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Interdependence of Biodiversity and Development Under Global Change

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Interdependence of Biodiversity and Development Under Global Change

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Cover photos (top to bottom): Agro-ecosystem used for thousands of years in the vicinities of the Mycenae palace (located about 90 km south-west of Athens, in the north-eastern Peloponnese, Greece). In the second millennium BC Mycenae was one of the major centres of Greek civilization (photo P. Ibisch).

Modern anthropogenic urban ecosystem dominated by concrete, glass and steel materials (London City Hall, Great Britain) (photo P. Ibisch).

Undernourished child in deforested and desertified inter-Andean dry valley ecosystem (between La Viña and Toro Toro, northern Potosí, Bolivia) (photo P. Ibisch).

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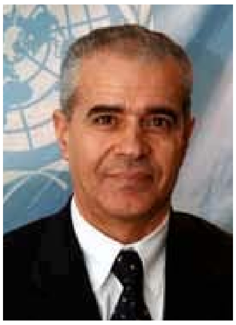

At its second meeting, held in Jakarta, November 1995, the Conference of the Parties of the Convention on Biological Diversity adopted the ecosystem approach as the primary framework for action under the Convention. The Ecosystem Approach recognizes that humans, with their cultural diversity, are an integral component of ecosystems. This has been known for a long time, but it has yet to be internalized by the whole society to assure present and future human survival.

Our modern civilization experiences—due to increased urbanisation and compartmentalised knowledge—an increasing alienation from nature obscuring common understanding of our real dependence on biodiversity and ecosystems. The complex global economy interwoven with a worldwide financial architecture has obscured the fact that all these human systems remain nested as sub-systems in the broader Earth eco-system. Humans and everything we create by using natural renewable or non renewable resources is subordinated to the general laws of nature that rule the functioning of this unique Earth system. Even though we are just a sub-system, human resource use driven by an ever accelerating growth and globalization of societies' activities has the power to catalyze irreversible degradation of the global ecosystem compromising human well-being and maybe even the existence of our civilization. As the Global Biodiversity Outlook 3 (GBO3) points out we are rapidly approaching critical tipping-points of life-supporting systems, if we don't break business as usual attitudes and habits.

Rediscovering the insights of these risks, the current technical series explores the manifold interrelations and interdependencies between biodiversity and human development. Applying system theory and through a transdisciplinary analysis of bio-cultural evolution, concrete up-to-date case studies and global statistical correlations this technical series goes deeply into the root-causes and drivers of environmental degradation and biodiversity loss. It shows that understanding the role and value of biodiversity and ecosystems for human well-being is more than ever a crucial pre-requisite and vital question for new and urgent needed development paradigms. In line with other initiatives like TEEB, IPBES or the Green Economy, among others, the technical series explores appropriate means and ways to translate proven knowledge and open questions into policy-relevant messages.

To find real solutions to both preserving biodiversity and securing sustainable development for the future in times of global socio-economic and environmental change, the authors of the technical series present and call for an in-depth understanding and comprehensive application of the CBD ecosystem approach. This requires to shift away from merely treating the symptoms of the biodiversity crisis. Following a precautionary approach, both knowledge and uncertainties should strategically be factored into decision-making to preserve the interests of current and future generations. New management systems for production, consumption for the global economy needs to be developed through a much more proactive management and by mimicking natural systems.

We are pleased to introduce this volume of the Technical Series of the Convention on Biological Diversity as a very useful contribution and enrichment of the debate on new paradigms for sustainable development in harmony with nature that actually move the agenda of committed scientists, policy-makers and practitioners worldwide.

Dr. Ahmed Djoghlaf
Executive Secretary
Convention on Biological Diversity

A. Technical section

A.2 MUTUAL MAINSTREAMING OF BIODIVERSITY CONSERVATION AND HUMAN DEVELOPMENT: TOWARDS A MORE RADICAL ECOSYSTEM APPROACH

Pierre L. Ibisch, Peter Hobson & Alberto Vega E.

A.2.1 CBD'S ECOSYSTEM APPROACH AND A CALL FOR A MORE RADICAL INTERPRETATION AND IMPLEMENTATION

Abstract

This paper recommends adopting a more intensive approach towards embedding principles and practice of ecosystem management in both the conservation sector and the wider development policy framework within and across state borders. In popularising the Ecosystem Approach, by for instance formulating the *Malawi principles* that target a broad audience, it has been expanded , almost to the point of diluting and losing some important underpinning fundamental scientific concepts rooted in ecosystem science. In an attempt to retrieve the fundamental messages of the Ecosystem Approach, this paper proposes an analysis of a *Radical Ecosystem Approach.* Radical, in this instance, refers back to the *roots* (Lat. *radices*) of the concept, specifically, inviting conservationists to focus strongly on the *root causes* of the problems that beleaguer the planet's ecosystems. In particular, recent evidence for human-induced climate change and the impacts it is already having on biodiversity has added to the sense of urgency, and the need for a much more *radical* reading and application of the Ecosystem Approach. Until now, there has been no acknowledgement that all problems arising from biodiversity loss, soil degradation/desertification and climate change are symptoms of the same root causes. This being the case, any workable solution would require a fully integrative strategy based on (eco)system science. Thus, a Radical Ecosystem Approach could also serve as a common basis for further integration of the different Rio conventions. The approach, outlined in 15 principles within four groups, is based on conclusions distilled from an extensive body of scientific literature as well as from empirical data related to the interlinkages of human development and biodiversity. It is of crucial importance to recognize that the "Earth super-ecosystem" is a complex system of higher order of nested and/or overlapping and interacting subsystems. Human systems are an integral and dependent part of the global ecosystem and all laws of nature that rule the functioning of this system should equally apply to the anthroposystem. Maintaining the function of the global ecosystem and avoiding significant state shifts of the Earth system must be the overarching goal of human development and biodiversity conservation. A competent and conscious dealing with non-knowledge is a fundamental part of ecosystem management (under global change). A post-normal science perspective recognizes the cognitive limitations of humans and provides important insights for management of pluralistic complex systems, which goes beyond the basis of 'hard' scientific evidence. We also discuss strategic objectives for biodiversity conservation that should be strongly focused on the root-causes of unsustainable development. Concrete elements for the implementation of a Radical Ecosystem Approach would include, amongst others, ecological economics and econics (a discipline that promotes the mimicking of ecological system dynamics and functioning for improved ecosystem management and functioning of socio-economic systems).

The Millennium Ecosystem Assessment (MA; e.g., Hassan & Scholes 2005) was a landmark study of the ecosystem services that support life on Earth. The findings revealed that about 60 percent of the ecosystem services such as fresh water, capture fisheries, air and water regulation, and the regulation of regional climate, natural hazards and pests were being managed unsustainably and in a state of degradation.

The prognosis for the future was that the situation would grow significantly worse in the next 50 years. Furthermore, the report stated that the ongoing degradation and loss of ecosystem services was an obstruction to the Millennium Development Goals (MDG) that had been agreed by the World leaders at the United Nations in 2000. The ongoing degradation of the ecosystem services examined in the study will have serious implications for human well-being.

The findings of the Millennium Ecosystem Assessment (MA) opened up a new moral imperative for today's society. The degradation to ecosystem services and loss of biodiversity are a direct result of human activity, and as such, the world has an ethical duty to restore the natural state of the planet. The MA exposes the paradox in the human-nature relationship. Human survival and development are dependent on ecosystem services—the very *stuff* of biodiversity. Throughout modern history, biodiversity has at best been marginalized or viewed as an inconvenience, and at times has been seen as a threat to social and economic progress, but never as essential to human well-being. More recently, this perception has been revised as a result of scientific evidence and better informed policy. Only now do we realise the extent and depth to which biodiversity supports and shapes human existence on this planet. There is no human life without biodiversity, the living planet is the life-support system of mankind, and from now on it must be central to all human endeavours and activities.

The **Ecosystem Approach** was not only designed as a primary framework for conservation action under the Convention on Biological Diversity, but it was equally expected to comprise strategies that were to adequately address the interlinkages between biodiversity and human development.

At its second meeting, held in Jakarta, November 1995, the Conference of the Parties (COP) of the Convention on Biological Diversity (CBD) adopted the Ecosystem Approach as the primary framework for action under the Convention, and subsequently has referred to the Ecosystem Approach in the elaboration and implementation of the various thematic and cross-cutting issue work programmes under the Convention (Decision II/8).

The Ecosystem Approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Application of the Ecosystem Approach will help to reach a balance of the three objectives of the Convention. It is based on the application of appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems.

