicide to which the crop plant was made resistant.

Let us suppose that a field used to grow glufosinate-tolerant rape is then sown with a glufosinate-tolerant cereal crop (e.g. wheat or corn; rape is an ideal preceding crop for almost all plants under crop rotation). Glufosinate-tolerant loss rape then competes with the maturing cereal crop and may become a problem as loss rape can no longer be controlled with glufosinate applications. To deal with the loss rape a selective herbicide has to be used in addition to glufosinate to control the loss rape without harming the cereal crop. The application of a total herbicide is then supplemented by

the use of selective herbicide, something which may increase the use of herbicide overall.
Another example, which has already occurred and which also concerns the aspect of outcrossing, involves 'triple-resistant' rape plants in Canada (www.producer.com/articles/20000210/news/ 20000210news01.html). Within a period of three years a Canadian cultivation area, in which three different rape herbicide systems were used, had seen the development of loss rape plants which were tolerant to all three herbicides due to outcrossing. The options for control were thus greatly reduced, to for example products such as 2,4-D (dichlorphenoxyacetic acid).
Another example from the USA involves transgenic herbicide-tolerant soya beans which can become a weed in cotton (www.biotech-info.net/weed_ shift.html). This occurs in areas where farmers practise crop rotation with 'Roundup Ready' soya and 'Roundup Ready' cotton. Loss 'Roundup Ready' soya can be barely controlled in cotton as soya is tolerant to various other herbicides suitable for cotton farming.
Another possibility for the development of herbicide-tolerant weeds is vertical gene transfer. If a crop plant is grown in a region in which wild weeds related to this crop plant also occur, there is the possibility of outcrossing from the crop plant to related crop weeds. The hybridisation of a gene for herbicide tolerance to a species of weed may be of possible benefit for the weed. Weeds which show transgenic herbicide tolerance would have to be controlled with herbicides to which they are not tolerant.

### 8.3.2 Insect-resistant plants

All insect-resistant transgenic plants currently licensed produce a toxin of the bacterium *Bacillus thuringiensis* (Bt), which has a more or less specific effect on various orders of insects. Of the transgenic Bt plants Bt corn is the most common, followed by Bt cotton and Bt potato. Bt cotton will probably never be of any great significance in Central Europe although Bt potatoes may possibly find an application. However, the leading position is occupied by Bt corn, which is already grown on a commercial basis in several European countries, albeit over very small areas to date due to problems with selling. The following scenarios thus specifically deal with the situation for corn.

**Scenario 1: Effects on non-target organisms**

Bt corn was developed to control the European corn borer. The Bt toxin is produced in the plant tissue during the entire vegetation period of the corn and thus offers permanent protection from the European corn borer. However, in Germany it is only every three to five years that the European corn borer attains population densities which result in economic harm necessitating control. It is true that the large-scale annual cultivation of Bt corn would make conventional control of the European corn borer unnecessary and reduce the use of insecticide against the European corn borer. However, as chemicals are only used occasionally to control the European corn borer in Europe, the savings in insecticides would tend to be small. In Switzerland it would be absolutely zero as no synthetic chemical insecticides are licensed for control of the European corn borer. Consequently, there cannot be any potential for sparing beneficial organisms.

Elimination of the European corn borer through large-scale cultivation of Bt corn may nonetheless reduce the natural opponents whose main prey is the European corn borer. The absence of the European corn borer and its natural opponents might open up a niche for other 'pests' and allow them to spread. To combat such organisms chemical insecticides would then have to be used. This would negate the savings in insecticides achieved with Bt corn, and the overall use of insecticides might possibly even increase (BENBROOK 2000a).

A change in the composition of non-target organisms and/or natural opponents might also be brought about through direct and indirect toxic effects of the Bt toxin on organisms other than the European corn borer (non-target organisms). Various laboratory studies on non-target organisms have demonstrated a potential hazard to natural opponents from transgenic Bt corn (HILBECK et al. 1998a & b, 1999). Whether such effects occur in the field as well is currently under investigation. This might also result in an increase in the use of insecticides.

Other laboratory studies have shown that in the soil the Bt toxin binds to soil particles, thus does not undergo degradation and retains its insecticidal effect (TAPP et al. 1994; KOSKELLA & STOTZKY 1997; CRECCHIO & STOTZKY 1998; TAPP & STOTZKY 1998). It has also been demonstrated specifically for transgenic Bt corn that the living plant actively eliminates the Bt toxin via its roots (SAXENA et al. 1999; SAXENA & STOTZKY 2000). This finding indicates possible effects on soil organisms, which may also result in food chain effects.

**Scenario 2: Development of resistance**

The continuous use of transgenic Bt corn means that the European corn borer is exposed to the Bt toxin every year during the entire vegetation period of the corn. This constant presence of the Bt toxin represents a major selection pressure on the

European corn borer, something which is generally known to entail a serious potential risk for the development of resistance in the species concerned (GROETERS & TABASHNIK 2000).

This invalidates the use of Bt corn, and we again have to fall back on other means to control the European corn borer, something which possibly results in an increased use of chemical insecticides (see BENBROOK 2000a). To prevent the development of resistance the goal is the maximum formable dose of Bt toxin in the plants in combination with refuges consisting of non-transgenic corn ('high-dose' strategy). It is assumed that resistance is passed down recessively. In refuges possible homozygote-resistant European corn borers should mate with non-resistant European corn borers. Their issue are then heterozygous, and the formed dose of Bt toxin in corn should then be high enough to kill these heterozygous European corn borers and prevent them reproducing.

From the viewpoint of pest control however, this strategy can be seen as 'overkill' as until the development of resistance 100% of the target organisms are killed. It is thus no longer possible to practise damage threshold concepts and target organism control according to the requirements. Both are key components of integrated plant protection. In addition, it is questionable whether this can prevent the development of resistance. It cannot be ruled out that heterozygous European corn borers are missed out by the 'high-dose' strategy, mate with other heterozygous European corn borers and produce resistant homozygous issue, particularly given that the development phenologies of resistant and susceptible European corn borers possibly differ and no randomised mating can then take place (BOURGUET et al. 2000, LIU et al. 1999).

## 8.4 FURTHER DEVELOPMENT OF INDICATOR 'USE OF PESTICIDES' FOR MONITORING TRANSGENIC CROP PLANTS

From the problems described above regarding the use of pesticides to control certain target organisms it has become clear that the indicator 'Use of pesticides' is a complex indicator which must consist of several survey parameters forming the subject of detailed monitoring if helpful answers are to be provided. It is most suitable for the 'general surveillance' programme stipulated by the EU for the commercial cultivation of transgenic plants according to the revised directive on the deliberate release of genetically modified organisms into the environment 2001/18/EG.

To ensure that this indicator is used properly for such monitoring we can learn from the experiences of the USA. For years this country has been striving to find appropriate parameters for describing the development in the use of pesticides in conjunction with the cultivation of transgenic plants. As already explained (section 8.2), there is no standardised monitoring of this data, no uniform pre-defined and generally acknowledged evaluation scheme, and thus no consensus whatsoever whether the use of pesticides is increasing or decreasing with the cultivation of transgenic plants. As no large-scale cultivation of transgenic plants takes place in either the EU or Germany, and the EU's revised directive stipulates monitoring for the commercial cultivation of transgenic plants, Germany finds itself in the advantageous situation of being able to learn from the shortcomings and problems of other countries.

The experience in these countries show that the type of monitoring involving individual parameters may result in entirely contradictory data and conclusions (see section 8.2.2). It is thus essential to establish that monitoring of pesticide use only makes sense if it is clearly determined beforehand which statements are to be made afterwards. This allows us to decide which data it is sensible to collect, something which has not taken place in the USA, for example, where there is no specific coordinated collection of data on genetically modified organisms. The data are compiled afterwards and originate from various different statistical surveys with varying objectives. For this reason there are always deficits in information which are open to interpretation by the analysts. Such a procedure comes up with different answers depending on the approach applied by the study and formulation of the problem.

From the controversy about the development in the use of pesticides in the USA we can see that the differing conclusions results from the information deficit as regards two questions: 1) Application objective and 2) Significance (see responses of BENBROOK 2000b und GIANESSI 2000).

**1) Application objective:** Which organism is the farmer targeting with the pesticide selected?

This question is of central importance when examining a linkage with the cultivation of transgenic crop plants. This is in particular the case when the aim is to evaluate the development tendencies over periods of less than or up to 10 years, for example when a limited licence has been granted and relicensing can only take place after previous assessment.

The annual use of pesticides varies greatly as the decision of the farmer which product to use is influenced by a range of factors: kind of problem (e.g. one or more target organisms?), extent of problem (local? just emerging? epidemic?), availability of product (leftover stocks? new purchase?), time of application, product's range of effects (against all or just one of the harmful organisms?), and so on. Often so-called tank mixtures are used, consisting of a number of pesticides which act against all kinds of organisms. The use of pesticides is therefore subject to major fluctuations each year in some cases as the phytophagous organisms also vary from year to year as regards the amount of damage caused. Development tendencies for the use of pesticides can only be identified after a number of years. The major annual fluctuations in the use of pesticides can only be offset by detailed monitoring of data to keep the margin for interpretation as small as possible. From this it is clear that the monitoring of genetically modified organisms should be carried out as a farmer-participatory instrument, i.e. the survey should involve farmers and be carried out for each farm.

**2) Significance:** Does this involve general or specific monitoring of the use of pesticides?

This focuses on the question of what an indicator 'Use of pesticides' is to reveal. Is the objective to generally monitor the use of pesticides in the cultivation of transgenic plants regardless of which target organism is involved, or is it only to consider and in finally also evaluate the use of the pesticide targeting the specific organism of the transgenic plant species; in other words, the European corn borer with Bt corn, for example or target weeds with the use of herbicide-tolerant soya beans? In the latter case we would disregard the use of pesticides to control all non-target harmful organisms, which however might possibly become relevant as a consequence of the use of transgenic plants (see scenarios).

### 8.4.1 Proposal regarding Significance of Indicator and Necessary Measured Quantities

As regards the environmental effects of pesticides to be basically averted and the objective of sustainable agriculture sparing resources, as called for in Agenda 21 (Chapter 14) and also the attainment of the aims postulated there, to which both the EU and German agricultural and environmental policy is committed, it is proposed here that a indicator 'Use of pesticides' should be employed to basically monitor the use of pesticides with the cultivation of transgenic plants - irrespective of the target organism. This also accords with the function of the indicator as an environmentally relevant target variable and as an instrument for monitoring success.

This results in the following individual parameters which should be monitored:

Parameters for use, which should be basically monitored per target organism (complex), crop species, cultivation area/farm and year:

- Substance or toxicity class (active ingredient) in unit of quantity (g or l) per area unit (ha)

  Data such as the quantity of a specific pesticide per area are not very meaningful as a pesticide always contains a large amount of other inactive substances, for the formulation, carrier substances, wetting agents or preservatives. The important factor for the assessment of an environmental effect is however the quantity and toxicity of the actual insecticidal substance, the so-called 'active ingredient', of the pesticide. With the older-type pesticides a relatively large amount of an active substance often had to be applied (i.e. high proportion of pesticide) before the desired control effect took place. Many modern pesticides are now based on biologically highly-active insecticidal chemicals, of which only small quantities are required for effective pest control. Such data thus plays a key role when assessing the environmental impact. From this data it can also be seen whether certain toxic pesticides are replaced by other less toxic products.

- Application frequency (i.e. number of applications of pesticide)

  The frequency of the spray applications per crop and area during a season is also important to evaluate an environmental effect. These figures and the previous data then allow the total load per area to be calculated.

- Time(s) of application per time unit in relation to crop plant phenology

  This data also plays a role for the assessment of a possible environmental impact. For example, if a pesticide is applied to an open soil surface without or only with very little plant growth, this pesticide penetrates into the soil in greater quantities than with closed vegetation cover. This means that in the first case the soil load is higher than in the second case. From the above data (type of substance, toxicity, application frequency and time of application) it can be assessed whether for example an impact on the groundwater is more likely to be expected when a pesticide is involved that is mobile in soil and relatively persistent, or contamination of the upper layers of soil when a pesticide that is immobile in soil and more persistent is concerned.

Success parameters which are not obligatory but helpful for the analysis and evaluation of the data collected:

- Development of target organism (i.e. 'harmful organism' [weed or insect] which is to be controlled with the help of the transgenic plants, either with or without the further use of a pesticide)

  Number, life stage [egg (only with insects), juvenile or adult stage (with insects and weeds]) of the target organism monitored by unit (i.e. number of test plants or field area) over a period of time indicates the population development of the target organism. This data can be used to gauge the success rate for treatment of the transgenic plant. Expressed in very simple terms, the more target organisms that survive, the less effective the treatment or the use of the transgenic plant, regardless of the causes. Other data must be used to clarify the reasons for this.

- Development of non-target organism (i.e. insect or plant species which were not the target of the treatment but were nevertheless treated at the same time. This may also involve a potential harmful organism).

  Number, life stage [egg (only with insects), juvenile or adult stage (with insects and weeds]) of a non-target organism or several non-target organisms monitored by unit (i.e. number of test plants or field area) over a period of time indicates the population development of the non-target organism(s). These data show whether other organisms (e.g. other harmful phytophagous organisms) in the field will themselves occupy the niche left by the target organism or will otherwise procure a competitive advantage from this. Such mechanisms are common with the application of pesticides and result in so-called 'secondary pests', which themselves then have to be controlled with pesticides. It is fairly likely that this parameter will have to be surveyed with the specific monitoring of transgenic crop plants anyway, irrespective of an indicator for the use of pesticides.

All the above data surveyed at farm level can provide us with a comprehensive picture of the development in the use of pesticides, which can also be considered afterwards from a number of different aspects or subjected to further analysis. Which species of target or non-target organisms have to undergo specific monitoring depends on the species of transgenic plant, the transgenic change and the cultivation region!

These data are already being collected in some cases, for example by authorities such as the statistical offices, plant protection and advisory services, in various forms and combinations. Above all monitoring may possibly need to be coordinated. The surveyed data can then be aggregated depending on the issue involved and expressed in indices, which provide a fast overview of pesticide development. One example of this is the insecticide index, which consists of the product of the number of insecticide applications multiplied by the cultivation area of the crop (HÜTTER et al. 2000). This figure is however relatively undifferentiated. No distinction is made whether these areas have actually been treated. The error may thus be considerable, explaining why sufficiently reliable conclusions can only be drawn over lengthy periods. In the USA efforts are being made to develop toxicity-weighted indices, according to the 4 toxicity indicators: Acute and chronic mammal toxicity (based on oral or dermatological $LD_{50}$ values from tests on mammals), ecotoxicity ($LD_{50}$ or $LC_{50}$ values for birds, fish, small mammals etc.) and side effects on beneficial organisms ($LD_{50}$ or $LC_{50}$ values with bees, rainworms, predatory insects etc.) (BENBROOK 1999). From this we can calculate simple indicators such as the 'toxicity-weighted factor', the product of the quantity applied of the active insecticidal constituent per hectare and the corresponding $LD_{50}$ value. This 'toxicity-weighted' factor is also known as the 'impact quotient' or 'environment influence point'. (BENBROOK 1999). These can then be converted to toxicity units per area unit (ha) for a crop species (example BENBROOK 1999). The final development of one or more aggregation index(es) must be effected in the context of the entire monitoring programme of transgenic organisms i.e. preferably at an advanced stage of the overall programme when it has been decided which information is to be obtained and which statements made.

### 8.4.2 Performance Description and Sensitivity of Indicator 'Use of Pesticides'

If the above parameters are monitored as proposed, the indicator 'Use of pesticides' can show the following:

a) impacts on the environment and resulting damage
b) regional phenology of any resistance developments (BUT: not an early warning system!)
c) statements about causes and extent of development of 'secondary pests' or secondary weeds
d) assessment of undesirable side effects on flora and fauna.

This allows us to make assessments regarding the fundamental possibility and degree of integration of transgenic plants in more sustainable farming methods. If parameters are surveyed with the level of detail specified above, i.e. per target organism / organism complex, crop species, cultivation area per farm and year, tendencies may then become visible after only a few years, offering sufficient reliability to be used as a data basis for relicensing procedures. The more approximate however the level of monitoring, the longer the time periods will have to be before reliable tendencies can be identified and the more speculative the significance of the indicator. This does not seem advisable in conjunction with the monitoring of transgenic organisms.

# 9 PROPOSALS FOR INDICATORS SPECIFIC TO GENETIC ENGINEERING AND A BRIEF JUSTIFICATION FOR SELECTION[31]

## 9.1 ENVIRONMENTAL EFFECTS OF TRANSGENIC CROP PLANTS AND POSSIBLE INDICATORS FOR THEIR PORTRAYAL

Table 22 summarises possible environmental effects of herbicide-tolerant and insect-resistant transgenic plants and the indicators[32] for their portrayal. In the following items 9.1.1 and 9.1.2 the environmental effects and indicators are explained in further detail.

Tab. 22: Environmental effects and indicators with herbicide-tolerant and insect-resistant transgenic plants

| Environmental effect | Indicator | Transgenic property |
|---|---|---|
| Shift in composition of arable flora | Composition of species, frequency and cover level of weed species | Herbicide tolerance |
| Effects on animal species associated with arable flora | Composition of species and abundance of species of insect and bird species | Herbicide tolerance |
| Vertical gene transfer to related crop weeds | Presence of transgenes (marker gene) in related crop weeds | Herbicide tolerance, insect resistance |
| Horizontal gene transfer to soil micro-organisms | Transgenic DNA in soil samples, presence of transgenes (marker gene) in soil micro-organisms | Herbicide tolerance, insect resistance |
| Change in micro-organism composition in soil | Composition of soil micro-organisms: detection of micro-organism groups; with herbicide tolerance: herbicide residues and their metabolites; with insect resistance: monitoring of still active gene product | Herbicide tolerance, insect resistance |
| Effects on non-target insects | Monitoring of populations of various insect species | Insect resistance |
| Occurrence of 'secondary pests' | Population densities of harmful organisms | Insect resistance |
| Development of resistance among target organisms | Population development of target organism | Insect resistance |

[31] *Contribution of Angelika Hilbeck & Matthias S. Meier, EcoStrat GmbH, Zurich*
[32] *The 'indicators' listed here involve a very low aggregation level and tend to remain on a par with parameters.*

### 9.1.1 Environmental Effects of Herbicide-tolerant Plants

The environmental effects of herbicide-tolerant transgenic plants do not result directly from the transgenic characteristic but only come about from combined application with the herbicide. The system of the herbicide-tolerant plant and herbicide is designed so that weed control can be effected solely with chemical means. In general the system is applied so that weed control is easier and less costly than in combination with mechanical control measures, for example.

The environmental effects of herbicide-tolerant transgenic plants are directly associated with the extent to which herbicides are used. It can be expected that environmental effects will be most serious in cultivation systems where weeds are controlled solely by the use of herbicide.

The direct environmental effects of transgenic herbicide-tolerant plants which are conceivable according to today's level of knowledge include the following:

- weed shift (weedshift); outlined in scenario 1
- development of tolerance among weeds; outlined in scenario 1
- change in composition of micro-organisms in soil; outlined in scenario 2
- outcrossing of herbicide tolerance; outlined in scenario 3

<u>Further possible indicators in addition to indicator 'Use of pesticides'</u>

The most direct environmental effect of transgenic herbicide-tolerant plants to be expected is a shift in the composition of the arable flora towards less herbicide-sensitive species (see scenario 1). To monitor such shifts the **composition of species**, **frequency** and **cover level** of the individual weed species occurring on the field should be surveyed regularly. The monitoring of these parameters provides further information about the development of resistance (scenario 1).

To register the plant species endangered by herbicide drift (scenario 1) in areas extending beyond the field (borders of field, hedges, Buntbrachen, etc.) the composition of species, frequency and cover level of the individual plant species should also be surveyed in these areas. Here particular attention should be paid to plant species which are already endangered. Once it is known which species are especially affected, the amount of effort involved in population monitoring could possibly be limited to a small number of indicator species in the areas outside the field.

As outlined in scenario 1, the large-scale and more frequent use of total herbicides not only has an adverse effect on the arable flora but also on animal species such as birds und insects which are dependent on the arable flora. Certain **species of insects and birds**, known to rely on the arable flora as their habitat and source of food, could consequently act as measurable parameters for a specific indicator relating to transgenic crop plants.

As regards insect species, we would have to identify the associated species which would be soonest affected by a reduction in their fodder and/or habitat plant. We should in particular consider whether the insect species identified also include those seen as endangered (for example certain species of butterfly). Such species should be included in a set of indicators without fail.

