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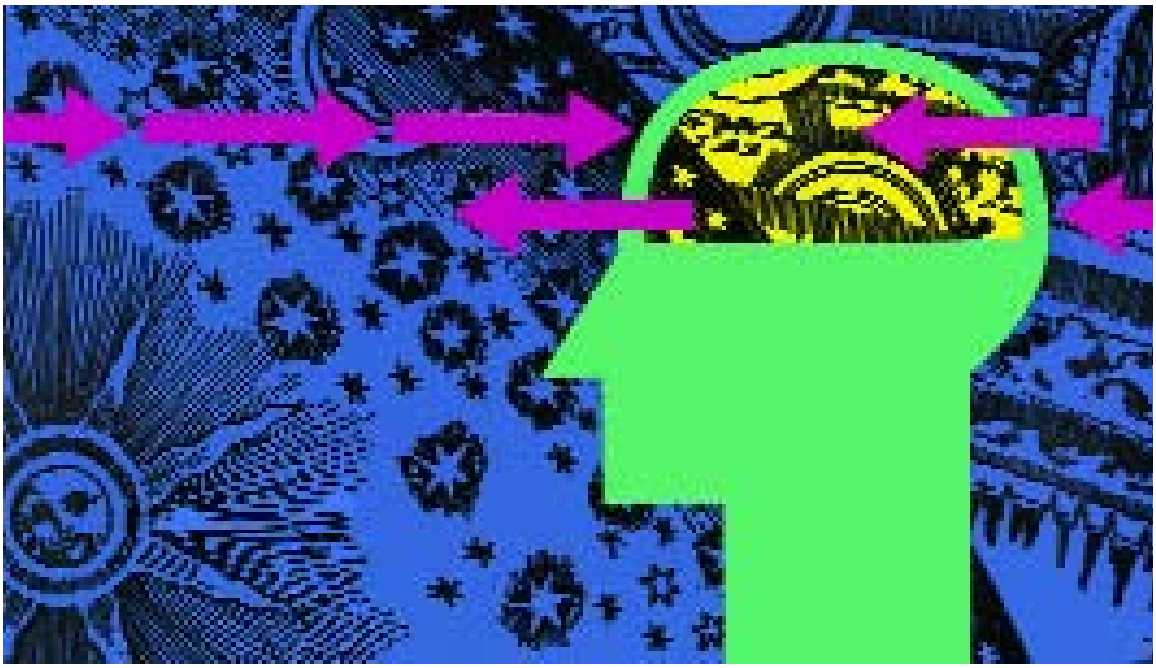
# Visions by Swiss Researchers



## Research on Sustainability and Global Change – Visions in Science Policy by Swiss Researchers

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Forum for Climate and Global Change
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In this document, Swiss researchers put forward their ideas and suggestions for possible action, thereby detailing their approach to research on sustainability and Global Change in a way which will enable them to both assume their social responsibilities and contribute to sustainable development.

This document is primarily intended for decision-makers in government, the private sector and the promotion of research – i.e., for those who define the appropriate boundary conditions – and for the research community, whose increased involvement in the areas mentioned below is essential.

# Contents and Structure

Page

# The Challenge of Achieving a Sustainable World

The natives of Easter Island were unable to fend off the predictalbe collapse of their ecology and culture

Jakob Roggeveen discovered Easter Island in the eastern Pacific in 1722. The barren island, measuring a mere 13 by 13 km, was scarcely able to sustain the roughly 2000 natives. However, there were more than 200 monoliths present, some of them weighing over 80 metric tons, and which could only have been made and transported by a highly organised society. We now know that Polynesians began to settle what was then a lush island rich in flora and fauna between 400 and 700 AD. A cultural peak was reached between 1200 and 1500. Decay set in because of an increase in population followed by overuse and the extinction of most animal and plant species – among them the local trees which must have been used to build ships and transport the statues. The natives were unable to slow the predictable collapse of their ecology and culture by moderating the use of their resources [Imboden, Baccini 1996], [Bahn, Flenley 1992].

Will we be able to make more sustainable use of the island Earth in the Solar System?

We are expecting the Earth to be threatened by billions of people. Soil degradation, for example, has claimed about a third of the Earth's arable land, or a sixth of its total surface. For the first time in the history of our planet, human actions are having an impact on the Earth as a whole [IPCC 1996]. There is no escaping from global environmental problems, which is why they are a unique threat. Whether or not we have caused any specific damage, we are all implicated. Will we be able to make more sustainable use of the island Earth in the Solar System than the natives of Easter Island did of their island?

We are aware of and research is underway into a large number of global environmental changes

A large number of global environmental changes are known [WBGU 1996]. The most important changes in parameters and processes are presented in Fig. 1, where they have been arranged thematically. While some changes are not on a global scale, their occurrence in a large number of regions nevertheless presents a hazard to the Earth as a whole (e.g. soil degradation, loss of biodiversity). Other changes present opportunities for society and the economy (e.g. growing environmental awareness, advances in medicine and environmental technologies).


[Imboden, Baccini 1996] Konzepte für eine nachhaltige Schweiz. Aus: Nachhaltige Entwicklung oder hoher Lebensstandard? Symposium 96, Konferenz der schweizerischen wissenschaftlichen Akademien (CASS). S.Wehowsky, K. Pieren, eds.: pp. 45-82

[Bahn, Flenley 1992] Easter Island, Earth Island, Thames and Hudson Ltd, London, 1992.

[IPCC 1996] IPCC International Panel on Climate Change (1996): Climate Change 1995. The Second Assessment Report of the IPCC. Cambridge University Press, Cambridge, New York, Melbourne.

[WBGU 1996] German Advisory Council on Global Change: Welt im Wandel: Herausforderung für die deutsche Wissenschaft, Annual Report 1996. Springer: Heidelberg, Berlin, New York.