(Extracts from the website of the Convention on Biological Diversity; http://www.cbd.int/ecosystem/)

The Ecosystem Approach has become one of the most influential and most cited concepts to be promoted in the context of implementation of the CBD. Internet search engines such as Google currently record hundreds of thousands of web pages and articles that mention the approach. *Google Scholar* alone lists about 22,100 texts, more than 3,500 published in the last 2.5 years[2]. Efforts to describe the concept and its application as a more effective approach to the conservation of biodiversity have been exhaustive. The term "*ecosystem approach*" has come to represent the new genre in environmental science for aspiring scientists, a buzz-word or jargon often used to widen publication opportunities. Sometimes the term and concept have been used as a marketing ploy to win support from the public. More worryingly, where it should count most, and provide the framework for good practice, ecosystem approach remains "*stuck in the clouds*" (Fee *et al.* 2009). Consequently, the absence of any effective leadership from conservation has reduced awareness and stunted development in ecosystem management across the wider social spectrum. Although most countries have fully endorsed the Ecosystem Approach none have demonstrated a serious commitment to implement appropriate practice. This is not to diminish all efforts by either international or national sectors to develop an ecosystem approach culture, in fact, there have been noticeable advancements made at both levels to build collaborative dialogue and policy frameworks. For instance, large-scale and transboundary conservation projects are promoted in the name of the Ecosystem Approach, and modern ecoregional conventions, such as the Carpathian

2 Search results from June 21, 2010.

Convention explicitly refer to it[3]. Thus, despite shortcomings on the ground, the utility of the Ecosystem Approach for orienting and informing policy development has been proven.

Over the years the Ecosystem Approach, has been carefully rounded and softened to accommodate for a much wider audience, and to encourage broad political appeal. In popularising the Ecosystem Approach, by for instance formulation of the *Malawi principles* that target a broad audience (Box 1), it has been expanded, almost to the point of dilution with the subsequent loss of important underpinning fundamental scientific concepts (see Box 2). Arguably, generalisations about ecosystem management have led to misconceptions or even perceived arbitrariness, and lack of application in the field

For practical and historical reasons, it is understandable that the *principles* themselves and the corresponding concepts of the Ecosystem Approach were adapted to correspond to the goals of the Convention on Biological Diversity, rather than the other way round. For instance, principle 10 states, "*The ecosystem approach should seek the appropriate balance between, and integration of conservation and use of biological diversity*". This principle reflects the interlinkage of biodiversity and development, without necessarily being built on principles of ecosystem science (see below). Similarly, the CBD's Ecosystem Approach sourcebook[4] reflects the wide array of topics treated under the approach's umbrella, while also allowing for insights into apparent priorities (e.g., compare the sequence of listed topics starting with public participation, education and awareness), and gaps (e.g., complex systems, global change, understanding threats and their root causes are *not* addressed).

BOX 1: The 12 Principles of the Ecosystem Approach

Principle 1: The objectives of management of land, water and living resources are a matter of societal choices.

Principle 2: Management should be decentralized to the lowest appropriate level.

Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should: a. Reduce those market distortions that adversely affect biological diversity; b. Align incentives to promote biodiversity conservation and sustainable use; c. Internalize costs and benefits in the given ecosystem to the extent feasible.

Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.

Principle 6: Ecosystem must be managed within the limits of their functioning.

Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.

Principle 8: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.

Principle 9: Management must recognize that change is inevitable.

Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of conservation and use of biological diversity.

Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

(Extract from the website of the Convention on Biological Diversity; http://www.cbd.int/ecosystem/)

3 Framework Convention on the Protection and Sustainable Development of the Carpathians (http://www.carpathianconvention.org/text.htm).

4 http://www.cbd.int/ecosystem/sourcebook/

In an attempt to retrieve the fundamental messages of the Ecosystem Approach (see Box 2), this paper proposes an analysis of a ***Radical Ecosystem Approach.*** Radical, in this instance, refers back to the ***roots*** (Lat. *radices*) of the concept, specifically, inviting conservationists to focus strongly on the ***root causes*** of the problems that beleaguer the planet's ecosystems. The concept of the Ecosystem Approach is fundamental to both preserving biodiversity and securing sustainable development for the future. Thus, we want to highlight the need for mutual mainstreaming of biodiversity conservation *and* human development. This paper recommends adopting a more intensive approach towards embedding principles and practice of ecosystem management in both the conservation sector and the wider policy framework within and across state borders.

BOX 2: The essence of the Ecosystem Approach as originally developed

The late Canadian J.J. Kay can be considered as one of the leading scientists who advanced thinking and scientific theories on the Ecosystem Approach. With his colleagues, Kay described the nature and function of complex systems using relatively recent concepts of non-equilibrium thermodynamics. Ecosystems were viewed as complex constructs of diverse interacting components, exhibiting emergent properties and the special characteristic of self-organization. The dynamics and numerous interactions between the large number of components within a complex system are often indeterministic and cannot be predicted. Consequently, outcomes and events are compounded by uncertainty that often frustrates the activities of managers. The laws of thermodynamics makes clear that changes within complex systems are inevitable; especially important are the abilities of nature to create order from chaos, to gather and form nested systems of higher order, and to evolve towards more complexity and higher thermodynamic efficiency. Out of the various laws of physics and concepts of ecology, a number of important conclusions can be drawn for the management of conservation projects, protected areas and sustainability. This is very well reflected in the works of Kay and colleagues, such as these cited below.

Kay, J.J. 1994a. The Ecosystem Approach applied to the Huron Natural Area. Document prepared for Environment Canada, State of the Environment Reporting, Ottawa, Canada.

Kay, J.J. 1994b. The Ecosystem Approach, ecosystems as complex systems and state of the environment reporting. Document prepared for North American Commission for Environmental Cooperation, State of the North American Ecosystem meeting, Montreal, Canada. 8-10 December.

Kay. J., Regier, H., Boyle, M. & Francis, G. 1999. An Ecosystem Approach for sustainability: Addressing the challenge of complexity. Futures **31**:721-742.

Waltner-Toews, D., Kay, J.J., & Lister, N. 2008. The Ecosystem Approach: Complexity, uncertainty, and managing for sustainability. Columbia University press series: Complexity in Ecological Systems. New York: Columbia University Press.

The impacts of human-induced climate change on biodiversity has added to the sense of urgency, and the need for a much more *radical* reading and application of the Ecosystem Approach. Inherent change in the character and behaviour of ecosystems is accepted as part of the natural evolutionary pathway, and is made explicit in the stated principles of the Ecosystem Approach (principle 9). However, very little reference to anthropogenic global (environmental) change is made in either the Convention or in the Ecosystem Approach. Even the Millennium Ecosystem Assessment can be criticized of oversimplification in its interpretation of the *biodiversity-ecosystem functioning* framework, which fails to adequately recognize the interdependency of biotic and abiotic components of the global super-ecosystem, as well as the critical importance of human globalization through trade and people's interactions (Naeem *et al.* 2009). Increasingly, climate change is seen as a major challenge to biodiversity conservation, and subsequent actions to mitigate against the effects of climate change are being viewed as a welcomed opportunity for the introduction of innovative conservation action (e.g. REDD—*Reducing Emissions from Deforestation and Degradation*). Climate change policy and related scientific work that is being promoted by the *Intergovernmental Panel on Climate Change* (IPCC), together with current mechanisms to evaluate the economic costs of climate change, have inspired conservationists to launch similar initiatives (see *Intergovernmental Platform on Biodiversity and Ecosystem Services*—IPBES, *The Economics of Ecosystems and Biodiversity*—TEEB).

Despite the various policies and strategies to combat the effects of climate change, there is little evidence of any real meaningful effort to tackle this problem in a fully integrated way with parallel concerns of biodiversity loss. Both concerns are commonly treated in isolation with their own set of causes and effects, rather than as interrelated facets of the same problem. There is much discussion about actual and potential synergies between policy and action in the fields of climate change mitigation and biodiversity conservation and increasingly joint activities between the three Rio conventions[5] are being sought. Whilst this is encouraging, there is still little movement in policy towards an acknowledgement that all problems arising from biodiversity loss, soil degradation/desertification and climate change are symptoms of the same root causes. This being the case, any workable solution would require a fully integrative strategy based on (eco)system science. Thus, a Radical Ecosystem Approach could also serve as a common basis for further integration of the different Rio conventions.

A.2.2 MESSAGES FROM SCIENCE: COMPLEX SYSTEMS, ECOSYSTEMS AND THE ANTHROPOSYSTEM

As a first step in the process of developing a Radical Ecosystem Approach this paper suggests a return to basics, including a more appropriate description of current knowledge and understanding of (eco) systems. A list of conclusions is distilled from an extensive body of scientific literature as well as from empirical data that have been processed in the background papers included in the second section of this document. The conclusions cover a range of issues including aspects of general system sciences and the overall Earth system, to specific dependent systems such as organisms, humankind and its social subsystems (Boxes 3-6).

BOX 3: Messages from system science, systemics

(For detailed analysis, discussion and references see Hobson & Ibisch, B.2.1. in this document)

Our world can be analysed and understood as a system consisting of interacting sub-systems. System theory is a key approach to inter- and trans-disciplinary understanding and work because it provides the necessary explanation and analysis of interactions of 'things', organisms, humans or institutions across disciplinary borders and scales. Systemics widens participation and acceptance amongst scientists and technicians across a broad spectrum through the use of familiar language and metaphors. System theory has had a significant impact on current thinking in both natural and social sciences. In a more applied context it has real potential for advancing practices in resources management. For instance, principles of complex systems management have been successfully transferred to business and institutional management.