For the identification of suitable bird species the same applies as for the insects: The species of bird which would be soonest affected by a reduction in certain arable plants must be ascertained. Here particularly in the case of birds, we must also take account of other factors determining their spread, for example the existence of suitable nesting sites, if were are to be able to attribute the changes to the cultivation of transgenic herbicide-tolerant plants.

As regards the species of birds and insects to be monitored individually they have to be redetermined in each region as the spread of species can vary greatly due to regional differences in landscapes and habitats. It is also conceivable that several potentially affected insect and bird species are identified per region and the individual parameters then result in an indicator which reflects the **shift in the composition of species** or the **species abundance** of the species observed.

To monitor any change in the composition of the micro-organisms in the soil (scenario 2) **microbial studies** of soil samples are required. It may also be possible to draw indirect conclusions regarding the impact on soil micro-organisms on the basis of **herbicide residues** and their **metabolites** measured in soil samples.

To register the possible outcrossing of herbicide-tolerant transgenic plants to related crop weeds (scenario 3), all field crop weeds related to the crop plant growing wild in the cultivation area must be basically taken into consideration. Special attention should be given to those related field crop weeds whose flowering time overlaps with that of the transgenic crop plant. However, related field crop weeds, whose flowering time does not coincide with that of the crop plant, may potentially hybridise with the crop plant if loss grain flowers at the same time as the crop weed. Random samples from populations of related field crop weeds have to undergo molecular biological analysis at regular intervals. The transgene – in this case the gene for herbicide tolerance – simultaneously serves as a **marker gene** to indicate whether outcrossing has occurred.

### 9.1.2 Environmental Effects of Transgenic Insect-resistant Plants

Unlike transgenic herbicide-tolerant plants, we can assume that the environmental effects of transgenic insect-resistant plants primarily come about through their gene product, something which has a direct affect on other organisms (e.g. Bt toxin).
The direct environmental effects of transgenic transgenic insect-resistant plants which are conceivable according to today's level of knowledge include the following:

- occurrence of 'secondary pests'; outlined in scenario 1
- food chain effects above ground and in soil; outlined in scenario 1
- effects on soil organisms in the rhizosphere; outlined in scenario 1
- resistance in target organism; outlined in scenario 2

<u>Further possible indicators in addition to indicator 'Use of pesticides'</u>

Given their toxic effect on insects it is to be expected that non-target organisms are also affected by the gene products of insect-resistant plants (scenario 1). Here it is not only the insects which directly feed on the insect-resistant plant that are affected but also insects which may take in toxins at higher trophic levels via prey, thus impairing their development (food chain effect). It thus follows that **population monitoring** of various **species of insects** could act as a further indicator to portray the environmental effects of insect-resistant transgenic plants. Special consideration should be given not only to endangered species but also 'beneficial insects' and pollinating insects as they are of both ecological and economic importance.
To determine insect species which are suitable in terms of indicators it must be known of the insect-resistant transgenic plant in which parts of the plant the gene product is produced and in what quantities. Here every transgenic plant type of a manufacturer has to be analysed anew as there may be differences in gene activity depending on the insertion point of the transgene in the genome. To determine the potential exposure paths the examination should include not only all plant tissue (including root tissue) but also whether the gene product is eliminated from the plant via its roots and whether the gene product is contained in the phloem, nectar and pollen. The next step is to investigate which insects feed on which parts of the respective transgenic plant above ground or in the soil and what predators they have. Finally it must be known of all insects whether they are affected by the insecticidal gene product and to what extent.
Which species of insect is to be selected as an indicator must be decided from case to case. This decision may differ between the individual cultivation regions. The following example shows that a thorough understanding of the system 'plant-herbivore-predator'

is the prerequisite for the selection of appropriate indicator insects: As was revealed by HILBECK et al. (1998a & b, 1999) in laboratory tests, green lacewing larvae show higher mortality rates when they feed off prey who themselves consume the Bt toxin by eating Bt corn but are not lethally affected. The green lacewing would thus be a potential indicator for food chain effects in transgenic Bt corn. In laboratory tests MEIER & HILBECK (2001) also demonstrated that green lacewing larvae, when allowed to choose between prey which has fed off transgenic Bt corn or non-transgenic corn, prefers prey that has not previously fed off transgenic corn. If we suppose that aphids can spread widely in certain cultivation regions due to niches becoming vacant in transgenic Bt corn, it can be assumed that green lacewing larvae will eat more aphids in corn, particularly given that aphids are one of the preferred quarries of the green lacewing larvae. Given that aphids are phloem-sucking but no Bt toxin has been detected in the phloem of Bt11 corn (RAPS et al. 2001), no adverse effects will probably occur in the green lacewing in this case.

This example shows that the same organisms may show effects in some cases depending on the ecological conditions, and in others none at all.

The occurrence of 'secondary pests' (scenario 1) can be surveyed by monitoring **pest population densities**. Which insects are potential 'secondary pests' has to be re-established for every transgenic crop. The group of potential 'secondary pests' is further reduced by the fact that only harmful insects which are not lethally affected by the gene product are a possibility. To make a statement about the development of resistance among the **target organisms** (scenario 2), their **population development** in the transgenic crops must be observed. However, such monitoring does not include an early warning system to survey the development of resistance. The monitoring of population development can only serve to document the resistance phenology. For an early warning about the development of resistance the resistance alleles in the genome of the target organisms would have to be identified and the frequency change of these alleles measured.

With transgenic insect-resistant plants which actively eliminate the gene product via the roots and on the basis of dead transgenic plant material in the soil, we can assume that the gene product may also have a potential impact on the composition and distribution of the soil micro-organisms and the mycorrhiza. To monitor such effects soil samples should be analysed to register the gene product still active at regular intervals throughout the year. Besides the gene product the soil samples should also be examined for transgenic DNA as there is the possibility of a horizontal gene transfer to micro-organisms particularly in the case of soil with its high microbial activity. The composition of the soil micro-organisms should also be directly determined where possible. Here the detection of individual micro-organisms is of little relevance as to date approx. 95% of soil micro-organisms are still not known or cannot be cultivated, and the abundance of individual micro-organisms may fluctuate in terms of time and space. Instead we should use molecular biological methods to identify micro-organism groups and their percentage-based shares in the soil.

# 10 POSSIBILITIES FOR USE OF INDICATOR CONCEPTS IN GENERAL TERMS AND OF EXISTING INDICATOR CONCEPTS FOR FIELD OF BIOTECHNOLOGY AND GENETIC ENGINEERING

The following discussion takes into account the papers presented and in particular the discussions resulting at the workshop held in Berlin on 16 January 2001.

International sets and systems of indicators and in particular proposals or concepts, which have been developed for global use, relate to themes with worldwide relevance. Proposals for environmental indicators in the international context must thus apply for example to a very wide range of agricultural systems and practices and to a spectrum of different ecosystems which is at least equally extensive. This simultaneously means that they can hardly be tailored to specific situations. This must be taken into consideration when examining internationally proposed environmental indicators as regards use of the indicators for a new theme.

Another problem which was generally cited for international sets of indicators during the workshop is that the debate about indicators at an international level is often influenced by the wish of each state to select the indicators which will show the development of its own country in the most positive light.

During the workshop reference was again made to a circumstance which has already been pointed out when evaluating international proposals for environmental indicators on a number of occasions: For abiotic environment media objectives for environmental action have already been developed both internationally and nationally at a statutory and professional level for some years. These are reflected in proposals for indicators which are highly specific in some cases. In addition, impacts can often be shown relatively clearly here by a small number of indicators and are comparatively easy to measure.
However, for the field of biotic environmental media, such as biodiversity or the landscape, we do not yet have either binding national or international goals. At most specific standards are derived from scientific guide values, for example minimum (individual) figures for individual species of fauna and flora or area percentages of natural and largely natural biotope types in the total area.

To monitor biodiversity we also require a wider set of indicators as it is not easy to show changes in their existing diversity, the complex interactions and with processes which are not yet fully understood.
In addition, efforts towards retrospective monitoring at species level will come up against limiting factors where they relate to 'Red Lists' as the criteria have been changed for these in some cases.
In this context the question was posed at the workshop whether indicators in the field of biodiversity can be supported with data in a productive manner at all.

Unlike the monitoring of chemical/technical parameters (e.g. Environmental Sampling Bank), we have not yet seen the collection of comprehensive data records to monitor ecosystem developments or proposals for such collection apart from a few exceptions (national proposals for Ecological Area Sampling and Ecosystem Environmental Monitoring), particularly in the biotic field.

Sets of indicators which have been developed internationally relate to environmental issues recognised and acknowledged as problem areas, even where the linkages for these problems are not always entirely clear and definitively specified.
The use of transgenic organisms in agriculture is controversial. To date no consensus has been reached as to whether environmental effects are to be expected and if so, what they will be. As the data available from laboratory and field tests raises doubts (TAPPESER et al. 2000), there is general uncertainty regarding the effects to be expected from large-scale cultivation. In biotechnology and genetic engineering a comparatively recent technology is the subject of examination. This means that as yet there is no or very few relevant data series from which to derive indicators specific to genetic engineering. To date national and international environmental indicator concepts have not given special consideration to possible environmental impacts specific to genetic engineering or the field of biotechnology and genetic engineering. It would thus be necessary to adapt indicators on other themes to the context of biotechnology and genetic engineering if no separate development of indicators is initiated in this regard.

"Different users of environmental indicators have different needs. Thus, the appropriate set of indicators depends on their particular use." (OECD 1993)

There is inevitably a fundamental problem when indicators from an indicator concept on a specific theme are to be used for another field or theme.
To obtain optimum sets of indicators we should proceed from a clear problem in order to derive indicators specific to the problem and issue. An ideal requirement on systems of environmental indicators is therefore the call for indicators to be founded on ecological linkages and for clear impact linkages between the indicator and the environmental effect to be described. (WALZ et al. 1997). The application of indicators to other subjects in the context of biotechnology and genetic engineering thus only seems sensible when the indicators from other concepts are also supported with cause-effect linkages specific to genetic engineering and when the existing indicators can offer meaningful information about indicants with specific reference to biotechnology and genetic engineering.

The application of indicators is also rendered more difficult because existing indicator programmes rarely include a definition of their objectives and above all barely outline their underlying scale of values. In addition, the normative criteria for narrowing down the set of indicators are seldom specified. At most pragmatic criteria which played a role in the selection of indicators are described. Nevertheless, all lists of indicators involve systems which have been set up against the background of objectives which have either been explicitly specified or implicitly understood. In addition, some changes in the state of the environment cannot be easily quantified or interpreted as being either positive or negative. This is particularly true of topics where societal value judgements are involved in the assessments (OECD 1999a) or where we still have major gaps in our knowledge.
When clear-cut objectives, directions and thresholds are laid down in indicator systems for the indicators, the question of applicability can be examined. Unfortunately, a clear definition of objectives for indicators is lacking in virtually all programmes evaluated.

Indicators often undergo extensive aggregation. A direct relation to one cause is thus seldom possible without a link to other data or information. In addition, it should be borne in mind that an observed phenomenon may also be multicausal (OECD 1999b). This likewise results in problems for the application of an indicator to another theme.

Indicators generally aggregate information over large time units as well. This means on the one hand that processes are only shown when they occur on a large scale or on a small scale but to a striking extent. With a high degree of aggregation in terms of space regional effects, for example of certain cultivation processes very quickly become statistically 'diluted'. It is also more difficult to establish a specific and correct causal relation as the underlying data may be influenced by many different factors, particularly over large areas.

The pragmatic criteria, which are often applied to indicators and in particular environmental indicators, include the call for simple, clear-cut low-cost indicators which are easy to interpret. It is obvious that such requirements result in a greatly simplified picture of the environment. The wish for a small number of aggregating indicators involves similar problems. Once again we are confronted with problems for the application of indicators from one field to another as the reduction in complexity has been carried out with significance for one specific theme and is thus not appropriate for another.

With all requirements for simplification and for a small number of indicators or even only one it is repeatedly emphasised that particularly in the context of ecosystems one indicator alone cannot normally make a clear-cut statement (OECD 1999a). Only a set of indicators is able to clarify a theme to a sufficient extent. However, for the individual indicators this also means that they must have a meaningful place and significance in this set, and that a set of indicators cannot be a random compilation of available indicators.

A final examination of the applicability and usability of indicators from concepts with particular regard to biotechnology and genetic engineering can only be carried out for each indicator (see also sect. 8). Such specific examination of individual indicators for their suitability should be made as soon as indicator concepts are implemented.

A discussion regarding the possibilities of incorporating additional indicators for the effects of genetically modified plants in existing indicator concepts is initially superfluous as all indicator concepts proposed to date have not yet been implemented.

The discussion of indicators in the field of biotechnology and genetic engineering allows us to clarify which expectations are made overall on the monitoring system of genetically modified plants under long-term environmental surveillance, which also satisfies the requirements on general monitoring of the EU directive 2001/18/EG (amendment of EU-RL 90/220/EEC). Here the FEDERAL ENVIRONMENTAL AGENCY (2001) has already come up with some preliminary considerations. According to these such monitoring should fulfil the following functions:

1. portray the state of the balance of nature and its changes,
2. specify the causes of such changes,
3. predict developments in the balance of nature,
4. determine and evaluate the effectiveness of state environmental protection measures on the state of the balance of nature.

Such continuous monitoring should go beyond a case-specific clarification of clear-cut questions or suspicions.

Besides the expectation of allowing us to monitor situations, monitoring should thus also be aimed at evaluation, which is geared towards environmental quality objectives and the aim of 'ecological sustainability'. In addition monitoring should reveal linkages and if possible, act as an early warning system.

At this point it is once again necessary to look at the potential of indicators (section 3). Indicators can only portray cause-effect linkages which are already known. As they are to supply us with information by means of aggregation, indicators can only provide a greatly simplified picture of the environment and are always associated with a loss of information.

This means that a monitoring approach involving indicators, as already considered by the research projects of the Federal Environmental Agency, can only be an approach involving various instruments of environmental monitoring.

During the workshop it was stressed in particular by attendees, who were or are involved in developing environmental indicators for other topics, that a problem definition is initially required for the development of indicators. To create indicators we need general objectives for a specific circumstance for example, the goal of $CO_2$ reduction. When indicators are selected for corresponding objectives, they can then be used as a basis to make the objectives more specific (e.g. 50% reduction in $CO_2$ emissions).

We distinguish between:

1. problem and hypothesis-driven approaches for the monitoring of transgenic organisms (see e.g. R&D 299 89 406, see sect. 1.1). These should allow us to portray the complexity of relationships and states and to reflect environmental changes with specific reference to genetic engineering in a differentiated system.
2. an indicator system to describe general tendencies and possibly general warnings with only possibilities for indirect conclusions regarding causes.

Both approaches are currently being pursued in parallel and are meant to culminate in an overall concept.

However, as the basis for an indicator approach we should initially consider for the monitoring of transgenic useful plants which circumstances should be examined for which question and with what aim.
At the workshop it was emphasised several times that a search for appropriate indicators can only be a second step once effects have first been scrutinised and data collected for same, subsequently allowing us to derive indicators.

For the stepwise process towards indicators as an aid for formulating and evaluating policy specific work steps have been proposed by STADLER (2001).
1) determination of target group and their requirements for information
2) identification of key questions which must be answered
3) selection of criteria
4) selection of indicators
5) determination of a frame of reference
6) 'trial run'

In the context involved here the determination of a frame of reference for the indicators should also consider how analysis must be set up and organised (methodology, responsibility, time(s), financing etc.).
If purely descriptive indicators suitable for the commercial farming of transgenic plants are to be selected from existing indicator concepts or newly developed, only the change or degree of change can be subsequently described by monitoring the associated data in time series.
The question then results whether the indicators are also to be used to evaluate the situation. In this case we must consider at an early stage what is to happen to the data after monitoring.

If an indicator is to have a normative character, it must be provided with a standard for evaluation specific to the theme in question. This includes for example target or limiting values and thresholds, tolerance ranges and criteria for action or discontinuation or stipulated reactions in the event that specific values are reached. The establishment of such evaluation standards is not a process solely involving natural science. On the one hand it is based on existing data to establish the status quo and a possible frame of reference. On the other hand, an evaluation standard should be derived from quality and policy objectives and laid down prior to the monitoring of data for the indication (see also sect. 3). As shown by the example of the controversy surrounding the analysis of data for the quantities of pesticide applied in the USA (see sect. 8), a compilation of data already collected from diverse statistical surveys with differing objectives may result in information deficits which offers a margin for analysis depending on the approach of the study and problem involved.

Although it is desirable for the development of indicators to be partially based on existing statistics, it should not be guided by the current availability of such data. Despite the importance of making savings during the monitoring of data, they should not imply stipulations for the determination of the appropriate geographical level for environmental indicators or for the identification of the relevant themes (EU COMMISSION 2000). If it is initially established which indicators are theoretically desirable, it will be easier later on to perceive and describe the limits of the indicators ultimately selected.

At the workshop held in January 2001 considerable time was devoted to discussing the scale to be used for data monitoring.

Wide approval was given to the surveying of agricultural data on a regional basis at a farm level, followed by the incorporation of the data for a representative selection of farms in the indicators.

In this context it was debated whether large-scale detailed surveys are possible to the maximum extent in the framework of a trial operation network, but would otherwise probably fail in terms of financing. As regards this problem it was considered whether it would be possible to combine the issue of farming licences for transgenic plants with stipulations regarding data monitoring.

It was pointed out that nowadays there are already obligations for operational logging (e.g. fertiliser regulations), for example for the use of plant protective agents. The draft amendment of the German Federal law on nature conservation, which was discussed

in May 2001, provides for plot-specific documentation regarding the use of fertilisers and plant protective agents. However, due to the legal situation prevailing and often for reasons of data protection it is not possible to ask for or evaluate relevant data at the present time. In the case of data analyses carried out today the farm-level data must be coded for the sake of anonymity. This however makes it difficult to link up agronomic and environmental data.
Existing indicator approaches, which are set at an farm level, were not evaluated for this project as to date these proposals have only been tested in the framework of projects limited in terms of region and time, have not yet been implemented and do not represent national proposals (cf references in chapter 5). Corresponding approaches should however undoubtedly be included in the preparation of a comprehensive multilayer monitoring concept for the commercial cultivation of transgenic plants as such an approach allows cause-effect links to be established and trends identified most quickly.

During the debate about the use of farm-level approaches it was emphasised that monitoring of the possible effects of genetically modified crop plants cannot be discussed without considering the respective farming practices. It was asked whether agricultural monitoring performed on a wide basis covering all farms would not be more meaningful than specific monitoring focusing on transgenic plants.
Here it is possibly sensible to distinguish between transgenic plants which result in a change in farming methods due to their change in characteristics, for example resistance to herbicides, and transgenic crop plants, whose composition of constituents has changed.
In the first case it may be possible to portray environmental impacts first and foremost via agricultural monitoring. In the second case we have already seen discussion and monitoring, in particular regarding the effects of transgenic plants on decomposers or organisms which feed from these plants. It is probably not possible to show corresponding effects via conventional agricultural monitoring.
In addition, it will not be sufficient under any circumstances to solely consider agricultural farming areas as effects going beyond the agricultural farming areas should be expected. Effects, which manifest themselves in areas not used for agriculture and above all in largely natural areas, are thus also to be observed.

During the workshop it was emphasised overall that the data monitoring and analysis procedures of various monitoring projects should be harmonised as far as possible.

# 11 SUMMARY AND RESULTS

In the last ten years the monitoring and analytical observation of the environmental situation has become increasingly important both at a national and international level.

It is being endeavoured, particularly in the EU, to extend environmental monitoring to possible effects from the use of biotechnology and genetic engineering in agriculture. The adoption of the amended directive on the deliberate release of genetically modified organisms into the environment 2001/18/EG now stipulates monitoring for the cultivation of transgenic plants on a binding basis. It calls on the member states to develop relevant concepts and approaches. Also in this context the present study considers whether existing proposals and concepts for environmental indicators offer a possible basis to also indicate environmental impacts caused by the use of transgenic organisms.

This study examines the potential offered by an indicator approach in the field of environmental surveillance and monitoring. It is investigated whether and if so, which indicators from existing sets or concepts of environmental indicators proposed above all in an international framework could be used to monitor effects from the use of transgenic organisms. We have assessed:

- the proposals for environmental indicators and agri-environmental indicators put forward by the OECD,
- the proposals for sustainability indicators put forward by the UN CSD,
- the proposals for biodiversity indicators in the context of the CBD,
- the proposals for environmental pressure indicators and environmental 'headline' indicators put forward by the EU,
- the indicators used to date in a report on the state of the environment issued by the EEA,
- the proposals for environmental 'headline' indicators put forward by the EEB,
- the German proposals for state of the environment indicators in the framework of Green National Accounting (in particular Ecological Area Sampling),
- the German considerations for Ecosystem Environmental Monitoring,
- proposals from a project on the development of parameters and criteria as the basis for the evaluation of ecological performance and burdens of agriculture,
- the indicator proposals put forward by the Commission of Inquiry ''Protection of Mankind and the Environment' of the 12th German Bundestag,

- the proposals for sustainability indicators from a joint project between Novartis AG, the Foundation Risk Dialogue, the Austrian Ecology Institute and the Institute for Applied Ecology with specific reference to transgenic Bt corn .

