A Regional Concept of Qualitative Growth and Sustainability

A Pilot Project for the German State of Baden-Württemberg

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Discussion Paper

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The Center of Technology Assessment in Baden-Württemberg publishes essays and presentations of its scientists as well as selected interim reports and end reports of research projects under the title 'Center work reports' which come out in no particular order. This series wants to give the interested experts and members of public the opportunity to follow the Center's work with criticism and appreciation. All comments and ideas in connection with all work published are welcome.

Contents

I. Summary of Discussion Paper

1. Theoretical Concept: Principles of Sustainable Development

a) *Acknowledgment of absolute limits with respect to the carrying capacity of the earth:* Although utilization rates of the carrying capacity for human purposes depends on the productivity of the economy, the world's resources are limited and critical loads have already been reached in many parts of the world. Future economic activities must use natural resources more efficiently rather than expanding further the share of resources that humanity uses.

b) *Limits of substitution of artificial for natural capital:* Traditional economic theory suggests that elements of the artificial capital can be substituted for natural resources. Prices constitute the exchange rate between elements of the natural versus elements of the artificial capital. Many natural resources are irreversibly lost, however, when used for economic purposes. At the same time, artificial substitutes provide only insufficient compensation for these losses. It is therefore reasonable to protect these resources and take them out of the market process.

c) *Focus on resilience of anthropogenic ecosystems:* Renewable resources appear to be self-sustaining over time since they regenerate themselves. Their regeneration capacity depends, however, on the resilience of the system to cope with unexpected events and external constraints. Monocultures or ecosystems that are designed to produce a maximum yield demonstrate a high degree of vulnerability vis-a-vis natural or human induced constraints. A sustainable economy needs to assess the resilience of economic activities and incorporate resilient strategies into its decision making framework.

d) *Incorporation of social and cultural values into environmental policies:* In addition to the ecological and economic consequences associated with human's use of the environment, societies link social and cultural values to nature and its inhabitants. Typical examples are the protection of animals and plants beyond the economic utility and the aesthetic pleasure derived from preserving biodiversity (even if it is done far away from one's own region) are typical examples. Any concept of sustainability needs to acknowledge the intrinsic value and benefits provided by

nature, and design policies that are in line with the predominating social preferences for environmental changes.

2. Definition of Sustainability

Sustainability denotes a process by which the capital of natural resources is preserved to the extent that the quality of life available for future generations will not be inferior to the quality of life of the present generation.

There are three elements that are central to this understanding of sustainability: an increase of resource productivity, preservation of natural cycles that enable human and other species to survive and extension of the present level of welfare to future generations. Sustainability is defined strictly as an external constraint for human action, dictated neither by economics nor by ecology. Rather it is an ethical norm imposed on human activities for ensuring inter-generational equity.

Some of the terms in this definition require explanation.

- At this point in human history, with almost six billion people on earth, it is unrealistic to assume that humans can live off the interest on natural capital alone. The objective is therefore to stretch the natural resource base and use natural resources more efficiently. Strategies for more efficient resource use are increased substitution of artificial capital for natural resources, the improvement of the productivity of each element of natural capital, the closing of material cycles, and an educational process to direct human preferences to products and goods requiring less environmental pollution or resource input.

- The needs of future societies are unknown for the present generation. It would be futile to extrapolate today's needs into the future. At the same time, however, there is no social theory that could predict with any degree of accuracy the needs and values of future generations. In this dilemma, the project team has taken refuge to the somehow vague term "quality of life". Future generations should have the option of a quality of life at least as high as today's generation. The enjoyment and experience of quality depends on the availability of social and natural resources. A sustainable development path should provide these generations with the same conditions for developing and using such resources as the present generations has

had. All physical, economic, and social prerequisites leading to a certain level of quality of life should be available to future generations, no matter whether they will need or value them at all. There is no other reasonable measure for sustainability as preservation of the present conditions for quality of life. Such conditions include the availability of natural resources.

3. Definition of Qualitative Growth

Qualitative growth is a process during which resource productivity increases continuously with economic welfare.

Qualitative growth is characterized by a further increase, or at least by stability in human welfare, although the resource use and environmental damage decrease. This is possible because knowledge and immaterial services are substituted for material resources and manual work. The project distinguishes among three stages of qualitative growth:

- In Stage I, qualitative growth means a continuous decrease in resource use per unit of domestic national product. This first stage has already been accomplished in many sectors of the economy.

- In Stage II, qualitative growth means a continuous decrease in resource use per capita. The second stage has been accomplished in only a few areas of resource use and pollution abatement.

- In Stage III, qualitative growth means a continuous decrease in resource use per national economy. Stages II and III are identical for societies without population growth.

4. Guidelines for Sustainable Development and Qualitative Growth in Baden-Württemberg

a) *Energy resources that are non-renewable can only be used until the sum of resources to be exploited in a period exceeds the sum of the reserves found in that period or the resources known to be forthcoming in some economically utilizable form through technological progress.* The time span for synchronizing exploitation with renewal of supply should be short enough to allow for fast corrective action as soon as a gap opens

up between the two. Once that point is reached, society should promote substitution of other energy resources for the non-renewables by means of taxation, other price mechanisms, or - if those don't work - direct governmental interventions.

b) *Raw materials of the non-renewable type which are not used for conversion into energy, can only be used as long as they can be recycled without prohibitive economic expenditure - or, to put it in other words, as long as the raw materials can be re-used in a cycle that is at least partly closed.* Of course, recycling too is subject to the law of entropy, and needs more energy the more often one tries to recycle them. Recycling forever is therefore out of the question. But that was never the aim of qualitative growth. The real aim is to stretch resources, and not recycle them forever.

c) *Raw materials of the renewable type, and the media needed to keep them growing, can only be used at a rate which allows a balance to come about between consumption and regeneration by means of limiting human intervention (such as intentional intervention to boost the production of renewable resources).* The limit for such intervention depends on the regeneration capability and the resilience of the ecosystems concerned. Given all the necessary interventions in the environment, society's aim should be to preserve the function of soil, water and biotopes in such a way that humans will be able to gather long-term harvests even under unfavorable conditions and unexpected surprises.

d) *Environmental damage is to be avoided wherever it clearly impairs human health or preservation of naturally controlled systems (the continuity of vital cycles such as water, carbon, nitrogen, etc.).* n simple terms: any action that has a high probability of lethal or other serious injury to future generations has to be prohibited now. The question of course arises as to the degree of probability beyond which such a prohibition should come into effect. Since all formal methods to establish objective criteria for determining acceptability criteria for risks, we recommend public debates and discourse as the best solution, during which representatives of today's generation, in the interest of future generations, set limits not to be violated even for attractive economic gain.

e) *All other interventions in nature not explicitly covered under Rules a - d above can be left to market forces under the condition that, wherever external effects exist, collective strategies should be permitted to control prices through taxation or to restrict quantities of undesirable environmental products (pollution, wastes) through issuing certificates in alignment with other market forces.* Such a market strategy presumes that the external

effects of production and consumption have been internalized. Besides internalization, a market-type solution to environmental problems also means using modest discount rates for future environmental damages, i.e. negative interest on environmental consequences in the future.

f) *Although interventions in the environment should be accountable in terms of so much damage on the one hand and so much benefit on the other, every society or group of nations should also be free to attach immanent values to certain exceptional elements in nature that its members can agreed upon, even if they show a negative cost/benefit ratio.* For instance, there might be ethical reasons for protecting certain animals or for keeping animals in more humane living conditions which do not yield a monetary benefit, but can be justified out of a respect for the Creation.

5. Reasons for a Regional Focus on Sustainability

The prerequisites for sustainable development can be operationalized effectively only on the regional level. Although the principles of sustainable development are supposed to apply to all, it is necessary to observe the particularities and requirements of the states and regions concerned when implementing principles of sustainability and turning them into agreements and laws. Realistic approaches to sustainable development must be based on factors such as population density, environmental conditions, the level of education and development attained, economic structure and cultural identity. To be realistic, approaches must develop regionally adapted strategies that both make good ecological sense, and can be put into practice politically and economically under the given conditions.

Given today's worldwide trade links, each region depends on imports from elsewhere, and exports its own products and services (including external effects such as emissions) to other regions. For this reason, even with a regional approach to sustainability, one has to take a closer look at the unit's trade balance. Otherwise the criticism would be justifiable that limiting oneself to a particular region was promoting the formation of an ecological island at the ecological cost of other regions. For these reasons, the call for regional sustainability includes making the region commit itself to demand only such products from other regions as ones that satisfy the internal rules of sustainability. Such a regional trade balance based on ecological criteria has a lot of advantages:

- The regional focus is maintained. The advantages of working with manageable quantities remain even after accounting for imports and exports.

- Each material flow is investigated individually, taking into account the specific conditions in the particular country of origin or reception.

- Most of the authorities responsible for import and export reside in the region itself (expect for ones administering generally applicable laws of fair competition).

- Concentrating on regional imports and exports makes it easier to rank categories in which to implement the requirements for sustainability.

- In applying the principles of sustainability to imports and exports, one has a lot of instruments available that are hardly available on a global level. In addition to regulatory measures by the state, there are also voluntary commitments by individual importers or exporters, bilateral agreements among producers and buyers and the use of labels for imported sustainable products.

- If one can assume that the demand for most of the products coming from developing countries is relatively inelastic (for untreated raw materials and agricultural products especially), i.e. a slight price increase by all sellers does not cause a significant drop in demand, then converting to sustainable products would not mean loss for the countries of origin for the population living there today.

- A decision to buy only sustainable products also dampens the criticism that industrialized countries are acting in an eco-imperialistic fashion. Firstly, such a decision binds both sides equally: imports and exports must satisfy the principle of sustainability. Secondly, any buyer is free to determine quality standards for products that s/he buys.

- The forces of the market and free world trade remain hardly affected at all by these rules. International competition for favorable production conditions remains with the approach we are promoting - unlike subsidies, which almost always cause inefficient solutions. The market can develop, but only on the condition that competition take place among sustainable products.

II. Summary of the Sustainability Project by the Center of Technology Assessment in Baden-Württemberg:

1. Title of the Project:

Qualitative Growth as Prerequisite for Sustainable Development in Baden-Württemberg

2. Senior Investigators:

Prof. Dr. Ortwin Renn and Prof. Hans Mohr

3. Additional Scientific Investigators:

Dr. Clar, Dr. Flaig, Dr. Kastenholz, Dr. Lehn, Dr. Pfister, Prof. Dr. Weimann

4. Research Objectives:

a) Conceptualization of the terms "sustainability" and "qualitative growth" and their operationalization for a regional conversion strategy;

b) Design of a regional strategy aiming at the conversion of the economic structure of the State of Baden-Württemberg towards sustainability;

c) Development of policy tools to initiate, promote, intensify, and facilitate the process of conversion;

d) Drawing up several case studies from industry, trades, agriculture, forestry, insurance, the construction industry, and education system.