Key messages:

- The components of this world tend to interact with each other exchanging energy, material and/or information. Ultimately, all interactions are the result and cause of energy conversion according to the laws of thermodynamics.
- Systems are created from interacting components that often produce combined effects that are larger and different from those expected from the individual components: emergent properties.
- Systems that have evolved tend to start interacting with other systems and thereby give rise to systems of higher order. Consequently, the world is composed of nested systems, in which components are simultaneously a self-organizing and functioning *whole* and a *part* of a bigger system (they are *holons*).
- A driving force of system conformation seems to be the tendency towards achieving thermodynamic efficiency, the ratio of possible order and work created by the use of a certain amount of energy. This appears to lead to a maximum closeness of the systems that in turn strengthens system definition and induces a 'boundary effect.' However, as systems are not completely closed but interact with other systems, these boundaries are not isolating, but rather perforated. The active maintenance of system boundaries is

5 Three international treaties have been adopted at the United Nations Conference on Environment and Development in 1992 in Rio de Janeiro, Brazil—a meeting popularly known as the 'Rio Earth Summit': The Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), and the United Nations Convention to Combat Desertification (UNCCD).

especially characteristic of living organisms and is fundamental to maintaining thermodynamic efficiency and avoiding entropic collapse.

- The interaction of the components in systems tends to create system dynamics and change that are often characterized by feedback loops, (and thus) an auto-referential, auto-regulative and self-organizing performance, and non-linear and unpredictable behaviour.
- System characteristics or features such as occupied space, complexity, energy and material turnover adopt specific states or operating points. The non-linear performance of systems is related to the shifting of the system from one state to another.
- Over time, system shifts can correlate with an increase in structural and functional complexity as well as the degree of 'nestedness'. This is the process of evolution. A corresponding decrease is related to degradation or even dissolution and collapse.
- Systems that persist as a result of auto-regulative processes without significantly and abruptly changing structural and functional complexity, i.e. their characteristics (emergent properties), are described as *sustainable*.
- Unpredictability, uncertainty and the probability of surprising emergent properties increase with the complexity of the systems. Complexity is a measure that depends on the number of system components and their interactions.

BOX 4: Messages from Earth system science and ecology

(For detailed analysis, discussion and references see Hobson & Ibisch, B.2.1., Ibisch & Hobson, B.2.2., Hobson & Ibisch, B.2.3. in this document)

Earth is a complex "super ecosystem" consisting of multiple nested and interacting subsystems with interacting biotic and abiotic components. Ecology is the science that studies the interaction of these components, which are characterised by permanent change. The human system (anthroposystem) is a dependent component of the global ecosystem, but has evolved the capacity of influencing the course of change of the super ecosystem.

Key messages:

- Interacting biotic and abiotic subsystems are semi-open to inter-system exchange of material, energy and information These relatively closed subsystems occur at all scales including continental, regional and local (e.g., terrestrial ecosystems on small oceanic islands are more identifiable as local 'systems' than parts of large sub-continental forest biomes).
- The smaller embedded systems are obligatory members of higher order systems and they depend on the dynamics and function of the latter. However, systems of lower order can create significant feedback changes to the systems of higher order (e.g., plants subtracting CO_2 from the atmosphere and producing oxygen).
- All systems on Earth are subject to the basic natural laws (especially laws of thermodynamics) and systemic rules (e.g., emergent properties, non-linearity). The global ecosystem is an open system with energy input primarily from the sun. The dissipation of incoming energy is a fundamental characteristic of living systems. Furthermore, nature is able to convert and store this energy as exergy (e.g., fossil and living carbon sources such as oil or wood), which is the potential of a system to cause a change as it achieves equilibrium with its environment. The photoautotrophic primary producers are the basis for providing exergy in living systems as they are able to convert solar energy into organic compounds.
- Conversion and storage of incoming energy and the work of living organisms has auto-regulative consequences, that is to say that life on Earth has a significant influence on the environmental conditions on Earth (e.g., influencing atmospheric composition and climate).
- Abiotic changes (e.g., related to solar influx or geological processes on Earth) as well as biogenic changes of the environment cause permanent local, regional and global change of the Earth system and/or the subsystems.
- Throughout the history of the planet, sporadic, abrupt, non-linear shifts in global ecosystems caused by feedback-loops (e.g. to different climate regimes) have driven systems to so-called tipping points, challenging the persistence of many subsystems.
- Throughout the history of the planet, global change has led to significant and dramatic impacts on subsystems. Notable events have included mass-extinction events that have changed the course of biological evolution. However, over time, the self-organizing forces of biological evolution have continued to drive

living systems towards increasing structural and functional diversity and complexity. This process is likely to continue until conditions for life on Earth become more unfavourable (e.g., by changes of solar energy influx).

- Ecosystems can be classified according to their ecological functions based on the contribution they make to regulating and stabilizing the planetary 'super-ecosystem'. For instance, large forest blocks interact with the climate system by absorbing and reflecting radiation, by sequestrating CO_2, and dissipating energy, emitting O_2, taking up and storing precipitation and evaporating it.
- Biodiversity, which is the variability of living systems and the ecosystems they live in, is fundamental in safeguarding ecological functions. The diversity of life contributes to multiple functions that locally and regionally can be affected by stochastic changes.
- As systems diversify and build in complexity they develop resilience, becoming less vulnerable to extreme changes. However, from a certain point onwards, hypercomplexity contributes to opening up systems, decreasing their thermodynamic efficiency and increasing their vulnerability to non-linear system shifts.
- The human species has created a dependent, ultra-complex system complete with its own nested sub-systems. Initially, these sub-systems functioned in isolation to each other (e.g., exchange of people, species, and material). Later development of social behaviour brought about changes including discovery of fossil fuels, and this resulted in the degradation and loss of diversity of ecosystems and their components together with a massive release of exergy stored in the Earth for millions of years (oil, gas, and coal). This development has led to changes that could have far-reaching effects including the potential to synergistically trigger non-linear state shifts of the Earth system and/or its subsystems. These shifts would occur at certain tipping points, e.g. related to the climate system.
- Many anthropic systems, including biomass-poor agricultural areas with biologically impoverished soils, are characterized by a very low thermodynamic efficiency in contrast to ecosystems not dominated by humans. As energy and exergy are the drivers to system evolution and persistence, this low efficiency seems to be a major factor contributing to unsustainability. Industrial ecology[6] has started to focus on issues such as material and energy flow studies, dematerialization and decarbonization and life-cycle-assessments. Clearly, the relevance of this discourse goes far beyond industry.). It is useful for the evaluation of the current development models and their impacts on ecosystems. Comparable approaches exist e.g. in agriculture (agroecology).
- The development of complex anthropogenic systems coupled with human-induced global change dynamics has increased the risk of future unexpected and sudden changes in the global 'super-ecosystem'. Unfortunately, scientific evidence gathered from studies carried out at this scale and level of detail is limited. What is required is a more competent and conscious integration of non-knowledge-based analysis with clearly defined objectives such as investigating complex systems-related uncertainty; the management and interactions of ecological and social systems (proactive adaptive management). Even then, there will always be a frontier to the unknowable. From emergent systems come new opportunities for knowledge gain, but equally for unattainable knowledge.

BOX 5: Messages from anthropology, history and social sciences

(For detailed analysis, discussion and references see Ibisch & Hobson, B.2.2. in this document)

Early humans evolved in Africa as an integral species to the local ecosystems at the time. The distinctive evolutionary traits that gave rise to the 'human condition' were advanced social cooperation, intelligence and culture. The emergence of these characteristics can be explained by a systemic process of interaction with the environment. An understanding of human evolution, and the development of complex social behaviour, specifically the psychological relationship with nature, is imperative to the construction of practical frameworks for sustainable development, especially in the context of increasing alienation of people from ecosystems. Humanity must come to terms with its own cognitive limitations and recognize that there are systems and processes governing nature that are of such complexity that they operate well outside the human sphere of influence and understanding. The acceptance of cognitive limitations is a key concept of post-normal science.

Key messages:

- *Homo sapiens* represents a heterotrophic species that evolved the extraordinary ability to exploit ecosystems extensively, including a wide nutritional spectrum. It is the first species on Earth to significantly and permanently change and broaden its ecological niche. This was possible thanks to an auto-accelerating cultural evolution and expansion of the geographical range. Humans are also the first species to use ecosystems without inhabiting them (by transporting and trading ecosystem products).

6 "Systems-based, multidisciplinary discourse that seeks to understand emergent behaviour of complex integrated human/natural systems" (Allenby (2006)).