A number of other proposals were not considered to be relevant after examination of their fundamental orientation and thus did not undergo evaluation.

The analysis of existing proposals on environmental indicators, in particular in the international context, shows that to date there is no set or system of environmental indicators which is the subject of consensus or has been implemented. This means that we have not yet been able to use indicators from another context for monitoring in the field of biotechnology and genetic engineering. However, it might be possible to base monitoring on the data of the EEA's 'indicator fact sheets', from which the EEA derived indicators on the environmental situation in 1999 for the first time and plans to repeat this every three years in the future. These 'indicator fact sheets' should undergo detailed evaluation both for the development of indicators and for other monitoring approaches.

From the proposals for environmental indicators examined 130 indicators were identified as having possible relevance for monitoring transgenic crop plants (see sect. 6), with considerable overlapping resulting in terms of content.

One thing that all the selected indicators have in common is that they cannot be directly used as indicators for the field of biotechnology and genetic engineering. The indicators considered first have to be adapted to the specific theme in question.

Only a small number of indicators have the potential to show direct consequences of the large-scale usage of genetically modified plants; the majority of the indicators will only become relevant in a global evaluation by helping to explain phenomena or shedding light on background circumstances.

Many of the proposed indicators from the field of agriculture can be used first and foremost to evaluate the possible benefits discussed (e.g. reduction in the use of pesticides) resulting from the application of genetic engineering in agriculture.

A comprehensive investigation of the ecological effects does not seem possible using the existing indicator proposals. This is partly due to the gaps in knowledge and indicators seen as a weak point in the overall debate about indicators in the field of biodiversity. This deficit in discussion of the indicators is a problem when establishing

indicators to evaluate possible effects from the use of biotechnology and genetic engineering as mainly impacts on biodiversity are expected here.
In addition, the field of biodiversity calls for a wider set of indicators than other themes, thus making it more difficult to find indicators and also establish the consensus involved.

Additionally, many indicators proposed are not suitable for the portrayal of the possible effects of all genetically modified plants but are only of significance when considering specific transgenic species and changes in characteristics.

None of the indicators selected allows us to draw a conclusion regarding a direct linkage between a change observed in the indicator value and the cultivation of genetically modified plants as a sole possible cause. Only in conjunction with other data and information might it be possible to establish such a link.

Overall we can say that indicators, which have been developed with reference to a theme or for a specific issue, can only be used in another context when the indicators are (or can be) associated with a theme-specific problem. Ideally the indicators considered should also be associated with cause-effect hypotheses and possibly with an evaluation basis in the long term. Such a 'bottom-up' approach, as pursued by other research projects of the Federal Environmental Agency, is a valuable supplement and in some cases also a prerequisite for the development of meaningful indicators.
The unresolved situation regarding the diverse indicator systems can be seen as an opportunity to introduce proposals which have been adapted at any early stage and can then be discussed and coordinated at an international level.
As the debated environmental impacts can possibly only be portrayed on a large scale in the long term, we should consider whether a trial should be started at a national, regional and in some cases farm-scale level. This would allow us to check the meaningfulness of a selection of the proposed indicators as regards the problem chosen by way of example. We could test which sets of data are necessary. For such testing we could use the indicator of pesticide consumption, which is included in almost all programmes covering the environmental effects of agricultural practices.

In conjunction with a monitoring concept, which is currently being developed on the basis of cause-effect considerations and specific issues, this would give us the opportunity to merge the two approaches. At both levels of monitoring, the hypothesis and problem-driven approach on the one hand and an indicator-based approach on the other, extensive work still remains in conceptional terms.

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# 13 APPENDIX

## 13.1 INDEX OF ABBREVIATIONS

| | |
|---|---|
| BIONET | Biodiversity Action Network |
| BITI | Biodiversity Indicators and Targets Initiative |
| BMELF | Federal Ministry for Food, Agriculture and Forestry, today: Federal Ministry for Consumer Protection, Food and Agriculture |
| FEA | Federal Environmental Agency |
| CBD | Convention On Biological Diversity |
| COP | Conference of the Parties |
| CSD | Commission on Sustainable Development |
| D-S-R model | Driving forces–State–Response model |
| D-P-S-I-R model | Driving force-Pressure-State-Impact-Response model |
| EAS | Ecological Area Sampling |
| EEA | European Environmental Agency |
| EEB | European Environmental Bureau |
| EIONET | European Environment Information and Observation Network |
| EPRG | EU Environmental Policy Review Group |
| FAO | Food and Agriculture Organization |
| FUE | Forum Umwelt & Entwicklung (Forum Environment & Development) |
| GBF | Global Biodiversity Forum |
| GCEQ | German Council on Environmental Quality |
| GMO | Genetically modified organisms |
| GMP | Genetically modified plants |
| GNA | Green National Accounting |
| GWP | Greenhouse warming potential |
| ICSU | International Council of Scientific Unions |
| $LC_{50}$ | Lethal concentration at which 50% individuals die |
| $LD_{50}$ | Lethal dose at which 50% individuals die |
| NEC | No effect concentration |
| NGO | Non-Governmental Organisation |
| NMVOC | Non methane volatile organic compounds |
| ODP | Ozone depleting potential |
| OECD | Organisation for Economic Co-operation and Development |

| | |
|---|---|
| PARCOM | Paris Convention: Convention for the Prevention of Marine Pollution from Land-based Sources, Paris, 1974 |
| PEC | Predicted environmental concentration |
| PPA | Plant protective agent |
| PROSA | Product Sustainability Assessment |
| P-S-R model | Pressure–State–Response model |
| RAUMIS | Regionalised Agriculture and Environmental System |
| SAG | Scientific Advisory Group in 'TEPI' project |
| SBSTTA | Subsidiary Body on Scientific, Technical and Technological Advice (to CBD) |
| SCOPE | Scientific Committee on Problems of the Environment |
| TEPI | Towards Environmental Pressure Indicators for the EU |
| UN CSD | UN Commission on Sustainable Development |
| UNDP | United Nations Development programmes |
| UNEP | United Nations Environment programmes |
| WHO | World Health Organisation |
| WWF | World Wide Fund for Nature |

## 13.2 TANSLATION OF TECHNICAL TERMS AND NAMES OF INSTITUTIONS

| **Englisch** | **Deutsch** |
|---|---|
| Characteristic bird species | Leitvogelart |
| Ecological area sampling | Ökologische Stichflächenprobe |
| FEDERAL AGENCY FOR NATURE CONSERVATION | Bundesamt für Naturschutz |
| Federal Environment Agency | Umweltbundesamt Wien (UBA-Wien) |
| Federal Environmental Agency (FEA) | Umweltbundesamt, Berlin (UBA) |
| Federal Environment Ministry | Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit |
| Federal Ministry of Consumer Protection, Food and Agriculture | Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft |
| Federal Statistical Office | Statistisches Bundesamt |
| Fertiliser utilisation | Düngeaufwand |
| Forest dieback | Waldsterben |
| GERMAN COUNCIL ON ENVIRONMENTAL QUALITY | Der Rat von Sachverständigen für Umweltfragen (SRU) |
| Green national accounting | Umweltökonomische Gesamtrechnung |
| Useful plant | Nutzpflanze |

## 13.3 TABLES

Tab. 23: UN CSD sustainability indicators potentially relevant to the field of biotechnology and genetic engineering with further information re definition and unit of measurement (UN 1996)

| **Indicator** | **Brief Definition** | **Unit of Measurement** |
|---|---|---|
| *Category: Social, Chapter 6: Protecting and promoting human health, State Indicators* | | |
| Life expectancy at birth | The average number of years that a newborn could expect to live, if he or she were to pass through life subject to the age-specific death rates of a given period | Life expectancy at birth as expressed in years |
| Adequate birth weight | Adequate birth weight is defined as equal or greater than 2500 grams, the measurement being taken preferably within the first hours of life, before significant postnatal weight loss has occurred | The indicator is expressed as the number of children per 1000 live births whose birth weight is equal or greater than 2500 grams |
| Infant mortality rate | The number of deaths under 1 year of age during a period of time per 1000 live-births during the same period | Rate per thousand live born |
| Maternal mortality rate | Number of maternal deaths per 1.000 (or per 10.000 or per 100.000) live births | Ratio. Due to the considerable decrease of MMR in many countries, this ratio is now increasingly expressed per 10.000 or more often per 100.000 live births, which is acceptable if preferred and indicated by the country |
| Nutritional status of children | Children under age five whose weight-for-age and height-for-age is between either 80% and 120% of the reference value of the country, or within two standard deviations of this value. | % |
| *Category: Social, Chapter 6: Protecting and promoting human health, Response Indicators* | | |
| Proportion of potentially hazardous chemicals monitored in food | Proportion of potentially hazardous chemicals monitored in food which are appropriate for the country's stage of development | % |

Table 23 Cont'd

| | | |
|---|---|---|
| *Category: Environmental, Chapter 14: Promoting sustainable agriculture and rural development, Driving Force Indicators* | | |
| Use of agricultural pesticides | Use of pesticides per unit of agricultural land area | Pesticide use in metric tons of active ingredients per 10 $km^2$ of agricultural land |
| Use of fertilisers | Extent of fertilizer use in agriculture per unit of agricultural land area | Metric tons of fertilizer nutrients per 10 $km^2$ of agricultural land |
| *Category: Environmental, Chapter 15: Conservation of biological diversity, State Indicators* | | |
| Threatened species as a percent of total native species | Number of species as a percent of total native species | % |
| *Category: Environmental, Chapter 16: Environmentally sound management of biotechnology, Response Indicators* | | |
| Research & Development expenditure for biotechnology | The value of R & D expenditure in the area of biotechnology | $US |
| Existence of national biosafety regulations or guidelines | The existence or non-existence of national biosafety regulations or guidelines | Yes/no |
| *Category: Institutional, Chapter 8: Integrating environment and development in decision-making, Response Indicators* | | |
| Sustainable development strategies | Indicator under development | Yes/No |
| Mandated Environmental Impact Assessment | Legally binding requirements at the national level for EIA | Yes/No |
| *Category: Institutional, Chapter 40: Information for decision-making, Response Indicators* | | |
| Programmes for national environmental statistics | Programme for the development and compilation of environment statistics, leading to the regular publication of a state of the environment report and/or a compendium of environment statistics | Yes/No |

Tab. 24: Compilation of all indicators potentially relevant to the field of biotechnology and genetic engineering from the studies and concepts evaluated here

| Indicator | Type | Project/programme |
|---|---|---|
| ▪ *Biotopes* | | |
| Share of endangered biotopes | state | WALZ et al. 1997 |
| Share of endangered und extinct biotopes in total number of occurring biotope types | state | FEM 2000b |
| Share of endangered biotope types in all non-technical biotope types represented in Germany in % | state | EAS |
| Protected areas as a percentage of total area by ecosystem type | response | OECD 1993 |
| Habitat alteration and conversion of land from its natural state | pressure | OECD 1993 |
| Fragmentation of habitats both in the agro-ecosystem and 'natural' habitats | | OECD 1999a |
| Impacts on habitat of different farm practices and systems | | OECD 1999b |
| Length of the "contact zone" between agricultural and non-agricultural lands | | OECD 1999a |
| ▪ *Species population* | | |
| Wildlife species | | OECD 2000a |
| Threatened species<br>-% of total species or certain taxonomic groups<br>-% endemic species threatened<br>- threatened species in protected areas | state | CBD |
| Threatened or extinct species as a share of known species | condition/ state | OECD 1993 |
| Share of endangered/extinct animal and plant species | state | WALZ et al. 1997 |
| Threatened species as a percent of total native species: Number of species as a percent of total native species in % | | UN 1996 |
| Threatened (and extinct) species as a percent of total native species | | FEM 2000b |
| Red List species (total and in % all native species) | | WWF 1994 |
| Change in numbers of endangered species related to agro-ecosystems | | OECD 1999b |
| Protected species as a percentage of threatened species | response | OECD 1993 |
| Population sizes of rare, endangered and/or characteristic species | state | GEIER et al. 1999 |
| Share/Number of rare plant species | state | EAS |
| Share of endangered plant species (cover) | state | EAS |
| Share of endangered species of mosses, lichens, algae, fungi and wildlife ferns and flowering plants (Red List species) in the total number of corresp. species occurring in Germany in % | state | EAS |
| Share of endangered wildlife species: vertebrates, mammals, reptiles, amphibians, fish, Cyclostomata and birds (Red List species) in the total number of corresp. species occurring in Germany in % | state | EAS |
| Occurrence and number of rare and/or endangered grassland species or arable weeds and small animal species directly or indirectly dependent on same (fields: insects such as ground beetles, hover flies) | state | GEIER et al. 1999 |
| Wildlife species diversity related to agriculture: Appropriate key species indicators for each agro-ecosystem | | OECD 1999b |

| | | |
|---|---|---|
| Wildlife species diversity related to agriculture: The extent of changes in the agricultural area and type of land cover (this indicator would draw from the wildlife habitat and land use/cover indicators) (Method of calculation and interpretation p. 84, OECD 1999b) | | OECD 1999b |
| Occurrence and number of endangered and characteristic higher-order consumers (fields: partridge, quail, skylark) | state | GEIER et al. 1999 |
| Number of species of vascular plants per area unit | state | EAS |
| Number of Red List species (vascular plants) per plot | state | EAS |
| Occurrence of Red List species (vascular plants) in biotope type | state | EAS |
| Species population (vascular plants) of plots in chronological development | state | EAS |
| Regional species loss / flora | | Enquete 1994 |
| Biotic / abiotic diversity: How large are the biotic and abiotic diversity and thus the number of functional groups (categories) in the system? | | BARKMANN et al. (2001) |
| Spectrum of strategy types (vascular plants) | state | EAS |
| Change in abundance and/or distribution of a selected core set of species | state | CBD |
| Development of stock of guiding indicators for ecosystem changes (e.g. characteristic bird species) | state | WALZ et al. 1997 |
| Index for ecosystem changes (e.g. characteristic bird species) | state | FEM 2000b |
| Number of breeding pairs (breeding birds) per area unit | state | EAS |
| Abundance of selected species (breeding birds) | state | EAS |
| Number of species (breeding birds) per area unit | state | EAS |
| Number of rare species (breeding birds) per area unit | state | EAS |
| Number of Red List species (breeding birds) per area unit | state | EAS |
| Number of breeding pairs Red List species (breeding birds) per area unit | state | EAS |
| Alien/invasive species:<br>- % habitat colonized by invasive species<br>- % protected areas colonized by invasive species | pressure/ response | CBD |
| Non-native species | | OECD 2000a |
| ▪ *Working animals and crop plants* | | |
| Measures to conserve working animals and crop plants | response | GEIER et al. 1999 |
| Overview of hazard levels and extent of working animals und crop plants | state | GEIER et al. 1999 |
| Share of endangered indigenous crop plant types in the respective total number | state | FEA 2000b |
| Changes in proportion of commercial species | pressure/ response | CBD |
| Replacement of indigenous crops | state | CBD |
| Replacement of land races with few imported ones | state | CBD |
| Genetic diversity of domesticated livestock and crops: Change in the sum of all recognised and utilised varieties of domesticated livestock and crops | | OECD 1999b |
| Genetic diversity of domesticated livestock and crops: Change in the share of different livestock and crop varieties in the total population or in total livestock and crop production | | OECD 1999b |
| ▪ *Genetic diversity* | | |
| Biodiversity index based on genetic and habitat variety (has yet | | EEB |

| | | |
|---|---|---|
| to be developed) | | |
| Biodiversity index based on genetic and habitat variety | | EPRG |
| Genetic diversity | | OECD 2000a |
| Reduction in DNA variance | | ENQUETE 1994 |
| Introduction of new genetic material and species | pressure | OECD 1993 |
| Increase in cultivation of hybrid cultivars (This indicator is linked to the indicator originally proposed by the SAG "Loss of genetic resources - non-utilisation of available crop species and varieties") (this indicator is probably not included in the set of between 60 - 80 environmental pressure indicators) | | TEPI project |
| ▪ *Landscape, landscape structure, land use* | | |
| Landscape typologies | | OECD 2000a |
| Land characteristics of agricultural landscape: Natural features, covering, for example, the land's slope, elevation, soil type, etc | | OECD 1999b |
| Physical elements, environmental features and land use patterns | | OECD 2000a |
| Land characteristics of agricultural landscape: land type features including changes in agricultural land use and land cover type | | OECD 1999b |
| Land use changes | pressure | OECD 1993 |
| Land management practices | | OECD 2000a |
| Land area under agricultural use (in % of land) | | WWF 1994 |
| Area used agriculturally | | EEB |
| Agricultural land use (types of use: agriculture, grassland, wetlands, forestry) | | OECD 2000a |
| Agricultural intensity: area used for intensive arable land | | TEPI project |
| Intensively farmed agricultural habitats: The share of each crop in the agricultural area | | OECD 1999b |
| Share of especially extensive land farming processes in land area | response | FEM 2000b |
| Share of integrated farming in land area | response | FEM 2000b |
| Percentage of biologically farmed area | | EEB |
| Organic farming | | OECD 2000a |
| Area with organic farming | response | EEA |
| Share of ecological farming in land area | response | FEM 2000b |
| Environmental whole farm management plan | | OECD 2000a |
| Impacts on biodiversity of different farm practices and systems | | OECD 1999b |
| Changes in traditional (extensive) land-use practice Definition: 'Changes in traditional high value farming practices resulting in homogenisation of land use and loss of habitat and species diversity' | | TEPI project |
| Exergy uptake: To what extent can the high-value energy introduced to the system be taken up by it? | | BARKMANN et al. (2001) |
| Level of organisation: How large are the interactions between the system categories? | | BARKMANN et al. (2001) |
| Accumulation (pools): To what extent can the system compensate for fluctuations in the availability of energy, nutrients and water? | | BARKMANN et al. (2001) |
| Nutrient losses: Is the ecosystem organised so that a loss of important nutrients can be prevented? | | BARKMANN et al. (2001) |
| Metabolic efficiency: How efficiently can the biotic elements of an ecosystem obtain the available energy resources (biomass)? | | BARKMANN et al. (2001) |
| ▪ *Fertiliser and plant protective agents* | | |

| | | |
|---|---|---|
| Fertiliser consumption per hectare | | EEA |
| Use of fertilisers [Metric tons of fertilizer nutrients per 10 $km^2$ of agricultural land] | driving force | UN 1996, FEM 2000b |
| Use of fertilisers | | substance indicator for GNA |
| Use of fertilisers and pesticides (per capita and in kg per hectare of productive land | | WWF 1994 |
| Use of agricultural pesticides [Pesticide use in metric tons of active ingredients per 10 $km^2$ of agricultural land] | driving force | UN 1996 |
| Pesticide use on land (this indicator is probably not included in the set of between 60 - 80 environmental pressure indicators) | | TEPI project |
| PPA use | | substance indicator for GNA |
| Consumption of pesticides by agriculture | | TEPI project |
| Pesticide consumption per hectare | driving force | EEA |
| Pesticide use [Pesticide use in metric tons of active ingredients per 10 $km^2$ of agricultural land] | | OECD 2000a, FEM 2000b |
| Pesticide usage (tonnes of active ingredients weighted according to human and eco toxicity) | | EEB |
| (Total quantity) Pesticides (by type – herbicides, fungicides etc) used per year (per hectare?) of utilised agricultural area* / on agricultural land | | TEPI project |
| PPA use (quantity), N balance (as per PARCOM), area w/o PPA use, extent of permanently covered borders of bankland. (In addition same indicators in water protection areas.) | pressure | GEIER et al. 1999 |
| Index of pesticide use (active ingredients) | | OECD 1999b |
| Aggregated indicator PPA soil | pressure | WALZ et al. 1997 |
| Use of agricultural pesticides, plant protective agents risk indicator | driving force | FEM 2000b |
| Terrestrial ecotoxicity: PEC[33] value | | ENQUETE 1994 |
| Terrestrial ecotoxicity: changed microbe population | | ENQUETE 1994 |
| Toxic chemical consumption by economic activity (D67/548/EC) - updated version: Consumption of toxic chemicals | | TEPI project |
| Proportion of potentially hazardous chemicals monitored in food [%] | | UN 1996 |
| Use of integrated pest management | | OECD 1999b + 2000a |
| Use of non-chemical pest control methods | | OECD 1999b + 2000a |
| Use of reduced and zero-tillage and other best land management practices including crop rotations | | OECD 1999b |
| ▪ *Fertilisers and plant protective agents – Water* | | |
| Aggregated indicator PPA, NMVOC[34] and ubiquitous substances / Water | state | WALZ et al. 1997 |
| Contamination of groundwater/drinking water with plant protective agents | state | WALZ et al. 1997 |
| Contamination of groundwater with nitrate, plant protective agents, parameters relevant to acidification | state | FEM 2000b |