5. Time Schedule:

Phase 1:	Initial data collection for Baden-Württemberg	1993
Phase 2:	Concept and operationalization of sustainability	1993 - 1994
Phase 3:	Assessment of resource potentials	1993 - 1995
Phase 4:	Investigation of the carrying capacity of the State	1994 - 1995
Phase 5:	Case Studies	1994 - 1996
Phase 6:	Political strategies for conversion	1995 - 1997

6. Methodology

Phase 1:	Literature research, data banks
Phase 2:	Literature research, interviewing experts, Delphi session, surveys
Phase 3:	Literature research, independent contractors, surveys
Phase 4:	Literature research, data banks, ecological surveys
Phase 5:	Collaboration with affected groups and individuals, interviews
Phase 6:	Literature research, expert workshop

7. Description of Each Research Phase:

a) An inventory of the existing economic structures in Baden-Württemberg: The aim of this survey is to characterize the present situation of the State and to assess the potential for possible conversion processes to reach a more sustainable economic status.

b) Conceptualization and operationalization of sustainability: A discussion paper prepared by the project team serves as the main input for an interdisciplinary workshop bringing together economists, ecologists, and social scientists from around the world. The workshop is intended to help accomplish a common understanding and a consistent operationalization of the concepts of regional sustainability and qualitative growth. In addition, the workshop will address the adequacy of different policy tools for facilitating and promoting the necessary conversion to a sustainable economic condition on the regional level.

c) Assessment and analysis of renewable and non-renewable natural resources, energy needs, and human resources: This assessment provides the basis for identifying those economic sectors for which conversion processes are needed most urgently. In addition, the assessment of human resources facilitates planning for educational needs and occupational qualifications. These assessments will be carried out in separate projects (water, soil, human resources, and others).

d) Quantitative assessment of the carrying capacity and the appropriated carrying capacity for Baden-Württemberg: The goal of this research phase is to identify and quantify the material flows from and into Baden-Württemberg and assess their impacts on sustainability inside and outside the State.

e) Drawing up case studies from agriculture, forestry, trades, manufacturing, the service sector, and construction industry.

f) Analysis and evaluation of conversion strategies and instruments which promise to facilitate the transition of the present economy into a sustainable economy: A strategy workshop is planned to design efficient, practical, and cost-effective policy tools. The results of this workshop form the basis for multiple workshops with representatives of industry, political and social institutions, and the public.

8. Project Products:

- an edited volume containing comments on our discussion paper and the contributions of the experts taking part in the first workshop,
- individual reports about each case study,
- a comprehensive report about the resource situation in Baden-Württemberg, including human resources,
- a report of the carrying capacity of Baden-Württemberg and an ecological audit for imports and exports,
- an edited volume containing the contributions by the participants of the lecture series on sustainable development,
- an edited volume containing the contributions by the participants in the second workshop
- a final report with the political recommendations.

9. Further Information

Further information can be obtained from the Center of Technology Assessment in Baden-Württemberg. The address of the Center is:

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III. Discussion Paper

1. The Problem: Sustainability*

The concept of sustainable development has enjoyed unprecedented popularity in recent years. It was originally introduced as a microeconomic concept in forestry meaning a strategy aimed at providing wood continually without wiping out the forest. Since the mid-Eighties, though, it has become a popular catchword for attempts to link economic development with maintenance of an ecologically determined carrying capacity. At the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, the concept of sustainable development played a central role. More than 300 pages of recommendations in reference to this concept were collected and published as Agenda 21. In addition to the United Nations, many other national and international organizations have jumped on the sustainability bandwagon. These include the World Bank, ecological research institutes and corporate groups as well. Entire new research institutes have been set up throughout the world with "sustainability" as their field of concentration.

How can such sudden popularity of a concept taken from forestry be explained? For one thing, it reflects the environmental debate that is raging currently. Public opinion demands that environmental concerns are included in industrial and economic policies. Secondly, it suggests that there is a way to reconcile economic expansion with ecological limits. Hardly anyone doubts that there are limits to quantitative/expansionary growth. The radius r of Planet Earth is a finite quantity, and so is the earth's surface area. Pollution and resource consumption cannot grow indefinitely. The productivity of the environment simply can no longer be boosted as one might like it to be.

The very phrase "can no longer be boosted" hints that productivity, and with it the environment's carrying capacity for human purposes, has been influenced in the past, and

* Members of the project team on "Qualitative Growth as a Prerequisite for Sustainable Development in Baden-Württemberg" have actively contributed to this pilot study through their comments, suggestions, criticism, suggestions and a lot of discussion. Therefore special thanks is due to Prof. Hans Mohr, Dr. Clar, Dr. Flaig, Dr. Kastenholz, Dr. Lehn, Dr. Pfister, and Prof. Dr. Weimann. Professor Goble of Clark University and Dr. Conrad improved this version by means of their written comments. Finally I am grateful for the extensive and constructive discussions with members of the Center's Advisory Board, which helped clarify the intentions of this pilot study and make the expression of its content more precise.

perhaps could be influenced again, by human inventiveness. In spite of the fact that an absolute limit is placed on the environment's carrying capacity by ecological conditions, it is the economic and social conditions that determine the productivity of the carrying capacity for human purposes below the absolute threshold. 12,000 years ago, about 5 million people were living on earth, and the carrying capacity - given the productivity attainable at the time, an era of hunters and gatherers - was also limited. Even the agrarian/preindustrial culture that predominated around 1750 had a strictly limited carrying capacity of about 750 million people in the entire world.

Today the world supports almost 6 billion people - with the total still rising. Every nine months, another 80 million people are added - as many as in Reunified Germany. That is a carrying capacity a thousand times larger than that of the New Stone Age, a level still improving with each new gain in productivity. This enormous achievement of human culture has been accomplished with the aid of the five "Promethean innovations": harnessing fire, inventing agriculture, transforming heat from fossil fuels into mechanical energy, industrial production, and the substitution of information for material.

However, there are more and more signs telling us that the growth of humanity and rising consumption in those countries in which the pro-capita consumption of goods and services is increasing can no longer keep pace with the need for global carrying capacity, despite the accelerated innovation intended to adapt productivity to the development of humanity. The clock of exploitation is running ahead of the clock of natural rejuvenation and human advances in boosting productivity. Today's population density in conjunction with the level of consumption of the rich are claiming a complete transformation of nature into productive environment. At this rate it appears necessary to resort to unique and very limited fossil energy reserves and raw materials, and to exploit regenerative resources until they will no longer be able to regenerate themselves. Humanity depends on nonrenewable energy sources for over 80 per cent of its energy needs. But these will be depleted soon - perhaps not quite as soon as many thought a few years ago - but within a foreseeable time span of decades or centuries at the latest.

Even if the speed of innovation cannot keep up with the growth of humanity's desire to get more out of its environment, a national economy's innovative potential is still important. It's too late to go back; the situation will no longer allow it. Without technical

progress and without boosting micro- and macro-economic efficiency, things would be much worse. Only with the aid of structural change triggered by innovation can the necessary substitution processes be set off; processes that are needed to bring about innovations in products and production techniques, in order to secure the level of affluence we've achieved. At the same time, structural change means a chance to increase the efficiency of environmental utilization, and thus also the world's carrying capacity for human purposes, as can be seen from past experiences. Therefore, a solution to the environmental crisis of our time must begin on both ends: first, by means of innovation, we must try to improve the productivity of the environment, and thus the earth's carrying capacity. Secondly, we must reduce the demand for consumption of the environment. Both of them are needed: ongoing development of economic productivity in the direction of more efficient use of the available production factors, and of the environment factor in particular, while at the same time adapting demand structure to the ecological conditions governing carrying capacity.

In developing countries, the need to get economic development in line with maintenance of carrying capacity is even more pronounced than it is in the industrialized world. Rapid population growth, the special conditions under which the natural environment is often used there, an unfair distribution of wealth and a productivity level lower than that in industrialized countries are a few of the factors causing many groups in the population of these countries to suffer, as all of us claim to deplore. To ask them to do with even less would be perverse. All the same, it is in these very countries that one can already see exploitation of the environment getting worse, leading to soil erosion, steppification, water pollution and an even less efficient utilization of fossil energy resources than hitherto.

The term "sustainable development" is a prophetic combination of two words which unites both aspects - economic progress and environmental quality - in one vision. This vision of an economic structure that meets all needs of this generation without restricting the needs of future generations is highly attractive, because it reconciles the terms "economy" and "ecology" - terms seen so often as opposites - and postulates a generally acceptable distribution rule among generations. Sustainability is a vision of a society living below or near its carrying capacity, but which is nonetheless able to satisfy its needs. As attractive as the concept may be, of course, few concern themselves with the

question as to how the magic formula can be transformed into reality, leaving it instead to the user to decide which of its two components he really likes best: ecology or economy.

The problem with a concept that so many people share as a common goal, and that has become a political catchword showing up in many discussions without anyone's considering what it really means, is that it can be defined and operationalized however anyone wants. When environmental activists and conservative executives use the same term for their very different purposes, they are sure to be using it with different meanings. Sustainability is used all too often as a patronizing phrase to legitimize one's own interests and to hide concealed conflicts. Then the concept loses it normative effect, which could otherwise be an integrating one ultimately.

Should we then do without the term sustainability? That would be throwing the child out with the bath-water. On the one hand, the concept has to be understood correctly; only then can it serve as a realistic and ethical guide for the future development of both industrialized and developing countries. On the other hand, getting the many players in politics and society to agree on any common ground at all offers a great chance to begin making common strategies to implement a concept. There is already a change underway in society towards more environmentally compatible products, which could be reinforced by strategies emphasizing ecological criteria. The type of structural change called for by the concept of sustainable development always requires that a change be underway in one's own behavior and own goals. And reflection on those personal aspects involves a vision of the future that is considered worth living for. Sustainable development has become a common vision for many groups and can serve as an integrative engine to keep parties with diverse interests heading for the same goal.

Lest such terms deteriorate into meaningless pleas, sustainable development must be nailed down and laid out into definite requirements. What is needed is a description of the concept that is as exact as possible, and details on how to operationalize it. Such a definition should allow for flexibility - but not arbitrariness - in implementing the concept. At the same time, the concept must have the strength of broadly accepted reasons behind it in order to remain applicable above and beyond the interests of the various players involved.

The project of the Center for Technology Assessment in Baden-Württemberg with the title "Qualitative Growth as Prerequisite for Sustainable Development in Baden-Württemberg" is an attempt to accomplish this. It is an attempt to help interpret the implications of the concept by developing general guides and conversion strategies for the various levels of players involved. It will then test, and try to improve upon, the means proposed to operationalize the concept through case studies in the region that have been derived deductively from the concept.

The main objective of this pilot study is to develop principles and directives for action. This text concludes with a detailed project description, which comprises the research plan and a list of further steps to be taken to transform the concept into concrete case studies.

2. Perspectives on Sustainable Development

What does sustainable development mean? Apparently it refers to a type of economic development that makes it possible for future generations to have any environment left to use. Such a general answer as this, of course, is not enough to develop an operational strategy. If one has a look at the literature, one finds significant differences in how the term is interpreted and operationalized. We have collected a few of these definitions of "sustainable development" in the appendix. They will give the reader an idea of the range of possible definitions and at the same time illustrate the great confusion still surrounding the term. The confusion arises mainly from four sources:

- differences in the perspectives and approaches of the various academic disciplines and research traditions concerned with sustainability;
- differences in the values and interests of the players concerned, who perceive the situation and evaluate possible strategies very differently from one another;
- differences in the horizons in which the term is used as regards both space and time;
- differences in the writer's intention in the particular context in which the term is used: whether it is a moral plea, a planning basis or an element of technology assessment.