- The processes that have shaped biological evolution are the very same that are responsible for cultural development. Cultural evolution, as well as biological evolution, led to diversification, increased complexity, and expansion of subsystems, the social systems, and their subsequent condensing and formation of systems of higher order.
- Principles of system evolution, adaptation to changes, sustainability and collapse can also be applied to social systems and are backed by historical processes of developing and degrading or even collapsing societies.
- Cultural development and progress have enabled humans to consciously change and manage ecosystems according to arising and changing needs. Whenever humans directly use or depend on ecological functions provided by ecosystems or their components, these can be called ecosystem services.
- Cultural evolution and corresponding success related to ecosystem manipulation and management were accompanied by an accelerating alienation from ecosystems, culminating in the generation of urban landscapes.
- Science is the principal means of investigative study and evidence-gathering in the analysis of the human–nature relationship. However, conventional practices of applying reductionism and experimentation have led to an underestimation of the degree of dependence on ecosystem services provided by relatively intact, unmanaged ecosystems. The globalization (and apparent atopization) of ecosystem uses, and sharing of labour with ever fewer rural people involved in directly managing provisioning ecosystem services, has further obscured this relationship, and frustrated attempts to analyse it scientifically.
- Human-induced (global) changes to the environment with subsequent resource depletion and loss, challenge traditional notions human's ability to control and regulate planetary systems and processes. Human failings have created real risks of driving many of the planet's systems over the tipping point with unforeseeable consequences. Dangerous climate change alone could overburden many ecological, biological and social subsystems. Of particular concern are the responses of political systems to increasing multiple stresses. Global change-induced political crises and warfare will present threats to the stability of human civilization, long before direct natural impacts such as temperature rise reach critical impact levels.
- Modern civilization faces the challenge of understanding and resolving the difficult problems arising from global-change-related crises and their complex interaction. Solutions to these problems require a solid foundation of knowledge and applied skills. The combination of intellectual and technical advancements has created a global society overwhelmed by information and knowledge. Accelerated knowledge gain has created its own problems by generating rapidly widening gaps between information availability, information accession and knowledge application. In addition to the surplus banks of information, scientists also face the growing realisation that uncertainty, indeterminacy and ignorance, especially related to global (environmental) change, are exposing a systemic knowledge deficit in matters relating to the human–nature relationship.
- The "deficit model" proposes that scientific knowledge is increasingly decoupled from sector-related practices and policy. At another level, the rate of scientific progress is outstripping the ability of practitioners and policy makers to translate and implement much needed knowledge.
- Current observations and translations of environmental phenomena are presented as simple linear and mostly sectoral models to facilitate understanding and appeal across the social spectrum. However, these models fail to capture the natural complexity of ecosystems, and the interactions between humans and nature. Decision-making does not keep pace with scientific progress and explosion of both knowledge and non-knowledge.
- The post-normal science perspective recognizes that biological systems are so complex, in particular, the relationship they have with energy, that conventional lines of scientific inquiry (physics, chemistry and ecology) provide only part of the answer or solution to problems. It goes further in suggesting that uncertainty and indeterministic tendencies inherent in nature will always generate the unknowable.

BOX 6: Messages from economy and development under global change

(For detailed analysis, discussion and references see Ibisch & Hobson, B.2.2., Freudenberger *et al.*, B.1.1., Kiefer *et al.* and Geyer *et al.*, B.1.2., Herrmann et al., B.1.3. in this document)

The growth and expansion of modern civilisation has dramatically accelerated the demand for energy and raw materials. This progress of *growth*, normally called *development*, has exploited Earth's exergy and other natural resources as well as the occupation of space. The acquisition of land and resources has been possible by the repression of other living systems. The human appropriation of net primary production of plants has reached a historical maximum. As livelihoods, health and safety improve for more people, the incentive for continued '*growth-based development*' remains high. In particular, human economic systems depend on growth to persist and function. All aspects of the environment and society require innovative schemes for development policy as well as economic and financial flows. The global environmental problems create interlinks between social systems that have had no previous political or economical association. In the current economic climate it is impossible to analyze the complex relationships between human development and biodiversity at the local scale only.

Key messages:

- The conversion and exploitation of ecosystems, and the management of required ecosystem goods and services, has spawned principles and practices of neo-classical economics. Continued alienation of humans from nature has contributed to the sense of decoupling between biodiversity, ecosystem function, and human survival and well-being. More specifically, the neoclassical economic system has ignored the environmental and traditional values of land, and natural resources by externalizing environmental costs (to other countries, regions, continents), and also by overlooking hidden global environmental costs (such as the emission of greenhouse gases that slowly trigger global climate change). The costs of coping with global environmental problems also have impacts on both natural and social ecosystems.
- Developed countries partly compensate for the loss of ecosystem services or existing ecological deficits (less available bioproductive area than required for satisfying the needs of the population) by importing goods and using technological innovation. Conversely, poor countries generally export ecosystem products and services to richer neighbors and consequently increase the *footprint* and resource degradation in their territory.
- In developing and transforming countries multiple direct dependencies on biodiversity can be observed. Clearly, on the one hand, there are cases where biodiversity represents a safety net that mitigates against the consequences of economic and political crises. On the other hand, critical loss of ecosystem services in poor countries is likely to contribute to governance problems.
- Biodiversity loss, decreasing dependence on local ecosystem services, and the integration into the globalized market economy are accompanied by loss of cultural diversity and related biodiversity knowledge.
- Despite the homogenising tendencies of modern civilisation, cultural diversity continues to thrive in many regions, offering a diversity of perspectives and visions on biodiversity, its conservation and human development.
- Climate changes (as well as other environmental change processes) will have negative impacts on ecosystems and ecosystem services all over the world, but developing nations are more susceptible to these impacts. The high numbers of rural populations, their direct dependency on locally generated ecosystem services and agricultural products is increasing the exposure of these communities to the impacts of climate change.
- Environmental economics attempts to assess the values of ecosystems and ecosystem services according to conventional neoclassical rationales. Alternatively, ecological economics factors into the economy natural laws related to ecosystem properties and functioning as well as existing limits to spatial and material growth. Traditional monetary valuation of ecosystem services has limitations in cases where the intrinsic value of biodiversity is considered (as it has been done with the adoption of the CBD).
- Biodiversity valuation continues to be a problem for other reasons. For instance, it is difficult to account for the values placed on biodiversity by future generations. There are clear ethical considerations with this issue. The evaluation of ecosystem services such as regulating and supporting services has tangible elements with real practical implications for human well-being or even existence, and these measures of worth cannot be accounted for in monetary or commercial terms. Global environmental change and the threat of reaching dangerous tipping points of global systems show that global regulative services of ecosystems are of infinite value.

A.2.3 DEVELOPMENT OF THE ECOSYSTEM APPROACH TOWARDS A MORE UNIFYING FRAMEWORK FOR SUSTAINABILITY: A RADICAL ECOSYSTEM APPROACH

All relevant human actions, development and economic activities ultimately depend on ecosystem services. Supporting and provisioning services provide the necessary natural capital required for human physiological maintenance and economic activities, whilst regulating services prevent the Earth system from shifting to other operating points or system states that would be less or not favourable for our species or our civilization. The Ecosystem Approach has the desired potential for establishing a unifying framework for sustainability. To achieve this goal, it is suggested in this paper that certain amendments are made to the existing set of principles and strategic objectives outlined in the Ecosystem Approach.

The underpinning principle to an effective strategy is to accept that sequence and hierarchy matters. All aspects of the Ecosystem Approach are important, but some are of higher importance than others. For instance the integration of humans into ecosystems is fundamental to sustainable development. Furthermore, there is one 'super ecosystem' (Earth ecosystem) on which all sub-systems depend, and is conversely, dependent on the dynamics of these nested lower order systems. Another key feature of this revised strategy is that sustainability is discussed explicitly in the context of future generations. Finally, it is proposed that anthropogenic global change and the globalization of environmental problems is given special attention in the Ecosystem Approach. Some principles can be merged, and others deserve additional clarification (Box 7).

BOX 7: A Radical Ecosystem Approach

Ecosystems as complex, nested systems that change permanently and dynamically

Principle 1: The "Earth super-ecosystem" is a complex system of higher order of nested and/or overlapping and interacting subsystems.

Principle 2: Human systems (the *anthroposystem* comprising both their biological population and their social systems) are an integral and dependent part of the global ecosystem and all laws of nature that rule the functioning of this system should equally apply to the anthroposystem. Biodiversity, especially, will benefit from improving the thermodynamic efficiency of the anthroposystem.

Principle 3: Naturally complex ecosystems shall be managed with due consideration to emergent properties, non-linearity or feedback loops as well as the main drivers of self-organization and evolution. The laws of thermodynamics are of special importance for the understanding of systems' functioning and change.

Principle 4: The ecosystem approach shall be undertaken at the appropriate spatial and temporal scales *(Principle 7 of conventional Ecosystem Approach)*. In a socio-economically and politically globalizing world, with eminent threats related to global environmental change, ecosystem management must be implemented on the local, national and global scale.

Principle 5: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term (*Principle 8 of conventional Ecosystem Approach*).

Principle 6: Management must recognize that change is inevitable (*Principle 9 of conventional Ecosystem Approach*).

Maintaining the sustainable function of the global ecosystem as a key priority

Principle 7: Conservation of ecosystem structure and function, as a prerequisite to maintaining ecosystem services, should be a priority target of the ecosystem approach *(Principle 5 of conventional Ecosystem Approach)*. Maintaining the function of the global ecosystem and avoiding significant state shifts of the Earth system (that comprises all other ecosystems and species as well as all social systems) must be the overarching goal of human development and biodiversity conservation.