[33] *PEC = predicted environmental concentration*
[34] *NMVOC= non methane volatile organic compounds*

| | | |
|---|---|---|
| Results of waterworks regarding contamination of drinking water and groundwater measuring points with nitrate and PPA. PPA levels in surface waters. The results presented by the waterworks should quantify PPA contamination | state | GEIER et al. 1999 |
| Aquatic ecotoxicity: species shift / population dynamics | | Enquete 1994 |
| Aquatic ecotoxicity: PEC value | | Enquete 1994 |
| Contamination of surface waters with plant protective agents | state | FEM 2000b |
| ▪ *Water – Efficiency* | | |
| Eco-efficiency in agriculture | pressure | EEA |
| Water use / technical efficiency | | OECD 2000a |
| Water use / economic efficiency | | OECD 2000a |
| Biotic water utilisation: How efficiently can the biotic elements of an ecosystem tap into the available water resources? | | BARKMANN et al. (2001) |
| Irrigated land | driving force | EEA |
| Water stress | | OECD 2000a |
| ▪ *Soil* | | |
| Soil tests | | OECD 2000a |
| Soil qualitiy (indicator group) | | OECD 2000a |
| Nitrogen balance | | OECD 2000a |
| ▪ *Erosion* | | |
| Erosion, erosion risk (referred to whole of Germany) | state | WALZ et al. 1997 |
| Change in 'state of land', soil erosion | state | FEM 2000b |
| Erosion | | ENQUETE 1994 |
| Soil erosion of agriculturally productive land and other areas (total area in km², in tonnes of soil and in % of relevant soils) | | WWF 1994 |
| ▪ *Measure indicators* | | |
| R&D expenditure for biotechnology: risk and safety research | response | FEM 2000b |
| Research & Development expenditure for biotechnology in $US | response | UN 1996 |
| Labelling of genetically modified products and procedures or those free of genetic engineering | response | FEM 2000b |
| Market share of foodstuffs from organic farming | driving force | FEM 2000b |

Tab. 25: Indicators of proposal developed in 1997 regarding further development of OECD proposals on environmental indicators and application to Germany (WALZ et al. 1997)

| Pressure | State | Response |
|---|---|---|
| Indicators for greenhouse effect | | |
| • $CO_2$ equivalents [GWP 100a]<br>Emissions/consumption<br>• $CO_2$, $CH_4$, $N_2O$, CFC 11-/-12/-13/-113/-114/-115, $CCl_4$, methyl chloroform<br>• *Inclusion of CFC substitutes, other climate-relevant trace gases (medium/long-term)* | • Atmosph. concentrations: $CO_2$, $CH_4$, $N_2O$<br>• Global change in mean temperature<br>• *Changes in radiation balance of earth* (*long-term)* | • Degree of fulfilment of $CO_2$ reduction target<br>• *Aid for renewable energy sources and efficient use of energy* (*medium-term)*<br>• Consumption of heating energy per $m^2$ of living area<br>• Mean power generation efficiency<br>• Car fleet consumption |
| References to indicators in other areas | | |
| • Energy consumption | | • Fall in production of CFC 11 equivalents<br>• Measures for reduction in use of fertilisers |
| Indicators for stratospheric ozone depletion | | |
| • Consumption of CFC 11 equivalents *(*all substances from CFC halon prohibitive regulations; *medium-term: other halogenated CFCs)*<br>• Consumption of fully halogenated CFCs in t/a | • Thickness of ozone layer<br>• *UV-B measured values* (*medium-term)* | • Fall in production of CFC 11 equivalents compared with 1986 in % *(all substances from CFC halon prohibitive regulations; medium-term: other halogenated CFCs)* |
| Indicators for eutrophication | | |
| • Consumption of N and P fertilisers (commercial fertilisers + semi-liquid manure; t/km² agriculturally productive land); *medium-term poss. nutrient balance on agr. productive land*<br>• N and P inputs in flowing waters in Germany (t/a)<br>• N and P loads in seas /<br>• abroad (t/a; total for Rhine, Weser, Elbe, Ems, Danube) | • Difference between actual load/critical load with nitrogen inputs in woodland<br>• Distribution for nature of flowing waters: concentrations of N and P<br>• N and P concentrations in Heligoland and *(medium-term) for the Baltic Sea* | • Share of population served by biological sewage treatment plants with N and P elimination<br>• *Measures for reduction in use of fertilisers (long-term)* |
| References to indicators in other areas | | |
| • $NO_x$ and $NH_3$ emissions<br>• Atmospheric inputs of nitrogen compounds<br>• Loss of upper soil/erosion | • Nitrate pollution of groundwater | • Proportion of land forming water protection areas<br>• Measures aiding extensification of agriculture<br>• Capacity/shares of $NO_x$ retention technologies at stationary sources<br>• Investment in environmental protection |

Table 25 Cont'd

| Pressure | State | Response |
|---|---|---|
| Indicators for acidification | | |
| • Emission of acidification equivalents<br>• Emissions of $SO_2$, $NO_x$, $NH_3$<br>• S and N loads exceeding limits | • Mean values for $SO_2$ and $NO_x$ concentration in the air<br>• Deposition of S and N compounds (*medium-term incl. wet N deposition and poss. dry $NH_3$ deposition)*<br>• Distribution of difference between actual load/critical load of acid inputs on forest soil acc. to excess classes | • Capacity/shares of $SO_2$ and $NO_x$ retention technologies at stationary sources<br>• Proportion of car fleets equipped with ("controlled") catalytic converters<br>• Regulations governing maximum S levels in mineral oil products<br>• Reduction targets from ECE[35] sulphur and nitrogen oxide protocols |
| References to indicators in other areas | | |
| • Consumption of N fertilisers<br>• Car mileage | • Areas of forest damage | • Measures aiding extensification of agriculture<br>• Greenhouse effect<br>• Investment in environmental protection |
| Indicators for toxic contamination | | |
| • **Overall indicator Soil**<br>• Aggregated indicator Heavy metals Soil<br>• Aggregated indicator Plant protective agents Soil | • **Overall indicator Air**<br>• Aggregated indicator Main constituents of air pollution<br>• Aggregated indicator Heavy metals Air<br>• Aggregated indicator PAH[36]s Air<br>• Aggregated indicator NMVOCs Air<br>• **Overall indicator Water**<br>• Aggregated indicator Heavy metals Water<br>• Aggregated indicator Plant protective agents, NMVOCs and ubiquitous substances Water | |
| References to indicators in other areas | | |
| • WASTE<br>• VOC emissions, dust in investigation areas<br>• Extracted water volumes<br>• Intensive farming (in ha) | • Plant protective agents in groundwater/drinking water<br>• VOC immissions, dust | • Extensification of agriculture<br>• Capacity/shares of $SO_2$ and $NO_x$ retention technologies at stationary sources<br>• Proportion of car fleets equipped with catalytic converters |

[35] *ECE = Economic Commission for Europe*

[36] *PAH = polycyclic aromatic hydrocarbons*

Table 25 Cont'd

| Pressure | State | Response |
|---|---|---|
| **Indicators for urban environment** | | |
| • Emissions of $SO_2$, $NO_x$, dust and VOCs in investigation areas<br>• *Distribution of vehicle mileage frequency in the administrative districts (Kreise) and towns not belonging to a Kreis*[37] *(medium-term)* | • Concentrations of $SO_2$, $NO_x$, dust and VOCs from *Länder* monitoring networks<br>• Concentration of $O_3$ from *Länder* monitoring networks<br>• *Number of winter smog episodes (medium/long-term)*<br>• *Measured values for benzole concentrations (long-term)*<br>• Proportion of population disturbed by noise in towns | • Share of local public transport in passenger traffic, share of non-motorised traffic<br>• *Investment in transport infrastructure: share of individual traffic and local public transport, railways (medium-term)*<br>• Noise emission limit values for road vehicles in type testing procedures |
| References to indicators in other areas | | |
| • TOXIC CONTAMINATION<br>• Energy consumption | • Sealing level<br>• TOXIC CONTAMINATION<br>• WATER RESOURCES | • Capacity/shares of $SO_2$ and $NO_x$ retention technologies at stationary sources<br>• Proportion of car fleets equipped with catalytic converters<br>• Regulations governing maximum sulphur levels in mineral oil products |
| **Indicators for biological diversity and landscape protection** | | |
| • Intensive farming (in ha)<br>• Change in traffic and built-up area in total area<br>• Intersection effect through decrease in intact low-traffic areas | • Proportion of endangered/extinct species of animals and plants<br>• Proportion of endangered biotopes<br>• *Development of stock of guiding indicators for ecosystem changes (e.g. characteristic bird species) (long-term)* | • Measures aiding extensification<br>• Share of protected areas in total area (nature reserves and national parks) |
| References to indicators in other areas | | |
| • Consumption of N and P fertilisers<br>• Emissions of $SO_2$, $NH_3$, $NO_x$<br>• Structure of surface waters<br>• Land use<br>• Fishing | | • Regional shutdown<br>• EUTROPHICATION<br>• ACIDIFICATION<br>• Renatured course length of flowing waters |

[37] *i.e. an administrative district in their own right* - Translator

Table 25 Cont'd

| Pressure | State | Response |
|---|---|---|
| **Indicators for waste** | | |
| Volume of waste<br>• total waste volume<br>• domestic waste, bulky waste, trade wastes similar to domestic waste (absolute and per capita)<br>• manufacturing waste<br>• building waste, excavation<br>• special waste<br>• radioactive waste | • Number of disposal alternatives for waste volume disposed of (landfill, incineration, composting, other); export<br>• Static residual time/landfills<br>• *Stocks of landfilled domestic waste and special waste (long-term)*<br>• Stocks of radioactive waste | • Recycling rates for glass, paper, aluminium<br>• *Proportion of bio-waste treated separately (medium-term)*<br>• Usage rate for waste from manufacturing industry<br>• *Volume and level of special waste charges (long-term)*<br>• *Financial aid for waste avoidance measures (long-term)* |
| References to indicators in other areas | | |
| • Non-energetic consumption of raw materials | • Sewage sludges, agricultural waste (semi-liquid manure) | • Investment in environmental protection |
| **Indicators for water resources and quality of surface water** | | |
| • Intensity of use of water resources (ratio between water demand and supply)<br>• Water available in public water supply and industry<br>• Per capita water consumption (households) | • Groundwater: reformation in relation to extraction | • Extent of water use (quantity of water used in relation to water supply)<br>• Drinking water prices and sewerage charges |
| • Extracted water volume from (industrial and municipal treatment plants)<br>• *River works (long-term)* | • Nitrate contamination of drinking water (short-term) *and nitrate contamination of groundwater (medium-term)*<br>• *Contamination of groundwater/drinking water with plant protective agents (medium-term)*<br>• Level of pure water in drinking water extracted<br>• Integrated Saprobic Index for nature of surface waters<br>• *Chemical Index for nature of surface waters (medium-term)*<br>• *Structure of surface waters: morphology incl. bank land (long-term)* | • Share of protected water catchment area in land<br>• Volume of sewerage charges<br>• *Renatured course length of flowing waters (long-term)* |
| References to indicators in other areas | | |
| • Aggregated indicator Plant protective agents<br>• Consumption of N and P fertilisers<br>• Intensive farming | • TOXIC CONTAMINATION | • EUTROPHICATION<br>• Investment in environmental protection |

Table 25 Cont'd

| Pressure | State | Response |
|---|---|---|
| Indicators for forests | | |
| • Ratio between wood felling/growth | • Number of forestry areas in $km^2$<br>• Areas of forest damage<br>• Endangered forest biotopes<br>• Forest structure (share of deciduous/coniferous/mixed forest) | • Share of natural forest reservations in total forest area<br>• Forest management ("Helsinki" Indicator) (long-term) |
| References to indicators in other areas | | |
| • Emissions of $SO_2$, $NO_x$ and $NH_3$<br>• Consumption of N fertilisers<br>• VOC emissions | • Actual load/critical load on forest soils<br>• Aggregated indicator NMVOCs Air | • ACIDIFICATION<br>• EUTROPHICATION |
| Indicators for fish resources | | |
| • Annual landing levels | • *Fish stocks in North and Baltic Sea (medium-term)* | • *Control of fish stocks through fishing quotas (long-term)* |
| References to indicators in other areas | | |
| • TOXIC CONTAMINATION (water)<br>• Emissions of $SO_2$, $NO_x$ and $NH_3$<br>• Consumption of N fertilisers<br>• Extracted water volume from treatment plants | • TOXIC CONTAMINATION (water)<br>• N and P concentrations in North and Baltic Sea<br>• Structure of surface waters<br>• Integrated Saprobic Index<br>• Chemical Index for nature of surface waters | • EUTROPHICATION<br>• ACIDIFICATION<br>• Renatured surface water courses<br>• Volume of sewerage charges |
| Indicators for soil resources | | |
| • Share of farming land in total area<br>• Sealing level | • Erosion, risk of erosion<br>• *Soil compaction (long-term)* | • Share of disused areas in total agricultural land |
| References to indicators in other areas | | |
| • Emissions of $SO_2$, $NO_x$ and $NH_3$<br>• Consumption of N and P fertilisers (mineral fertilisers)<br>• Intensive farming<br>• TOXIC CONTAMINATION | • Actual load/critical load for acid inputs on forest soils<br>• Actual load/critical load for nitrogen inputs on forest soils<br>• TOXIC CONTAMINATION | • Extensive farming<br>• Measures aiding extensification of agriculture<br>• ACIDIFICATION<br>• EUTROPHICATION |

Table 25 Cont'd

| Pressure | State | Response |
|---|---|---|
| **Indicators for radiation exposure** | | |
| Guide indicator | | |
| | • Mean effective equivalent dose in Germany through civilisatory radiation exposure | |
| Indicators for nuclear plants, nuclear tests and accidents | | |
| • β total radiation in air (becquerel/$m^3$)<br>• γ total dose (µGy/h)<br>• Gamma spectrometry in all food (Bq/kg) | • Share of mean effective equivalent dose from properly operated nuclear plants, nuclear tests and accidents (mSv/a) | • Permissible annual total body dose for persons in entire population (mSv/a)<br>• Limit value for food contamination with Cs-134 and Cs-137 (Bq/kg) |
| Indicators for radon contamination | | |
| • Radon contamination in houses (becquerel/$m^3$) | • Share of mean effective equivalent dose from contamination with radon (mSv/a) | • Recommended value for homes (Bq/$m^3$) |
| Risk indicators | | |
| • Number of atomic reactors in Germany | • Number of notifiable events at nuclear power plants (International Nuclear Event Scale - INES) | |
| Comparative indicators | | |
| • Number of medical examinations using radiation sources (referred to population figure) | • Share of mean effective equivalent dose from medical examinations (mSv/a) | |
| | • Mean effective equivalent dose in Germany through natural radiation (mSv/a) | |
| References to indicators in other areas | | |
| • Volume of radioactive waste | • Stocks of radioactive waste | |

Table 25 Cont'd

| Pressure | State | Response |
| --- | --- | --- |
| General Indicators | | |
| • Population growth/density<br>• Gross Domestic Product (incl. share of industry, agriculture)<br>• Private consumption<br>• Energy consumption<br>• Car mileage in billion car km/a<br>• Stock of cars in millions<br>• Modal split<br>• Land use<br>• Non-energetic consumption of raw materials (biotic/ abiotic) | | • Ongoing expenditure on environmental protection<br>• Investment in environmental protection<br>• Environmental awareness<br>• *Jobs in environmental protection medium-term*<br>• *Share of ecological charges in overall charges (medium-term*) |

Tab. 26: OECD agri-environmental indicators from 1999
from appendix to OECD publication: Environmental Indicators for Agriculture – Volume 2 Issues and Design, The York workshop. OECD Publications Paris (OECD 1999b)

## LIST OF RECOMMENDED OECD AGRI-ENVIRONMENTAL INDICATORS

This Annex provides a detailed list of OECD agri-environmental indicators and their definitions, recommended for both "short-and long-term development", summarised into five tables, as follows:

**Annex Table 1 – Contextual Indicators**

1. Land
2. Population
3. Farm structures

**Annex Table 2**

4. Water Quality
5. Water Use
6. Soil Quality
7. Land Conservation

**Annex Table 3**

8. Biodiversity
9. Wildlife Habitat
10. Landscape

**Annex Table 4**

11. Farm Management
    - Farm Management Capacity
    - On-farm Management Practices
12. Farm Financial Resources
13. Socio-cultural Issues (Rural Viability)

**Annex Table 5***

14. Nutrient Use
15. Pesticide Use
16. Greenhouse Gases

* These three areas where not discussed at the York Workshop, but OECD work is underway to develop indicators that address these areas, see OECD (1999), *Agricultural Policies in OECD Countries: Monitoring and Evaluation 1999,* Chapter IV, Volume I, Paris, France.

Table 26 Cont'd

**Annex Table 1. List of recommended contextual indicators**

| Land | Population | Farm structures |
|---|---|---|
| **Agricultural Land use and Land Cover Changes**<br><br>1. Changes between the share of land in agriculture and other uses<br>2. Changes in the share of agricultural land cover type | **Number of full-time farmers**<br><br>Changes in the number of full-time farmers | **Number and type of farms**<br><br>Changes in farm types and numbers |

**Annex Table 2. List of recommended indicators proposed for the water, soil and land areas**

| Water Quality | Water Use | Soil Quality | Land Conservation |
|---|---|---|---|
| **Nitrate concentration in water in agricultural vulnerable areas**<br><br>The proportion of ground and surface water, in agricultural vulnerable areas, above a reference level of nitrate concentration ($NO_3$ mg/l) | **Water use intensity**<br><br>The proportion of water resources subject to diversion for agricultural use | **Risk of soil erosion by water**<br><br>The agricultural area subject to water erosion (i.e. the area for which there is a risk of degradation by water erosion above a certain reference level) | **Water buffering capacity**<br><br>The quantity of water that can be stored over a short period, *in* the agricultural soil, as well as *on* agricultural land where applicable (e.g. flood storage basins) and *by* agricultural irrigation and drainage facilities |
| **Phosphorus concentration in water in agricultural vulnerable areas**<br><br>The proportion of surface water bodies, in agricultural vulnerable areas, above a reference level of phosphorus concentration ($P_{total}$ mg/l) | **Water stress**<br><br>The proportion of rivers subject to diversion for irrigation without Defined Minimum Reference Flows | **Risk of soil erosion by wind**<br><br>The agricultural area subject to wind erosion (i.e. the area for which there is a risk of degradation by wind erosion above a certain reference level) | |

Table 26 Cont'd

**Annex Table 2 Cont'd**

| Water Quality | Water Use | Soil Quality | Land Conservation |
|---|---|---|---|
| **Risk of water contamination by nitrogen**<br><br>The area of agricultural land potentially vulnerable to water contamination by nitrogen | | | |
| *Risk of water contamination by pesticides*<br><br>The area of agricultural land potentially vulnerable to water contamination by pesticides | *Water use technical efficiency*<br><br>For selected irrigated crops, the mass of agricultural produce (tonnes) per unit of the volume of irrigation water consumed, the latter being the volume of water, in megalitres, diverted of extracted for irrigation less return flows | *Inherent soil quality*<br><br>Agricultural areas where there is a mismatch between the soil capability as indicated by the index of inherent soil quality and the actual or impeding land use | *Off-farm sediment flow*<br><br>The quantity of soil sediments delivered to off-farm areas from agricultural soil erosion |
| | *Water use economic efficiency*<br><br>For all irrigated crops, the monetary value of agricultural production per unit of irrigation water volume consumed, the latter being the volume of water, in megalitres, diverted or extracted for irrigation less return flow | | |
| | *Policy and management response to water stress*<br><br>Indicates potential economic distortions in the use of water caused by underpricing, free access or government intervention in the management of irrigation water, in particular, in countries or regions with a high intensity of water use | | |

Indicators in **bold** are for short-term development and those in *italics* are for medium- to long-term development.