Although it is hard to classify these differences in meaning systematically, there are two main factors according to our literature review which seem to determine the perspectives of the authors who have written about sustainable development: firstly, the way an author associates specific images with nature, and secondly, the particular home discipline or research tradition from which a writer comes. Concerning the images of nature involved, one can distinguish anthropocentric from biocentric approaches. The former can be subdivided further into utilitarian and protectionistic perspectives. Here is a short run-down of each:

1. Utilitarian perspectives

- Nature as a cornucopia for resource utilization: Nature in this context constitutes a resource base for satisfying human needs. Sustainability means preserving this resource base for future generations.

- Nature as modeling clay for the creation of cultivated land (gardens, agriculture, forestry, material cycles): In this context, sustainability means transforming unproductive nature into cultivated land that can bear crops for human consumption and that societies can utilize economically and preserve permanently. Nature is only of use for humankind when transformed into cultivated land. But this transformation depends on natural contingencies and is limited by the need to preserve fundamental, natural material cycles.

2. *Protectionistic perspectives*

- Nature as a wilderness worth preserving: Nature means the preservation of unspoiled land as a response to the immediate need of humans to enjoy and learn from nature. Preservation is independent of any utilization of the resources to be found there. Sustainability then includes not only the preservation of a resource base, but also acceptance of nature's intrinsic value the way it presents itself without human intervention.

- Nature as a fragile object to be protected from human intervention: Seen this way, sustainability is not so much protecting man's basis for life as it is protecting nature (or the environment that nature has become today) from man's intervention. Any further human intervention in, or more intensive utilization of, the environment is to be avoided.

3. *Biocentric perspectives*

- Nature as the unity of all Creation: All creatures have, in principle, the right to occupy their own niches in nature. But humans are in a position to expand their natural habitat beyond the extent that nature would normally have planned for them. Therefore, humans have a special responsibility to curtail their demands on the natural environment, so as to enable humans, animals, and plants to coexist close to nature. This context, however, never questions the priority of human interests over those of competitors in cases where conflicts arise for the same resources.

- Nature as a place for creatures with equal rights: All creatures not only have a right to an undisturbed biosphere, they also have the same right as humans to develop their lives within the limits set by the rules of nature. In conflicts over the use of

resources, all creatures, in principle, should have the same chances. Only in cases threatening their own lives do humans have priority over the rights of their fellow creatures.

Of course, these five prototypes of authors' images of nature are seldom to be found in their pure forms, and often occur in different mixtures, and in different social contexts. They make themselves felt in everyday experience as individual preferences regarding the use of natural or quasi-natural biotopes, or as preferences for different schools of environmental policy. It would surely be an interesting empirical challenge to investigate systematically authors' concepts of nature and the environment, and to derive implications from them for environmental planning and policy. However, this informally compiled classification will suffice for the purposes of the project: it is only meant to serve as an orientation for explaining conceptual differences in the literature, and to aid in the process of reaching a consensus on how to operationalize the term sustainability.

In addition to the images that authors associate with nature, the academic discipline or research tradition to which they adhere plays a major role in their attempts to define the concept of sustainability. Similar to the influence of the images explained above, disciplines too display differences in the meaning of sustainability, although here again there are many hybrid concepts, some of them intentional. These differences come from:

- Economics: Sustainability describes an economic system in which future generations will enjoy at least the same level of welfare as the present generation. In the narrow definition of welfare, it can include only marketable, priced goods; the broad definition of welfare preferred by some authors includes non-marketable goods as well such as social and political stability, resilience, and the immaterial conditions needed for subjective well-being. Such a broad definition of welfare could also be termed "quality of life" (both individual and collective). A central tenet in the economic view is that the welfare level is determined by some aggregate measure of individual utility, no matter what elements individuals include in such a utility assessment. Consequently, economists assume that many possibilities exist to substitute artificial capital (such as machines, production processes) for natural capital (resources for production and the environment as a repository for waste). Then sustainability implies a necessity to preserve natural capital only when it is not possible to substitute artificial elements for it. The main evaluative criterion for

assessing sustainability is the level of aggregate utility, regardless of whether some of its components are irreplaceable.

- Ecology: Sustainability means the use of natural resources to the extent that the carrying and regenerative capacities of the corresponding ecosystem are not jeopardized. The focus is not on individual resources, whether they are production inputs or waste repositories, but rather on the interaction of related resources within one ecosystem. The system may only be disturbed by human intervention as long as the functionality and regenerative capabilities of the system are not jeopardized. Within the field of ecology, there are different methods of measuring the degree of anthropogenic influence on ecosystems. One especially meaningful one is the degree to which net primary production is used for human purposes. Annual net primary production (NPP) is defined as the amount of energy left after subtracting the respiration of primary producers (mostly plants) from the total amount of energy (mostly solar) that is fixed biologically*.

- Physics (and other natural sciences): Sustainability is the ability of biological systems to create permanent order (negentropy) using solar energy. The time scale over which a well-ordered world can be sustained is limited only by the sun's life cycle. This interpretation of sustainability is based on the Second Law of Thermodynamics. As every transformation of energy increases entropy (which is disorder), all physical processes are ultimately aimed at disorder, and thus a standstill. Biological systems, however, have the ability to create order on a limited scale by using solar energy, and to keep the inevitable entropy outside their own systems. The practice of human societies of transforming more energy by consuming fossil fuels than the sun offers on a continuous basis, and of using more and more of the order-rich products created by biotic systems for its own purposes decreases the biological systems' ability to survive and regenerate themselves (analogous to the ecological approach). Therefore the central issue in connection with sustainable development is continual preservation of the biotic systems' potential to create negentropy.

* This definition is taken from Peter M. Vitousek, Paul R. Ehrlich, Anne H. Ehrlich and Pamela A. Matson, Human Appropriation of the Products of Photosynthesis, BioScience, 36, No. 6 (June 1986), pp. 368-373

- Chemistry: Sustainability means closing anthropogenic material cycles. All resources used by humans (as either production factors or waste repositories) have to be integrated in closed material cycles in such a way that the outputs (wastes) of one player can be used as input for another player (humans, plants, animals) within the limits of the second law of thermodynamics. Waste, for instance, has to be reused as an energy carrier or recycled into new products or services. Non-reusable waste should be in a condition such that it would decompose into non-toxic, non-polluting substances.

- Social sciences: Sustainability means the social and cultural compatibility of human intervention in the environment with the images of nature and the environment constructed by different groups within society. It does not matter whether there is a real environmental crisis in the sense of facts proven by natural sciences. The social science perspective takes as its starting point the social perception that there is a crisis. Social perception of environmental conditions is always selective and suggests that certain (culturally determined) assessment patterns are to be used. Statements on sustainability are thus preferences of the current generation as to the levels of environmental quality and quality of life that it allows itself, and those that it will allow future generations. Issues of distributional equity dominate in social visions of sustainability.

These differences among disciplines are not only semantic, but have further implications. The economic understanding of sustainability, for example, places sustainability in the context of scarcity. The goal of sustainable development is to express the relative scarcity of the resource "environment" in comparison to other production factors through eco-taxes (Pigou), or negotiations for environmental rights (Coase). Given a dynamic price system, the price based on scarcity provides for optimal allocation (reflecting the relative scarcities). The term "relative" not only refers to scarcity in comparison to other production factors, but also to the urgency with which the consumption goods are in demand. Environmental goods are also subject to this exchange in a free market economy; they can be exchanged for other goods. However, most economists conclude, the prices prevailing for most environmental goods are below the actual level of scarcity for reasons of market failure or market imperfections (not further explained here). Therefore, measures are absolutely necessary to correct the price distortion by governmental interventions.

Many approaches to resource economics assume that production factors can be substituted for one another in any proportions. However, this view is unreconcilable with most natural science perspectives. Natural scientists claim that there are absolute limits to the utilization of the environment, which may not be exceeded, no matter how beneficial it might appear from a purely economic viewpoint. This difference in approach also expresses itself in the types of measures that the respective proponents call for: Economists prefer financial incentives as a means of correcting a market imperfection retroactively, because incentives help reach ecological goals in a cost-efficient manner, thus helping conserve both natural and human resources. Natural scientists, on the other hand, usually prefer (preemptive) mandated regulations based on absolute limits, because regulations reflect the absolute limits of carrying capacity. The social scientists, yet again, emphasize the constructive character of the concept "sustainability" and focus on equity conflicts, which can be solved neither by incentives nor by regulations, but demand specific political measures of redistribution or communication (legitimation).

Despite the variety of approaches to, and perspectives on, sustainability that exist, the particular challenge for this project is to develop a basic definition that is acceptable to most authors and practitioners, and then to integrate the particular strengths of each perspective into it. In order to meet this challenge, two requirements have to be fulfilled:

a) It may be possible to develop a generally valid definition of sustainability, which reflects the views of most representatives of the concept. Eventually, however, such a consensus is likely to break down when we try to operationalize it. Instead, therefore, it seems appropriate to select modules to operationalize the principles for the different types of applications; they support one or the other of the above perspectives depending on the particular context of the problem. For instance, setting absolute limits or standards, as suggested by the physical interpretation of sustainability, may be more appropriate for managing nonrenewable energy resources (such as coal or oil) than the economic considerations regarding relative scarcity. As for the issue of maintaining natural biotopes, a protectionist perspective may be more appropriate than a utilitarian one. In principle, the perspective should be used which appears best suited on the basis of general criteria (described later on in this pilot study).

b) Every attempt to operationalize the term sustainability has different implications when we consider global, national or regional levels, and when we apply it to countries with different levels of economic development. Developing such a wide range of modules for many areas of application would go beyond the scope of this project. Instead, therefore, let us restrict ourselves deliberately to the region of Baden-Württemberg. Not only is the Center obliged to address primarily the problems of this state, but a focus on the regional level also provides a more reliable and valid data base so that the success of policies towards sustainability - or lack thereof - can be measured empirically within geographical borders. If the approach turns out to be useful for analyzing and managing the necessary conversion processes in this region, it could be extended beyond its current regional limits. Towards the end of this pilot study, we shall go into the chances and problems of using a regional approach to sustainability once again.

In the following two sections we will describe the requirements for an economic structure based on sustainability, and then develop from that analysis our concept of sustainability, in which the various perspectives can be integrated.

3. Prerequisites for Sustainable Development

Modern societies cannot live in harmony with nature, but rather at best in harmony with their environment. Nature and the environment are two different phenomena, however they share some basic natural cycles that make them both function. Environment is a product of culture - i.e. human-made, not something humans found waiting for them. In transforming nature into environment, human societies invest knowledge, thought and work; individuals and groups express aesthetic needs in the process as well. That yields an ecological added value. This ecological added value has comprised society's basis for existence since the New Stone Age.

Thus the natural world became first an agricultural, then an urbanized world; natural ecosystems (originally more or less self-regulating) all around the world were transformed into anthropogenic ecosystems. These anthropogenic ecosystems are what yield food and products for billions of people. Modern societies cannot live from nature alone, but they cannot survive without nature either. Humans use about 95% of the earth's tillable soil as their environment: agriculture, forestry, settlements and infrastructure facilities leave little room any more for the original nature.