Principle 8: Ecosystems must be managed within the limits of their functional capacity *(also Principle 6 of conventional Ecosystem Approach)*, and ecosystem managers or users should consider the effects (actual or potential) of their activities on adjacent and other ecosystems *(Principle 3 of conventional Ecosystem Approach)*. Ecological deficits created by human use of ecosystem services shall not be compensated by externalization of environmental costs to other systems, but shall be reduced by seeking autosufficiency (comprising strategies of sustainable degrowth according to the carrying capacity of the ecosystems supporting a certain social system).

Principle 9: Due consideration must be given to the interlinkages between ecosystems particularly in the context of global environmental change and human globalization. No ecosystem should be treated in isolation; adaptive strategies to global change must be an integral part of ecosystem management, as well as a means to mitigate against the effects of global change.

Principle 10: The ecosystem approach should seek the appropriate balance between the conservation and exploitation of biological diversity *(Principle 10 of conventional Ecosystem Approach)*. Ecosystem use and its consequences must not compromise the functionality of the global ecosystem.

Responsible social participation, economic interests and future generations

Principle 11: Management objectives for land, water and living resources are a matter of societal choices *(Principle 1 of conventional Ecosystem Approach).* Participatory decision-making shall take into account the interests of future generations irrespective of the constraints to development opportunities for current generations and stakeholders.

Principle 12: Holistic management principles that recognise the virtue and gains of economic evaluation of ecosystems should be practiced *(modified Principle 4 of conventional Ecosystem Approach)*. Equally, ethical and practical limits to the economic valuation of biodiversity shall also be respected.

Principle 13: Management should be decentralized to the lowest appropriate level *(Principle 2 of conventional Ecosystem Approach)*, keeping vertical coherence between higher intervention levels and horizontal coherence between development sectors and scientific disciplines. Ideally, the structure, behaviour and institutional arrangements of management systems should reflect the nested complex systems of nature.

Principle 14: The use of local, regional and global ecosystem services shall follow the principle of equitable benefit sharing. All aspects of human development should be regulated and measured using appropriate indicators of ecological sustainability and equitable benefit sharing. These indicators of sustainability should reflect ecosystem function, efficiency and resilience (principles and measures of thermodynamic efficiency apply here) as well as social justice among present and future generations.

Use of information, proactive adaptive management and post-normal science

Principle 15: The ecosystem approach shall consider all forms of relevant information, including scientific, indigenous and traditional local knowledge, innovations and practices *(Principle 11 of conventional Ecosystem Approach).* In addition, all relevant sectors of society and scientific disciplines should be included in the process *(Principle 12 of conventional Ecosystem Approach)*. Limits to knowledge, knowledge gaps, uncertainty and blind spots must be factored into all aspects of practice and management. Whilst evidence-based management demonstrates good practice, equally, a competent and conscious dealing with non-knowledge is a fundamental part of complex ecosystem management. Adaptive management should be as proactive as possible, anticipating potential impacts of future changes. A post-normal science perspective recognizes the cognitive limitations of humans and provides important insights for complex systems management.

A.2.4 STRATEGIC OBJECTIVES FOR SUSTAINABLE DEVELOPMENT UNDER A RADICAL ECOSYSTEM APPROACH

Failure by the international community to meet 2010 biodiversity targets has prompted a degree of soul searching and a review of conservation policy (e.g., Mace *et al.* 2010). In the future, "*ambitious but realistic*" targets shall be pursued that also "*address the drivers of biodiversity loss*" (CBD—Convention on Biological Diversity 2009a). Ideally, a future strategic plan for the implementation of the CBD would adopt principles of a Radical Ecosystem Approach especially acknowledging that conserving the Earth's biodiversity is about the management of a spatially limited complex system. Biodiversity loss cannot be halted unless mankind recognizes its specific role as an integral and fundamental part of the global ecosystem. The root cause of all drivers of biodiversity loss is the prevailing human development paradigm that does not sufficiently respect the laws of nature and the need to integrate human economy into ecosystem functioning (and not vice versa).

The COP decision dealing with the post-2010 strategic plan (CBD—Convention on Biological Diversity 2009b) explicitly deals with interlinkages of development and biodiversity, but only to the extent that it is acknowledged that "*conservation and sustainable use of biodiversity should contribute to poverty eradication at the local level and not harm the livelihoods of the poor*". However, it is obvious that CBD's diagnoses are becoming more clear-cut and radical: "*Scientific consensus projects continuing loss of habitats and high rates of extinctions throughout this century, if current trends persist, with the risk of drastic consequences to human societies as several thresholds or "tipping points" are crossed. Unless urgent action is taken to reverse current trends, a wide range of services derived from ecosystems, underpinned by biodiversity, could rapidly be lost. While the harshest impacts will fall on the poor, undermining efforts to achieve the Millennium Development Goals, no-one will be immune from the impacts of the loss of biodiversity*" (Executive Secretary, CBD 2009).

It is more widely accepted that "*biodiversity will benefit people in many ways, including through better health, greater food security and less poverty*" (same document cited above). Now, the challenge is to "*address the underlying causes of biodiversity loss, including consumption patterns, through the mainstreaming of biodiversity throughout government and society*" (same document). A number of recent concepts for CBD strategic targets state that 'ecological limits' have to be respected (Executive Secretary, CBD—Convention on Biological Diversity 2009b). Mace *et al.* (2010) propose a set of red, green and blue targets, based on urgency and priority. The highest priority is awarded to targets that address biodiversity change that is directly harmful to people such as collapse of marine fisheries or changes of intact functioning forests (red targets). Green targets would comprise the 'society-wishes-to-have' targets which would be less critical for survival and well-being of humans, and blue targets refer to knowledge gaps, "*enabling understanding and governing the system*". However, this proposal does not cover strategic objectives as it stops short of addressing the symptoms of biodiversity crisis (however motivated and guided by the principle of human well-being) and the call for more knowledge.

BIODIVERSITY AND DEVELOPMENT CRISIS: A POST-NORMAL APPROACH TO METASYSTEMIC MANAGEMENT

What if there is sufficient knowledge to understand the crisis, but an inability to use it? In modern conservation science, knowledge extends beyond simple inventories, the description of single elements of biodiversity or ecological studies. Conservation biology has produced abundant literature on problem analyses. Take the example of the study on Chimpanzees in Côte d'Ivoire (Campbell *et al.* 2008). The results indicate that the number of chimpanzee nests encountered has dropped by 90% from 1990 to today. In this case, a *strategic approach* would not call for increased efforts to monitor the obvious decline. Disease understood—patient dead. Rather, the relevant non-knowledge, not addressed by this kind of problem-focused research, refers to the solution of the problem. With all environmental and biodiversity problems, it is advantageous to know the dimensions and immediate mechanisms of a threat before formulating a strategy for recovery. In a number of cases the scientific 'diagnosis' fails to provide an answer to the problem. In the chimps' case, of course, the root causes of the problem are not related to their biology but instead, to human demographic and socio-economic changes; for instance, in the last 18 years the number of people in Côte d'Ivoire increased from 12 million to 18 million, amplifying poaching and deforestation. This example demonstrates the importance of patterns and factors outside the conventional sphere of biodiversity studies that have relevance to conservation practice. Relevant root causes to conservation problems are linked with the prevailing development issues. However, seldom is conservation research in a position to change the course of development and degradation. Consequently, it is often tarnished with the reputation of working in isolation, detached from reality, "*displacement behavior of academia*" (Whitten *et al.* 2001).

The perceived detachment between science and practice is also raised as a factor limiting the successes in effectively resolving conservation problems. Too often scientific knowledge is presented in an inappropriate style or format for use by practitioners. Equally, practitioners fail to keep abreast with scientific development, often because they are distracted by bureaucratic administration and work overload. Consequently, many conservation management plans and actions are carried out without the appropriate underpinning scientific evidence (e.g., Pullin *et al.* 2004). In recent years attempts to resolve this issue have been forthcoming, in particular, the initiation of evidence-based conservation (e.g. Sutherland 2000, Pullin & Knight 2001). This initiative has made much better use of existing knowledge, and as a result it has greatly improved the credibility of the conservation sector. However, questions remain about measurable improvements in conservation practice as a result of these changes (Grantham *et al.* 2009). For instance, does evidence-based conservation integrate or hamper the use of non-knowledge in concept-building, planning and action for the maintenance of biodiversity? Is there a danger that the focus on generating more knowledge and compiling all the evidence leads to counterproductive results—because the increasing relevance of non-knowledge is ignored or underestimated? Finally, in times of rapid global change with many complexly related and dynamically acting factors, should the emphasis not shift towards a non-knowledge-based approach rather than a knowledge- or evidence-based one? Or are these approaches complementary and of equal importance?