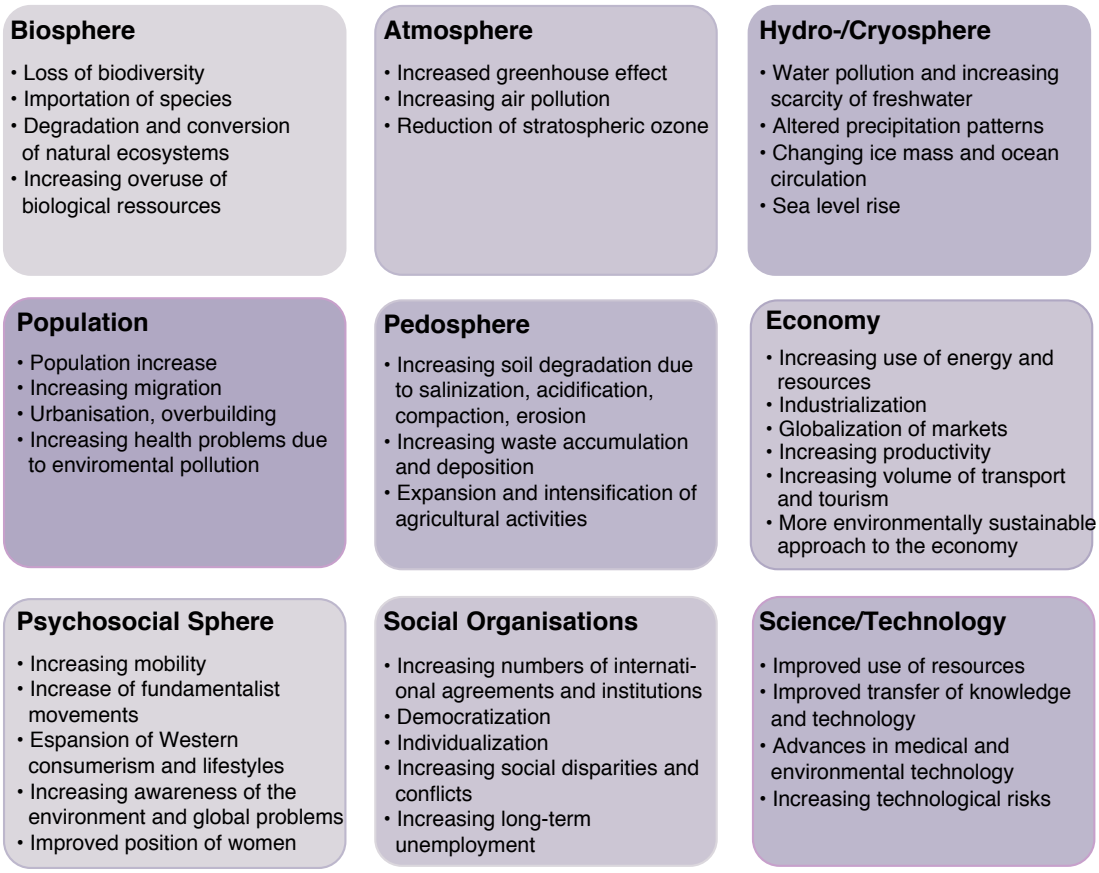


Fig. 1: The most relevant changes of global significance, arranged thematically (modified Table 5 of the WBGU Annual Report 1996, p. 112).

The majority of changes presented in Fig. 1 can be combined in global key problem areas (see list under Thesis 1). These issues are the subject of public debates at an international level.

Certain aspects are already being studied in the large international research programs "World Climate Research Program" (WCRP), "International Geosphere-Biosphere Program" (IGBP), "International Human Dimension Program" (IHDP), and "Diversitas"; their findings have been summarized in synthesis reports (e.g. [IPCC 1996], [Biodiversity 1995], [Ozone 1995]). The gaps in research identified by these programs and synthesis reports, and the relevant Swiss research activities have been compiled in three reports [ProClim- et al. 1995/96]

This report, Visions by Swiss Researchers, is concerned with overarching research issues in order to help bridge the gap between knowledge and action.

[IPCC 1996] cf. reference on p. 5

[Biodiversity 1995] Global Biodiversity Assessment , United Nations Environment Program UNEP, V.H. Heywood, Exec. Editor, R.T. Watson, Chair, 1995.

[Ozone 1995] Scientific Assessment of Ozone Depletion: 1994, WMO Global Ozone Research and Monitoring Project – Report No. 37.

Research on sustainability requires the involvement of humans as instigators, as affected parties and as authorities for assessment and solutions

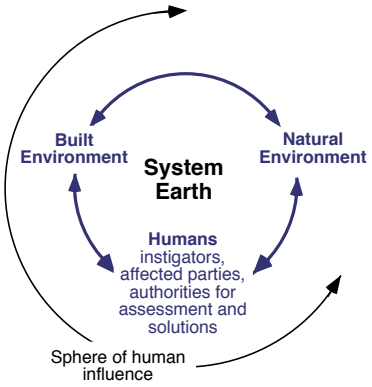


Fig. 2: Humans increasingly alter the system Earth, not just locally, but globally. The syndrome concept (Thesis 5) involves humans in systemic considerations.

To arrive at a deeper understanding of complex interactions, it is of great importance to study the relevant interrelations within any of the key problem areas pertaining to Global Change. However, such more or less isolated, discipline-related research needs to be complemented by studies involving humans in all their various functions (Fig. 2).
It is the overall aim of environmental research to supply knowledge that will facilitate responsible decisions and actions leading to a sustainable use of our habitat.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Ecological, economic and social aspects are rated as equally valuable. [Brundtland 1987].

[ProClim- et al. 1995/96] Research and Monitoring Climate and Global Change in Switzerland:
Part I – Physical Climate System (1995), jointly with the Swiss Commission for Climate and Atmospheric Research (CCA) , A. Arquit Niederberger.
Part II – Biogeochemical Processes (1996), jointly with the National Committee of the International Geosphere Biosphere Program (IGBP), A. Arquit Niederberger.
Part III – Human Dimension (1996), jointly with the National Committee of the International Human Dimension Program (IHDP), M. Jochimsen.

[Brundtland 1987] World Commission on Environment and Development, "Brundtland Report", 1987, and the UN Conference on Environment and Development in Rio in 1992

The necessary development towards sustainability is a challenge for our whole society.

Owing to the natural boundaries of our planet, there is no long-term alternative to a sustainable way of life. The necessary fundamental changes also involve economic opportunities [Schmidheiny 1992; von Weizsäcker 1997]. In its report, "Sustainable Development – Plan of Action for Switzerland" (BUWAL/ FOEFL 1997), the Conseil du développement durable (Swiss Council for Sustainable Development) set initial priorities and made recommendations for the introduction of the necessary changes.