Table 26 Cont'd

**Annex Table 3. List of recommended indicators proposed for the biodiversity, wildlife habitat and landscpae areas**

| Biodiversity | Wildlife habitat | Landscape |
|---|---|---|
| **Genetic diversity of domesticated livestock and crops**<br><br>1. Change in the sum of all recognised and utilised varieties of domesticated livestock and crops<br>2. Change in the share of different livestock and crop varieties in the total population or in total livestock and crop production | **Number of full-time farmers**<br><br>The share of each crop in the agricultural area. | **Number and type of farms**<br><br>1. Natural features, covering, for example, the land's slope, elevation, soil type, etc.<br>2. Environmental appearance, including the landscape, ecosystems and habitat types<br>3. Land type features, including changes in agricultural land use and land cover type |
| **Wildlife species diversity related to agriculture**<br><br>A. Quality<br>1. Appropriate key species indicators for each agro-ecosystem<br>2. Key threatening processes that can damage agricultural production activity<br>3. Proportion of semi-natural and uncultivated natural habitats on agricultural land<br><br>B. Quantity<br>4. The extent of changes in the agricultural area and type of land cover (this indicator would draw from the wildlife habitat and land use/cover indicators) | **Semi-natural agricultural habitats**<br><br>The share of the agricultural area covered by semi-natural agricultural habitats | **Cultural features of agricultural landscape**<br><br>Key indicative cultural features |
| | **Uncultivated natural habitats**<br><br>1. Area of wetland transformed into agricultural area.<br>2. Area of aquatic ecosystems transformed into agricultural area<br>3. Area of natural forest transformed into agricultural area<br>4. Area of agriculture re-converted into aquatic ecosystems | **Management functions of agricultural landscape**<br><br>The share of agricultural land under public and private committment to landscape maintenance and enhancement |
| *Change in numbers of endangered species related to agro-ecosystems*<br><br>*Impacts on biodiversity of different farm practices and systems*<br>*Effects on biodiversity caused by off-farm soil sediment flow* | *Habitat heterogeneity (average size of habitats)*<br><br>*Habitat variability (number of habitat types per monitoring area)*<br><br>*Impact on habitat of different farm practices and systems* | *Landscape typologies*<br><br>*Monetary valuation of societal landscape preferences (from public surveys)* |

Indicators in **bold** are for short-term development and those in *italics* are for medium- to long-term development.

Table 26 Cont'd

**Annex Table 4. List of recommended for the farm management, farm financial and socio-cultural (rural viability) areas**

| Farm Management | | Farm Financial Resources | Socio-cultural (Rural viability) |
|---|---|---|---|
| **Farm management capacity** | **On-farm management practices** | | |
| **Standards for environmental farm management practices**<br><br>Number of established national and/or sub-national environmental farm management standards, regulations, codes of practice, etc. | **Matrix of environmental farm management practices**<br><br>The matrix includes an issue substructure (nutrients, soil, pesticides, water, etc.) and specified management practices under each, with countries reporting on the level of adoption or "actual" use of those practices most relevant to their specific natinonal and regional situations. The focus in the short term should be on measuring specific management practices; both the share of farms (or land area) using the practice and its implementation | **Public and private agri-environmental expenditure**<br><br>Public and private expenditure on agri-environmental goods, services and conservation (both investment and current expenditure) | **Agricultural income**<br><br>Share of agricultural income in relation to total income of rural households |
| **Expenditure on agri-environmental research**<br><br>Expenditure on agr-environmental research as a percentage of total agricultural research expenditure | | **Farm financial equilibrium**<br><br>The equilibrium between the net farm perating profit after tax (i.e. farm monetary receipts), and the cost of capital (i.e. financial costs to the farm) | **Entry of new farmers into agriculture**<br><br>Number of farmers, accoding to age and gender, entering the agricultural sector |
| **Educational level of farmers**<br><br>Average educational attainment of farmers, presented as the share of farmers attaining different levels of education or years of education | | | |

Table 26 Cont'd

**Annex Table 4 Cont'd**

| **Farm Management** | | **Farm Financial Resources** | **Socio-cultural (Rural viability)** |
|---|---|---|---|
| **Farm management capacity** | **On-farm management practices** | | |
| *Ratio of agricultural advisers*<br><br>Number of public and private agricultural advisers trained in environmental management practices of farmer | *Implementation Index*<br><br>The Implementation Index could be used to measure the extent to which environmental farm management practices are actually used by farmers. It would be a way to express the results of the matrix of environmental farm management practices (see above) in a comprehensive manner for a given country | *Adjusted farm financial equilibrium*<br><br>Adjusting farm financial resources for changes in natural resource depletion and pollution, for example, soil erosion and nutrient soil surface balance | *Soil capital in agricultural and rural communities*<br><br>The strength of social institutions and forma/informal networks, voluntary organisations, etc., in agricultural and rural communities |

Indicators in **bold** are for short-term development and those in *italics* are for medium- to long-term development.

Table 26 Cont'd

**Annex Table 5. List of indicators for nutrients, pesticides and greenhouse gases**

| **Nutrient Use** | **Pesticide Use** | **Greenhouse Gases** |
|---|---|---|
| **Nutrient balances (soil surface balances of nitrogen and phosphorus)** | **Index of pesticide use (active ingredients)** | **Gross agricultural emissions (methane, nitrous oxide and carbon dioxide)** |
| *Farm gate nutrient balance*<br><br>*Nutrient use efficiency (technical and economic)* | *Pesticide use efficiency (technical and economic)*<br><br>*Pesticide risk indicators* | *Agriculture's contribution to renewable energy (biomass production)*<br><br>*Net emissions of carbon dioxide from agricultural soils*<br><br>*Economic efficiency of agricultural greenhouse gas emissions* |

Indicators in **bold** are for short-term development and those in *italics* are for medium- to long-term development. These indicator areas were not discussed at the York Workshop, but are included among the areas for which the OECD is developing agri-environmental indicators.

Tab. 27 OECD proposal for agri-environmental indicators from 2000

| Complete list of OECD Agri-environmental Indicators[1] | | |
|---|---|---|
| I.AGRICULTURE IN THE BROADER ECONOMIC, SOCIAL AND ENVIRONMENTAL CONTEXT | | |
| 1. Contextual information and indicators | | 2. Farm financial resources |
| • *Agricultural GDP*<br>• *Agricultural output*<br>• *Farm employment*<br>• *Farmer age/gender distribution*<br>• *Farmer education*<br>• *Number of arms*<br>• *Agricultural support* | • *Land use*<br>- Stock of agricultural land<br>- Change in agricultural land<br>- Agricultural land use | • *Farm income*<br>• *Agri-environmental expenditure*<br>- Public and private agri-environmental expenditure<br>- Expenditure on agri-environmental research |
| II. FARM MANAGEMENT AND THE ENVIRONMENT | | |
| 1. Farm management | | |
| • *Whole farm management*<br>- Environmental whole farm management plans<br>- Organic farming | • *Nutrient management*<br>- Nutrient management plans<br>- Soil tests<br>• *Pest management*<br>- Use of non-chemical pest control methods<br>- Use of integrated pest management | • *Soil and land management*<br>- Soil cover<br>- Land management practices<br>• *Irrigation and water management*<br>- Irrigation technology |
| III. USE OF FARM INPUTS AND NATURAL RESOURCES | | |
| 1. Nutrient use | 2. Pesticide use and risks | 3. Water use |
| • *Nitrogen balance*<br>• *Nitrogen efficiency* | • Pesticide use<br>• Pesticide risk | • *Water use intensity*<br>• *Water use efficiency*<br>- Water use technical efficiency<br>- Water use economic efficiency |
| IV. Environmental impacts of agriculture | | |
| 1. Soil quality | 3. Land conservation | 4. Greenhouse gases |
| • Risk of soil erosion by water<br>• Risk of soil erosion by wind | • *Water retaining capacity*<br>• *Off-farm sediment flow (soil retaining capacity)* | • *Gross agricultural greenhouse gas emissions* |
| 2. Water quality | | |
| • *Water quality risk indicator*<br>• *Water quality state indicator* | | |
| 5. Biodiversity | 6. Wildlife habitats | 7. Landscape |
| • *Genetic diversity*<br>• *Species diversity*<br>- Wild species<br>- Non-native species<br>• *Eco-system diversity*<br>(see Wildlife Habitats) | • Intensively-farmed agricultural habitats<br>• *Semi-natural agricultural habitats*<br>• *Uncultivated natural habitats*<br>• *Habitat matrix* | • *Structure of landscapes*<br>- Environment features and land use patterns<br>- Man-made objects (cultural features)<br>• *Landscape management*<br>• *Landscape costs and benefits* |

[1] This list includes all the agri-environmental indicators covered in the Report. For a detailed description of each indicators, see Main Report.
*Source*: OECD Secretariat.

Tab. 28: Environmental Pressure Indicators (EU), proposed indicators

| POLICY FIELD | INDICATOR |
|---|---|
| Air Pollution | AP1: **Emissions of $NO_x$** |
| | AP2: **Emissions of NMVOCs** |
| | AP3: **Emissions of $SO_2$** |
| | AP4: **Emissions of particles** |
| | AP5: **Consumption of petrol & diesel oil by road** |
| | AP6: **Primary energy consumption** |
| Climate Change | CC1: **Emissions of $CO_2$** |
| | CC2: **Emissions of $CH_4$** |
| | CC3: **Emissions of $N_2O$** |
| | CC4: **Emissions of HFCs** |
| | CC5**: Emissions of PFCs** |
| | CC6: **Emissions of $SF_6$** |
| Loss of Biodiversity | LB1: **Protected area loss, damage and fragmentation** |
| | LB2: **Wetland loss** |
| | LB3: **Agriculture intensity: area used for intensive** |
| | LB4: **Fragmentation of forests & landscapes by** |
| | LB5: **Forest damage** |
| | LB6: **Change in traditional land-use practice** |
| Marine Environment & Coastal Zones | ME1: **Eutrophication** |
| | ME2: **Fishing pressure** |
| | ME3: **Development along shore** |
| | ME4: **Discharges of heavy metals** |
| | ME5: **Oil pollution at coast and at sea** |
| | ME6: **Tourism intensity** |
| Ozone Layer Depletion | OD1: **Emissions of halons** |
| | OD2: **Emissions of CFCs** |
| | OD3: **Emissions of HCFCs** |
| | OD4: **Emissions of $NO_x$ by aircraft** |
| | OD5: **Emissions of chlorinated carbons** |
| | OD6: **Emissions of industrially produced Methyl** |
| Resource Depletion | RD1: **Water consumption** |
| | RD2: **Energy use** |
| | RD3: **Increase in territory permanently occupied by** |
| | RD4: **Nutrient balance of the soil** |
| | RD5: **Electricity production from fossil fuels** |
| | RD6: **Timber balance** |
| Dispersion of Toxic Substances | TX1: **Consumption of pesticides by agriculture** |
| | TX2: **Emissions of POPs** |
| | TX3: **Consumption of toxic chemicals** |
| | TX4: **Index of heavy metal emissions to water** |
| | TX5: **Index of heavy metal emissions to air** |
| | TX6: **Emissions of radioactive materials** |
| Urban Environmental Problems | UP1: **Energy consumption** |
| | UP2: **Non-recycled municipal waste** |
| | UP3: **Non-treated waste water** |
| | UP4: **Share of private car transport** |
| | UP5: **People endangered by noise emissions** |
| | UP6: **Land use (change from natural to built-up area)** |
| Waste | WA1: **Waste landfilled** |
| | WA2: **Waste incinerated** |
| | WA3: **Hazardous waste generated** |
| | WA4: **Municipal waste generated** |
| | WA5: **Industrial waste** |
| | WA6: **Waste recycled/material recovered** |
| Water Pollution | WP1: **Emissions of nutrients** |
| | WP2: **Ground water abstraction** |
| | WP3: **Pesticides used per ha of utilised agriculture** |
| | WP4: **Nitrogen quantity used per hectare of utilised** |
| | WP5: **Waste water treatment** |
| | WP6: **Emissions of organic matter as BOD** |
| TOTAL | **60** |

Tab. 28, Cont'd: Environmental Pressure Indicators (EU), discussed indicators

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Air Pollution | Emissions of nitrogen oxides .. | Emissions of non-methane volatile.. | Emissions of sulphur dioxide .. | Emissions of particles | Consump-tion of gasoline & diesel | Primary energy consumption | Emissions of ammonia (NH3) | Emissions of selected persistent .. | Use of pesticides for agric. | Electricity consumption |
| **Climate change** | Emissions of carbon dioxide.. | Emissions of methane (CH4) | Emissions of nitrous oxides .. | Emissions of chlorofluoro | Emissions of nitrogen oxides .. | Emissions of sulphur dioxides .. | Emissions of particles | Removal of carbon dioxide .. | Emissions of non-methane volatile.. | Emissions of hydrochloro-fluoro |
| **Loss of Biodiv.** | Protected area loss, damage .. | Wetland loss through drainage | Agriculture Intensity: area used for .. | Fragmen-tation of forests &.. | Clearance of natural & semi-.. | Change in traditional land-.. | Loss of genetic resources – non -.. | Pesticide use on land | Loss of forest diversity-.. | Riverbank loss through artificiali.. |
| **Marine Environment & Coastal Zones** | Eutrophi-cation | Overflashing | Development along shore | Priority habitat loss | Discharges of heavy metals | Oil pollution at coast & at sea | Discharges of halogenated organic .. | Wetland loss | Tourism intensity | Faecal pollution |
| **Ozone Layer Depletion** | Emissions of bromocluoro .. | Emissions of chlorofluoro | Emissions of hydrochlorofluoro | Emissions of carbon dioxide.. | Emissions of nitrogen oxides .. | Emissions of chlorinated carbons | Emissions of methylbromide .. | Emissions of methane (CH4) | Emissions of nitrous oxides .. | Emissions of methylchloro .... |
| **Resource Depletion** | Water consumption per capita | Use of energy consumption per capita | Increase in territory permanently | Nutrient-balance of the soil | Electricity production from fossil | Timber balance (new growth ..) | Use of nimeral oil as a fuel | Surface water abstraction | Exceedance of fisch catch quots | Ground water abstraction |
| **Dispersion of Toxic Substances** | Consump-tion of pesticides by agriculture | Emissions of persistent organic .. | Consumption of toxic chemicals | Index of heavy metal emissions | Index of heavy metal emissions | Emissions of radioactive material | Emissions of heavy metal by | Production of chlorinated compounds | Consumption of household toxic | Vehicle distribution by technology |
| **Urban Environmental Problems** | Energy consumption | Non-recycled municipal waste | Non-treated wastewater | Share of private car.. | People endangered by noise emissions | Land use (change from..) | Inhabitants per green area | Water consumption per capita | Emissions of sulphur dioxide | Derelicted areas |
| **Waste** | Waste landfilled | Waste incinerated | Hazardous waste | Municipal waste | Waste per product, during a.. | Waste recycled/waste recovered | Waste from other economic .. | Consumption of hazardous materials | Waste from energy production | Waste disposed to sea |
| **Water Pollution & Water Resources** | Nutrient (nitrogen & phosphorus) | Ground water abstraction | Pesticides used per hectare | Water treated/water collected | Index of heavy metals emissions | Emissions of organic matter | Industrial water uses | Waste water collected/water .. | Households & public utilities water .. | Water recycling by industry |

Tab. 29: 'Headline indicators' (EU Commission & EEA 2000)

| ISSUE | CURRENT INDICATORS | PROPOSALS FOR IDEAL HEADLINE INDICATORS IN MEDIUM - LONG TERM |
|---|---|---|
| **Climate change** | | |
| 1. Climate Change | Preliminary aggregated emissions of 3 main greenhouse gases ($CO_2$, $CH_4$, $N_2O$) expressed in $CO_2$ -equivalents<br>Sectoral breakdown | Aggregated emissions of 6 greenhouse gases of the Kyoto Protocol ($CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$,) expressed in $CO_2$ -equivalents |
| **Nature & bio-diversity** | | |
| 2. Nature & Biodiversity | Designated “Special Protection Areas (SPAs)” according to the Birds-Directive (as a part of the NATURA 2000 network) | Bio-diversity index based on the variety of:<br>- Species;<br>- Genes;<br>- And habitats/ecosystems/ landscapes<br><br>An indicator based on evaluation of trends in conservation status of key species and habitats e.g. those listed in Habitats and Birds Directives as well as more common species which are particularly sensitive to changes in land use. |
| 3. Air Quality | Aggregated emissions of acidifying substances ($SO_2$, NOx, $NH_3$) weighted by acid-equivalents.<br>Sectoral breakdown | Aggregated emissions of acidifying substances ($SO_2$, NOx, $NH_3$, NMVOCs) weighted by acid-equivalents. |
| **Environment & human health** | | |
| 4. Air Quality | Aggregated emissions of ozone precursor substances (NOx, NMVOCs, CO, $CH_4$) weighted by Tropospheric Ozone Precursor Potentials<br>Sectoral breakdown | Aggregated emissions of ozone precursor substances (NOx, NMVOCs, CO, $CH_4$) weighted by Tropospheric Ozone Precursor Potentials.<br><br>Number of days of pollution exceeding standards |
| 5. Urban Areas | Urban air quality indicators (number of days of exceedance pollution of several pollutants) | Urban air quality indicators or index<br>Urban transport indicators |
| 6. Water Quality | Phosphate concentration in (large) rivers, which represents mostly point sources (households, industry)<br><br>Nitrate concentration in (large) rivers, which represents mostly diffuse sources (agriculture) | Development of a consistent "European index for the status of water bodies” to move towards EU-wide water quality classes |
| 7. Chemicals | No current Indicator due to lack of statistical data and scientific assessment | Indicator on changes in the impacts of hazardous chemicals on the environment and human health |
| **Waste & resources** | | |
| 8. Waste | - Municipal waste landfilled<br>- Municipal waste generated<br>- Hazardous waste generated | Indicator measuring resource use and in line with the waste strategy, in terms of measuring:<br>- Prevention of waste;<br>- recycling and reuse; and<br>- optimal final treatments |
| 9. Resource-use | Gross Inland Energy Consumption | Indicator derived from material balance demonstrating what materials are used, consumed and disposed by the whole economy |
| 10. Water Quantity | Total fresh water abstraction for selected Northern and Southern countries | Intensity of water use (water abstraction/renewable water resources) by sectors and spatial dimension |
| 11. Land-use | Evolution of land use by land categories (arable land, permanent grassland, permanent crops, forest land, built up areas, length of road network) | Evolution matrix of land use changes telling what the changes are and where they come from. |

Tab. 30: Indicators for 'benchmarks' of EEB (1999)

| INDICATOR | TIMETABLE | FINAL TARGET |
|---|---|---|
| | ENVIRONMENT AND HEALTH | |
| | ***Air quality*** | |
| Emissions of 4 pollutants (SOx, NOx, NH3, VOCs) | Medium term: reductions of 84% for SO2, 55% for NOx, 29% for NH3 and 60% for VOC compared to 1990 levels by 2010. | Good air quality within 30 years. The critical loads for pollutants and the WHO standards for air pollutants with respect to human health should not be exceeded any more. |
| | ***Water quality*** | |
| Percentage of clean surface waters | Immediate compliance with existing legislation. Proposed Water Framework Directive should aim at attaining good surface water status by 2010. | 100% of inland waters with natural chemical background values |
| | ***Climate change*** | |
| Total CO2 and five other greenhouse gas emissions (CH4, N2O, HFCs, PFCs, SF6) | Short term: full implementation of "Kyoto"+) Medium term: 30% reduction should be reached by 2010 and 55% reduction by 2020. | By 2030 more than 75% reduction of current greenhouse gas emissions. |
| | ***Hazardous substances*** | |
| An index of released hazardous substances weighted according to human and eco toxicity (has yet to be introduced) | Medium term: halve all releases by 2010 compared to 1995. | By 2020 no human made releases (OSPAR and HELCOM target) |
| | LAND USE AND BIODIVERSITY | |
| | ***Land use*** | |
| Amount of built-up areas compared to total area | See final target | Net stabilisation of non built-up areas by 2000, allowing for some mitigation and exchange between different areas |
| | ***Biodiversity*** | |
| Biodiversity index based on genetic and habitat variety (has yet to be developed) | Effective implementation of the EU Biodiversity Strategy by 2000+) | A halt to habitat decline and the extinction of species in the EU+) |
| | RESOURCE USE | |
| | ***Water use*** | |
| Total water use and percentage of natural replenishment | Sustainable water use by 2010a) | Adequate natural replenishment in 100% of water sources |
| | ***Material use*** | |
| Total material use and waste production incl. percentage of reused or recycled material | Short term: stabilisation of waste generation at 1985 levels (actual reduction)+) | Within 30 years a Factor 10 lower primary non-renewable material use, with material recycling and re-use above 95%, resulting in untreated waste going to landfill towards 0. |
| | CRUCIAL SECTORS | |
| | ***Transport*** | |
| Total passenger- and ton-kilometres travelled and total energy consumption | Short term: the necessary pre-conditions to reverse the current trends need to be in place within five years. | Within 30 years stabilisation of total distances (pkm/tkm) travelled and halving of total energy consumption (level 2000) |
| | ***Agriculture*** | |
| Pesticides usage (tonnes of active ingredients weighted according to human and eco toxicity) | Short term: halve pesticide usage within 10 years.b) | No use of pesticides that are not allowed for organic farming by 2020 |

