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New ecological critique and renewal of the sustainability discourse

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Abstract

The idea of sustainable development inspired the environmental movements and resulted in global policy programmes since the breakthrough of the discourse with the UNCED-conference in Rio in 1992. The “Rio+20”-debate and conference in 2012 showed sustainability policies under the influence of neoliberal, market-oriented “green economy”- thinking, adapted to the interests of powerful economic and political global players. In the scientific discourse critical arguments against sustainability came up - the complex processes of global environmental change and nonlinear change cannot be managed, therefore the idea of sustainability should be given up. These arguments are influenced by resilience thinking that developed in ecology during the past decade, tending to reduce sustainability to strategies of adaptation to disturbance, neglecting possibilities of transforming society and resource use. The sustainability term can be criticised for its inexactness; still an alternative to leaving it can be, as discussed in human and social ecology, to develop sustainability analyses and practices continually with social-scientific and ecological knowledge, for example, in the newly developing research on transition or transformation to sustainability. It is concluded that interdisciplinary knowledge integration can improve the perspectives and strategies for sustainable resource management and socio-ecological transformation.

Key Words:

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1. Sustainability debates in policy and science: knowledge problems

The ideas of sustainability and sustainable development result from the practices of policy and resource management as bridging concepts or regulative ideas guiding the communication about resource use problems. They were not designed as scientific and theoretical concepts, but can be interpreted with knowledge from different disciplines and sources, scientific and practical knowledge. This happens in selective, often disciplinary knowledge perspectives with the consequence of dissolving the sustainability discourse in disjointed pluralism and controversially discussed ideas and perspectives of action. The progress in terms of joint learning and knowledge improvement is slow because of such controversies about the process of sustainable development and insufficient use of scientific and theoretical analyses of interaction between modern society and nature.

The reduction of sustainability to a normative idea, political goal or vague principle is among the reasons why the discourse has come into crisis and is in need of new knowledge. So far mainly ecological and economic knowledge was used in the policy process, supplemented by managerial and practical knowledge about political and resource management. Further, especially social-scientific knowledge can help to renew the sustainability discourse and the analysis of transformation problems, including theoretical knowledge to understand the systemic processes in interacting social and ecological systems. The idea that sustainability requires broader knowledge integration is discussed in the human-ecological discourse, where sustainability is framed in analyses of the interaction between man, society and nature in different historical epochs of human societies and cultures. After a long public, political and scientific debate about sustainability emerges in recent years in human and social ecology a view of sustainable development as social-ecological transformation of modern society and its relations with nature. The following analysis refers to this transformation debate where transformation is seen as a complex and long process in connected social and ecological systems. The complicated part of the transformation of modern society to sustainability seems the interface of the ecological, economic and socio-cultural dynamics in the globalising modern society that need to be matched in environmental governance.

Transformation does not work through political power alone, but in complex interactions between political, cultural and economic processes, in system and value changes. These processes of socio-cultural, economic and ecological transformation towards sustainability at various scales of modern society, from local to global, cannot be reduced to individual changes of lifestyles and consumption or changes of cultural values and worldviews (as discussed in the ecological discourse, e.g., Inglehart 1977). To discuss possibilities of transformation of complex social and ecological systems can be done with inter- and transdisciplinary knowledge integration where knowledge from different disciplines and knowledge practices is re-interpreted and synthesised to reconnect science, politics and collective action. Interdisciplinarity (the crossing of knowledge boundaries between scientific disciplines) and transdisciplinarity (the crossing of

knowledge boundaries between scientific and other, especially practical and local forms of knowledge), are complex knowledge practices for all social forms of collective action, not exclusively for science and research.

Achieving sustainability requires such integrated knowledge practices. The process is not only an ecological one that can be managed with ecological knowledge about planetary boundaries of resource use (Rockström et al 2009). The social-ecological transformation comprises interconnecting processes of ecological, economic, political, cultural, and societal transformation with different qualities and dynamics. This transformation includes processes that are manageable and others that are not or only indirectly manageable. To conceptualise the process of transformation a theoretical reconstruction of the interaction of modern society with nature as it is developing in the newer discourse of social ecology is useful.