The sustainable development of our economic sphere and of our habitat requires a technical, economic and social reorientation. However, we lack the fundamental scientific knowledge and efficient method required for its implementation. These need to be developed.

Visions by Swiss Researchers is intended to indicate the tasks, approaches and required structural changes to research that will enable researchers to make their contribution. The focus is on previously neglected, but nevertheless vital, issues.

The following text has been divided into 18 numbered Theses, usually followed by a brief Explanation, Recommendations highlighted in blue, and Examples. The Theses define the existing deficits or fields of research requiring expansion. The Recommendations identify the specific ways in which institutions promoting research – as well as the researchers themselves – can encourage desirable developments.

[Schmidheiny 1992] St. Schmidheiny: Changing Course: Global Business Perspective on Development and the Environment. MIT Press, 1992.

[von Weizsäcker 1997] E.U. Von Weizsäcker, A.B. Lovins, L.H. Lovins: Factor Four: Doubling Wealth, Halving Resource Use. Earthscan Publications, 1997.

### Thesis 1

Systems knowledge concerning the key problem areas will contribute to sustainability-oriented actions.

# Introductory Theses

Science, especially in the wealthy countries, must provide sufficient systems knowledge about the key problem areas of Global Change.

Close links with international research programs ensure that Swiss research groups can actively contribute and participate in the latest developments and results in international research.

- Environmental research primarily needs to support projects with a strong link to the key problem areas. These are:
  - climate change
  - land use and soil degradation
  - destruction of ecosystems and loss of biodiversity
  - increasing scarcity and pollution of water, soil and air
  - natural disasters caused by humans
  - population dynamics and disparities in development
  - health risks and food security
  - energy and resource securities
- Switzerland needs to set research priorities within the key problem areas that take into account Swiss interests and existing research capacities.
- A high level of knowledge needs to be reached in all key problem areas by promoting top research in individual groups which is closely linked to large international research programs.

The list of key problem areas is based upon the recommendations of [ASCEND 21] and [WBGU 1996].

Example:

- Being an alpine country, Switzerland has long focused on mountain research and has made basic contributions, e.g. to the key problem areas of 'water use' and 'natural disasters' in hydrology and the study of lakes and rivers, to the key problem areas of 'climate change' and 'soil degradation' in glaciology, paleo and climate research, and in the study of mountain ecosystems.

[ASCEND 21] An Agenda of Science for Environment and Development into the 21st Century (ASCEND 21) Cambridge University Press, 1992.

## Thesis 2

Understanding complex systems requires more than an analysis of the parts.

So far, scientific achievements – primarily in the natural sciences – have mostly been founded upon the analysis of narrowly defined, areas of research. However, work in the environmental, economic and social sciences is almost never concerned with isolated phenomena but with complex processes and relationships. Understanding these complexities requires integrated approaches to research. It is often impossible to make precise predictions concerning the development of coupled systems, and responses to their changes are usually not as precise as those for narrow fields. Nevertheless, studies that take into account such uncertainties are better attuned to reality, even though their results are more difficult to convey. Society has perceptual problems when handling uncertainty; its usual consequence is inaction. One important reason why there have been serious problems of understanding, communication and acceptance between science and society is the insufficient integration of the human and social sciences.

- Understanding coupled systems requires a broad approach to research and education which focuses on interactions, variability, problems of scale and proportions, and system properties, and which will search for explanations in simple sub-systems only if required – rather than starting and remaining there, as has so far too often been the case.
- Research projects increasingly need to focus on human problems of perception and assessment.
- It is necessary to reveal, visualize and – most importantly – to communicate complex and long-term interrelations. Science is required – more urgently than ever before to reveal the complex social and environmental tendencies that are not immediately accessible to our senses.

Examples:

- "Failing to see the forest for the trees" is a popular idiom. Research on forest decline, largely bound to the paradigm of classical, sectoral research only twenty years ago, has often conveyed false images. Investigators believed that they could study reactions "of the forest" in potted seedlings, looking for the one factor causing the damage. They overlooked what evolution research has taught: that for a population to remain viable some (limited) disease needs to exist. It was also research on forest decline, however, that has revealed the limitations of this narrow approach.
- While it is possible to predict the place and time of impact of an object in free fall (in a vacuum), this is not possible for a feather in the air (although the probability that a feather will drop at a given place and at a given time can be calculated) – an unpredictable certainty. Predictions concerning the climate or social developments are a great deal more complex.
- The impact of air pollutants on humans has traditionally been assessed using toxicological methods (exposure of test animals to high doses of toxic

substances). Epidemiological studies, on the other hand, ascertain human health under real conditions. Numerous influences can be studied simultaneously. This approach requires both the cooperation of many disciplines, e.g. medicine, sociology, air pollution control, statistics, etc., and flexible funding structures.

## Thesis 3

Research on sustainability must assume responsibility in social development.

Apart from studying the problems and phenomena of Global Change, science needs to consider specific political, economic and social needs and constraints, and to find and supply adequate responses. In this way, science will bear its part of the social responsibility for the future of humans and the environment.

- Researchers need to accept their share of responsibility in social development by considering the specific needs of politics, economy and society.

Science acts responsibly if and when its voice is heard in the overall social decision-making process, and when it actively promotes the application of research results and insights.

## Thesis 4

The dissociation of instigators and affected parties in space and/or time worsens environmental problems, because this makes it more difficult to ascertain causalities and the impact of individual actions.

To understand the phenomena of Global Change it is essential to consider various spatial and temporal dimensions as well as their interactions. This requires an analysis of both the interactions between short and long-term processes, and the connections between local and global phenomena, and of individuals and society.
Little attention has been paid to the fact that, owing to globalization, social processes are beginning to become completely dissociated from space and time. As a consequence, interactions between individual actions and their impacts can no longer be immediately experienced; hence responsibility is reduced. Non-sustainable actions dissociated from local and/or regional conditions are being encouraged.

- We need to find structures and ways of life that will entail a better integration in space and time of natural and social processes.