But our future does not depend on maintaining nature in its original state, but rather on maintaining the anthropogenic ecosystems that we call the environment. Having an intact and productive environment is an indispensable condition for human existence and culture. If the environment degenerates, modern society's existential basis disintegrates. The anthropogenic ecosystems from which humanity lives require a continual input of energy (or to be more exact, negentropy) and continual preventive intervention to keep them from breaking down. Nothing in today's world regulates itself automatically for the human benefit; social forces have to intervene continually to correct environmental conditions. That's why knowledge about the ecological basis of our life is so important. Using such knowledge creatively is a prerequisite for the survival of humanity.

Carrying capacity is a concept of central importance for continuing humanity's economic survival. For humans, the carrying capacity of a region is determined by the techniques of economic conversion or production used. These increase carrying capacity, but not beyond certain limits - neither regionally nor globally. There are biological reasons for

that: since nobody knows of any technique to boost sufficiently global photosynthesis, and thus net primary production, there are objective limits to carrying capacity. Annual net primary production (NPP), a term mentioned above, is a finite quantity; it refers to the amount of energy left after subtracting the respiration of primary producers (mostly plants) from the total amount of energy (mostly solar) that is fixed biologically. Everything that is alive lives from NPP. But it's like living from hand to mouth. There simply are no significant reserves of it. Modern societies have already laid claim to - or influences for their own benefit - 40% of all land surfaces' potential net primary production. Starting from that basis, attempts to expand carrying capacity would come up against limits very soon, even if humans were to grant all living things besides himself no more right to live than as their domesticated animals and potted plants. In many regions of the earth, societies have already reached - and in some instances, even exceeded - the critical load, the limit to irreversibly damaging the environment.

In addition, social constraints limit the maximum yield of NPP for productive purposes. A distinction must be made between the earth's biophysical carrying capacity on the one hand, and its social capacity on the other. Even if it is theoretically possible to make much of the remaining 60 per cent of NPP usable for mankind, it would be neither realistic nor desirable, because humans have social needs for environmental quality that goes beyond the environment's economic value. These needs deserve respect in addition to their physical needs. Take the social need for parks as an example - parks in which there is still at least one leaf not earmarked for some economic purpose. Increasing the percentage of NPP used is therefore of limited value for coping with the environmental crisis. Instead further economic development must boost the efficiency of how NPP is being currently utilized and transformed by humans. The real challenge consists of finding a way to set off a development process which would use the potential of efficiency boosts, while still respecting the absolute limit that applies to the yield capacity of the environment for productive purposes.

4. Sustainability: Essentials for a Realistic and Pragmatic Concept

What conclusions can be drawn from these thoughts on carrying capacity and economic development to help better understand "sustainability?" One metaphor commonly used to characterize sustainable development is to see it as an economy in which people can live off the interest generated by capital stock without invading the capital itself. Given our population density today, to think that we have or could accomplish such an economy would be an illusion. If we were to limit the energy supply for the almost 6 billion inhabitants of this earth to annual solar input alone, leaving all non-renewable resources untouched, reverting to agricultural production methods that are purely extensive and taking other measures necessitated by such a limitation, it would bring about a social catastrophe that would make all catastrophes ever known throughout the history of mankind look mild by comparison. Nor could it be legitimized by any argument of intergenerational equity.

The high carrying capacity that modern society has established already requires not only transformation of nature into productive environment; it also implies dipping into nonrenewable reserves of fossil energy and raw materials, while voraciously exploiting renewables. This "strategy" cannot be maintained much longer. The dilemma is clear: our current economic beast is gnawing away at our capital stock of natural resources, thus digging its own grave. Likewise the call for preserving natural capital stock for future generations would compromise the claim of the present generation to enjoy at least a modest quality of life, considering today's population densities. Not even a development oriented around sustainability can avoid living from nature's capital stock. Man can only stretch natural supplies, not make them last forever.

The ultimate goal of sustainable development must be to maintain both the productivity of nature and the environment, as well as immaterial gains in their utility, for as long as possible. Given today's economic structure, this goal is still far off. Neither in the area of energy utilization nor in the consumption of nonrenewable resources is it imaginable that we continue with today's production techniques and rates of utilization over the long term. But today it is possible, and would be sensible, to develop ways and strategies of coming closer to this goal. At this point in human history, we need to focus on the path to

sustainability rather than to implement a sustainable economy at once. This path towards sustainable development is characterized by the following four principles:

- Increasing resource productivity: The utility gained from the use of natural resources must be improved continually, so that the natural assets consumed to produce a given quantity of goods and services sink continually. That requires growth in the stock of artificial capital as the only way of keeping the welfare of a country at least constant.

- Acknowledgment of the limits of substitution between natural and artificial capital: In traditional economic theory, the monetary value of any good determines the rate at which it can be exchanged for other goods. For certain goods, however, this rule of exchange does not work, as production or consumption of them incurs such high external costs that infinite compensation of those damaged would be needed to make the transaction economically efficient. If, for instance, the quality of the air we breathe were jeopardized by emission of a toxic gas, there would be no macroeconomic benefit great enough to compensate humanity as a whole for the consequences of the poisoning. Within a few minutes, there would be no humanity to compensate anymore. For this reason, the natural cycles necessary for mankind's survival must be identified (by ecological science primarily), and protected by political measures.

- Focus on the resilience of anthropogenic ecosystems: Renewable resources would appear to be utilizable for the long term, since they regenerate themselves. Their regeneration capacity lasts, however, only as long as they remain invulnerable to changes in their natural and anthropogenic environments. Monocultures, or ecosystems intensified so as to produce a maximum yield, can only yield a constant output per unit of time under optimal internal and external conditions. However, if those conditions change (by having had excessive strain placed continuously on a production medium such as the soil, or by interaction with the environment such as being attacked by diseases and parasites), these systems break down, i.e. exhibit an abrupt decrease in yield - or worse yet - a permanent reduction in, or disappearance altogether of, their yield potential.

- Incorporation of social values in man's relationship to the environment and nature: Whereas economists emphasize the utility of the environment and nature that can be accounted for in prices, and natural scientists concentrate on the function of cycles and structures vital to the system, social scientists attach a number of aesthetic and symbolic values to the environment and nature, which are of central importance to individual and social well-being. They are however, undervalued in conventional economic processes because they belong to no-one but the public; and public resources are either neglected or overexploited in decentrally organized economies (the so-called "tragedy of the commons"). This is the reason that when we speak of the "quality of life" in our project, we are referring to a combination of utility and the attachment of social value to certain living conditions delineated from the enjoyment of environmental quality. Both the concrete utility that a society derives from the use of the environment, and the vitality or satisfaction that man derives from experiencing, or even communing with, the environment and nature must be taken as a yardstick of sustainability.

For this reason, the Center of Technology Assessment in Baden-Württemberg has chosen the following definition: *Sustainable development denotes a process by which the capital assets of natural resources are preserved to the extent that the quality of life available to future generations will not be inferior to the quality of life of the present generation.* This definition points the way to the goal of utilizing the environment for the long term. It is a matter of ensuring continuity in the supply of natural resources, and of preserving the biosphere's reception capacity for material flows that have been anthropogenically caused or influenced by human activities. This must be done so that future generations as well can enjoy a level of welfare similar to that of today's generation. Although the definition contains economic and ecological concepts, the call for sustainable development is an external norm arising out of an ethical motivation, which does not result automatically from any efficiency criterion of economics, or any concept of limitations in ecology. Instead its justification is to be sought in the principle of intergenerational equity. Why should our descendants be worse off than we are? Just because we didn't use resources efficiently (although we knew better)? Sustainability is a constraint on economic development much like human rights; it does not question - much less cancel out - the basic intention of economics, namely to orient human economic activity towards

maximum efficiency nor does it ignore the absolute limits imposed by the carrying capacity for human purposes.

A few terms in this definition require explanation. One of them is the idea that natural resources can only be stretched, not made to last forever, while nonetheless keeping their function intact for the production of welfare. Ultimately, we will reach this aim only if two conditions are met: if the functions desired by humans (including immaterial functions as well) which can be fulfilled by natural capital continue on into the future; and secondly, if all needs of future generations can be fulfilled by a mixture of natural and artificial capital, with only limited substitutions possible between the two. But what kinds of needs will future generations have? It would be oversimplifying to extrapolate our needs today into the future. Today's preferences for certain goods will prove to have been transitory, and thus not suitable for extrapolation into the future.

Therefore we have taken refuge in the term quality of life. This term is useful for expressing the association between utility and the attachment of immaterial value. Furthermore, it comprises an abstract idea that will remain independent of transient fashion. Quality of life includes the social experiences that determine personal well-being, and the objective conditions that make such experience possible. Even if it is impossible to know exactly what requirements future generations will place on their experience, we can determine preemptorily what potential will have to remain to give these generations the chance of having certain experiences (which are desirable ones today). If they don't want to use that potential, no problem; it would not even be a waste of resources because generations after them might change the trend again. However, if coming generations are deprived of the chance to have these experiences, they lose quality of life. Basically the project assumes that the physical, economic and social foundations and conditions associated with a certain level of quality of life will have to have some significance for some future generation as well - regardless of whether the more immediate descendants need, or even appreciate, them.

It would be an illusion to assume that the present state of the environment needs to be sustained for generations to come. Firstly, nature itself acts an agent of change and influences the development of environmental transformations over time. Secondly, human forces will always alter the environment through economic and social activities. What

needs to be preserved are those elements of our environment that individuals of the present generation value for economic, social, or cultural reasons. Sustaining quality of life means therefore preserving those environmental conditions that humans appreciate today as options for future generations of which we do not want to deprive them. If they don't value these conditions, their quality of life would not be reduced. If they value aspects of the environment that present societies have not included in their portfolio of valuable natural assets, it is our hope that these losses can be compensated by the increase in artificial capital that we accumulate and hand over to the next generation. Any other solution to the problem of what to select for preservation would either overtax the capabilities of the present generation to predict future needs or increase the probability that future generations would have less quality of life than today's generation. How to draw the line between the essential environmental elements that we need to preserve and those that can be further transformed and changed will be a major task of our research project.

Focusing on Baden-Württemberg mitigates another problem: the quality of life for the present generation may not be a desirable yardstick for many, maybe even most, regions of the world. For the state of Baden-Württemberg it is easier to estimate an average level of aspiration as a reference quantity because the mean variation in incomes is relatively small (as compared to the world population), and the level of general welfare is relatively high. It would be a lot more difficult to estimate these structural properties in international projects involving other regions because of the great difference there between the levels of economic prosperity and the incomes of the rich and poor. Sustainability does not imply to perpetuate the present quality of life if this quality is undesirable even for the present generation.