With such re-interpretation the temporal perspectives of transformation to sustainability appear as much longer than the short-term views of social change and planning prevailing in politics, economy and resource management which are used to frame and programme the sustainability process in national and international policies. Sustainability is not development as usual and not incremental change; it requires long and complex processes of re-combining knowledge and re-configuring social structures and knowledge practices. With regard to that the knowledge from economics seems less important to describe the resource use practices required in a new, more sustainable society: they differ from the practices of individual and collective rationality that guide economic research and the routines of social action today. New forms of economic action that develop in the global transformation process cannot be described in old terms and institutional patterns that maintain the economic order in the modern world system. The difficulties to achieve a sustainable state of the society are not yet understood with theoretical ideas as post-industrial, post-capitalist, or post-modern society; these terms are only giving names to scientific ignorance. Ignorance and the unforeseeable future need to be dealt with in new forms for which the sustainability discourse is the paradigmatic case of knowledge use. The formulation of “docta ignorantia” (learned or scientific ignorance) by the philosopher Cusanus (1985) is useful in this transformation debate. The older Socratic reasoning of “scio, nescio” (I know that I do not know”) was developed further by Cusanus, analysing the impossibility to understand god with scientific knowledge. Nowadays an awareness of the limits of scientific knowledge for the understanding of transformation to sustainability can help to redesign strategies of sustainable development that need to deal with ignorance about the future. What can be done when the limits of knowledge at a certain historical time are achieved? Knowledge limits do not imply the impossibility of action, only to think in other ways about the use of knowledge - in the sustainability discourse: through the use of inter-and transdisciplinary knowledge syntheses.

The problems in the sustainability process are analysed in the following, guided by the question of adequate forms of knowledge use. Whereas ecological knowledge has a privileged role in the sustainability discourse, controversies begin when further knowledge and interdisciplinary knowledge syntheses are discussed; they can as well

complement as countervail ecological knowledge in the construction of strategies for sustainable development. The interdisciplinary subjects of human, social and political ecology show ways to deal with interdisciplinary syntheses.

2. The sustainability discourse in a human ecological perspective

2.1 Summary and assessment of the discourse

The political sustainability discourse is to a large degree developing from the differing worldviews, visions, cultural values and norms of the many actors and participants in national and international environmental action and policy processes. The policy programmes for sustainability, for example, “Agenda 21”, are wishing lists for incompatible goals, or visions of wanted futures that are not sufficiently underbuilt with knowledge about the institutional changes required for socio-ecological transformation. None of these programmes, including the recent vision for 2030 of the UN, formulated the conditions of socio-ecological change necessary for achieving sustainability. Only in the scientific discourse develop perspectives that approach the complexity and the difficulties of the sustainability process, centring on the notion of a great transformation (Krausmann et al 2009; WBGU 2011). The practical difficulties include changes of established power structures in society, politics and economy and confronting vested interests of powerful global actors. The political sustainability discourse tends, with its normative framing in terms of visions, scenarios and wanted futures, to neglect the requirements of further knowledge integration and synthesis. This neglect is one of the reasons why the public sustainability discourse remains, since its beginning three decades ago, diffuse, contested, and vulnerable to political instrumentalisation by powerful actors and global players.

1987, the year when the Brundtland report was published with its well-known definition of sustainable development as intra- and inter-generational solidarity of resource use, did not yet mark the begin of a broad global and political debate. Only after the collapse of East European socialism and with the debate about a new world order the discourse intensified. Whether there is a causal connection between the collapse of socialism and the rise of the sustainability discourse is controversial. However, it can be assumed that the collapse of one part of the industrialised societies (at that time called “the second world”) influenced and intensified the search for ways out of the dead end of industrial society and its environmental problems.

1992, the year of the UNCED-conference in Rio de Janeiro and the formulation of “Agenda 21” as global programme for sustainable development, showed the discourse and global sustainability policy still at the beginning. Sustainability was discussed in inexact terms and with insufficient knowledge. The requirements of social, political, economic changes to achieve sustainability were formulated in conventional terms of policy and reform processes, in terms of “business as usual”. Although sustainable development became the guiding idea of most governmental policies, it remained a soft goal, not programmed in legally binding action, not strongly supported by governments

and business elites, compliance and implementation continually insufficient, as also scientific knowledge syntheses from environmental research (in difference, for example, to climate policy that was much more intensively investigated).