Specific measures:

- Demonstrate how human alienation from spatial and temporal relations runs counter to the requirements of sustainability;
- Study possibilities to reconstruct the spatial and temporal relations of sustainability;
- Use striking examples to evoke concern and to direct sustainability-related discussions to local/regional resources or phenomena;
- Analyse interactions between individual and social actions;
- Demonstrate the scope for action and predictable changes based on historical processes.

Examples:

- Study the significance of spatial and temporal relations between actions as a prerequisite for cooperative action and the will to take responsibility;
- What role do temporal aspects (e.g. the interaction between, and superimposition of short and long-term changes) play in natural factors and processes, or in social change?

## Thesis 5

The Syndrome Concept is a suitable research approach to promote sustainability.

As a result of the various interactions between humans and the environment, the causes of Global Change differ from one region to the next. However, the patterns of change are often similar. The 1996 WBGU report calls these patterns 'syndromes' (a set of symptoms indicating disease), and lists a total of 16 syndromes of Global Change#. Examples include:

– Mass tourism syndrome: Development and degradation of natural spaces for recreational purposes;

– Smokestack syndrome: Environmental degradation owing to the widespread, diffuse distribution of mostly persistent substances;

– Suburbia syndrome: Planned expansion of cities and infrastructures with concomitant environmental degradation and loss of nearby recreational areas. This syndrome contrasts with the favela syndrome: uncontrolled urbanization characterized by the growth of slums, and widely differing impacts on humans and the environment compared with the suburbia syndrome.

– Sahel syndrome: Agricultural over-use of marginal locations.

# The syndrome concept is discussed in detail in Annual Report 1996 – Welt im Wandel (pp 109ff) of WBGU (cf. reference on p. 5), where the 16 basic syndromes are also explained (pp. 121ff). Swiss researchers made significant early contributions to the development of the syndrome concept, i.e. in the 'Man and Biosphere Program' (MAB).

The syndrome approach is based on local and regional situations. It therefore has a greater emotional impact on society and specific solutions are easier to find. The syndrome approach involves humans as instigators and affected parties, and as authorities making assessments and supplying solutions, and is always closely linked with natural resources. Syndromes therefore connect the anthroposphere and the biosphere (Fig. 2). They always concern several key problem areas and penetrate various thematically related areas (Fig. 1), such as the economy, the biosphere and society.

The syndrome approach and its comprehensive assessment of a defined system requires interdisciplinary or transdisciplinary research[‡]; it is complementary to the key problem area approach, where the focus is predominantly on disciplinary studies of processes specific to a given problem.

The syndrome approach aims at identifying vicious circles that are likely to worsen a syndrome, and at suggesting measures to break out of them. In this way the causes are addressed, and "end-of-pipe" solutions avoided.

- Predominantly disciplinary research within the key problem areas needs to be complemented by an holistic approach to research which considers regional specificities while studying particularly critical and typical interrelations of causes and effects.
- Of particular relevance is the study of interrelations of causes and effects apparent in numerous regions of the Earth (syndromes). Understanding these will significantly contribute to the solution of one or several global key problems.

Example:

- Large parts of the Swiss Plateau, especially the agglomerations around the larger population centers, are examples of the suburbia syndrome. Comparative studies with other regions, for example, would allow a selective comparison of the role of land planning and the forestry law as instruments for the conservation of recreational areas, and their consideration within a larger context.

[‡] Interdisciplinarity: The joint planning and execution of projects across various disciplines. Key factors are the joint definition and elaboration of the concept, the adoption of findings from other disciplines, and the joint presentation of findings to the public.

Transdisciplinarity: The expansion of the interdisciplinary approach towards participation, e.g. researchers working with affected parties and users (cf. Thesis 16, Participation). This method is expected to lead to new approaches in environmental research as a prerequisite to a holistic assessment of the environment.

## Thesis 6

Early identification and rapid understanding of unexpected environmental change require specialized knowledge in unpredictable areas.

Unexpected environmental change and its causes need to be identified early. The required expertise can only be produced by a worldwide network of curiosity-driven research rather than immediate usefulness. Research needs to be ahead of social needs; it should not be exclusively "reactive" to them. Reactive research carries the risk that it will be difficult to apply its results in rapidly changing systems.

Swiss researchers have a long-standing tradition in gaining new insights in human, natural and technological sciences, which were later to lead to unexpected but significant insights in environmental sciences.

- Basic research, which produces results not yet perceived as "useful", needs to maintain a secure place in the world of research and science.

Example:

- The hole in the ozone layer was discovered by a long-term monitoring program. Rapid interpretation of possible casual chains was feasible thanks to access to a worldwide pool of knowledge in atmospheric chemistry and meteorological processes.
  This knowledge also made it possible to interpret the increase in malignant skin cancers (melanomas) and to suggest protective measures.

# The Contribution of Science to Sustainability

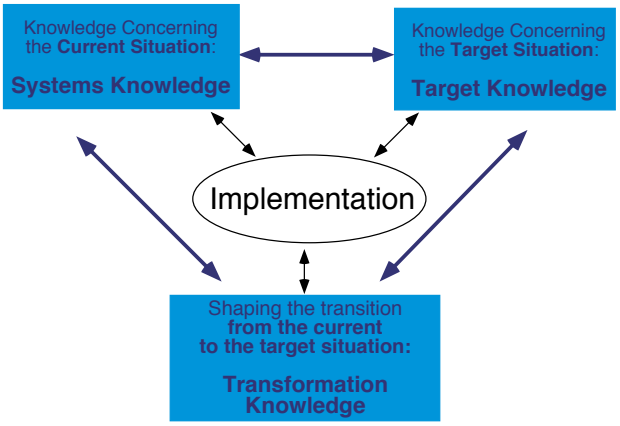


Fig. 3: The contribution of science to sustainability is based upon three types of knowledge

## Thesis 7

Sustainable development is a task to be resolved by all society, and science should supply the systems knowledge, target knowledge and transformation knowledge.

The long-term protection of our natural resources (soil, air, water, biological diversity), cultural wealth and functioning social structures is essential for the conservation of a healthy and productive environment for coming generations. The transition to sustainable development is a challenge for all society. Science needs to supply fundamental knowledge concerning natural and social factors and processes, and their connections. Moreover, science needs to stimulate public discussion on the value and targets of future development. To this end, three types of knowledge are required (Fig. 3):

1. Knowledge of the current status: Systems knowledge of structures and processes, variabilities, etc..
2. Knowledge concerning that which may and may not be: Target knowledge, i.e. the evaluation of current situations, prognoses and scenarios; providing critical levels, "guiding ideas", ethical boundry conditions, visions.
3. Knowledge on how to make the transition from the current to the target situation: Transformation knowledge, i.e. gaining knowledge on how to shape and implement the transition from the existing to the target situation.