[+)] *Already offical EU policy*

[a)] *Officially, the sustainable exploitation of freshwater resources is a target for 2000 (5th Env. Action Plan).*

[b)] *The European Crop Protection Association expects an overall decrease in the volume of active substances of around 30% between 1996 and 2008.*

Tab. 31: UN CSD sustainability indicators from 1996

## CSD Working List of Indicators of Sustainable Development
### Working List of Indicators of Sustainable Development

This should be seen as a flexible list from which countries can choose indicators according to national priorities, problems and targets. The indicators are presented in a Driving Force – State – Response framework. “Driving Force” indicators indicate human activities, processes and patterns that impact on sustainable development. “State” indicators indicate the “state” of sustainable development and “Response” indicators indicate policy options and other responses to changes in the “state” of sustainable development. The social, economic, environmental and institutional aspects of sustainable development are covered by this list of indicators following the chapters of Agenda 21.

| **CHAPTERS OF AGENDA 21** | **DRIVING FORCE INDICATORS** | **STATE INDICATORS** | **RESPONSE INDICATORS** |
|---|---|---|---|
| CATEGORY: SOCIAL | | | |
| *Chapter 3: Combating poverty* | • Unemployment rate | • Head count index of poverty<br>• Poverty gap index<br>• Squared poverty gap index<br>• Gini index of income inequality<br>• Ratio of average female wage to male wage | |
| *Chapter 5: Demographic dynamics and sustainability* | • Population growth rate<br>• Net migration rate<br>• Total fertility rate | • Population density | |
| *Chapter 36: Promoting education, public awareness and training* | • Rate of change of school-age population<br>• Primary school enrolment ratio (gross and net)<br>• Secondary school enrolment ratio (gross and net)<br>• Adult literacy rate | • Children reaching grade 5 of primary school<br>• School life expectancy<br>• Difference between male and female school enrolment ratios<br>• Women per hundred men in the labour force | • GDP spent on education |

Table 31 Cont'd

| CHAPTERS OF AGENDA 21 | DRIVING FORCE INDICATORS | STATE INDICATORS | RESPONSE INDICATORS |
|---|---|---|---|
| *Chapter 6: Protecting and promoting human health* | | • Basic sanitation: Percent of population with adequate excreta disposal facilities<br>• Access to safe drinking water<br>• Life expectancy at birth<br>• Adequate birth weight<br>• Infant mortality rate<br>• Maternal mortality rate<br>• Nutritional status of children | • Immunization against infectious childhood diseases<br>• Contraceptive prevalence<br>• Proportion of potentially hazardous chemicals monitored in food<br>• National health expenditure devoted to local health care<br>• Total national health expenditure related to GNP |
| *Chapter 7: Promoting sustainable human settlement development* | • Rate of growth of urban population<br>• Per capita consumption of fossil fuel by motor vehicle transport<br>• Human and economic loss due to natural disasters | • Percent of population in urban areas<br>• Area and population of urban formal and informal settlements<br>• Floor area per person<br>• House price to income ratio | • Infrastructure expenditure per capita |
| CATEGORY: ECONOMIC | | | |
| *Chapter 2: International cooperation to accelerate sustainable development in countries and related domestic policies* | • GDP per capita<br>• Net investment share in GDP<br>• Sum of exports and imports as a percent of GDP | • Environmentally adjusted Net Domestic Product<br>• Share of manufactured goods in total merchandise exports | |

Table 31 Cont'd

| **CHAPTERS OF AGENDA 21** | **DRIVING FORCE INDICATORS** | **STATE INDICATORS** | **RESPONSE INDICATORS** |
|---|---|---|---|
| *Chapter 4:*<br>*Changing consumption patterns* | • Annual energy consumption<br>• Share of natural-resource intensive industries in manufacturing value-added | • Proven mineral reserves<br>• Proven fossil fuel energy reserves<br>• Lifetime of proven energy reserves<br>• Intensity of material use<br>• Share of manufacturing value-added GDP<br>• Share of consumption of renewable energy resources | |
| *Chapter 33:*<br>*Financial resources and mechanisms* | • Net resources transfer/GNP<br>• Total ODA given or received as a percentage of GNP | • Debt/GNP<br>• Debt service/export | • Environmental protection expenditures as a percent of GDP<br>• Amount of new or additional funding for sustainable development |
| *Chapter 34:*<br>*Transfer of environmentally sound technology, cooperation and capacity-building* | • Capital goods imports<br>• Foreign direct investments | • Share of environmentally sound capital goods imports | • Technical cooperation grants |
| CATEGORY: ENVIRONMENTAL | | | |
| *Chapter 18:*<br>*Protection of the quality and supply of freshwater resources* | • Annual withdrawals of ground and surface water<br>• Domestic consumption of water per capita | • Groundwater reserves<br>• Concentration of faecal coliform in freshwater<br>• Biochemical oxygen demand in water bodies | • Waste-water treatment coverage<br>• Density of hydrological networks |
| *Chapter 17:*<br>*Protection of the oceans, all kinds of seas and coastal areas* | • Population growth in coastal areas<br>• Discharges of oil into coastal waters<br>• Release of nitrogen and phosphorus to coastal waters | • Maximum sustained yield for fisheries<br>• Algae index | |
| *Chapter 10:*<br>*Integrated approach to the planning and management of land resources* | • Land use change | • Changes in land condition | • Decentralized local-level natural resource management |

Table 31 Cont'd

| CHAPTERS OF AGENDA 21 | DRIVING FORCE INDICATORS | STATE INDICATORS | RESPONSE INDICATORS |
|---|---|---|---|
| *Chapter 12: Managing fragile ecosystems: combating desertification and drought* | • Population living below poverty line in dry land areas | • National monthly rainfall index<br>• Satellite derived vegetation index<br>• Land affected by desertification | |
| *Chapter 13: Managing fragile ecosystems: sustainable mountain development* | • Population change in mountain areas | • Sustainable use of natural resources in mountain areas<br>• Welfare of mountain populations | |
| *Chapter 14: Promoting sustainable agriculture and rural development* | • Use of agricultural pesticides<br>• Use of fertilizers<br>• Irrigation percent of arable land<br>• Energy use in agriculture | • Arable land per capita<br>• Area affected by salinization and waterlogging | • Agricultural education |
| *Chapter 11: Combating deforestation* | • Wood harvesting intensity | • Forest area change | • Managed forest area ratio<br>• Protected forest area as a percent of total forest area |
| *Chapter 15: Conservation of biological diversity* | | • Threatened species as a percent of total native species | • Protected area as a percent of total area |
| *Chapter 16: Environmentally sound management of biotechnology* | | | • R&D expenditure for biotechnology<br>• Existence of national biosafety regulations or guidelines |
| *Chapter 9: Protection of the atmosphere* | • Emissions of greenhouse gasses<br>• Emissions of sulphur oxides<br>• Emissions on nitrogen oxides<br>• Consumption of ozone depleting substances | • Ambient concentrations of pollutants in urban areas | • Expenditure on air pollution abatement |
| *Chapter 21: Environmentally sound management of solid wastes and sewage-related issues* | • Generation of industrial and municipal solid waste<br>• Household waste disposed per capita | | • Expenditure on waste management<br>• Waste recycling and reuse<br>• Municipal waste disposal |

Table 31 Cont'd

| **CHAPTERS OF AGENDA 21** | **DRIVING FORCE INDICATORS** | **STATE INDICATORS** | **RESPONSE INDICATORS** |
|---|---|---|---|
| *Chapter 19: Environmentally sound management of toxic chemicals* | | • Chemically induced acute poisonings | • Number of chemicals banned or severely restricted |
| **CHAPTERS OF AGENDA 21** | **DRIVING FORCE INDICATORS** | **STATE INDICATORS** | **RESPONSE INDICATORS** |
| *Chapter 20: Environmentally sound management of hazardous wastes* | • Generation of hazardous waste<br>• Imports and exports of hazardous wastes | • Area of land contaminated by hazardous wastes | • Expenditure on hazardous waste treatment |
| *Chapter 22: Safe and environmentally sound management of radioactive wastes* | • Generation of radioactive waste | | |
| CATEGORY: INSTITUTIONAL | | | |
| *Chapter 8: Integrating environment and development in decision-making* | | | • Sustainable development strategies<br>• Programme of integrated environmental and economic accounting<br>• Mandated Environmental Impact Assessment<br>• National councils for sustainable |
| *Chapter 35: Science for sustainable development* | | • Potential scientists and engineers per million population | • Scientists and engineers engaged in R&D per million<br>• Expenditure on R&D as a percent of GDP |
| *Chapter 37: National mechanisms and international cooperation for capacity-building in developing countries* | | | |
| *Chapter 38 : International institutional arrangements* | | | |
| *Chapter 39: International legal instruments and mechanisms* | | | • Ratification of global agreements<br>• Implementation of ratified global agreements |
| *Chapter 40: Information for decision-making* | | • Main telephone lines per 100 inhabitants<br>• Access to information | • Programmes for national environmental statistics |

Table 31 Cont'd

| CHAPTERS OF AGENDA 21 | DRIVING FORCE INDICATORS | STATE INDICATORS | RESPONSE INDICATORS |
|---|---|---|---|
| *Chapter 23-32: Strengthening the role of major groups* | | | • Representation of major groups in national councils for sustainable development<br>• Representatives of ethnic minorities and indigenous people in national councils for sustainable development<br>• Contribution of NGOs to sustainable development |

Tab. 32: UN CSD sustainability indicators of German test phase

## *Testing of CSD sustainability indicators in Germany*

### Appendix I to Report of Federal Government:
### *- German test list -*

This is the list of indicators which are to be tested or developed further under the German CSD test phase. This does **not** include theme areas or individual indicators from the CSD list of indicators which are not seen as being relevant or a priority for Germany and are thus not taken into consideration in the German test phase.

For comparison with the CSD list of indicators reference is made to the table included in the report of the Federal Government, section V.2.2.

Legend:

| | |
|---|---|
| ○ | Theme areas and individual indicators taken from the CSD list of indicators |
| ● | Newly added theme areas and individual indicators |
| >> | Substitution or particularisation of individual indicators |
| (> sect. x) | Indicator is relevant but already included in another section x |
| (?) | Theme area or individual indicator needs to be examined more closely |
| * | Key word for potential indicators |

| Chapter 40 of Agenda 21 | Pressure indicators | State indicators | Response indicators |
|---|---|---|---|
| CATEGORY: SOCIAL | | | |
| **Chapter 3**: Combating poverty/General social development | | ● Unemployment rate<br>*>> men / women / youngsters*<br>● Gini Index for income distribution<br>● Ratio for average wage earned by men and women<br>*>> Ratio of gross monthly earnings in %*<br>*○ Time budget for paid and unpaid work of men and women*<br>*○ Number of people on income support in resident population at end of year*<br>*○ Homeless per 1000 inhabitants*<br>*○ Number of private households heavily in debt*<br>*○ Number of criminal acts in total*<br>______<br>Key word:<br>** Culture* | *○ Sole expenditure on income support per inhab. in year*<br>*○ Persons employed in job creation schemes*<br>*○ Persons attending state-funded training and retraining programmes*<br>*○ Aid towards unification of work and family* |

Table 32 Cont'd

| | | | |
|---|---|---|---|
| **Chapter 5**:<br>Population dynamics and sustainable development | ● Population growth rate<br>● Net migration rate<br>● Aggregated birth rate<br>○ *Average age of mothers on birth of first child*<br>○ *Number of childless women*<br>○ *Infant mortality*<br>○ *Life expectancy of persons aged 0, 20, 60 and 80 years) (male/female)* (> Ch. 6) | ○ *Total population (male / female)*<br>○ *Age structure (number of persons under 20, over 60 and over 80 years)* | |
| **Chapter 6**: Protection and promotion of human health | <u>*Nutrition*</u><br>○ *Body Mass Index*<br>○ *Weekly consumption of fruit and vegetables*<br>○ *Alcohol consumption*<br><u>Smoking</u><br>○ *Number of smokers in total population*<br>○ *Intensity of smoking (average cigarette consumption per smoker/day)*<br><u>Exercise</u><br>○ *Number of persons who do more than 2 hrs. sport a week*<br><u>Health & Safety</u><br>○ *Number of accidents at workplace*<br><u>Key words</u>:<br>* *Contamination of interiors*<br>* Environmental pollution (> Category: Environment | ● Life expectancy at birth<br>*>> and at age 60*<br>○ *Occurrence of cardiovascular diseases and cancer*<br>○ *Occurrence of allergies*<br>○ *Number of persons suffering from Aids (patients and deceased)* | ● Immunisation against contagious diseases<br>● Proportion of Gross National Product spent on national health<br>*>> Amount for prevention, curative treatment and care* |
| **Chapter 7**: Promotion of sustainable residential area development | ○ *Population density*<br>○ *Average household size*<br>○ *Average distance between home/work* | ● Proportion of population in urban areas<br>● Living space p. person<br>● Price of buying homes in relation to income<br>*>> Proportion of monthly household income spent on living costs (rent + interest + repayment of mortgage)*<br>○ *Ecological building* | ○ *Aid for ecological building*<br>○ *Aid for inner-city development*<br>○ *Aid for building using existing structures* |

Table 32 Cont'd

| CATEGORY: ECONOMIC | | | |
|---|---|---|---|
| *NEW:*<br>*General economic development*<br><br>(<u>Note</u>:<br>The indicators are mainly oriented towards economics and have been partially taken from Ch. 2 + 4 of the CSD list; additional relevant indicators from the aspect of sustainability are included in other chapters) | ● Proportion of Gross Domestic Product for net investment (from Ch. 2)<br>*>> Gross investment rate*<br>● Share of exports and imports in GDP (from Ch. 2) / *Share of foreign sales in total sales of manufacturing industry /*<br>○ *Real growth rate of Gross Domestic Product*<br>○ *Rate of inflation*<br>○ *Share of budget deficit in Gross Domestic Product / share of public debt in Gross Domestic Product* | ● *GDP per capita* (from Ch. 2)<br>○ *Private consumption per capita*<br>○ *Labour productivity: GDP per person in gainful employment*<br>○ *Economic structure: share of economic sectors in gross creation of value*<br>*>> Share of S + M-sized businesses*<br>*>> Share of economic sectors making intensive use of raw materials and environment* (from Ch. 4)<br>○ *Insolvencies*<br>○ *Founding of new businesses*<br>○ *Employment:*<br>*>> Total number of persons in gainful employment*<br>*>> Total number of persons in gainful employment acc. to economic sectors (incl. state; share of S + M-sized businesses)*<br>--------------------------------<br>*>> Unemployment rate* (> cf. also Chapter 3) | <u>Key words, no indicators as yet</u>:<br>* Information, advice<br>* Publicity<br>* Economic instruments<br>* Government procurement |
| **Chapter 4**: Change in consumer behaviour<br><br>(<u>Note</u>:<br>Additional relevant indicators from the aspect of sustainability are included in other chapters) | ○ *Consumer spending of private households per capita*<br>○ *Market share of products*<br>*- w. environmental label*<br>*- from recycled material*<br>*- from "Fair Trade"*<br>○ *Market share of organically farmed foods*<br>○ *Frequency and distance of private travel (per capita/year)* | ● Annual energy consumption per capita<br>*>> Share of energy consumed by private households in final energy consumption*<br>● Intensity of material consumption<br>*>> Raw materials productivity*<br>*>> Energy productivity*<br>○ *Consumption of exhaustable raw materials (total / share of imports)* | (?) |

Table 32 Cont'd

| | | | |
|---|---|---|---|
| | | ● Share of renewable energy sources in primary energy consumption (> Ch. 9) | |
| **Chapter 33**: Financial resources and financing mechanisms | | | *>> Amount paid in to GEF[38] and Montreal Fund*<br>○ *Proportion of GNP spent on state foreign aid (ODA)*<br>○ *Amount of average aid element of ODA[39]*<br>○ *Share of ODA for environment, protection of resources* |
| **Chapter 34**: Transfer of envir. compatible technologies, cooperation and development of capacity | *>> Direct investment in developing countries and middle and East European (MOE) states* | *>> Export: share in world trade with environmental protection goods* | ○ *Aid for transfer of environmental technology* |
| *<u>NEW</u>:*<br>***Chapter 30**:*<br>*Strengthen role of private industry* | (?)<br><br>(Indicators to describe the outline conditions for greater environmental orientation of industry: still have to be developed) | ○ *Companies with a (certified) environmental management system*<br>*>> Share of staff*<br>*>> Share in consumption of resources*<br>○ *Companies with regular envir. reporting*<br>○ *Usage of Code of Practice in industry* | ○ *Encourage envir. awareness in business through associations / chambers etc.*<br>○ *In-house information and further staff training on envir. themes*<br>○ *Expenditure of private industry on envir. protection* |
| CATEGORY: ENVIRONMENT | | | |
| **Chapter 18**: Protection of quality and quantity of freshwater resources | ● Annual extraction from groundwater and surface waters<br>*>> Water extraction (public supply, industry, power plants, agriculture)*<br>● Domestic water consumption per capita<br>*>> Water consumption of households per capita*<br>○ *TOC (total organic carbon) in waste water*<br>-------------------------------<br>○ *Use of plant protective agents / PPA risk indicator* (> Ch. 14)<br>○ *Use of fertilisers / nutrient balance excesses* (> Ch. 14)<br>○ *Emission quantities of air pollutants causing acidification* (> Ch. 9) | <u>Water volume</u>:<br>*>> Ratio between new creation/extraction of groundwater*<br>○ *Intensity of use of water resources (ratio between extraction volume and potential supply)*<br><u>Water quality</u>:<br>*>> Contamination of groundwater with nitrate, plant protective agents, parameters relevant to acidification*<br>○ *Contamination of surface waters with total nitrogen, total phosphorus, AOX, TOC (requirements of quality class II in each case)*<br>○ *Contamination of surface waters with , plant protective agents* | ● Level of waste water treatment<br>*>> Level of connection to biological sewage treatment plants*<br>○ *Water recycling rates in industry*<br>______________<br>○ *Area of land under extensive and organic farming* (> Ch. 14) |

[38] *GEF = Global Environmental Facilities*

[39] *ODA = official development assistance*

Table 32 Cont'd

| | | | |
|---|---|---|---|
| **Chapter 17**: Protection of oceans, seas and coastal regions | ● Input of oil in coastal waters<br>● Introduction of nitrogen and phosphorus in coastal waters<br>○ *Reduction in introduction of mercury, cadmium and lead, referred to 1985 (in %)*<br>○ *Inputs of hazardous organic substances with high persistence* | | |
| **Chapter 10**: Integrated approach for planning and management of soil resources | *(here many indicators from other chapters are relevant)* | ● Changes in "state of the land"<br>*>> Soil erosion*<br>● Changes in land use<br>*>> Increase in traffic and built-up areas >> including: Resealing*<br>*>> Unsealed areas*<br>*>> Built-up and traffic area / inhabitants*<br>○ *Proportion of soils with excessively high substance inputs (substance balances)*<br>○ *Area productivity*<br>*>> GDP / built-up and traffic areas*<br>*>> Area used per job* | ○ *Quota for fallow land use*<br>○ *Status for decontamination of abandoned hazardous sites*<br>*>> Examination and evaluation rate*<br>*>> Decontamination rate*<br>———<br>Key word:<br>* *Measures for reduction in contamination of agricultural land use* |
| **Chapter 13**: Management of sensitive ecosystems: sustainable management of mountainous areas[1)] | (?) | (?) | (?) |
| **Chapter 14**: Aid for sustainable agriculture and rural development | ● Use of plant protective agents<br>*>> PPA risk indicator*<br>● Use of fertilisers<br>○ *Nutrient balance excesses*<br>● Use of energy in agriculture | ● Agriculturally used area per capita | ● Agricultural training<br>○ *Share of land under esp. extensive farming in agricultural land (AL)*<br>○ *Share of land under ecological farming on AL*<br>○ *Share of land growing raw materials on AL* |
| **Chapter 11**: Combating deforestation | ● Intensity of wood utilisation<br>-------------------------------<br>○ *Emissions of air pollutants (> Ch. 9)*<br>○ *Change in land use (> Ch. 10)*<br>○ *Change in state of land (> Ch. 10)* | ● Change in forest area<br>○ *State of forest soil*<br>○ *Proportion of trees with marked damage*<br>○ *Stocks of wood* | ● Share of protected forest areas in total forest area<br>○ *Initial afforestation*<br>———<br>Key word:<br>* Semi-natural forest management |

1) Further consideration should be given to the questions of whether and if so, how the theme of sensitive ecosystems can be adequately described in a manner representative of Germany overall using indicators. Sustainability indicators are already being developed as a monitoring instrument for certain mountain regions, e.g. for the Alps. The results of this work should undergo evaluation.