In 2012 the sustainability discourse has become affected by the neoliberal ideology of a market-based “green economy” as the “Rio+20”-conference showed. The original aims of sustainable development as global solidarity in resource use vanish in this distorted version of sustainability where science and politics are subjected to the rule of the market. The market, the institution from which the least can be expected for a sustainable transformation of modern economy, has become the subject to act in terms of sustainability. The capitalist world market, strengthened through globalisation, dictates the conditions of development and enforces economic growth with all its negative environmental effects. The process of subjecting sustainability to the politically dominant neoliberal discourse, following market-based policies is presently influential - this must not be forever.

2030 is the time horizon of the new agenda for sustainable development of the United Nations that shows attempts to renew the discourse. But the knowledge required to reconstruct sustainability as social-ecological transformation is widely missing in the new formulation of targets and tasks, as already visible in the formulations in the preamble, where, as in the whole document, emphatic normative and moral reasoning dominates, in the attempt to cover a large number of social, environmental and normative improvements without considering hindrances, conflicts and possibilities to achieve them: prosperity, universal peace, larger freedom, eradicating poverty, including all countries and stakeholders in collaborative partnership, healing and securing our planet, shifting the world on to a sustainable and resilient path (UN 2015:3). The weakness of sustainability as a political goal is programmed with such reasoning - it avoids the analysis of problems that cause the unsustainability of the global society and economy.

Since the beginning of the public and political sustainability discourse three decades ago scientific knowledge has improved and changed more than the institutions in society and economy from which the achievement of sustainability depends. The new information technologies with the internet were much less supportive in the transition to sustainability than often expected. These technologies imply the innovation processes that support the neoliberal practices of globalisation and growth, contradicting in many regards the requirements of societal and economic transformation. The late attempts of industrialisation in countries like India and China show the reliance on continuing economic growth and intensification of natural resource use. The social worlds of economic society and civil society changed in different forms and directions:

- the “neo-liberalising” of society and economy succeeded in temporary control of policy processes and governmental institutions by market requirements under the name of “green economy” that maintains economic growth and manages simultaneously the decline of large parts of economy and social groups;

- resistance against divided development with austerity and impoverishment comes from a civil society coalition that includes parts of science, new social and environmental movements, and citizen groups that oppose the socially and environmentally destructive consequences of economic deregulation and disembedding.

Potential ways to the future society are not that of the market economy in the present economic order that was diagnosed by Fukuyama as “the end of history” achieved with the collapse of East European socialism. The broader sustainability discourse, including political and scientific debates, has less helped to clarify potential pathways to sustainability, more revealed the complexity of problems and processes addressed with the misleading notion of sustainable development. A much more complex process of socio-ecological transformation needs to be conceptualised to support improvements of sustainability policies. In the Millennium Ecosystem Assessment of 2005 the sustainability discourse was criticised as not yet having brought the changes of policies and institutions to initiate transitions to sustainability. The whole discourse, including political and scientific forms, can be summarised in several perspectives: regarding (1) scientific knowledge generation, (2) development of normative ideas guiding the debates, and (3) human-ecological reflections of sustainability.

(1) The scientific discussions and reflections of sustainability, based on the broadening stream of environmental research, brought to the forefront the idea of sustainability as transformation of society. It is a renewal of the term “great transformation” in the work of Polanyi (1944), where it meant the replacing of older economic rationality of reciprocity and redistribution through the logic of individual maximisation of utility in modern capitalist market society. The new great transformation towards sustainability implies the opposite: to overcome the logic of the market in other forms of economy, with new combinations of the economic principles of market, reciprocity and redistribution. This is an abstract formula in search of alternatives to the self-destructive dis-embedded economy with deregulated markets. How such combinations work, in which variants, is still unknown, cannot be found out from looking back to pre-capitalist forms of economy. It needs to be found out on the way of transformation how new forms of economy that do not ruin society and its natural resource can be built. Yet, it is clear that forms of sustainable economies need to include principles of sharing and redistributing resources.

In ecology as privileged knowledge source in the sustainability discourse, Palmer et al (2005) argue that ecology has contributed to the understanding of nature and human impact on nature, but the future development of the discipline requires refocusing *“towards research that ensures a future in which natural systems and the humans they include coexist on a more sustainable planet. Acknowledging that managed ecosystems and intensive exploitation of resources define our future, ecologists must play a greatly expanded role in communicating their research and influencing policy and decisions that affect the environment.”* (Palmer et al 2005: 4) This reasoning shows that ecology does not consequently open towards interdisciplinary knowledge production and cooperation. Innovative ecological research should, according to the authors, inform political decisions ecologically, building a “forward-looking and international ecology”. Although the

cooperation of researchers, managers and decision-makers is recommended, the understanding of the sustainability process is reduced to one where ecological research informs knowledge users, in conventional forms of knowledge application and science communication - in policy, resource management and the public, for example, in analyses of ecosystem services and human societies.