- Future environmental and sustainability research needs to place significantly greater emphasis on target and transformation knowledge as well as systems knowledge in the human and social sciences.

## Systems Knowledge

### Thesis 8

Research needs to place greater emphasis on long-term observatios of both natural and man-made systems.

Long-term system observations are essential to be able to assess the causes and the extent of change, as well as the impact of remedial measures.

Paleodata are equally essential, as short-term observations of current environmental change do not enable the evaluation of natural variability; nor do they allow any insights into the frequency of extreme events.

- Incentives, institutions and organizational and structural facilities need to be created which will enable long-term system observations.
- The collection and treatment of paleodata need to be promoted.
- Research needs to be given free access to existing long-term data sets. Governmental and research institutions need to make their data accessible.

Examples:

- Recording the natural variability of the climate system and its changes in the past, making use of the latest diagnostic methods, such as isotope monitoring networks;
- Development of global (but regionally sensitive) instruments that periodically record the factors that determine the behaviour of humans and of institutions (e.g. perceptions, ideas, motivation etc).
- Continuous, worldwide observation of environment-related health problems or slow physiological changes, and defining indicators for morbidity.

### Thesis 9

Our understanding of processes and interrelations, in particular interactions between natural and man-made systems, needs to be improved.

In recent years, much knowledge has been gained about individual systems, but comparatively little is known concerning their interactions. The need for more knowledge about the interactions between social and natural systems is especially great.

- The methodology of inter- and transdisciplinary research into patterns of interaction between natural and man-made systems needs to be developed further, specifically in the following two directions:
  (a) Abstraction: Definition of adequately differentiated patterns of interaction by means of system approaches, modeling, etc. (further development of the syndrome concept)
  (b) Concretization: Problem and solution-oriented research of specific patterns of interaction (case studies, impact assessments, especially historical and intercultural)

Examples:

- Studying the interrelation between agricultural uses in a specific socioeconomic setting and the loss or conservation of biodiversity;
- Studying the interrelations between various global key problem areas (e.g. soil degradation, loss of biodiversity, scarcity of freshwater) as well as their interrelatedness with human factors, such as population fluctuations, disparities in development, poverty, and institutional differences.

## Thesis 10

The study of natural resources and potentials for development needs to be complemented by the integration of human and social resources.

Sustainable development increasingly needs to take into account human and social resources (e.g. human capital, social and cultural security, cultural heritage), as – alongside the natural resources – they have a significant impact on the potential for development and the stability of societies as well as the use of natural resources.

- Research on cultural, social and human resources relevant to sustainable development needs to be increased.

Examples:

- Studying the dynamics of life-styles, consumer and investment behaviors. Detecting opportunities to direct learning processes towards sustainable life-styles.
- Promotion of knowledge concerning the interrelations between demographic, cultural and economic development;
- Improvement and transfer of knowledge concerning the interrelatedness of a healthy environment, healthy nutrition, poverty and the state of health of the population.

## Target Knowledge / Knowledge Concerning Assessments

### Thesis 11

To implement the principle of sustainability, risk evaluation and risk assessment are of utmost importance.

Largely unknown risks exist in connection with irreversible changes in ecosystems (loss of biodiversity, soil degradation, changing vegetation zones), in the climate system (ocean and atmospheric circulation, atmospheric chemistry), and in the socioeconomic system (land use, migration, habitability, health, economic growth).

Knowledge useful in assessing risks will become available when scientists study the critical levels and constraints in individual systems, which factors influence them, and how they can be determined. In cases where critical levels cannot be clearly quantified, mechanisms and/or processes need to be developed to allow expert judgment to bear on the decision-making process.

- Risk evaluation and assessment need to become two of the focal points of environmental and sustainability research. These are essential for decisions being made with incomplete knowledge.

Examples:

- Development of risk assessment strategies for the public health sector, based on changes in the ecosystem;
- Risk assessment of the potential effects of toxic substances which may alter critical functions in organisms, especially with regard to their long-term effects;
- Comprehensive assessment of the effects of local climate change on local economic systems.

### Thesis 12

To achieve sustainable development, knowledge is required which will enable the formulation of specific social and economic targets.

In order to evaluate and assess implementation instruments for sustainability, knowledge and targets are required on how best to integrate nature (resources) and living conditions (including immaterial values) into any economic calculations. Studies need to be made of how to make the best use of the flow of resources. Energy research, and in particular the evaluation of various fuels and their cycles, will play a key role.

Quantitative and qualitative target knowledge can only be successfully gained through close cooperation between decision-makers, interest groups and researchers (cf. Thesis 16, Participation).

- Knowledge concerning production methods which are ecologically acceptable, non-polluting and do not waste resources needs to be summarized.
- Indicators are needed to assess and monitor sustainability. Research must be performed to assess which natural and social parameters may vary or need to be changed within what limits in order to achieve sustainability. These studies must include international knowledge.

Examples:

- What $CO_2$ emissions can Switzerland, as an industrial nation, responsibly allow itself, taking into consideration the interactions of social and global political processes (equity)?
- Any guidelines on sustainable use of resources also need to take into consideration the food sector. Production methods and transportation routes need to be assessed.
- Land exhaustion and soil erosion run counter to any sustainable development. Social concepts need to consider the significance of such irreversible changes, as well as the capital of natural resources.

## Thesis 13

Both the concept of sustainability and the image of humans and their position in nature require ethical clarification.

Preliminary remark: Among other things, ethics should ask uncomfortable questions and critically examine fundamental problems, as well as the prerequisites for the solution of social problems. One aspect of such examinations would therefore be the conceptual and terminological/ideological foundations required by social and environmental policy.

Any concept of sustainability implies a certain understanding of nature and certain convictions regarding the position of humans, both within and as part of nature. Only when the philosophical and anthropological requirements of sustainability have been clarified can they be implemented in a meaningful way.