5. Qualitative Growth as a Prerequisite for Sustainable Development

The special attraction of the term "sustainable development", as already mentioned, lies in the way that it unites two apparently contradictory demands: one of them for non-destructive utilization of the environment, and the other for further economic development. A number of authors have repeatedly emphasized that the term "development" should cover only structural change, but not growth in the economic sense. In our considerations, we do not want to dismiss the idea that a zero-growth economy is possible in theory, and it certainly appears to be more in harmony with the concept of sustainable development than a growth-oriented economic order. However, we must continue to regard this solution as problematical for the following four reasons:

1. As long as people associate consuming ever more products with welfare, the strategy of relying less on one's natural capital stock can let the level of welfare remain constant, or let it even improve, only if the assets of artificial capital grow at the same time. In principle, taking strain off the environment by using it more efficiently is only possible by boosting artificial capital, unless welfare is allowed to drop. There are many indications that there may be no immanent limits to boosting artificial capital. This hope is supported primarily by the realization that "knowledge" is a production factor with special characteristics: it displays no evidence of wear whatsoever, i.e. knowledge, once acquired, can be reproduced as often as desired (no rivalry arises). Nor does one presumably have to expect diminishing returns in the production of knowledge.

2. After the fall of Communism, various forms of free market orders have become the new world standard. Within these economic orders, structural change takes place only because there is hope for growth. In principle, growing and shrinking industries could balance one another off; but no one can tell in advance. As long as one maintains the freedom to invest, without which free market systems would not be feasible, market players have to be allowed the hope of growth.

3. If one assumes that the prices in a free market economy reflect relative scarcities, then there is really no argument why a condition in which everyone feels better than before should be rejected. As long as the market imperfections that have caused

natural capital to be underpriced can be compensated for by establishing new exchange ratios, there is no reason why people shouldn't be allowed to try to improve their individual benefits. If we were able to internalize the external costs of using natural assets as well as all other social costs, then economic growth would reflect the improvement of human welfare. There may be limits for internalizing external costs which would necessitate direct governmental interventions. Such limits, however, do not compromise the function of economic growth for stabilizing and even improving economic welfare as long as external costs are accounted for in some way. The argument often put forth in the discussion of growth to the effect that growth enlarges the gap between rich and poor is not aimed at growth per se, but rather against the unfair ratio according to which any surplus wealth attained is distributed.

4. Zero-sum growth might make sense for industrialized countries living in relative affluence, but not for the people in developing nations living in poverty and desperation. A concept such as sustainable development should apply to all, or at least its basic principles should, even if individual elements have to be adapted from region to region. The fact that population growth in developing countries comprises a particularly critical factor does not contradict the basic tenets developed here (refer to the third phase of qualitative growth below).

For these four reasons, it appears appropriate to acknowledge the mechanism of growth as an integral component of a sustainable economic system, although it has undoubtedly been one of the causes that have had negative effects on the environment in the past. But we intend to fill it with new life in such a way that it would no longer be in contradiction to the second prerequisite, the one calling for maintenance of the natural basis of life, for which there is no substitute. The term "qualitative growth" has come into use meaning economic development that is controlled or influenced according to certain external criteria. The project limits the quality of the growth to "ecological" aspects. We decided not to include explicitly the social or political visions of desirable development trends, which are often associated with the term - not because we think they are any less important, but because otherwise the sustainability concept would become overloaded with too many requirements (some of them including conflicting values), and dependent upon too many external value judgments.

Qualitative growth in our context means a process during which resource productivity increases continuously with economic welfare. The increase in the performance of a national economy attained by growth has to be continued, but by using less of non-renewable resources, and while causing less environmental damage. At the same time care has to be taken that renewable resources are used only at the rate that they can regenerate themselves continually under the strained conditions of cultivated land, or at the rate that they can be replaced by equivalent forms of artificial capital. Every unit of nature should become more productive in such a way that national economies need less of nature altogether. The objective would be to create a second event parallel to the historic achievement that we have seen, during which an enormous increase in the productivity of work per hour was attained. Now we need to initiate a new era characterized by a rising productivity of natural resources (per unit of energy or raw materials). Qualitative growth is thus characterized by a further increase in productive services although the use of resources and environmental damage decrease. This becomes possible because knowledge and immaterial services are substituted for material resources and manual work: structured knowledge and software replace raw materials, exergy and time. The project distinguishes among three stages of qualitative growth:

- In Stage I, qualitative growth means a continuous decrease in resource use per unit of domestic national product* . Every product has to use less resources than the one replacing it. This also applies to utilization of the environment as a repository for no longer recyclable waste. Most industrialized countries have reached this first phase of qualitative growth for most economic goods.

- In Stage II, qualitative growth means a continuous decrease in resource use per capita. Here we have the additional criterion that the saving effects derived from better use of the environment have to be greater than any additional use of resources resulting from an increase in production or consumption. Only such sectors would grow in Stage II that bear promise of creating an disproportionately large value added while using less of the environment. This second stage of qualitative growth has been reached in the manufacturing sector for only a few products thus far.

* As long as we don't have a better and commonly accepted indicator for measuring overall welfare, we will stick to the conventional (and in many aspects problematic) economic indicators such as the gross domestic product.

- In Stage III, qualitative growth means a continuous decrease in resource use per national economy, and thus indirectly on the global level as well. Stages II and III are identical for societies without population growth. In this third stage, which applies specifically to countries in which a high birth rate or migration has caused the population to grow, the absolute utilization of resources also has to decrease. Then economic structural changes not only have to compensate for the greater consumption demands of each individual, but also for the collective demands caused by population growth as well. This third stage of qualitative growth therefore will be the hardest one to accomplish. Success will only be possible if measures for checking population growth are enforced in parallel to structural changes.

Qualitative growth is not an illusion. Creating added value using software is routine; the history of technology is full of examples of using innovation to find substitutes for scarce goods. The new dimension of substituting software and knowledge for material and energy that has been created through the progress of science opens a new dimension of qualitative growth. Such innovations lay the foundation for the requirements needed to bring about Stage II of qualitative growth encompassing all sectors. Of course, even future technologies cannot provide added value for nothing. Economic growth decoupled from resource consumption is neither free of side effects, nor can it reduce the input of raw material and energy indefinitely. No economic structure can guarantee a one-hundred-percent closed material cycle - at least not given today's population density. But there is a lot of room for improvement over business as usual.

6. Operationalizing the Principles of Sustainable Development

How can this potential for stretching resources be put into practice? Recommendations for implementation are different, of course, depending on who is supposed to carry them out. Here, again, we want to restrict ourselves to the region of Baden-Württemberg. The following rules for conversion of a regional economy go along with the modular concept of sustainability explained later on: for some problem areas, we use an approach from the natural sciences, for others, ideas from economics or a social science. In some applications, we regard natural resources as raw materials in the utilitarian sense, in others as cultural goods and in yet others as fellow creatures. The approaches do not exclude one other as long as one accepts a broad interpretation of the anthropocentric perspective as one's standpoint, as we have done throughout this project. The choice of approach is always based on the realization that it is ultimately a human being who decides about whether a field of application is appropriate or not. Humans have the option of treating other living things as fellow creatures in one context, and as domestic plants or animals in another. In choosing the appropriate perspective, one has to identify the specific fields of application in which the perspective of the discipline concerned and the relationship of nature and environment used in it conforms best to the overall goal, sustainability. Although approaches may not always be exclusive, mixing them within applications would be a problem, and would lead to inconsistency. Thus we should always keep to one perspective within an application. The following basic rules have been developed in line with that principle:

1. *Energy resources that are non-renewable can only be used until the sum of resources to be exploited in a period exceeds the sum of the reserves found in that period or the resources known to be forthcoming in some economically utilizable form through technological progress.* The time span for synchronizing exploitation with renewal of supply should be short enough to allow for fast corrective action as soon as a gap opens up between the two. Once that point is reached, we should promote substitution of other energy resources for the non-renewables by means of taxation, other price mechanisms, or - if those don't work - direct governmental interventions. We find that this point has probably already been reached today, for example, in the case of the fossil energy resource oil, and within the next few decades with gas as well. Normally we would

expect the prevailing market price to reflect the fuels' relative scarcity, and to set off substitution of other fuels for them. But many indicators suggest that the price mechanism on raw material markets is distorted. Many developing countries, for instance, have abandoned sustainability, and have begun ravaging their natural resources just to sell products on the world market and reduce their overwhelming foreign debt. Evidently it is not attractive enough for raw- material exporting countries to spare their own resources by taking out development loans instead. Selling products so desperately often causes ruinous prices on raw material markets. It is unrealistic to believe that this situation will change within the next few years. Furthermore, energy resources are special, and the economic principle of relative value (in principle, everything being exchangeable for something else) does not apply to them in the same way as it does to other commodities because the principle fails to account for objective scarcities. Substituting elements of artificial capital for these resources is not realistic either. Therefore we need government intervention for non-renewable energy resources to keep them available for future generations. The state, or better yet, the international union of states, should first use instrument of taxing such raw materials before employing more radical means.

In order to initiate these substitution processes, which are necessary, but take effect only slowly, Ernst von Weizsäcker has suggested introducing an energy tax which could be increased by the same percentage every year (about 4 per cent). This way the economy and consumers would slowly adapt to the idea that they have to find substitutes for the energy resources running out, that they have to make full use of energy-conservation potentials and/or that they have to develop new energy carriers. Additional study needs to be done to determine whether this suggestion is economically and socially feasible, and whether it should also be extended to those energy resources still available in great quantities. But still this suggestion is a logical extension of our basic postulate that state action is needed for non-renewable energy resources, wherever more of them are being irrevocably used up than new ones can be found or produced otherwise.

2. *Raw materials of the non-renewable type which are not used for conversion into energy, can only be used as long as they can be recycled without prohibitive economic expenditure - or, to put it in other words, as long as the raw materials can be re-used in a cycle that is at least partly closed.* Of course we cannot expect too much here either. Neither aluminum, for example, nor plastics can be recycled as often as we like.

Recycling raw materials too is subject to the law of entropy, and needs more energy the more often one tries to recycle them. Recycling forever is therefore out of the question. But that was never the aim of qualitative growth. The real aim is to stretch resources, and not recycle them forever. In order promote recycling practically, two things are needed: first, internalization of the external costs of raw material use, and reflecting the external savings made through recycling in the product price. Secondly, we need to create and maintain horizontal economic cooperation among industry, crafts and trades in order to develop the organizational prerequisites for recycling.

3. *Raw materials of the renewable type, and the media needed to keep them growing, can only be used at a rate which allows a balance to come about between consumption and regeneration by means of limiting human intervention (such as intentional intervention to boost the production of renewable resources).* The limit for such intervention depends on the regeneration capability and the resilience of the ecosystems concerned (for example, exhaustion of soil or extermination of natural competitors or food competitors). At first this complicated rule does not seem very reasonable. Why should renewable resources not be used at the rate that they regenerate themselves? We can fell as many trees as we plant new ones. The problem lies in the different intensities of intervention. On a long-term basis, the risk that a harvest will fail increases, if, for example, a monoculture of pine trees is substituted for naturally mixed woodland, or if all natural enemies of a popular edible fish are eliminated from a fish pond so that even more of the edible fish can be caught than was the case previously (the principle of resilience). Even given all the necessary interventions in the environment, our aim should be to preserve the function of soil, water and biotopes in such a way that we will be able to gather long-term harvests even under unfavorable conditions and unexpected surprises.