The realized knowledge deficit between the unknown or unknowable and the capacity to gain knowledge sets strong constraints on any strategy that relies on evidence-based practice. Vitek & Jackson (2008) call for an *ignorance-based worldview.* They are aware of the traditional negative connotation of *ignorance* that is generally seen as a deficient human condition that can and should be corrected. We propose a more moderated perspective—*non-knowledge*—a neutral term widely used in sociology and philosophy. It encompasses ignorance, uncertainty and the other facets of the unknown and the unknowable (e.g. Weinstein & Weinstein 1978, Böschen et al. 2006). Furthermore, we propose to adopt *non-knowledge-based conservation* as a kind of post-normal approach to the efforts of saving Earth's biodiversity (Ibisch *et al.* 2009).

This implies that pragmatic and mistake-friendly adaptive management, sited in the Ecosystem Approach, is an important part of this concept. Problems relating to the unknown and the unknowable, knowledge deficiency or overload are no longer treated as constraints or hindrances to effective management and decision-making. In an ideal world, absolute knowledge would help resolve all problems, but in times of rapid and uncertain change the relentless pursuit of knowledge to find the solution fails to "beat the clock".

A *non-knowledge-based conservation approach* would draw on an understanding of complexity of biological/ecological and social systems, and would also adopt lessons learned from applied principles of complex systems, such as those developed in business administration. Observation and steering of the system should not be implemented on a detailed object-systemic level, but rather on a metasystemic level. According to Malik (2008), metasystemic management implies that the direct contents of the problem solving process is less important than the general characteristics of this process. Metasystemic variables include the relative importance of a specific problem in a systemic context; the quality of the solution; the available resources for problem solving; the acceptable or required stress for the problem solving system; and ethical principles and rules (Malik 2008). It is also worthwhile to explore traditional (non-)knowledge systems and approaches to risk management, which are not founded upon detailed information about the natural science of agricultural production, but in many cases achieved to adapt to harsh environmental conditions and changes.

Malik (2008) compares the management of complex systems with a game that operates with changing rules, for instance, alteration in the number of players (some of which are carrying names such as *chance* or *accident*). To be a successful player, it is important to empathise with the other players and guess how they might (re)act; what kind of new players will join the table; and what you then need to do in order to stay in the game. Clearly, this game was easier to play in early times of biodiversity conservation, when the number of players was limited, velocity of change of rules was slower, and the players themselves were less complex.

More recently, international biodiversity conservation has developed conceptually towards more holistic and systemic approaches. The CBD's Ecosystem Approach currently is pretty much in line with post-normal science (Kay 2008). In particular, the approach integrates uncertainty into descriptive models and decision-making practices. Furthermore, it adopts a pluralistic strategy to dealing with problems (Ravetz 1986, Funtowicz & Ravetz 2008). Rather than dealing with elements of a system in isolation, the conservation of ecosystem structure and functioning are made priority targets (principle 5). The consideration of appropriate spatial and temporal scales (principle 7) and the acknowledgement of the need for long-term efforts (principle 8) as well as the principle that change is inevitable (principle 9) implicitly relate to non-knowledge philosophy. Thus, the Ecosystem Approach—if interpreted and developed adequately—is an appropriate framework for managing environmental and social sustainability

(Waltner-Toews 2008). The systematic exploration of principles and methods of post-normal science is of strategic importance for the development of the Ecosystem Approach and CBD's strategic plan.

The integration of the perspectives of the 'post-normal scientists' will also have to be consolidated under the umbrella of the new IPBES (*Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*). As it has been acknowledged that this "*intergovernmental science policy platform for biodiversity and ecosystem services should be established to strengthen the science policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long term human well-being and sustainable development*" (*Busan outcome*; UNEP 2010) The *Busan outcome* sends an encouraging message to the conservation sector: "*Use clear, transparent and scientifically credible processes for the exchange, sharing and use of data, information and technologies from all relevant sources, including non peer-reviewed literature, as appropriate.* (…) *Recognize and respect the contribution of indigenous and local knowledge to the conservation and sustainable use of biodiversity and ecosystems.* (…) *Recognize the unique biodiversity and scientific knowledge thereof within and among different regions, and also recognize the need for full and effective participation of developing countries as well as balanced regional representation and participation in its structure and work* (…). *Take an inter- and multi-disciplinary approach that incorporates all relevant disciplines including social and natural sciences*".

STRATEGIC OBJECTIVES—OUTCOME AND ROOT-CAUSE ORIENTATION

Strategic objectives for the implementation of a Radical Ecosystem Approach should be a prerequisite to any major strategy in biodiversity conservation. As well as clearly stated outcome objectives and prioritized action that help to reduce *dangerous biodiversity change*, it is also necessary to include complementary statements detailing the means of achieving these outcomes. These types of objectives would be an important tool for mainstreaming conservation and development. Ultimately, strategic objectives for the conservation of biodiversity are not '*conservation objectives*' but rather '*development objectives*'. For instance, in many cases, national biodiversity strategies are criticized for the apparent lack of a logical strategic framework (and consequently ineffective) because they simply represent wish lists of outcomes related to the state of biodiversity without going into the mechanisms of biodiversity loss. Strategic and effective conservation is more than a simple justification for the relevance and (economic) value of biodiversity or describing desirable states of species and ecosystems and naming the threats. Rather, it should include the development of constructive alternatives, such as *industrial ecology* or *ecological economics*. Furthermore, it should operate within parameters of nature that include inevitable change, indeterministic dynamics and uncertainty, and scale-related patterns, and feedback processes. The concerns linked to human development and economics is justifiably as much an issue for conservation as is the conventional protection of biodiversity. Both paradigms identify two ends of a continuum.

The **overall goal** or **vision** of a strategic plan in line with a Radical Ecosystem Approach should be written in the context of the Earth super-ecosystem, and should emphasise the importance of creating bridges with the directives for sustainable development as well as the other Rio conventions. The goal statement could be the following:

> ***"To secure a functional and sustainable global ecosystem that provides the necessary services for the well-being of current and future generations without diminishing ecosystem quality or driving systems beyond tipping-points towards alternative unstable states"***.

A corresponding **biodiversity-outcome-objective** would state the following:

> ***"Biodiversity as a prerequisite to human existence is maintained and restored so that it may be fit for purpose for all future generations".***

The formulation of clearly defined and principled objectives presented as a set of holarchic priorities that cut across spatial and temporal scales are fundamental to the process. For instance, where it is accepted that anthropogenic climate change represents one of the major threats to biodiversity and global ecosystem functionality, and thus sustainable development, mitigation of climate change must be of highest priority. Furthermore, those ecosystems that play a major role in gaseous and water transference with the atmosphere, such as forests or mires, must be prioritized for conservation. For instance, uninhabited boreal forests can contribute to global alleviation of (current and especially future) poverty as much as tropical rain forests, and thus deserve equal protection status. All ecosystem services that help to reduce vulnerability against global change should be prioritized. Of course, areas of the world that have high rates of poverty and social vulnerability should be especially targeted. The current draft of the CBD strategic plan proposes that "*ecosystems that provide essential services and contribute to health, livelihoods and well-being, are safeguarded and/or restored and equitable access to ecosystem services is ensured for all*".

Various indicators can be used to describe nature's status and its benefits for people (see e.g., Layke 2009). However, in monitoring, especially on a global level, it is important to reduce the number of indicators to an absolute minimum. The evaluation and monitoring of global ecosystem functionality and quality ideally should be based on a few proxy indicators of system function and dynamics. The following measures could be adequate candidates (see Hobson & Ibisch, B.2.3. in this document):

- Biomass production/carbon storage
- Diversity of native primary producers (species richness)
- Diversity of plant growth forms (functional groups/ strategic types)
- "Trophic tree index" (the number of functional groups of fauna and flora).

Objectives relating to the root-causes of biodiversity loss will have to address the problems of the prevailing development models. One issue is how socio-economic progress is achieved and what development means in terms of material and energy flows. In response, a strategic objective could include the following statement:

> ***"Future technological, scientific and socio-economic developments should be designed to operate towards thermodynamically-efficient systems".***

- ◦ To protect biodiversity, the soils, the climate and the whole Earth system, efforts should focus on decoupling human well-being from the following:
- ◦ Ever-accelerating energy and material flows;
- ◦ depletion of the Earth's stored exergy (e.g., fossil and living carbon sources, such as oil or wood);
- ◦ globalization of environmental problems, among others, by externalizing and exporting environmental costs (e.g., through inter-continental trade of timber or agricultural commodities including biofuels).

The goal is eco-innovation towards eco-efficiency (Huppes & Ishikawa 2009)[7]. This includes the mainstreaming of principles of industrial ecology beyond simply decarbonization of energy-provision. It relates to socio-economic development and especially natural resource management towards improved feedback processes, closed cycles and systemic management. Much can be learned from natural systems, and a corresponding key-concept could be called ***econics*** (Box 8).

7 Eco-innovation is a change in economic activities that improves both the economic and the environmental performance of a society (Huppes & Ishikawa 2009).