The way humans treat nature and non-renewable resources is always deeply influenced by cultural and religious traditions and leanings. If the religious dimension of human existence – including the explicit rejection of or indifference to religion – is disregarded, it becomes difficult to realize and understand human motivations and predispositions for action.

- The conditions for the concepts of sustainability require thorough philosophical and theological examination and clarification.

At least three things can be expected from such clarifications:
– a broader and deeper interdisciplinary discussion of fundamental ideas;
– materially improved quality of environmental policy recommendations;
– greater clarity of underlying sociological and sociopolitical assumptions and goals.

## Transformation knowledge: Shaping the transition from the current to the target situation

### Thesis 14

We require knowledge about socioeconomic and institutional prerequisites likely to advance sustainable development.

Ecological and social costs are not currently reflected in the prices for goods and services. Existing incentives, therefore, encourage individuals and collectives to a one-sided valuing of short-term, private, material gains. This also leads to constraints and social conflicts which restrict the scope for actions that will not harm the environment.

Certain starting-points, instruments and strategies suitable to begin a reorientation have been known for some time; implementation has been attempted here and there. Examples include: legal and economic instruments (e.g. ecological tax reform), new forms of conflict management and reconciliation, and new political instruments. Such experiments, however, have all too rarely been scientifically and systematically studied and evaluated. We therefore lack generally applicable knowledge about the implementation of such concepts.
Examples:

Science therefore needs to:

- study the political and socioeconomic institutions and general conditions as well as the interest and power structures which may be able to transform existing structures;
- draw up scenarios, options and instruments which may produce a reorientation in socioeconomic structures.

- What political, economic, technological and social conditions are required to improve the social acceptance of sustainable products and production methods, and hence lead to their greater presence in innovative processes?
- How can we achieve the necessary technological, economic and social innovations and changes in order to reduce current consumption of primary energy by half (Europe), or six-fold (Canada)?
- How can the problem of equitable (inter- and intragenerational) distribution of access to resources, as well as of costs and effects of economic development, be resolved?
- Science needs to demonstrate the reassessment of the economy by supplanting the indicator "gross national product" by that of "ecological national product".

# Turning Knowledge Into Action: What science needs to do

In order to assess the extent to which knowledge is relevant to action, both knowledge and action need to be viewed in a wider perspective. Knowledge is not usually directly translated into action; human actions are not directed by knowledge alone but are also influenced by perceptions, attitudes and conditions (e.g. basic needs, cultural diversity and tradition, state of technology, access to resources, balance of power, institutional restrictions, ethics, social networks, ecological dynamics, etc.) (Fig. 4). Only if scientists are prepared to reflect on and to study these complex interrelations will they be able to conduct research relevant to practice, and make a contribution towards the solution and prevention of environmental problems. Moreover, research is also required into why and how certain instruments applying scientific knowledge are successful and why others are not. This is the only way to improve existing instruments and develop new ones.

However, knowledge is not the most critical factor determining the solution of such problems. It will not suffice to meet the challenges of today simply by amassing more knowledge.

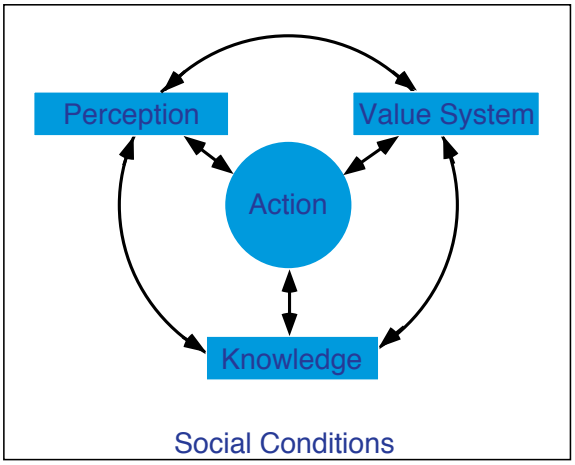


Fig. 4: Knowledge alone does not lead to action, and action is not directed by knowledge alone.

## Thesis 15

Environmental research needs to study the interrelatedness of knowledge and action, and to make a greater contribution to the application of knowledge.

Research has generated a great deal of knowledge concerning processes and problems, but has shown little concern about how – and how efficiently – this knowledge is being integrated into problem-solving actions.
The great distance between knowledge generated by the technical, natural, social and human sciences and its application has not been taken seriously enough as an autonomous and relevant science-related and social issue.
A more comprehensive view of individual systems, in the sense of the syndro-

- The selection of research projects needs to place greater emphasis on their suitability to and orientation towards application.
- Improved cooperation between universities and funding institutions with research and development activities pursued in the private sector, in government as well as state and private institutions, is required.
- Improved structural and personal resources to support application- driven research, e.g. the research/society interface, transfer of knowledge, etc., are required.
- Increased research into the application and transfer of knowledge, as well as their impediments, is required.

me approach (Thesis 5), could improve the application of scientific results. However, this would require the involvement of all the stakeholders, as set forth in the following thesis.

## Thesis 16

The public needs to be much more involved in the planning and realization of research projects – participation means ongoing implementation.

The participatory approach will contribute to:

- a coherent and comprehensive consideration of environmental problems in their socioeconomic and sociocultural context;
- early identification of risks and conflicts of interest, which can therefore be controlled more successfully;
- researchers focusing on issues high on the decision-makers' list of priorities. Consequently, better and more consistent use will be made of available knowledge;
- better implementation of research results, since target groups will be involved and more prepared to support solutions;
- the identification of the largest possible range of options for action.

Participatory approaches are especially relevant for applied research; however, basic research will also be able to benefit from these learning processes and an enhanced acceptance of research. Participation complements expert-centered governmental advisory groups and strengthens the democratic decision-making process, which is an important principle of sustainability.

- The involvement of decision-makers (from the government, the administration, the private sector) and non-governmental organisations in the planning and realization of research projects needs to be increased in order for implementation to begin early.
- Participatory approaches need to be much more forcefully applied in the study of global and local environmental problems.