This is where economists distinguish between maximum and optimum yield of renewable resources (optimum sustainable yield). Intervention in the ecosystem that is too intensive may increase the average yield, but it also increases the ecosystem's vulnerability to surprises (such as disease, weather damage, breakdowns of the system, etc.). The relationship is not necessarily linear between the depth of intervention and the vulnerability. Many anthropogenic ecosystems have greater stability than natural ones. However, after a certain degree of intervention, the vulnerability of anthropogenic ecosystems to exterior influences increases. Nonetheless, it would be illusory to believe that we could do without any interventions at all (i.e. without intensive agriculture or

forestry, for example). But these interventions have to respect the balance between the understandable desire for plentiful harvests and the necessity for stability and long-term preservation of natural regulatory systems and cyclic processes. Achieving this balance in practice is very difficult. Often producers are interested in short-term maximization of yield, even if it leads to long-term destruction of regeneration potential for themselves or their neighbors. The increase in steppification and devastation is clear evidence of such short-range thinking. The practice common in industrialized countries of buying agricultural products at fixed prices (regardless of the quantities offered) also works against this aim, since producers can maximize their own yield this way if they consider only their personal interest. However such a practice often disregards great negative external effects on other producers and consumers (such as polluting ground water with nitrates). Subsidies in agriculture should therefore only be paid in cases in which positive external effects exceed negative ones. In this way, payments could be coupled with the aim of maintaining the functionality of the ecosystem.

Moreover, one should investigate whether the users of renewable resources should not be obliged to insure the stability of their resources against damage from overuse, and thus to integrate the stability into the market process. Insurance companies could reward those users with bonuses who protect their ecosystem's stability, and punish those who damage their regeneration potential too much in favor of short-term profits. Insurance should be mandatory because all experience gained insuring against natural disasters in the USA up to now has shown that the government has to pay disaster aid, even in cases in which the individual user has intentionally neglected to take out private insurance. Apparently no politician can openly refuse to help in the face of such catastrophes. Therefore it is cheaper for the individual user not to take out any insurance, relying instead on others' solidarity. Mandatory insurance for all ecosystem users would not impair competition and would be a measure for internalizing stability risks in harmony with market forces.

4. *Environmental damage is to be avoided wherever it clearly impairs human health or preservation of naturally controlled systems (the continuity of vital cycles such as water, carbon, nitrogen, etc.).* Most constitutions in the western world already cover the first possibility: every citizen has a basic right to avoid bodily harm. Such a basic right should not be withheld from individuals in future generations either. In simple terms: any action that has a high probability of lethal or other serious injury to future generations has to be prohibited now. The question of course arises as to the degree of probability beyond

which such a prohibition should come into effect. Completely avoiding risk would mean completely avoiding any intervention in nature whatsoever. Nobody would seriously consider this possibility. But avoiding great risk potentials can be a problem, even if basic needs can be fulfilled without them. Social systems have to carry on adaptation processes continually, and to mediate innovatively between changes of the natural environment and the demands of their members. Trying to eliminate all risk from social development would make a social system so inflexible that it might not be able to adapt anymore to the external conditions of its own existence which are constantly changing.

But where can we draw the line? It is one of the lines that cannot be drawn as a matter of principle. Society still has right to draw such lines. It is even a social and moral duty to do so. But whether we can draw such an abstract borderline between acceptable and unacceptable risks, as many engineers and politicians would like to do is questionable. At the same time, the economic solution of covering such risks with higher prices (such as insurance) is unsatisfactory too, because economic instruments do not work against risks which are so unacceptable that no compensation could offset their negative potential for harm. Furthermore, economic instruments establish trends rather than meet predefined targets. More importantly, risks are usually unintended side effects that hurt other persons besides the partners in an economic transaction. Thus, both the problem of inviting potential free-riders or, conversely, imposing unwanted risks on others who are not part of the economic transaction are characteristics typical of situations in which market forces fail. This leaves public discourse* as the only solution, during which representatives of

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* A rational discourse is defined as a communication process in which all affected parties resolve a conflict by

(1) reaching a consensus on the procedure that the participants want to employ in order to derive the final decision or compromise, such as majority vote or the involvement of a mediator;

(2) basing their factual claims on the "state of the art" of scientific knowledge and other forms of legitimate knowledge; in the case of scientific dissent all relevant camps should be represented;

(3) interpreting factual evidence in accordance with the laws of formal logic and argumentative reasoning;

(4) disclosing the values and preferences of each party, thus avoiding hidden agendas and strategic game playing;

(5) attempting to find a fair solution whenever conflicting values or preferences occur, including compensation or other forms of cost and benefit sharing.

today's generation, in the interest of future generations, set limits not to be violated even for attractive economic gain.

Risk becomes an even more serious problem when it concerns the operability of ecosystems. People can reach agreement quickly on the unacceptability of interventions in nature that someday would have lethal consequences for identifiable members of their community. But, nobody can say objectively just what is so precious in nature that it should be held aloft from any human intervention at all, regardless of how valuable it might be from a utility standpoint. Therefore we have no commonly acceptable reason to make any natural systems taboo in such a far-reaching and universally valid manner unless they are ones that jeopardize humans' ability to survive and continue on this planet economically, should disturbances arise in their function, or vital cycles be destroyed.

Once the air becomes so polluted that the respiratory tract is attacked; once the water becomes so scarce that the water-supply systems don't work; and once the soil becomes so polluted that renewable resources won't grow on it anymore - then this criterion would be obviously fulfilled. But until things get that bad, the limits will remain somewhat cloudy, particularly in cases of serious consequences. The limits have to be set over and over again in keeping with research findings and observed consequences.

If specific economic activities have been identified in public discourses as unacceptable, they have to be prohibited, and the prohibition enforced, in the form of either regulations and/or cultural norms (some of the latter might be even religious in character). Cultural norms (like taboos) have the functional advantage that they are very efficient and effective once they are successfully internalized into a society's value hierarchy. Then they provide a high level of conformity at a relatively low administrative cost. Cultural anthropologists have convincingly proven that placing taboos on the environment has been of great advantage for the cultural evolution of human societies. However, it is an open question as to whether it is possible to embed generally compulsory cultural standards of nature preservation into pluralistic value hierarchies and a world order like ours. But we should nevertheless give it a try, especially since almost all humans are very receptive to the idea of an intact environment, as many surveys have documented.

5. *All other interventions in nature not explicitly covered under Rules 1 - 4 above can be left to market forces under the condition that, wherever external effects exist, collective*

strategies should be permitted to control prices through taxation or to restrict quantities of undesirable environmental products (pollution, wastes) through issuing certificates in alignment with other market forces. Much has already been written about these two market compatible instruments, so we can do without further explanation of them now. What really matters is the insight that any intervention not covered under Rules 1 - 4 be governed by the principle that utility and damage be regarded as interchangeable and compensatory factors, even if there is a lot of uncertainty as to how much of each is involved in a given tradeoff.

Such a market strategy presumes that the external effects of production and consumption have been internalized. (Social) external effects are damages and unpleasantness inflicted on - or in some cases, positive attributes imparted on - third parties by production or consumption, either directly or indirectly, without being reflected in the price. Pollution of the environment is a classic example of external costs not accounted for anywhere. The costs of environmental protection, of course, have to stay within affordable limits, but sustainable growth depends critically upon keeping consumers and producers from externalizing their costs, to keep them from passing costs on to the general public or future generations.

Besides internalization, a market-type solution to environmental problems also means using discount rates for future environmental damages, i.e. negative interest on environmental consequences in the future. Whether such discounting serves the purpose of sustainable development over time is a very controversial topic in the literature. Nevertheless, there are three reasons that we would like to use a variable discount rate for environmental damage.

Firstly, it is easy to see that using a discount rate of zero for non-renewable resources would make it necessary to introduce infinite prices. When the nth generation comes to the end of the resource concerned, and if it is to have the same right to the resource as our generation has, the potential marginal utility (and therefore the price) would increase infinitely. This is more than just a game of mathematics, and has important implications. Using a discount rate of zero would be ideal if humanity really could live on only the interest off nature. Since, as pointed out earlier, that is impossible as a matter of principle, no more non-renewable resources could be used anymore in the interest of intergenerational equity. Neither could future generations do so either, as they, in turn,

would have to show consideration for their future generations. This in consequence would lead to a misallocation of resources.

Secondly, it is not our aim to perpetuate natural resources, but rather to stretch them over time. The lower the discount rate, the greater the obligation becomes for the present generation to enhance resource productivity, ceteris paribus. Variable discount rates could therefore be used as instruments for enhancing resource productivity flexibly. Flexibility of the discount rate makes it possible to set different rates of depreciation for different interventions in nature. This frees society from the need to use the same period of its responsibility for all types of intervention, as suggested in some philosophical treatises on long-term responsibility. Of course, we are referring to discount rates merely as planning aids that do not necessarily reflect actual market interest rates.

This brings us to item three: the alignment of the market for capital with that for nature. Low discount rates on nature versus those on capital would force economic players to clarify their own preferences for future investments versus present consumption, to recognize the logical relationships between private and public debt, the reluctance to save and the desire to consume. Whoever goes into debt to finance present consumption, is abusing the intergenerational contract. On the other hand, whoever funds projects which are sustainable and benefit future generations may pass on a share of the costs to the next generation. The idea of discounting is, after all, to "reward" saving and to "punish" direct consumption.

This applies as well to negative effects of environmental degradation. It is always more attractive to postpone an environmental damage than it is to suffer from it immediately, all other things being equal. The intensity of the time preference between accepting damages immediately as versus accepting them after a delay can be expressed as a discount rate. Discount rates and interest rates are indicators for the preferences that today's generation has concerning the desired distribution of consumption possibilities among generations. They are thus not at all arbitrary, but instead reflect the duty accepted by general public to prepare for future generations. But people are often not conscious of this: they want to spend more than they earn, and preserve the environment at the same time. This discrepancy becomes apparent when looking at the difference between the interest rate on capital and discount rate on resources. An ideal national economy's marginal rate of

substituting money capital for natural capital would balance its market optimally. For many reasons, this balance today is distorted, so that taking the interest rate prevailing on the capital market as a discount rate for natural assets is not believed to be reasonable anymore, not even by the World Bank when it plans projects relevant to the environment. Discounting is an instrument for the allocation and distribution of resources among generations. The discount rate makes interdependencies apparent among the different production factors.

6. *Although interventions in the environment should be accountable in terms of so much damage on the one hand and so much benefit on the other, every society or group of nations should also be free to attach immanent values to certain exceptional elements in nature that its members can agreed upon, even if they show a negative cost/benefit ratio.* For instance, there might be ethical reasons for protecting certain animals or for keeping animals in more humane living conditions which do not yield a monetary benefit, but can be justified out of a respect for the Creation. Biodiversity can also be justified intrinsically (by consciously placing a value on it), and is not dependent on a line of reasoning that anticipates a possible future need as part of a consideration of monetary benefits (which is usually not very convincing anyway). For such a divergence from the cost/benefit principle to be rational, however, decision-makers have to be aware of the costs of the measure before they consent to it. Granting ethical reasons validity and opting for a solution other than that of maximum utility can always be legitimated vis-a-vis future generations, even if the future generations would not be able to follow the ethical reasoning that lead the present generation to do so. The reason that our ancestors did not want to eat horsemeat surely does no harm to us, even if we only abstain from horsemeat for traditional reasons. The deliberate decision not to use a resource for economic purposes can never compromise the possibility of future generations to improve their level of welfare.