BOX 8: Econics

The authors propose this term and concept as a logical complement or homologue concept to bionics. Just as *bionics* (or *biomimimcry*) is the application of biological methods and structures found in nature to the study and design of engineering systems and technology (e.g., enzymes, surfaces, materials), then so too might *econics* be the discipline that promotes the mimicking of ecological system dynamics and functioning for an improved ecosystem management and functioning of socio-economic systems. This concept, whilst new, had already been proposed by Dirk Althaus („*Ökonik*"; in German, Althaus 2007), who suggested, that more research into a system science and ecosystem management approach to economic activities in a 'post-fossil society'[8] was needed to inform human activities and socio-economic development.

Econics could be subdivided into approaches that would look at 1. systemic processes and interactions of components in complex systems, 2. thermodynamic and material efficiency of ecological systems, and 3. the role of diversity in the minimization of risks and building adaptive capacity. Energy-dissipating processes that regulate the ecological dynamics within the Earth's biosphere are of special importance (e.g., Ripl 2003). Industrial ecology (Allenby 2006) that aims at achieving thermodynamically efficient material and energy flows as observable in efficient mature ecosystems would be a subdiscipline of econics. Econics would embrace the concepts of permaculture (e.g. Holmgren 2003) and agro-ecology (e.g., agriculture based on small-scale, biodiverse farms, especially in the context of climate change, Altieri 2002, 2008, Altieri & Koohafkan 2008), as well as a well-implemented and 'close to nature forestry' that mimicks natural dynamics of undisturbed forests, structural diversity and complexity and other characteristics found in undisturbed forests. The development of econical strategies would have particular relevance and value in various strategies devised to meet the challenges of climate change. Specifically, it would promote a better understanding of the thermodynamic efficiency and resilience of natural ecosystems, and how this information could then best be translated into practice that mimics these patterns. In biodiversity conservation and ecosystem utilization, metasystemic management (see above) that mimicks self-regulative processes of complex (eco)systems, would be another example of an econic approach.

A significant improvement in the human footprint could be achieved by reducing the complex and globe-wide use of provisioning and supporting ecosystem services. A successful initiative to promote effective self-sufficiency in sovereign states or even smaller political units would significantly reduce the pressure on ecosystems, especially in biodiverse areas in developing countries. In many cases, it would also contribute to the reduction in vulnerability of (poor) people and regions against sudden changes in the global commodity markets or energy/fuel prices. A reorganising of regional agricultural production cannot be implemented without significant paradigm-shifts in trade, economy and development.

Proxy measures for ecosystem efficiency could take the following form (see Hobson & Ibisch, B.2.3. in this document):

- Quantity of energy input and utilization
- Exergy capacity (stored, usable energy in the system + carbon storage—resource banking)
- Positive feedback measures (quantity of non-recyclable energy and material—waste material and heat loss/capacitance)
- Connectivity/connectedness (biodiversity).

Mainstreaming thermodynamic efficiency would be complemented by the strategic objective of exploring development models beyond economic growth:

EXPLORE POLITICALLY AND SOCIALLY ACCEPTABLE WAYS OF IMPLEMENTING A STEADY-STATE AND RESILIENT GLOBAL ECONOMY.

The entire discipline of ecological economics (see Ibisch & Hobson, B.2.2. in this document) is in line with the Radical Ecosystem Approach as outlined above. To maintain a course towards full ecosystem recovery and long-term sustainability, a serious commitment to the radical principles of the Ecosystem

8 Althaus (2007) claims that the German Johann Heinrich von Thünen was a first protagonist of econics. In his *The Isolated State* (1826), von Thünen developed an analytical concept of spatial economics where the use of a specific plot of land is understood as a function of the costs of transport to markets and the land rent a farmer can afford to pay. Here, energetic efficiency is a key issue that informs the land use. The result was a proposal of an ideal spatial design with four concentric circles around urban centres with, for example, dairying and intensive farming in the inner one, and ranching in the outer one.

Approach would be required. Current trends in global environmental change warn of the planetary boundaries approaching or possibly exceeding tipping points (Meadows *et al.* 2004, Rockström et al. 2009). If one of the targets in sustainable development is to ensure that societies in developing countries reach certain measures of equitability to those in developed states, then compensatory action must be taken by richer societies that involves forms of socially sustainable de-growth (e.g., Fournier 2008). All forms of growth have to be addressed, from population growth to consumption and mobility growth. Parameters such as national biocapacity and ecological footprint or ecological deficit/reserve (Ewing *et al.* 2009), as well as the Human Development Index, would be relevant criteria for negotiating 'growth allowances'. This type of global environmental governance, with its new rules, would require new global governance structures or institutional arrangements. Clearly, the minimization of the externalization of environmental costs is rather incompatible with the current globalization paradigm in trade and economy. The 2009 Copenhagen climate change negotiations have given us an idea of a potentially dangerous future with an economically and environmentally globalized society without global (environmental) governance, nor effective organizations that can moderate political processes at the intersection of national short-term interests and global needs. Naturally, the "*intergovernmental processes that constitute*" environmental "*regimes are too closely allied with the forces that give rise to the problems in the first place to produce real change*" (Speth & Has 2006). Thus, possibly, it is not realistic to expect substantial changes to occur as a top-down process. Paradoxically, global environmental governance will (also) have to start in the form of multiple bottom-up processes. Some authors call even for new forms of civil disobedience in order to catalyze cultural change required for a "great transformation" (Leggewie & Welzer 2009).

Even alternative approaches to trade and production such as 'fair trade' or biological farming would have to further develop in order to embrace sustainability principles such as national self-sufficiency or thermodynamic efficiency of socio-economic systems. "Fair trade" is not necessarily ecologically sustainable, and "biologically produced" is not automatically thermodynamically efficient (e.g. when products are transported over long distances). Without any doubt, the hurdles for restructuring trade and global economy are immense. Additionally, initiatives seeking economic de-growth and agricultural self-sufficiency of developed countries could negatively affect developing countries whose economic structures are largely based on facilitating the externalization of environmental costs of developed countries (e.g., earning their money with the export of agricultural commodities or by the import of industrial waste).

While there is a clear consensus that extreme poverty, hunger and other lacks of human well-being in developing countries must be eliminated, it will be more difficult to achieve a general understanding in developed countries for the need of a reduction of the current consumption standard[9]. Proposing de-growth in developed countries is likely to meet with resistance, because, amongst other factors, it would mean a re-distribution of wealth and work. People would have to work for fewer hours but over an extended period of time, while earning and spending less (and being less free to move wherever they want). Clearly, this requires fundamental changes to socio-economic structures promoting a sustainable population while maintaining the social fabric. A 'down-sizing' in individual economic status of the rich few, brought on by a realisation that prudent accounting and use of the world's natural capital and exergy is the only means of securing long-term sustainability of the planet's biodiversity and peoples, will force modern society to re-assess values of human well-being.

In a limited way, the process has started with the development and implementation of the ecosystem services assessment (TEEB 2008, 2009). However, if this initiative is to move beyond the status of a political gesture and glorified paper exercise, certain traditional dogmas and increasingly dated and inappropriate structures and practices will have to re-invent themselves or go. A single reliance on monetary and materialistic wealth as an expression of well-being has stifled and suppressed much of the other individual and societal values. Recent resurgence in political and religious radicalism warns us of the perils ahead if this singular pursuit continues unchecked. Positive political signals from 'poor' countries

9 Not the *living standard* has to be reduced, but the *consumption standard*. According to a new development paradigm in 'beyond-GDP' societies consumption would not be equal to living standard (e.g., compare EU-Initiative: http://www.beyond-gdp.eu/).

such as the inclusion of mother Earth's rights in the constitution of Ecuador, or the Bhutan concept of Gross National Happiness (e.g., see Braun 2009), may give some hope.

Social and socio-economic indicators of a strategy for biodiversity conservation and sustainable development would have to address more complex and sustainable parameters than the conventional GDP. For instance, energy efficiency and happiness could be combined. Additionally, basic issues such as food security and social justice also have to be addressed.

- National Happiness per energy input and utilization
- Food security for all through sufficient access to vital ecosystem services
- Mechanisms towards a better social justice among present and future generations are established at various administrative and political levels (e.g., percentage of ombudsmen for young and future generations in parliaments).

Human endeavour and prosperity should be evaluated using criteria that define capacity building in communities; meaningful work, and participation in society or creative endeavour (Jackson 2009). This requires a paradigm shift in social logic away from a commodity-driven world to one that is based much more on human-centric values—participation, education and social cohesion (which itself requires the elimination of extreme poverty). Under this system, the economic domain is recognised as part of the biosphere and as such is based on natural capital rather than infrastructural capital. Ecological economics rejects the proposition that natural capital can be substituted for anthropocentric capital derived through the relentless pursuit of resource-hungry technology. Furthermore, the concept factors in irreversibility of environmental change, uncertainty and intergenerational equity. It is rather more adaptive to indiscriminate changes, relying on agent-based modelling techniques that recognise the value of 'self-organising systems.' This micro-system approach is complemented by macro-scale systems thinking that operates a holistic approach to deal with socio-economic interests.

The validation of the ecological economics model is underscored by the primary objective, which is to ground economic thinking and practice in the laws of nature. Success, goals and outcomes are no longer exclusively measured in monetary worth but also by using relative valuation and environmental accounting—biological and physical indicators of worth—a form of 'biodiversity financing'.