Examples:

- Soil degradation has damaged about one third of the arable land on Earth, and is the major cause of desertification. To avoid soil degradation a better understanding of the motives and reasons for soil misuse is required. It is important to take into account the diversity of instigators and their widely differing contributions. Only if the public is involved can such knowledge be generated and integrated successfully into context-related, effective concepts and strategies for sustainable land-use.
- Numerous technical solutions which minimize health hazards through environmental pollution and change have become firmly established, and have been tested for effectiveness. However, these solutions are often insufficiently adapted to and coordinated with varying sociocultural conditions and locally generated proposals for solutions.

## Thesis 17

Universities and institutions promoting research need to adapt their structures for sustainability research to become inter- or transdisciplinary.

The often purely reductionist study of environmental problems in separate academic disciplines is increasingly encountering its limitations (cf. Thesis 2). Current research structures therefore share some of the responsibility for non-sustainable development.

The inter- or transdisciplinary approach (cf. Thesis 5), as postulated by the syndrome concept, promotes synergies and communication across disciplinary boundaries and between researchers, decision-makers and affected parties. Moreover, it encourages the involvement of important instigators and affected parties in all aspects of research.

Science policy/Promotion of research:

- Institutions promoting research need to reorient themselves to encourage more inter- and transdisciplinary proposals for research projects. This will require flexible funding structures.
- "Quality" criteria for concerning inter- and transdisciplinary research need to be elaborated jointly by institutions promoting research and the researchers themselves.

However, there are also limits to interdisciplinarity. In applied research, the whole can only be approximated by means of several complementary models. Undergraduate and graduate studies need to be structured such that graduates consciously integrate the idea of sustainability into their actions, and play an active role in changing social values.

Examples:

- University structures/education:
- Traditional structures, e.g. individual disciplines, should be expanded by means of a matrix structure (Fig. 5) to promote collective learning processes and holistic and interdisciplinary thinking. This would also promote more flexible, interdisciplinary curricula.
- Disciplinary education needs to teach both the knowledge of methodologies for subsystems and for inter- and transdisciplinary research cooperation.
- A new generation of teachers needs to be educated who will teach comprehensive knowledge at all levels of the educational system.

- The Federal Institute of Technology in Zürich has already adopted a matrix model for its internal organizational structure [ETHZ 1996]. Examples of integrative approaches can be found in the fields of waste management and domestic waste water, as well as – in a more generalized form – in the field of sustainable use of renewable natural resources.
- The Priority Program Environment in part successfully utilizes interdisciplinary approaches. It has been shown that questions and projects need to be defined and elaborated jointly if integration adequate to the problem is to be achieved.
- POLLUMET is an example for a flexible funding solution: alongside funding for basic research, contributions were also made by the Swiss Confederation, Swiss cantons and the private sector, as well as by projects located in other countries.

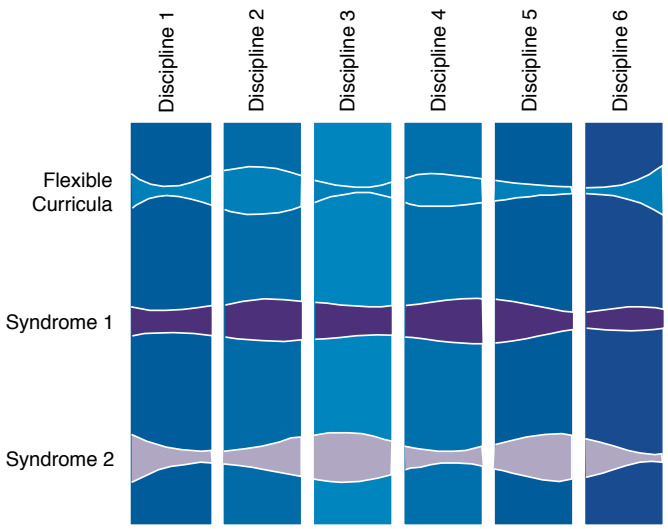


Fig. 5: Expansion of vertical, disciplinary education and research by creating more flexible curricula and inter as well as transdisciplinary project across the disciplines, involving these to a greater or lesser extent (cf. syndrome approach, Thesis 5).

## Thesis 18

Transnational environmental pollution and the increasing globalization of society create problems which increasingly require international cooperation.

One of the characteristics of international environmental problems is their transnational impact (e.g., $CO_2$, CFC, etc.), or the global impact of regional waste accumulation (e.g., toxic waste).

At the Rio Earth Summit (1992) a massive increase of research capacities in poorer countries and the international collaboration over research policies were agreed upon. Agreement was also reached to improve integration of local and national research and application experiences in international cooperation (transfer of knowledge, model solutions, model function).

In international research cooperation, especially in north-south partnerships, the challenges are:

- unequal distribution of global power, knowledge and income;
- regional differences in standards of and potentials for development;
- disparate national interests.

Research into the political contexts:

Alongside the creation of supranational organizations – or the endowment of existing organizations, such as the World Bank, with new competences – voluntary, bilateral cooperation has been gaining significance. Among other things, it can be promoted by:

- two-way transfer of knowledge,
- dismantling of economic barriers, i.e. equitable participation in world trade,
- Joint Implementation,
- introduction of ecological mechanisms into economic structures (e.g., internationally tradeable environment certificates).

Research tasks:

- to study the opportunities and impact of globalization on ecological and socioeconomic structures and processes;
- to elaborate structures for the promotion of international cooperation in solving global problems;
- to improve the integration of interdisciplinary, international programs into the structures of research promotion;
- to study the effectiveness and impact of political conditions.

Examples:

- Participation in the creation of an international network for specific environmental issues (syndromes);
- Assessment of the impact of international instruments intended to improve sustainable development, especially in local contexts;
- Special support of research partnerships with economically limited research institutions.

# Conclusion

These 18 theses outline the extent and the principles according to which Swiss researchers within the international community intend to assume their responsibility in our society. They wish to respond to the challenges of global and regional climate and environmental change with long-term, action-driven, strategic knowledge. To generate knowledge in this way, it is necessary to relate information across the boundaries of scientific disciplines, recombining it in new contexts. Hence, suitable methods of system analysis, creating models, and participatory research need to be systematically applied at the same time as new research concepts are being developed.