Even if all these six items were strictly observed, it would not mean that a sustainable economic structure would come about by itself. These six items are necessary prerequisites, but in no way to be taken as guarantees. The rules can be seen in three groups: Rules 1 - 4 require political instruments (governmental regulations as well as agreements among the major economic players), because the aims that they strive towards do not automatically result from market forces alone. Rule 6 allows for cultural values to

legitimize violation of the cost benefit principle. Rule 5, though, relies on commonly acknowledged market forces for the majority of economic decisions which influence nature and posterity. The philosophy upon which all of this is based is that a steady improvement in the efficiency of nature utilization constitutes the prerequisite for a just distribution of resources among future generations. But this is only the case if a society fixes the discount rate near zero, which means that it forgoes consumption in favor of future generations, and at the same time defines the limits of acceptability under Rule 4 in terms of rational criteria that others can understand. This willingness cannot be brought about by any market or other control system, "artificially" so to speak. Instead, it has to come from within humanity itself. That's why we regard the topic "Education to Promote Awareness of Sustainability" as a vital part our sustainability project.

7. Selection of Policy Tools for Sustainable Development

The six rules for implementing sustainable development need to be converted into policy tools that promise to accomplish the main targets of sustainability. For this purpose, we can draw again from the analysis of the basic modules that constitute the different concepts of sustainable development. The various types of limits, instruments and modules involved can be arranged into the following four policy packages, each of which comprises a logically interrelated unit:

1. In environmental areas in which it appears necessary and realistic to have absolute limits set, such limits have to be determined and instruments of environmental policy identified which will reliably prevent the limits from being exceeded. Such instruments would include regulatory standards and prohibitions, but could also be economical if success can be assured. In cases in which limits cannot be justified objectively (scientifically), or are extremely unsure - without however placing any doubt on their validity in principle - they will have to be determined democratically through a public discourse process. Exceeding the limits must be avoided, even if costs are high. The module upon which this package is based is the scientific perspective on sustainability in combination with a clear objective of protecting the environment.

2. In those environmental areas in which stretching the resource base or completing cycles is desirable, and limits are in danger of being exceeded with a high degree of certainty - albeit not ones upon which human health or the functioning of ecosystems depends - economic or social incentives are to be created to guide progress in the right direction. At the same time, policies of other political or economic agencies (such as the fiscal tax system, an economic development agency or an industrial board for enhancing international competitiveness) should be included in the analysis. These policies may act in favor of - or perhaps against - the incentives originated by environmental agencies. When policies are promulgated by different actors with different objectives in mind, it often results in inconsistencies and inefficiencies with respect to the overall goal of sustainable development. Thus integration of policies and regulatory activities is an important target for streamlining

sustainable practices. The module upon which this package is based is the economic perspective in combination with a utilitarian or gardener-like attitude towards nature.

3. In those environmental areas in which damage to the environment appears possible, but great uncertainty exists as to the possible consequences, the uncertainties should be determined quantitatively to whatever degree possible (otherwise qualitatively), and then included in the package sent to the legitimate decision makers for final decisions. If the catastrophe potential is high, the causal, or "polluter pays" principle appears appropriate, i.e. the state would regulate preemptorily. If the catastrophe potential is low, or risks affect primarily individual groups, communication measures to orient the groups about the risks should have precedence over government regulation (including product labeling). The module upon which this package is based is ecological in its approach, and shuns away from regulation if risks are seen as low and major inequities are not to be expected. Otherwise the precautionary principle should be applied to reduce potential risks even if their true extent is not yet known.

4. In those environmental areas in which no direct damage of environmental function is to be expected, but people attach value to certain types of intervention (such as rescuing Dolphins or calling for more humane animal treatment), or in which the distribution of risks causes perceived injustices, controls can be applied through communicative, economic or legal action, as long as the costs have been made clear to all those concerned. The module upon which this package is based is derived from the social science model of sustainability, and requires communicative or political instruments.

Among the many policy tools available, eco-taxation has gained much prominence in recent years. Eco-taxation and tax reform in general have been proposed as effective incentives for promoting sustainability. The overriding goal is to create a tax system that is neutral as regards total revenue, but punishes non-sustainable practices, and reinforces sustainable ones. The problem with eco-taxes is, however, that the new rates cannot be allowed to jeopardize the fiscal security of the state (that being the reason that the system cannot depend exclusively on levies that decrease with environmental improvements). Nevertheless, a healthy mix may be desirable. To tax labor does not make much sense in

international competitiveness and unemployment rates have become a major social challenge. It would be more logical to switch to consumption taxes, and possibly even raw material taxes. The more individuals allows themselves, the more use of the environment they make. It is therefore only just if they contribute accordingly to Internal Revenue.

The selection of policy packages and corresponding instruments depend on the target area to which these packages will be applied. In the course of the project such areas will be identified and conversion strategies will be developed. The following areas are prime candidates:

- the conservation potential in the consumption of nonrenewable resources;
- reduction of the consumption of energy and resources per product unit and per capita;
- utilization of renewable resources only to the degree that they regenerate themselves;
- reduction of terminal waste (i.e. no longer recyclable waste, in air, water and soil);
- avoidance or reduction of environmental and accident risks;
- promotion of energy-conserving and material-conserving innovations;
- finding substitutes for energy- or material-intensive products or services in the areas of production and consumption;
- re-using or recycling materials that are no longer usable for their original purposes;
- adapting educational and training systems to the requirements of sustainable development;
- improving the public's environmental awareness and environmental behavior both in the workplace and at home.

When operationalizing instruments and policies for each of these areas, the boundary conditions of cost-effectiveness (internalizing external costs wherever possible) and political feasibility (legally, economically and socially) must be identified and observed. It will be necessary to describe the conversion processes needed to get to the generally acknowledged targets from the actual situation at hand. That in turn will require exact details concerning the time frame for conversion processes and innovation cycles in the various economic areas. Such a job can only be done on the basis of concrete case studies. Our project will include a number of case studies that will help us to demonstrate feasibility and political acceptability of the required transformations.

8. Regionalizing Sustainability: Advantages and Problems

It is our opinion at the Center of Technology Assessment that the prerequisites for sustainable development listed above can be operationalized effectively only on the regional level. Although the principles of sustainable development are supposed to apply to all, it is necessary to observe the particularities and requirements of the states and regions concerned when implementing these principles and turning them into agreements and laws. Realistic approaches to sustainable development must be based on factors such as population density, environmental conditions, the level of education and development attained, economic structure and cultural identity. To be realistic, approaches must develop regionally adapted strategies that both make good ecological sense, and can be put into practice politically and economically under the given conditions. For example, agricultural practices that have made possible sustainable production of food for centuries in many parts of Europe cannot be transferred to tropical forests without major modifications.

Another advantage of regionalization is that most regions have suitable political institutions and regulatory mechanisms for legitimizing sustainability included in their state charters. Such political institutions are lacking on the international level, or have just started to form there. Regions also have institutions to implement measures, to monitor their observance and to enforce them, which have just started to form on the global level. Finally there is the problem that global approaches still have a tinge of eco-imperialism associated with them, as if developed, industrialized countries knew best what the whole world needs. Emerging nations in particular are suspicious of having any limits set on their aspirations towards economic expansion in the name of sustainability. International agreements and negotiations to support sustainable development are surely indispensable; real breakthroughs, though, can only be expected to come about once the principles of sustainable development have been implemented on a regional level. Successful examples beg emulation.

Using a region instead of a whole nation as a test area has the additional advantage of the region's relatively homogenous economic structures, which may even cross state borders. Similar regions can share experiences with one another and find solutions to typical problems. This would be much more difficult on the national level because of the

heterogeneity of structures within a whole country, and because of political psychology (nations are likely to be perceived as imperialists when attempting to teach sustainable practices to other countries). The other alternative would be to consider cities or counties as units of analysis. However, basing a study on units that are too small would cause the concept of sustainability to lose much of its effect because then too many products and services are either bought from, or sold to, parties outside the unit. It is easy to form an island of sustainability if all non-sustainable effects of production are exported and all non-sustainable products imported. Therefore, to be ideal, a test area would be a place in which most goods and services for which there is demand are produced, or at least could be produced within the region. But is such an idea of regional self-sufficiency realistic?

Given today's worldwide trade links, each region depends on imports from elsewhere, and exports its own products and services (including external effects such as emissions) to other regions. For this reason, even with a regional approach to sustainability, one has to take a closer look at the unit's trade balance. Otherwise the criticism would be justifiable that limiting oneself to a particular region was promoting the formation of an ecological island at the ecological cost of other regions. Larger regions, much like states, can also achieve considerable affluence and support a high population density if they are economically well endowed and take advantage of appropriated carrying capacity, i.e. laying claim to the carrying capacity of other regions. These units may observe all the rules of sustainability strictly on an internal basis, but flaunt them in taking advantage of external resources. Importing grain from foreign non-sustainable production makes it easy to have idyllic extensive animal husbandry within one's own region. However desirable it may be to look to one's own region first in trying to satisfy the requirements for sustainability, a regional focus can become a problem unless material flows into and out of the region are also considered.

For these reasons, our call for regional sustainability includes making the region commit itself to demand only such products from other regions as ones that satisfy the internal rules of sustainability. The region is not allowed to export environmental liabilities off onto other regions either. For example, it is not allowed to import clean water from one region and deliver it polluted to another. Appropriated carrying capacity is not an ecological problem as long as the same rules apply in the region in which it is practiced as in the home region. For this reason, it becomes necessary to analyze the material flows in

addition to the monetary flows arising from the economic interdependence of regions. One has to investigate imports and exports to see whether they promote or hinder sustainability in the country of reception or country of origin. Indicators for judging sustainability include water consumption, the utilization of surface area, soil degradation, energy conversion and the quantity of waste given off. The same principles that are valid for the region apply to its imported and exported goods and services as well. Such a regional trade balance based on ecological criteria has a lot of advantages:

- The regional focus is maintained. The advantages of working with manageable quantities remain even after accounting for imports and exports.

- Each material flow is investigated individually, taking into account the specific conditions in the particular country of origin or reception.

- Most of the authorities responsible for import and export reside in the region itself (expect for ones administering generally applicable laws of fair competition).

- Concentrating on regional imports and exports makes it easier to rank categories in which to implement the requirements for sustainability. One can start with agricultural products, for instance, whenever one considers the utilization of surface area and soil degradation to be particularly critical quantities in evaluating sustainability, as they certainly are.

- In applying the principles of sustainability to imports and exports, one has a lot of instruments available that are hardly available on a global level. In addition to regulatory measures by the state, there are also voluntary commitments by individual importers or exporters, bilateral agreements among producers and buyers and the use of labels for imported sustainable products. Examples include some American coffee roasters who have begun buying coffee beans from sustainable cultivation. The buyers are willing to accept a slight increase in price to benefit sustainable production.

- If one can assume that the demand for most of the products coming from developing countries is relatively inelastic (for untreated raw materials and agricultural products especially), i.e. a slight price increase by all sellers does not cause a significant drop in demand, then converting to sustainable products would

not mean loss for the countries of origin for the population living there today. Instead, such conversion sets the stage for an improvement in the welfare of the people living there today and in the future.