Table 32 Cont'd

| | | | |
|---|---|---|---|
| **Chapter 15**: Maintenance of biological diversity | ○ *Intersection effects: intact low-traffic areas (min. 100 qm)*<br>--------------------------------<br>○ *Change in land use (> Ch. 10)*<br>○ *Substance contamination (critical loads)* (> Ch. 9) | ● Percentage of threatened *and extinct animal and plant* species in total number of indigenous species<br>○ *The problem of the threat to indigenous crop plants and breeds of domestic animals should be portrayed by an indicator*<br>○ *Share of endangered und extinct biotopes in total number of occurring biotope types*<br>○ *Index for ecosystem changes* (e.g. Leitvogel species) | ● Percentage of protected areas in total area<br>○ *Network level: average size of protected areas*<br>○ *Share of land under integrated farming on AL*<br>--------------------------------<br>○ *Share of land under ecological farming on AL* (> Ch. 14)<br>○ *Reduction in substance inputs* (> Ch. 9)<br>○ *Share of protected forest areas in total forest area* (> Ch. 11) |
| **Chapter 16**: Environmentally compatible use of biotechnology | (?) | (?) | ● R&D expenditure on biotechnology<br>*>> Risk and safety research*<br>○ Existence of national biosafety regulations or guidelines (?)<br>○ *Labelling of genetically modified products and procedures / those free of genetic engineering* |
| **Chapter 9**: Protection of earth's atmosphere<br>*>> differentiated according to:*<br>*I. Greenhouse effect / Energy utilisation* | ● Greenhouse gas emissions<br>*>> $CO_2$, $CH_4$, $N_2O$, hal. CFCs, PFC, $SF_6$ (as $CO_2$ equivalents)*<br>*>> Specific emissions per capita and per unit of GDP*<br>*>> Percentage-based reduction in greenhouse gases compared with base year*<br>○ *Energy mix / energy supply (carbon intensity)*<br>○ *Share of renewable energy sources in primary energy consumption*<br>--------------------------------<br>○ *Energy productivity* (Ch. 4) | | ○ *Degree of fulfilment of national reduction targets for greenhouse gases*<br>○ *Aid for renewable energy sources and efficient use of energy (absolute and relative in relation to aid for fossil and nuclear energy sources)*<br>--------------------------------<br>○ *Sink formation by forests / initial afforestation* (Ch. 11) |
| *II. Ozone depletion in stratosphere* | ● Consumption of ozone-damaging substances *(ODS)*<br>*>> Absolute / pro capita*<br>○ *Emissions of ODS from old plant and products (refrigeration plant, foams)* | | ○ Extent of financial and technical aid to developing countries |

Table 32 Cont'd

| | | | |
|---|---|---|---|
| *III. Contamination in the air* | ● Emissions of $SO_2$, $NO_x$<br>*>> and: $NH_3$, NMVOCs (acidification equivalents)* | ● Pollutant concentrations in urban regions | ● Expenditure to combat air pollution |
| **Chapter 21**: Environmentally compatible handling of waste<br><br>*(link with Ch. 20)* | ● Production of solid industrial and municipal waste<br>*>> Volumes of waste (total and per capita), differentiated according to waste types*<br>○ *Volumes of sewage sludge (total / per capita)* | ○ *Number of household waste landfill sites with basic sealing, seepage water / landfill gas treatment* (share in total number of urban landfill sites)<br>○ *Number / capacity of waste incineration plants with flue gas purification (acc. to BAT[40])*<br>○ *Number of landfill sites complying with Technical Instructions for municipal waste* | ● Expenditure on waste management<br>*>> Expenditure on disposal of municipal waste (differentiated according to reuse and disposal)*<br>● *Household waste disposed of per capita*<br>*>> Disposal of municipal waste per capita (differentiated according to reuse and disposal)*<br>● Waste recycling and reuse<br>*>> Reuse quotas for*<br>** glass, paper, plastics, metals*<br>** waste from manufacturing industry*<br>** building waste etc.*<br>** sewage sludge*<br>** biodegradable waste*<br>○ *Share of reused waste on import/export*<br><br>Key word:<br>** Aid for waste avoidance* |
| **Chapter 20**: Environmentally compatible disposal of hazardous waste | ● Volumes of hazardous waste<br>● Import/export of hazardous waste<br>*>> according to EU law* | ● Areas contaminated by hazardous waste<br>*>> Number of suspect abandoned sites caused by old deposits*<br>*>> Share of land* | ● Expenditure on disposal of hazardous waste<br>*>> Removal / reuse*<br>○ *Share of hazardous waste with chem./phys. treatment, reuse, incineration* |

[40] *BAT = best available techniques*

Table 32 Cont'd

| | | | |
|---|---|---|---|
| **Chapter 19**: Environmentally compatible handling of hazardous chemicals | ○ *Production and use of hazardous chemicals (selection of certain substances, see below)* | ● Acute poisoning by chemicals | ○ *Number of "known" substances (incl. those in intermediate products* |
| **Chapter 22**: Safe and environmentally compatible handling of radioactive waste | ● Generation *of* radioactive waste<br>*>> Production of radioactive waste* | ○ *Quantity of radioactive waste produced* | ○ *Regulated removal of radioactive waste* |
| *<u>NEW</u>: Encouragement of a sustainable environmentally compatible traffic development* | ○ *Modal split / selection of modes of transport*<br>○ *Mileage (car / estate car / truck)*<br>○ *Number of cars by pollutant class*<br>○ *Specific fuel consumption*<br>*>> Total cars*<br>*>> New car fleets* | ○ *Annual climatic gas and pollutant emissions by traffic: $CO_2$, $NO_x$, VOC, particles (absolute; share)*<br>○ *Noise pollution by traffic*<br>○ *Land consumption by road traffic*<br>○ *Public transport facilities*<br>○ *Length of footpaths and bicycle paths*<br>○ *Number of traffic accidents*<br>--------------------------------<br>○ *Area intersected by traffic* (> Ch. 15) | ○ *Investments for railways, local public transport, roads, ships, aviation*<br>○ *Aid for low-emission cars*<br>○ *Citizen participation in traffic planning* |

Table 32 Cont'd

| | | | |
|---|---|---|---|
| CATEGORY INSTITUTIONS | | | |
| **Chapter 8**: Integration of environmental and development issues in decision-making | (?) | (?) | (?) |
| **Chapter 35**: Science at the service of sustainable development | | | ● Scientists and engineers working in R&D per million inhabitants<br>● Proportion of GDP spent on R&D<br>○ *Personnel and resources for*<br>*- environmental research*<br>*- socio-ecological research*<br>○ *Personnel and resources for*<br>*- peace and conflict research*<br>*- cooperation with developing countries and fast-developing nations*<br>○ *Personnel and resources for structural measures of research institutes* |
| **Chapter 36**: Aid for school education, public awareness and professional/further training<br><br>(from Category: Social) | ● Fluctuation rate among school-age children<br>● Attendance rate for elementary schools (gross and net)<br>● Attendance rate for secondary schools (gross and net)<br>● Proportion of adults able to read and write<br>*>> Acc. to OECD method* | ● Number of elementary school pupils attaining 5th grade<br>● Average length of schooling<br>● Difference in school attendance rate for boys/girls<br>○ Degrees awarded to students at universities (men/women)<br>● Ratio of women to 100 gainfully employed men<br>>> Cf. also Ch. 3<br>○ *Environmental awareness of population*<br>__________<br>Key word:<br>* Awareness of sustainability among population | ● Proportion of Gross Domestic Product spent on education<br>*>> Expenditure on educational establishments per pupil/student per year in relation to pro-capita income*<br>○ Time budget of curriculum's *and environmental instruction actually provided in grades 5 to 8*<br>○ *Time budget in grades 5 to 8 for "syndrome"*<br>○ *Time budget in grades 5 to 8 for project instruction*<br>__________<br>Key word:<br>* Environmental instruction at nursery school |

Table 32 Cont'd

| | | | |
|---|---|---|---|
| **Chapter 37**: National mechanisms and international cooperation to strengthen personnel and institutional capacities in developing countries | | | ○ *Share of Technical Cooperation in state development cooperation (ODA)* (from Ch. 34) |
| **Chapter 38**: International institutional outline conditions<br><br>*link with Ch. 39:* | | | Key words:<br>* *Membership*<br>* *Fulfilment of reporting obligations*<br>* *Financial contributions/ fulfilment of financial obligations*<br>* *Cooperation with international players* |
| **Chapter 39**: International legal instruments and mechanisms | | | ● Ratification of international conventions<br>● Enforcement of ratified international agreements<br>○ *Enforcement provisions*<br>○ *Fulfilment of substantial obligations*<br>○ *Fulfilment of reporting obligations*<br>○ *Fulfilment of financial obligations*<br>○ *Involvement of societal players* |
| **Chapter 40**: Information for decision-making process | (?) | ● Access to information<br>>> *Number of Internet pages on themes of Environment / Sustainability* (diff. for state, science, NGOs)<br>○ *Level of knowledge about sustainable development among population*<br>○ *Number of consumer advice centres* | ○ Aid for consumer advice centres<br>____________________<br>Key word:<br>* *Improvement of information facilities and systems* |
| **Chapter 23-32**: Consolidation of role of key groups | | ○ *Level of population organised into NGOs*<br>○ *Number of local and regional Agenda 21 initiatives* | ○ *Aid for integration of NGOs (including women's organisations)* |

Tab. 33: WWF proposal for sustainability indicators in context of CSD (1994)

## Indicators for a viable future and sustainable development

*From: WWF Environment Foundation for Germany, Dr. Stephan Singer, Mai 1994: "Die Umsetzung der 'Agenda 21': Indikatoren für eine tragfähige Zukunft und eine nachhaltige Entwicklung"*

**1. Key Elements of Sustainability**
- Human Development Index (HDI)
- Per capita production and consumption of energy
- Per capita production and consumption of non-renewable mineral resources
- Per capita consumption of water and paper (wood)
- Per capita production und consumption of cereals, meat, vitamin-containing fruit and vegetables
- Gross National Product and real Gross Domestic Product (GDP) per capita
- Share in percent (%) of poorest 40% households in national income
- Reduction (in %) of national reserves of energy, raw materials and water
- Annual population growth (in %)
- Fertility and birth rate among female population
- Mean calorie consumption (in % of minimum requirements)

**2. Financial Mechanisms**
- Resources for Global Environmental Facility (GEF) in % of GNP
- Bi- and multilateral foreign aid donated or received in % of GNP, in % of budget and in US$
- Share of foreign aid (in % of foreign aid budget) for environmental protection and nature conservation, fight against poverty (hygiene, rural development, preventative medicine etc.) and education/training
- Military expenditure (in % des GNP)
- Economic balance of payments (expenditure versus income in % des GNP)
- Debt service / revenue in % of GNP

**3. Education, Science, Transfer of Technology**
- Share of school-age persons attending elementary, secondary schools, technical colleges and high schools
- Average length of school attendance
- Proportion of girls in above indicators
- Literacy rate among adults
- Expenditure on research and education (in % of budget)
- Expenditure on projects and research in field of sustainable development (in % of research budget)
- Expenditure of industry (share in total income) for reduction in product-related use of raw materials and energy
- Re-use and recycling rate of selected raw materials and products such as paper, aluminium, glass etc. and composite products such as household appliances, cars etc. (in % of new products and total)

**4. Public Transparency and Civic Involvement**
- Number of official and private institutes, enterprises and authorities publishing annual reports about internal or external environmental protection measures (total and in % of respective corporations)
- Resources for ideas from Rio - environment und development - in own country (in % of budget)
- Share of public-sector staff in environmental sphere
- Number of non-governmental organisations (NGOs) from environmental and development sector involved in Rio-relevant problems and national implementation of obligations undertaken (in % of existing NGOs and in absolute terms)
- List of international agreements which have been signed and ratified by parliament
- Human Freedom Index (HFI)
- Share of women in employment market
- Share of women in regional and municipal government (in %)
- Number of elected parliamentary representatives per million citizens
- Number of NGOs involved in local/rural government

**5. Health, Housing and Clean Water**
- Life expectancy index (in years and in %, of industrial nations).
- Infant or childhood mortality under one years and under 6 years of age (per 1000 of age group)
- Infant mortality due to specific diseases such as measles, diarrhoea, lung disease and infestation with worms or parasites (per 1000 of age group)
- Mortality rate of mothers (per 1000 births)

- Proportion of rural and urban population with reliable access to clean drinking water and hygienic sewage disposal
- Consumption of clean drinking water per capita for own nutrition (in % of total water consumption per capita) and in % of annual replenishment via natural water cycle
- Biochemical oxygen demand (BOD) and dissolved oxygen (DO) in the major surface waters
- Increase (in %) of urban population

**6. Land Use, Forests and Diversity of Species**
- Deforestation rate in square kilometres ($km^2$) and in % existing forest
- Share of virgin forest areas (in % of forest and % of land area)
- Reforestation rate (in % cleared area) and intended purpose
- Red List species (total and in % of all native species)
- Loss of wetlands (in km and % of existing wetlands)
- Nature reserves (number, $km^2$ and % of land area)
- Quantity of fish caught from sea and freshwater (total in tonnes, per capita of population and % share, in world fishing)
- Soil erosion of agriculturally productive land and other areas (total area in $km^2$, in tonnes of soil and in % of relevant soils)
- Land area under agricultural use (in % of land)
- Average ownership of land (hectares) of poorest 30% of rural families
- Use of fertilisers and pesticides (per capita of population in kilograms (kg) per hectare of productive land)
- Agricultural yield per hectare and per capita of population
- Energy intensity of agricultural production (in litres of oil units per kg of cereals and meat produced and in litres of oil units per US$ of agricultural income)

**7. Atmosphere and Climate Protection**
- Carbon dioxide ($C0_2$) emissions from fossil energy generation (in tonnes and per capita)
- Sulphur dioxide ($S0_2$) and nitrogen oxide ($NO_X$) emissions from fossil energy generation (in tonnes and per capita)
- Number and % of days in the year when the WHO guidelines [41] for air pollution control are exceeded in cities
- Consumption of substances harmful to ozone such as CFCs and HCFCs [42] (total and per capita)

**8. Avoidance of Toxic Chemicals**
- Highly toxic (special) waste (total in cubic meters ($m^3$) or kg and per capita), broken down according to chemical, industrial and nuclear waste
- Production of domestic waste (total in cubic kilometres ($km^3$) or tonnes and per capita)
- Proportion of highly toxic waste exported

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[41] *WHO: World Health Organisation of United Nations*
[42] *Fully and partially halogenated chlorofluorocarbons*

Tab. 34: Biodiversity indicators from preparatory documents for SBSTTA-5

**Annex:** PROPOSED CORE SET OF BIODIVERSITY INDICATORS UNEP/CBD/SBSTTA/5/12, PAGE 1

| State indicator | | | Thematic areas 1 | | | | | | Data Sets | Methods | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | F | M/C | IW | D2 | M | Ag3 | | | |
| **Eco-system Quantity** | | 1. Habitat | | | | | | | Remote sensing data, vegetation maps, national forest cover inventories, coastal zone maps, wetland and freshwater inventories | Overlay maps, GIS, aerial surveys, ground truthing | Measured as % area/total land. Shows the extent of the area and whether habitat is being gained or lost in recent times |
| | | 1.1 Self-regenerating | ♦ | ♦ | ♦ | ♦ | ♦ | | | | |
| | | 1.2 Man-made | ♦ | | ♦ | ♦ | ♦ | ♦ | | | |
| **Ecosystem Quality** | **Ecosystem** | 2. Habit Fragmentation/Conversion | | | | | | | Land use plans, remote sensing data, surveys, FAO data | GIS, overlay maps | Shows trends in significant habitat disturbance |
| | | 2.1 Native vegetation fragmentation | ♦ | ♦ | ♦ | ♦ | ♦ | | | | |
| | | 2.2 Wetland drainage and filling | ♦ | ♦ | ♦ | ♦ | | | | | |
| | | 2.3 Conversion of coastal areas | | ♦ | ♦ | | | | | | |
| | | 2.4 Erosion | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | | 2.5 Irrigation | | | | ♦ | | ♦ | | | |
| | | 3. Species richness | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | National biodiversity data base, surveys, transect, sampling reports | Monitoring and research programs, inventories | Species richness data is being collected widely (at different taxonomic levels), but its use as indicator is limited by the uncertainty of the total number of species present ant taxonomical difficultires |
| | **Species** | 4. Change in abundance and/or distribution of a selected core set of species | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | Wide area, transect, sample results | Surveys and monitoring programs depending on the species involved | Can provide information on ecological changes and early warning signals regarding ecosystem processes. Species in the set to be included based on country-specific conditions (e.g. rare, endemic, keystone, flaship, economic, invasive, pests, livestock/grazers, scient. interest, ecosyst. functions etc.) |
| | | 5. Threatened species | | | | | | | Endangered and threatened species data sets | Surveys and monitoring | Indicate species for which most urgent actions are needed |
| | | 5.1 % of total species or certain taxon. groups | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | | 5.2 % endemic species threatened | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | | 5.3 Threatened species in protected areas | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | **Gen.** | 6.1 Replacement of indigenours crops | ♦ | | ♦ | ♦ | ♦ | ♦ | Allelic diversity, karyotype variants | Morphol. analysis, offspring parent regression, DNA sequencing, electrophoresis, karyotypic analysis | Will provide information on inbreeding depression, outbreeding rate, rate of genetic drift, genetic flow, etc. |
| | | 6.2 Replacement of land races with few imported one | | | ♦ | ♦ | ♦ | ♦ | | | |

1 F: Forest biodiversity; M/C: Marine and coastal biodiversity; IW: Inland water biociversity; D: Dryland biodiversity; M: Mountain biodiversity; Ag: Agrobiodiversity
2 Also reviewed by the liaison group on drylands; 3 Not discussed by the liaison group on biodiversity indicators.