A change of this magnitude amounts to a profound paradigm shift in social behaviour and cultural values, nothing less than an induced evolutionary turn in the history of mankind. The alternatives to this chosen pathway are severely limited in the current scenario of global ecosystem degradation and growing population demands. The laws of thermodynamics dictate the circumstances as they are—there is a finite capacity to the planet's exergy capital, surplus energy cannot be created, demands on energy cannot continue relentlessly (for more details see Hobson & Ibisch, B.2.1. in this document)—there is no such thing as continued growth. If survival of current and future societies and a healthy planet are the single most important human objective, then the decision is simple. However, the realisation of this objective is far more problematic, and will require a Radical Ecosystem Approach that guides our policies.

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REFERENCES

Allenby, B. 2006. The ontologies of industrial ecology? Progress in Industrial Ecology **3**:28–40.

Althaus, D. 2007. Zeitenwende. Die postfossile Epoche; weiterleben auf dem Blauen Planeten. 1. Aufl. Mankau, Murnau a. Staffelsee.

Altieri, M.A, 2002. Agroecology: the science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems and Environment **93**:1–24.

Altieri, M.A 2008. Small farms as a planetary ecological asset: five key reasons why we should support the revitalisation of small farms in the global South. Third World Network. Penang, Malaysia.

Altieri, M.A and P. Koohafkan. 2008. Enduring farms: climate change, smallholders and traditional farming communities. Third World Network. Penang, Malaysia.

Böschen, S., K. Kastenhofer, P. Wehling, L. Marschall, I. Rust and J. Soentgen. 2006. Scientific cultures of non-knowledge in the controversy over genetically modified organisms (GMO): the cases of molecular biology and ecology. GAIA—Ecological Perspectives for Science and Society **15**:294–301.

Braun, A.A. 2009. Gross National Happiness in Bhutan: a living example of an alternative approach to progress. Wharton International Research Experience. Wharton University of Pennsylvania (http://www.schoolforwellbeing.org/studiesz.php?id=19).

Campbell, G., H. Kuehl, P. N. Kouamé and C. Boesch. 2008. Alarming decline of West African chimpanzees in Côte d'Ivoire. Current Biology **18**:R903–R904.

CBD—Convention on Biological Diversity. 2009a. COP 9, Bonn.

CBD—Convention on Biological Diversity. 2009b. Revision and updating of the strategic plan: possible outline and elements of the new strategic plan.

Ewing, B., S. Goldfinger, A. Oursler, A. Reed, D. Moore and M. Wackernagel. 2009. The Ecological Footprint Atlas 2009, Oakland.

Fee, E., K. Gerber, J. Rust, Haggenmueller, H. Korn and P. L. Ibisch. 2009. Stuck in the clouds: bringing the CBD's Ecosystem Approach for conservation management down to earth in Canada and Germany. Journal for Nature Conservation **17**:212–227.

Fournier, V. 2008. Escaping from the economy: the politics of degrowth. International Journal of Sociology and Social Policy **28**:528–545

Funtowicz, S. and Ravetz, JR. 2008. Post-normal sciences in C. J. Cleveland, editor. Encyclopedia of Earth, Washington, D.C.

Grantham, H. S., K. A. Wilson, A. Moilanen, T. Rebelo and H. P. Possingham. 2009. Delaying conservation actions for improved knowledge: how long should we wait? Ecology Letters **12**:293–301.

Hassan, R. and R. Scholes, editors. 2005. Ecosystems and human well-being. Island Press, Washington, DC.

Holmgren, D. 2003. Permaculture: principles & pathways beyond sustainability. Nimbus Publishing.

Huppes, G. and M. Ishikawa. 2009. Eco-efficiency guiding micro-level actions towards sustainability: Ten basic steps for analysis* Ecological Economics **68**:1687–1700.

Ibisch, P.L., B. Kunze & S. Kreft 2009. Biodiversitätserhaltung in Zeiten des (Klima-) Wandels: Risikomanagement als Grundlage eines systemischen nichtwissenbasierten Naturschutzes. Pages 44–62 in: Ministerium für Infrastruktur und Landwirtschaft (MIL) des Landes Brandenburg, Landeskompetenzzentrum Forst Eberswalde (LFE), editors. Wald im Klimawandel—Risiken und Anpassungsstrategien. Eberswalder Forstliche Schriftenreihe Band 42, Eberswalde, Germany.

Jackson, T. 2009. Prosperity without growth: Economics for a finite planet. Repr. Earthscan, London.

Kay, J. J. 1994a. The Ecosystem Approach applied to the Huron Natural Area. Document prepared for Environment Canada, State of the Environment Reporting, Ottawa, Canada.

Kay, J. J. 1994b. The Ecosystem Approach, ecosystems as complex systems and state of the environment reporting. Document prepared for North American Commission for Environmental Cooperation, Montreal, Canada.

Kay, J. J. 2008. An introduction to systems thinking. Pages 4–13 in D. Waltner-Toews, editor. The ecosystem approach. Columbia Univ. Press, New York.

Kay, J. J., H. Regier, M. Boyle and G. Francis. 1999. An Ecosystem Approach for sustainability: addressing the challenge of complexity. Futures **31**:721–742.

Layke, Christian. 2009. "Measuring Nature's Benefits: A Preliminary Roadmap for Improving Ecosystem Service Indicators." WRI Working Paper. World Resources Institute, Washington DC. Available online at http://www.wri.org/project/ecosystem-service-indicators.

Leggewie, C. and H. Welzer. 2009. Das Ende der Welt, wie wir sie kannten. Klima, Zukunft und die Chancen der Demokratie. S. Fischer Verlag, Frankfurt am Main.

Mace, G. M., et al. 2010. Biodiversity targets after 2010. Current Opinion in Environmental Sustainability **2**:3–8.

Malik, F. 2008. Strategie des Managements komplexer Systeme: Ein Beitrag zur Management-Kybernetik evolutionärer Systeme. Haupt Verlag, Bern.

Meadows, D. H., J. Randers and D. L. Meadows. 2004. Limits to growth: The 30-year update. 1. printing. Chelsea Green Publ. Company, White River Junction, Vt.

Naeem, S., D. E. Bunker, A. Hector, M. Loreaeu and C. Perrings. 2009. Can we predict the effects of global change on biodiversity loss and ecosystem functioning? Pages 290–298 in S. Naeem, D. E. Bunker, A. Hector, M. Loreaeu and C. Perrings, editors. Biodiversity, ecosystem functioning, and human wellbeing. An ecological and economic perspective. Oxford Univ. Press, Oxford.

Pullin, A. S. and T. M. Knight. 2001. Effectiveness in conservation practice: pointers from mdecine and public health. Conservation Biology **15**:50–54.

Pullin, A. S., T. M. Knight, D. A. Stone and K. Charman. 2004. Do conservation managers use scientific evidence to support their decision-making? Biological Conservation **119**:245–252.

Ravetz, J. R. 1986. Usable knowledge, usable ignorance: incomplete science with policy implications. Pages 415–432 in W. C. Clark and R. E. Munn, editors. Sustainable development of the biosphere. Cambridge Univ. Pr., Cambridge.

Ripl, W. 2003. Water: the bloodstream of the biosphere. Phil. Trans. R. Soc. Lond. **358**:1921-934.

Rockström, J., et al. 2009. A safe operating space for humanity. Nature **461**:472–475.

Speth, J.G. and P.M. Haas. 2006. Global environmental governance. Washington, DC:Island Press.

Sutherland, W. J. 2000. The conservation handbook. Research, management and policy. Blackwell Science, Oxford.

TEEB—The Economics of Ecosystems and Biodiversity. 2008. The Economics of Ecosystems and Biodiversity: An interim report.

TEEB—The Economics of Ecosystems and Biodiversity. 2009. The Economics of Ecosystems and Biodiversity for National and International Policy Makers: Summary: Responding to the Value of Nature.

Thünen, J.H. von. 1826. Der isoli[e]rte Staat in Beziehung auf Landwirtschaft und Nationalökonomie, oder Untersuchungen über den Einfluß, den die Getreidepreise, der Reichthum des Bodens und die Abgaben auf den Ackerbau ausüben. Hamburg : Perthes.

UNEP (United Nations Environment Programme). 2010. Busan outcome. Third ad hoc intergovernmental and multi-stakeholder meeting on an intergovernmental science-policy plattform on biodiversity and ecosystem services.

Vitek, W. and W. Jackson. 2008. The virtues of ignorance. Complexity, sustainability, and the limits of knowledge. University Press of Kentucky, Lexington Ky.

Waltner-Toews, D., editor. 2008. The ecosystem approach: Complexity, uncertainty, and managing for sustainability. Columbia Univ. Press, New York.

Weinstein, D. and M. Weinstein. 1978. The sociology of non-knowledge: a paradigm. Research in the Sociology of Knowledge, Sciences and Art **1**:151–166.

Whitten, T., Holmes, D. and K. MacKinnon. 2001. Conservation biology: a displacement behavior for academia? Conservation Biology **15**:1–3.

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