- A decision to buy only sustainable products also dampens the criticism that industrialized countries are acting in an eco-imperialistic fashion. Firstly, such a decision binds both sides equally: imports and exports must satisfy the principle of sustainability. Secondly, any buyer is free to determine quality standards for products that s/he buys. The "Customer is King" principle also applies to collective preferences: Whatever one region wants to buy from another cannot be dictated to it by anyone. Such behavior is not protectionistic either, since the domestic economy must act under the same restrictions. Thirdly, other countries and regions are free to operate either sustainably or not in their markets for their own purposes. Industrialized countries can try to convince others, but not make laws for them.

- The forces of the market and free world trade remain hardly affected at all by these rules. International competition for favorable production conditions remains with the approach we are promoting - unlike subsidies, which almost always cause inefficient solutions. The market can develop, but only on the condition that competition take place among sustainable products.

There can be no doubt that the procedures for imports and exports proposed here still leave a lot of problems. Just think of the issue of competitiveness in a region that tries this alone. It is also difficult to determine whether a product meets the prerequisites of sustainability or not. This is especially true of modern industrial products that consist of hundreds of individual components from various parts of the world. And finally there is the problem of non-sustainable products that are dumped into the region via third- and fourth-party countries just to make testing for sustainability more difficult or even impossible. Despite these barriers, regionalization - together with the requirement that imports and exports be sustainable - appears to be a means of implementing sustainable development that is theoretically satisfying and practical within the limits set above.

The Center of Technology Assessment in Baden-Württemberg has decided to test this approach on the Region of Baden-Württemberg. There are reasons for this in addition to the region's being the location of the Center. One of them is that the economy here is

preparing itself for far-reaching structural changes at the end of a major recession. Furthermore, all requirements for an economic structure based on technology and information processing have been fulfilled here to a large degree. The structural change already underway in Baden-Württemberg could help the economy develop relatively fast into an example of qualitative growth. It is our hope that we can prove and demonstrate the feasibility of reorienting the economy and society around the idea of ongoing concern for the future by setting an example and taking pragmatic steps in the direction of sustainable development.

IV. APPENDIX

1. Definitions of Sustainable Development

1. Development in which all energy would be derived from current solar income and all non-renewable resources would be recycled.
(Pirages 1977)

2. Development that is likely to achieve lasting satisfaction of human needs and improvement of the quality of human life.
(Allen 1980)

3. Indefinite survival of the human species, quality of life beyond mere biological survival and persistence of all components of the biosphere, even those with no apparent benefit to humanity.
(Brown et al. 1987)

4. Pattern of social and structural economic transformations which optimizes the economic and societal benefits available in the present, without jeopardizing the likely potential for similar benefits in the future.
(Goddland and Ledec 1987)

5. Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
(Brundtland Report 1987)

6. Constancy of natural capital stock and living from the interest.
(Pearce et al. 1988)

7. Center of TA: Sustainable development denotes a process by which the capital assets of natural resources are preserved to the extent that the quality of life available to future generations will not be inferior to the quality of life of the present generation.

2. Detailed Description of the Project

The first phase of the project has been devoted to analyzing the present situation of economic performance in the State of Baden-Württemberg at least in broad brush strokes, and to portray economic structure and processes in terms of a small number of meaningful indicators. The following indicators have been selected:

- population data (density, settlement forms, incomes, consumption, etc.)
- the relative importance of the various economic sectors contributing to the domestic product
- a survey of available renewable resources (water, soil, biomass)
- a survey of resource consumption over time
- a survey of resource consumption by sectors of the economy

These data constituted the starting material for conceptualizing our regional approach to sustainability and the operationalizing process based on this concept (Phase II). Data from the surveys were used to determine the targets and operational ideas needed to attain qualitative growth as a prerequisite for sustainable development. These targets were qualitative or - whenever feasible - quantitative in nature.

During Phase II, a workshop with international experts will be held in the summer of 1994 on the topic of "Sustainability" to determine targets and how to best operationalize them. This workshop will bring together selected leading thinkers who have addressed the topic intensively. These experts will be asked to develop targets to be included in a draft optimized on the criteria for qualitative growth under the boundary conditions of cost-effectiveness and political feasibility. They will be provided with a description of the status quo in Baden-Württemberg in the form of a short version of the data collected by the project group to use as a basis along with a copy of the discussion paper on qualitative growth and sustainability. The expert opinions that they draw up are expected to provide the following additional inputs:

a) critical opinions on the conceptual proposals made in the discussion paper;
b) a draft for needed conversion processes drawn up around Baden-Württemberg;

c) an evaluation of the policy tools needed to induce these processes efficiently and in a socially compatible manner.

These expert opinions will comprise the discussion material for the workshop in the Summer of 1994. The workshop will be conducted according to the rules of the Delphi technique. The objective of the workshop will be to operationalize the concept of sustainability for the Region of Baden-Württemberg and to propose measures that appear necessary for conversion. In particular, we expect answers to the following questions:

- Which concept of "sustainability" can serve as a guiding vision for the project, and what does this concept mean for Baden-Württemberg?

- Which targets have to be tackled first, and how can they be integrated into the existing economic and political landscape?

- Which policy tools (mainly legal regulations, economic incentives, information and coordination instruments) are best suited to reach the targets?

Once set, the targets and operational interpretations of them have to be specified in greater detail over subsequent stages of the project, and tested on case studies (Phase III). This process starts with estimates of the resource potential, which are indispensable for conversion strategies, and necessary to achieve the goals anticipated in the workshop. Work started on these in 1993. The most important data from these estimates are being distributed to the participants in the first workshop. More precise estimates are to be taken throughout the years 1994 and 1995. Existing databases will be used for this whenever possible; however in individual cases, it will be necessary to do our own surveys, or to commission others to so some. Four subprojects are planned to develop estimates of potential:

- estimates of the potential of renewable resources;
- estimates of the potential of nonrenewable resources;
- estimates of energy requirements;
- estimates of human resources.

All these subprojects are limited to the Region of Baden-Württemberg. They will be done under the direction of Professor Mohr in the Biotechnology, Ecology and Health Department. Estimated energy requirements will come about as one of the results of the project entitled "Energy Scenarios with Low Climatic Impacts," which is directed by Dr. Schade (Department of Technology, Functionality and Quality of Life).

One other area in which work after the workshop will be concentrated is investigating carrying capacity, along with the related flows of imported and exported material (Phase IV). The aim is to develop a methodology for classifying exports and imports by their sustainability, and to apply it to Baden- Württemberg. Instruments for controlling imports and exports in such a way as to promote sustainable products should be studied, and some of them applied for test purposes after reaching agreement on them with the groups of people affected.

After potential and carrying capacity have been estimated, possible conversion processes should be described and analyzed on the basis of a few case studies (Phase V). In choosing the cases, one must differentiate by economic areas (of production and consumption), and by products or services. Attention has already been paid to having all examples represent sectors that have not yet reached the target levels, but which comprise enough potential to carry out conversion processes cost-efficiently. Judging from the analyses done thus far, the following areas appear particularly interesting:

- agriculture and forestry (internalization of positive and negative external effects);
- biotechnologies as a basis for new industries (high value added from low energy and raw-material inputs);
- crafts (to demonstrate both the potential of, and limitations to, ecologically compatible production and services);
- medium-sized industrial enterprises (to demonstrate both the potential of, and limitations to, the ecological application of technology);
- construction (to demonstrate prerequisites for construction and settlement structures);
- service companies, especially banks and insurance agencies (as means of controlling conversion processes through private-sector incentives)

These case studies may be modified over the course of the project. Some of them have been integrated into the academy's research program. The number and types of applications, however, may change over the course of the project in order to reflect the results of the workshop and analysis of potentials.

In the final phase of the project (end of 1996 to early 1997) the task will be to derive politically feasible strategies from the necessary conversion processes that have been developed through the selected case studies. We would advocate taking the case studies as a whole in keeping with the organic character of the sustainability concept. Differentiating by modules will also become meaningful again at that time. Selecting a certain module for one of the environmental areas or case studies under consideration suggests that the selection of a compatible package of policy tools. Instruments and strategies should be technically feasible, cost-effective, should observe legal regulations and remain within the framework of competitive democracy and socially accepted means of reaching a consensus.

The central issue will thus entail examining the political control instruments regulation, economic incentives, voluntary commitments (negotiations), mutual understandings and improvements in communication as to how they can help reach the targets that have been set. The particularly challenging aspect of this undertaking is to overcome the opinions and value judgments regarding political instruments that various societal groups will try vehemently to maintain, displaying a higher preference for the means under consideration than for the goals that they intend to achieve. That is the reason that this undertaking can only be accomplished through public discourse. It is planned for strategy experts to meet who have knowledge and experience in political negotiation, bargaining and shaping public opinion. They shall assist the research team in articulating political recommendations as a means of getting the various strategies and instruments put into effect. Once they have reached a consensus on the ways to get the targets of qualitative growth put into effect, the final phase can begin, in which a list of recommendations is to be drawn up and passed on to political bodies and societal groups. This stage will require that discourse sessions intended to reach common understanding on targets and necessary measures will have to take place both within the Center's Advisory Council (in which the major societal groups are represented) and within the public at large. These will be designed and organized by the Center's "Discourse" Department.

A separate subproject is planned to summarize the implications of project findings for the educational system, and to make them available through discourse with planners and practitioners alike. Our aim is not to introduce a new subject called "Sustainability." Rather we feel that the basic idea of the interrelationship between the economy and ecology can be best made apparent by leaving room to deal with it in various subjects and curricula. This applies to higher education as well. In order to put this intent into practice, the Center is holding a lecture series for students on the topic of "Sustainability" with the University of Tübingen in the Winter of 1994.

The results of the project stages extending over several years are to be evaluated and summarized in various final products. Currently we are considering the following forms of presentation:

- a discussion paper on the concept of sustainability and qualitative growth
- an edited volume containing comments on our discussion paper and the contributions of the experts taking part in the workshop,
- a summary report on the concept of sustainability and how it is to be operationalized,
- individual reports about each case study,
- a comprehensive report on the resource situation in Baden-Württemberg, including human resources,
- an edited volume containing the contributions by the participants in the lecture series on sustainable development,
- an edited volume containing the contributions by the participants in the second workshop,
- a final report with political recommendations.

Project work will be coordinated by a project council. It will include representatives of academia, business and politics. The job of the project council will be to evaluate work critically as it is going on, to make suggestions for further investigation, to recommend participants for workshops and to contribute special knowledge in collecting and interpreting data. We anticipate that eventually potential partners for further research and development would be welcome, either from academic circles or elsewhere.

The following work reports of the *Center of Technology Assessment in Baden-Württemberg* have been published so far*:

Nr. 1 *Lünstroth, U.; Weimer, W.:* Energie- und CO_2-Einsparpotentiale in Baden-Württemberg; Dezember 1993 (ISBN 3-9302241-01-3)

Nr. 2 *Renn, O.:* A Regional Concept of Qualitative Growth and Sustainability - A Pilot Project for the German state of Baden-Württemberg; 2nd edition February 1995 (ISBN 3-930241-05-6)

Nr. 3 *Renn, O.:* Ein regionales Konzept qualitativen Wachstums und nachhaltiger Entwicklung - Pilotstudie für das Land Baden-Württemberg; 2. Aufl. November 1994 (ISBN 3-930241-02-1)

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