Table 34 Cont'd



| Pressure and Response Indicators | | Thematic areas 1 | | | | | | Data Sets | Methods | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | M/C | IW | D2 | M | Ag3 | | | |
| Pressure Indicators | 7. Population density | | | | | | | National or local statistical data or surveys | Existing adminstrative data, translated to habitat level, socio-economic surveys, | Rapid growth likely to indicate negative impact on biodiversity. Increase inside or adjacent to protected areas might suggest illegal incursion |
| | 7.1 In/adjacent to key habitats | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 7.2 In/adjacent in protected area | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 8. Harvesting/use | | | | | | | National statistics, commercial production records, records by community groups | Record keeping and monitoring selected data | Trends in amount harvested, changes in harvest/effort can give early warning signals on over-harvesting. The data is most useful when compared as a set of several indicators. |
| | 8.1 Production totals | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 8.2 Export totals | ♦ | | | ♦ | ♦ | ♦ | | | |
| | 8.3 Imports totals | ♦ | | | ♦ | ♦ | ♦ | | | |
| | 8.4 Local processing capacity | ♦ | | | ♦ | ♦ | ♦ | | | |
| | 8.5 Domestic consumption | | | | | | | | | |
| | 8.6 Catch/effort | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 8.7 Changes in proportion of commercial species | | ♦ | ♦ | | | | | | |
| | 9. Infrastructure | | | | | | | Nation. Statis., commerc. records, remote sensing, surveys, records by community groups | Record keeping, overlaying maps, field reports | Trends associated with increase human pressure, extraction, habitat destruction, etc. |
| | 9.1 Road and transportation networks | ♦ | | | ♦ | ♦ | | | | |
| | 9.2 Dams | | | ♦ | ♦ | ♦ | | | | |
| | 9.3 Rate of housing development | ♦ | | | ♦ | ♦ | | | | |
| | 10. Pollution | | | | | | | Import, production, sale records, emission records, monitoring data | Record keeping, emissions and field monitoring | Indicator set to be developed on country-specific needs. Can be based on data regarding production, import, sale, use, emissions, contaminat. load, or levels in the environ. of salinity, dust, agrochemical and harmful substances. |
| | 10.1 Soil quality | ♦ | | | ♦ | ♦ | ♦ | | | |
| | 10.2 Water quality | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 10.3 Air quality | ♦ | | | ♦ | | ♦ | | | |
| | 11. Alien/Invasive species | | | | | | | Surveys, transects or sample results, patrol reports or repoerts from local communities | Monitoring of trends in distribution | |
| | 11.1 % habitat colonized by invasive species | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 11.2 % protected areas colinized by invasive species | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 12. Climate change | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | National statistics, records | Monitoring of trends | Several variables to be selected based on country-specific issues to be monitored and data availability (droughts, sea-level, temperature, storm frequency, etc.) |
| | 13. Habitat Management | | | | | | | Spatial plans, national statistics, remote sensing | GIS, overlay maps | Shows changes in conservation status and land-use |
| | 13.1 % protected (IUCN 1-3) | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 13.2 % protected (IUCN 4-5) | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 13.3. % managed for production | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 13.4. No. of fires/area burned/yr | ♦ | | | ♦ | ♦ | | | | |
| | 14. Special habitat | | | | | | | Spatial plans, national statistics, remote sensing, surveys | GIS, overlay maps | Shows trends and conservation status of fragile, threatened, biodiversity-rich habitats (e.g. Mangroves, peat-swamps, coral reefs). |
| | 14.1 % remaining | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |
| | 14.2 % protected | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | | | |

Tab. 35a:Indicator proposals for EAS – structure indicators for GNA (RADERMACHER et al. 1998)

National indicators for physical structure from existing data sources

| **Indicant** | **Indicator** |
|---|---|
| Threat to habitat types | Share of endangered biotope types in all non-technical biotope types represented in Germany in % |
| Level of threat to vertebrates | Share of endangered wildlife vertebrate species (Red List species) in the total number of vertebrate species occurring in Germany in % |
| Level of threat to mammals | Share of endangered wildlife mammal species (Red List species) in the total number of mammal species occurring in Germany in % |
| Level of threat to birds | Share of endangered bird species (Red List species) in the total number of bird species occurring in Germany in % |
| Level of threat to reptiles | Share of endangered reptile species (Red List species) in the total number of reptile species occurring in Germany in % |
| Level of threat to amphibians | Share of endangered amphibian species (Red List species) in the total number of amphibian species occurring in Germany in % |
| Level of threat to fish and Cyclostomata | Share of endangered fish and Cyclostomata species (Red List species) in the total number of corresp. species occurring in Germany in % |
| Level of threat to plant species | Share of endangered wildlife species of ferns and flowering plants (Red List species) in the total number of corresp. species occurring in Germany in % |
| Level of threat to mosses | Share of endangered moss species (Red List species) in the total number of corresp. species occurring in Germany in % |
| Level of threat to lichens | Share of endangered species of lichens (Red List species) in the total number of corresp. species occurring in Germany in % |
| Level of threat to algae | Share of endangered species of algae (Red List species) in the total number of corresp. species occurring in Germany in % |
| Level of threat to fungi | Share of endangered species of fungi (Red List species) in the total number of corresp. species occurring in Germany in % |

Tab. 35b: Indicator proposals for EAS – structure indicators for GNA
(FEDERAL STATISTICAL OFFICE & FEDERAL AGENCY FOR NATURE CONSERVATION 2000)

**Tab. 6**: Overview of basic data and indicators
**Tab. 6a**: Basic data surveyed

| Basic data surveyed | Method | Indicators | General indicant | | | Specific indicant |
|---|---|---|---|---|---|---|
| | | | Use | Structure | Rarity/ Risk | |
| Species population / vascular plants, level of cover / mosses | Preliminary field analysis, listing | Average number of species in monitoring areas/biotope type<br>Species population of plots in chronological development | x<br><br>x | x<br><br>x | x<br><br>x | - Stability (only within biotope type)<br>- Intensity of usage (as above)<br>- Floristic diversity<br>- Change in floristic and structural diversity over time |
| Cover level share of individual species on monitoring areas (% in classes) | Assessment acc. to Pfadenhauer in % | Evenness<br>Average evenness value of monitoring area for one biotope type (%) | x | x | | - Population structure (dominance relationships)<br>- Intensity of usage in conjunction with total number of species<br>- Structural homogeneity of biotope type |
| | | Frequency analysis / importance value (species groups) | x | x | | - Floristic homogeneity of biotope type<br>- Structural homogeneity of biotope type<br>- Intensity of usage acc. to structural criteria |
| | | Grouping of species into floristic population types | x | x | x | - Diversity of biotope type in terms of vegetation<br>- Site conditions<br>- Usage conditions |
| Height of population layers (cm) | Measurement | Average total cover | x | x | | - Productivity<br>- Competition conditions within population, niche diversity<br>- Intensity of usage |
| | | Average height | x | x | | - as above, more detailed indication |
| | | Average height of individual layers | | | | - as above, more detailed indication |
| Cover level of population layers (%) | Assessment | Average number of vegetation layers | x | x | | - as above, more detailed indication |

Table 35b Cont'd

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Average cover level of population layers | | | | - as above, more detailed indication |
| Affiliation of species to population layers (species/layer) | Allocation in field | Average number of species per population layer | | | | - Diversity per layer<br>- Intensity of usage |

**Tab. 6b**: Literature data

| Basic data from literature | Method | Indicators | General indicant | | | Specific indicant |
|---|---|---|---|---|---|---|
| | | | Use | Structure | Rarity/ Risk | |
| Allocation of species to groups of sociological behaviour (affiliation of species to sociological species groups) | Allocation acc. to existing data base | Spectrum of groups of sociological behaviour (shares of species in % on average of plot for a biotope type) | x | x | | - Diversity in terms of site<br>- Structural diversity<br>- Usage influences<br>- Degree of disturbance<br>- Stability |
| Allocation of species to life forms (life form types) | Allocation acc. to existing data base | Spectrum of life forms | x | x | | - Structural diversity<br>- Site conditions<br>- Usage influences<br>- Degree of disturbance |
| Allocation of species to strategy types (strategy types) | Allocation acc. to existing data base | Spectrum of strategy types | x | x | | - Intensity of usage<br>- Intensity and times of disturbance<br>- Constancy of site conditions<br>- "Stress" (extreme site conditions)<br>- Constancy of population structure |
| Allocation of species to leaf morphology (leaf morphology types) | Allocation acc. to existing data base | Spectrum of leaf morphology types | (x) | x | | - Effect of immissions (uncertain)<br>- Structural diversity |
| Allocation of species to Ecological Pointer Values (ordinal characteristic values determined empirically from 1 - 9) | Allocation acc. to existing data base | - Mean nitrogen figures*<br>- Proportion of leanness pointers | x | | x | - Intensity of usage<br>- Nutrient conditions<br>- Site quality for weak competing species |
| | | - Mean humidity figures*<br>- Proportion of dry/moisture pointers | x | | x | - Changes to soil caused by usage<br>- Moisture conditions<br>- Site quality for weak competing species |

Table 35b Cont'd

| | | | | | | |
|---|---|---|---|---|---|---|
| | | - Mean light figure* | x | x | x | - Intensity of usage (for meadows)<br>- Structural density<br>- Site quality for weak competing species |
| | | - Mean reaction figure*<br><br>** acc. to H Ellenberg* | x | | x | - Changes to soil caused by usage<br>- Soil reaction<br>- Site quality for weak competing species |
| Hemerobiotic values | Allocation acc. to existing data base | - Mean hemerobiotic value<br>- Proportion of pointer plants for low hemerobiotic value | x | | x | - Intensity of usage in general<br>- Site quality for weak competing species |
| Frequency of species in Germany | Allocation acc. to existing data base | - Average occurrence of rare plant species | | | x | - Relevance for floristic species protection |
| Threat | Allocation acc. to existing data base | - Occurrence of Red List species in biotope type | | | x | - Relevance for floristic species protection |
| | | - Average number of Red List species per monitoring area of biotope type | | | x | - Relevance for floristic species protection |

Tab. 35c:Indicator proposals for EAS – structure indicators for GNA (DRÖSCHMEISTER 2001)

**Table 3: Indicators for EAS level II: indicators are listed for the example of higher plants and breeding birds. The indicators are selected so as to be indicative of "Land use intensity", "Diversity" and "Threat" (cf. Table 1).**

| **Higher plants** | **Breeding birds** |
|---|---|
| **Land use intensity** | |
| • Proportion of nitrogen pointers<br>• Proportion of pointer species for moist and wet sites<br>• Proportion of pointer species for dry sites<br>• Proportion of light-loving species<br>• Proportion of acidification pointers<br>• Spectrum of life form types<br>• Spectrum of strategy types<br>• Total cover<br>• Height of population layers<br>• Naturalness | • Number of breeding pairs per area unit<br>• Number of food habitat guilds "Users of lean grassland"<br>• Number of ground-nesting birds<br>• Number of food guilds<br>• Abundance of selected species<br>• Evaluation re specific biotope types:<br>- biotope quality of grassland<br>- biotope quality of farm land<br>- biotope quality of forest |
| **Diversity** | |
| • Number of species per area unit<br>• Evenness<br>• Proportion/number of rare plant species<br>• Number of vegetation layers | • Number of species per area unit<br>• Completeness of ecological guilds?<br>• Number of rare species per area unit |
| **Threat** | |
| • Number of Red List species per plot<br>• Number of endangered plant species (cover) | • Number of Red List species per area unit<br>• Number of breeding pairs of RL species per area unit<br>• Proportion of types with certain dispositions to threat |

Tab. 36a: Summary and evaluation of indicator proposals of the project for the development of parameters and criteria as a basis for evaluation of ecological performance and burdens of agriculture from GEIER et al. (1999)

| Environmental effect areas | Indicator proposal | Effort involved in implementation | Type of requirement |
|---|---|---|---|
| 1. Species and biotope diversity | State: Occurrence and population sizes of target, guide and/or pointer species | high | Development requirement and new surveys necessary |
| | State/Pressure: Share of areas relevant to nature conservation (unused additional biotopes in agricultural areas, contractual nature conservation areas and extensively used semi-natural ecosystems) and their network level | low to medium | Evaluation of existing data / new surveys |
| | Pressure: Farming intensity of agriculture land use (share of intensive agricultural crops in land use, nutrient balances, PPA costs, proportion and use of grassland, heavy livestock) | low to medium | Evaluation of existing data, in some cases development requirement and surveying of new data |
| 2. Natural scenery | | | |
| Naturalness | State: Proportion of land and arrangement of partially natural, semi-natural, partially unnatural biotope types in the landscape | medium to high | Evaluation of existing data and surveying of new data |
| | State: Proportion of land and arrangement of natural-looking landscaping elements in the landscape | medium to high | New surveys |
| Diversity | State: Plot sizes and proportion of land at transitions between individual plots | low to medium | Evaluation of existing data, new surveys in some cases |
| | State: Number of crop species cultivated and their distribution in the agricultural landscape | low to medium | Evaluation of existing data, new surveys in some cases |
| Characteristics | State: Number of characteristic visually attractive landscape areas | high | Development requirement and new surveys |
| Harmony | State: Integration of agricultural farmsteads in the landscape | high | Development requirement and new surveys |

Table 36a Cont'd

| Environmental effect areas | Indicator proposal | Effort involved in implementation | Type of requirement |
|---|---|---|---|
| 3. Soil functions | | | |
| Compaction | State: Use of long-term soil monitoring areas<br>Pressure: Development of simple pressure indicators | high | New survey<br><br>Development requirement in some cases |
| Erosion | Pressure: Nationwide erosion potential assessment (t/ha) on scale of 1:25,000 on ABAG[43] basis. Level of ground cover | medium | In some cases new surveys and development requirement |
| Humus balance | State: Use of long-term soil monitoring areas and investigation of possible degree of regionalisation for existing balancing methods | high | New survey development requirement in some cases |
| Input of toxic substances | Pressure: Regionalised description of heavy metal inputs on basis of use of secondary raw material fertilisers. Extension to include other substances and input volumes is conceivable.<br>State: Results of waterworks regarding contamination of drinking water and groundwater measuring points with nitrate and PPA. PPA levels in surface waters. The results presented by the waterworks should quantify PPA contamination.<br>Pressure: PPA use (quantity), N balance (as per PARCOM), area w/o PPA use, extent of permanently covered borders of bankland. (In addition same indicators in water protection areas.)<br>Regionalised surveying to implement integrated plant protection | low<br><br>low<br><br>low<br><br>high | Evaluation of existing data<br><br>Evaluation of existing data<br><br>New survey in some cases<br><br>Development requirement and new survey |
| 5. Eutrophication | State: Results from surface water and groundwater measuring points for N and P. N depositions excluding non-agricultural shares. Exceeding of critical loads for eutrophication on forest soil.<br>Pressure: Development of a differentiated ammonia emission indicator. Incl. regionalised surveying. Excess N and P (as per PARCOM), extent of permanently covered borders of bankland. | low<br><br>low to high | Evaluation of existing data<br><br>Requirement for development and surveying in some cases |
| 6. Acidification | State: N depositions excluding non-agricultural shares. Exceeding of critical loads for acidification on forest soil.<br>Pressure: Development of a differentiated ammonia emission indicator. Incl. regionalised surveying. | low<br><br>high | Evaluation of existing data<br><br>Requirement for development and surveying in some cases |

[43] *ABAG = General Soil Erosion Levelling (SCHWERTMANN et al., 1987)*

Table 36a Cont'd

| Environmental effect areas | Indicator proposal | Effort involved in implementation | Type of requirement |
|---|---|---|---|
| 7. Greenhouse effect | Pressure: Methane and laughing gas emissions are registered. The BLE[44] should develop the statistics for energy use for the assessment of carbon dioxide emissions. | low | Evaluation of existing data for $CO_2$ |
| 8. Consumption of resources | Pressure: Use of primary energy, phosphate and potassium in commercial fertilisers and feed additives. Nutrient efficiency for N, P and K. Import of feeds. | low | Evaluation of existing data |
| 9. Ecotoxicity | Pressure: Use of PPAs as well as performance enhancers and drugs in animal housing.<br><br>For PPAs the environmental relevance of product use should also be evaluated. | low<br><br>medium | Evaluation of existing data<br><br>Requirement for coordination: evaluation using existing methods |
| 10. Human toxicity | State: Extension of environmental survey (for foodstuffs) and data relating to drinking water quality to include PPA levels<br><br>Inclusion of data from foodstuffs testing agencies | low<br><br>medium | Evaluation of existing data |
| 11. Odour nuisance | State: Examination of indicator for ammonia emissions at regional level via inspections similar to factory odour monitoring | medium | Development requirement in some cases |
| 12. Animal compatibility | Pressure: Ethological evaluation of animal housing (for cows and pigs). The use of existing methods is proposed. A procedure for random sampling should be developed.<br><br>Number of housing systems in poultry housing.<br><br>Indicators for transportation and slaughter: losses during transportation of animals, degree of compliance with regulations governing transportation and slaughter (number of trucks and abattoirs) | high<br><br>low<br><br>low | Development requirement and new surveys<br><br>New surveys in some cases |
| 13. Diversity of crop and useful plants | State: Overview of level of threat and extent of working animals and crop plants<br><br>Response: Measures for their conservation | low<br><br>low | Evaluation of existing data |
| 14. Ozone depletion | Pressure: Level and share of agriculture in emissions of laughing gas | low | Presentation of existing data |
| 15. Use of genetically modified organisms | Pressure and state indicators cannot be presented at current time.<br><br>Monitoring measures can be used as response indicators | <br><br>low | |

[44] *BLE = Federal Agency for Agriculture and Food*

Tab. 36b: Specification of proposals for indicators on biodiversity in agricultural areas in the project for the development of parameters and criteria as a basis for evaluation of ecological performance and burdens of agriculture (GEIER et al. 1999)

**Overview 12: Proposal for indicators and parameters to evaluate biodiversity in agricultural areas**

| Criteria | Indicator |
|---|---|
| Biotope quality of agriculturally productive land | Completeness of species inventory for plant communities of grassland and fields<br>Occurrence and number of rare and/or endangered grassland species or arable weeds and dependent small animal species directly or indirectly dependent on same (grassland: insects such as butterflies, grasshoppers, dragonflies; fields: insects such as ground beetles, hover flies)<br>Occurrence and number of endangered and characteristic higher-order consumers (grassland: whinchat, meadow pipit, lamprey, whitethroat, curlew; fields: partridge, quail, skylark)<br>Population sizes of rare endangered and/or characteristic species |
| Habitat potential on basis of existing land use (incl. unused additional agricultural biotopes) | Proportion of farm/grassland in land use<br>Proportion of extensively used semi-natural ecosystems (e.g. (oligotrophic grassland communities/meadows, litter meadows) or unused intermediate structures (edges of open country, borders of fields, slopes, Ruderal locations, hedges, bushes) in land use and their network level in the agricultural landscape<br>Proportion of contractual nature conservation areas (borders of fields, low mountain range / wetland meadow / litter meadow programme etc.) and proportion of grassland with gen. extensification stipulations for land use |
| Farming intensity of agricultural land use to assess external impairment of populations | Share of intensive agricultural crops (crops involving high levels of fertilisers and plant protective agents such as vegetables, maize, sugar beet, wheat) in land use<br>Type of grassland use (meadows used for haymaking or silage), ration grazing / continuous grazing or rotational land)<br>N/P/K full and/or (partial) balance/hectare of land use<br>PPA intensity (herbicides, e.g. herbicides applied before or after emergence; insecticides, e.g. insecticides sparing beneficial organisms or non-specific insecticides)<br>Heavy livestock /hectare (land use or main fodder area) |

Source: own data

## 13.4 PROGRAMMES OF WORKSHOP

**'Environmental Indicators in National and International Indicator Concepts and Programmes'**

**In context of R&D projects: Development of Environmental Indicators for Monitoring of Genetically Modified Plants (FKZ 299 89 405)**

**Federal Environmental Agency Berlin, Bismarckplatz 1**
**Room 1134**

*Workshop in deutscher Sprache*

***Tuesday, 16.01.01:***

9.00 - 9.10 Welcome and Introduction to Workshop
INGRID NÖH, Federal Environmental Agency

*Discussion chaired by:* DR. BARBARA SCHIEFERSTEIN, Federal Environmental Agency Berlin

9.10 – 10.50 *Topic OECD indicators*

9.10 - 9.25 DR. LUDWIG NELLINGER, Federal Ministry for Food, Agriculture and Forestry
*Development of Agri-environmental Indicators: Requirements, Discussion Status, Prospects*

9.25 - 9.40 ANGELA BERGSCHMIDT, Federal Research Institute for Agriculture
*Indicators for GMP in Selected Theme Areas focusing on 'Farm Management'*

Discussion

10.00 - 10.15 ASTRID THYSSEN, Federal Environment Ministry
*Development and Fundamental Concept for Subarea of Environment of OECD's Agri-environmental Indicators*

10.15 - 10.30 FRANK WETTERICH, Institute for Organic Farming, University of Bonn
*Indicators for National Monitoring of Environmental Impacts of Agricultural Production - Presentation of a Project for Implementation and Extension of OECD's Agri-environmental Indicators at University of Bonn*

| | |
|---|---|
| | Discussion |
| 10.50 - 11.00 | *Coffee / Tea break* |
| 11.00 – 11.30 | FRANK HÖNERBACH, Federal Environmental Agency, Berlin<br>*Status of Development of a Set of Sustainability Indicators in Germany*<br>Discussion |
| 11.30 – 12.00 | JUTTA STADLER, Federal Agency for Nature Conservation, INA Vilm<br>*Description of Discussion of Indicators in the Context of the CBD (Convention on Biological Diversity)*<br>Discussion |
| 12.00 – 12.30 | STEPHAN MOLL, Wuppertal Institute, Wuppertal<br>*Recent Indicator Developments at a European Level*<br>Discussion |
| 12.30 - 13.30 | *Lunch at FEA Canteen* |
| | *Discussion chaired by:* DR. BEATRIX TAPPESER, Institute for Applied Ecology, Freiburg |
| 13.30 – 14.00 | ARMIN BENZLER, Federal Agency for Nature Conservation, Bonn<br>*Structure Indicators in the Framework of Ecological Area Sampling*<br>Discussion |
| 14.00 – 14.30 | KONSTANZE SCHÖNTHALER, Bosch & Partner, Munich<br>*Cause-Effect Hypotheses in the Framework of Ecological Environmental Monitoring – with the Example of the Rhön*<br>Discussion |
| 14.30 – 15.00 | RUTH BRAUNER, Institute for Applied Ecology, Freiburg<br>*Examination of Indicator Concepts and Programmes as regards Use for Monitoring of Genetically Modified Plants*<br>Discussion |
| 15.00 – 15.30 | DR. ANGELIKA HILBECK and MATTHIAS MEIER, EcoStrat GmbH, Zurich<br>*Use of Pesticides - a Possible Indicator for Monitoring Insecticide and Herbicide-Resistant Transgenic Plants*<br>Discussion |
| 15.30 – 15.45 | *Coffee / Tea break* |
| 15.45 | **Final discussion** on experiences and further development of indicator systems presented as well as possibilities for use of existing environmental indicators for monitoring genetically modified organisms. |

End at approx. 17.30

## 13.5 LIST OF ATTENDEES OF WORKSHOP

**'Environmental Indicators in National and International Indicator Concepts and Programmes' 16.01.2001, Federal Environmental Agency Berlin**

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