Three central categories of knowledge have been identified. While each has its own tradition, the challenge is to fine-tune these three sub-sectors for a problem-oriented approach. At issue, therefore, is not only the continuation of internationally accepted research but the setting of new standards for the generation of knowledge, and the creation of incentives to acquire new scientific qualifications. The new standards are to distinguish long-term, strategic knowledge that transcends the boundaries of scientific disciplines. The new qualifications are to distinguish internationally successful scientists who are capable of producing answers to the key problem areas which are oriented towards action and control, and who focus upon system interrelations.

In order to reach these goals, it is necessary to create structures and incentives which will benefit these new standards and qualifications. Additionally, research funding needs to be adapted in such a way that the linking of national and international projects is encouraged. Funding may originate from the most disparate sources, be it for basic research, national or EU research programs, the cantons, or the private sector.

# How Were These Visions created? What Next?

Based on the so-called "Böhlen Report" [Böhlen 1995], the interdepartmental Working Group on Science (IDA-WI) recommended the creation of a Committee on "Strategies for Environmental Research and Sustainable Development in Switzerland". The Federal Department of the Interior adopted this recommendation, entrusting the Swiss Science Council in spring of 1996 with its implementation. By the end of 1997, the Committee will draw up a concept for environmental research, making recommendations on whether and how the research activities of the two large national environmental research programs are to be continued – the National Research Program "Climate and Natural Hazards", NRP 31, will be completed by the end of 1997; the second stage of the "Priority Program Environment" will come to term at the end of 1999.

The present report, "Research on Sustainability and Global Change –Visions in Science Policy by Swiss Researchers", is intended to enliven the debate on research policy with the opinion from the bottom – the researchers themselves.

The past two years have seen the publication of three reports on the state of

## Identification of research gaps and activities

research in Switzerland on Climate and Global Change [ProClim- et al. 1995/96], published jointly by ProClim- and the respective agencies of the Swiss Academies. Each report focuses on the physical climate system, on biogeochemical processes, and on the human dimension of Global Change. These three status reports complement Visions by Swiss Researchers by presenting specific gaps in international research, as well as in Swiss research activities.

## Visions by Swiss Researchers – A contribution to research policy

Based on these reports, from fall 1996 through spring 1997, the Conference of the Swiss Academies (CASS) and ProClim-, supported by the research community, carried out an analysis of medium-term research needs, resulting in Visions by Swiss Researchers. This document was created in a four-stage iterative process (Fig. 6), a project managed by ProClim-.

In the first stage CASS called upon researchers to present their ideas concerning research issues in the areas of sustainability and Global Change which are expected to dominate the coming decades.

[Böhlen 1995] B. Böhlen: Strategie Umweltforschung in der Schweiz, Vorschläge und Empfehlungen. BUWAL 1995.

[ProClim- et al. 1995/96] cf. reference on p. 7

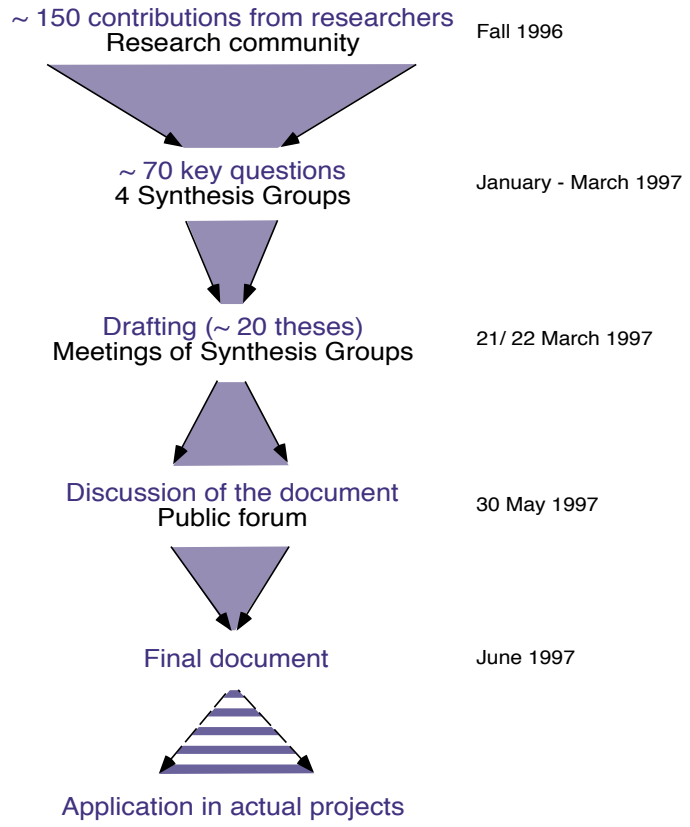


Fig. 6: Iterative process for the drafting of Visions by Swiss Researchers

The second stage was a discussion of some 150 contributions in four Synthesis Groups consisting of experts from various disciplines (natural, human, social, technical sciences, administration, private sector). The Synthesis Groups focused on the areas "Land use and biodiversity", "Climate and human impact", "Pollutants, the environment and public health", "Population dynamics, food security and sustainable use of resources". The result of this work was a set of some 70 key questions.
In addition to the researchers' contributions and the three ProClim- reports, "Research and Monitoring of Climate and Global Change in Switzerland", the book "Welt im Wandel: Herausforderung für die deutsche Wissenschaft" by the German Advisory Council on Global Change [WBGU 1996], provided a valuable basis for this document.

The third stage was a two-day closed meeting, during which the members of the Synthesis Groups edited the manuscripts used for the draft of the present document. The fourth and final stage was a public forum where the document was discussed by interested researchers prior to the final editing.

[WBGU 1996] cf. reference on p. 5

What next?

## The conception of coordinated transdisciplinary projects based on Visions by Swiss Researchers

The publication of Visions by Swiss Researchers is not the end of this process. It needs to be followed up by actual planning of coordinated inter- and transdisciplinary projects. This will require a great deal of time since mutual understanding among the parties involved will first need to be achieved – even though they share thematic interests. The recommendations presented above should serve as a basis for this process.

It would be in the sense of Visions to focus efforts on the creation of open projects and coordinating structures ("competence networks") characterized by common thematic foci (e.g. on one syndrome), and cooperation of various national and international groups. Such competence networks would encourage the internalization of these issues and would promote participatory approaches.
ProClim- will actively support the initiation of inter- and transdisciplinary projects, both at the national and at the international levels.

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