In contrast to this disciplinary knowledge strategy the sustainability process requires inter- and transdisciplinary knowledge exchange. Natural-scientific ecology is not the only generator of knowledge to understand nature-society interaction. To re-conceptualise the sustainability debate it seems useful to look at start from its historical development and at the analysis of socio-ecological transformations that happened in human history. Du Pisani (2006) described the historical unfolding of ideas of sustainable development in a more interdisciplinary perspective, going back to earlier phases of societal development, showing that sustainability is not a new or modern idea. In a more elaborate historical analysis Takács-Sánta (2004: 51) systematised the major transitions in the long history of human transformation of nature or the biosphere as the use of fire, language, agriculture, state-building, European conquests beginning with modern capitalism, and the technological-scientific revolution that brought fossil energy sources, usually described as industrial revolution. Not the different transitions or their technical quality are decisive to understand the nature of socio-ecological changes and their effects in terms of sustainability, but the successive connection of these changes in the course of human history which implied a continuous intensification of natural resource use and increasing human modification of nature. The historical changes towards intensification of resource use say about the future transformation to sustainability that it needs to be of a different kind, reducing the growth process that resulted today in trapped, path-dependent development. The reduction of global resource use is less dependent on moral persuasion of individuals to consume less, more on knowledge about the transformation of societal and economic systems that maintain and enforce high consumption levels. The social-ecological transformations in history show the human modifications of the biosphere and with these modifications change the sustainability problems in different forms of human societies, in dependence from the combinations of material and energy sources in a given mode of production (the “societal metabolism”: Krausmann et al 2009). These transformations created the conditions for further ones, resulting finally in the unprecedented global change that happened during the 20th century.

The progressing global change in modern society and nature is caused by factors that did not exist before in human history:

- the global reach of socio-ecological metabolic regimes connected with the global economy;
- the exponential growth of this economy and of natural resource use;
- the global population growth;
- the global climate change and further global social and environmental change processes;
- the approaching of planetary boundaries in resource use.

These changes have been analysed and discussed intensively in the scientific ecological discourse since the “limits to growth”- report of the Club of Rome from 1972. The changes imply a continuous *spatial rescaling* of societal development in the course of history. Other decisive factors beyond the differentiations of spatial scales that predetermine sustainable development in modern society are the differentiations of *temporal scales*: social and environmental change accelerated in modernity. With the industrial revolution global change happens in very short historical periods (Raskin et al 2010). As McNeill (2000) and other environmental historians described, the most dramatic changes and deterioration of the global environment and ecosystem happened in the course of the 20th century, more than all changes before in the very long history of human societies. The spatial and temporal complexity of global social and environmental changes and of transformation to sustainability does not provide all knowledge in sustainability research and thinking, rather summarising the positive knowledge created through environmental research. Further knowledge, empirical, theoretical and normative, is found in other areas of science, the problems becoming that of adequately connecting different forms and practices of knowledge.

(2) Normative and spiritual sustainability reflections remained a more controversial part of sustainability thinking. These debates were, in difference to environmental research, hardly guided and structured through processes of connecting and combining knowledge. In the normative and spiritual debates the discursive practices were dominated by ethically, not empirically justified ideas and normative orders to guide individual and collective action. The historical change is simplified in ideas and assumptions about harmony between society and nature, beliefs, visions and utopias. Also in discussions of sustainability based on empirical analyses of human resource use practices sometimes doubtful generalisations and simplifications are formulated in the search for final explanations. Rees (2010: 13), for example, sees modern homo sapiens as “unsustainable by nature”, although that conclusion is connected with analyses of the systemic interaction between industrial society and the ecosphere, that could direct towards better arguments than doubtful assumptions about human nature.

In the social-philosophical discourse about new normative orders (Forst and Klaus 2011) the empirical knowledge about social and ecological systems becomes less relevant, still more in spiritual discourses about new visions of society and nature (Jenkins 2009). The role of these discourses is to complement positive knowledge about modern society with ideas of new orders of human communities and societies and their relationships with nature. In such transcendental, religious, spiritual, philosophical and ethical thinking the social and environmental problems and forms of injustice in present society are discussed for purposes of normative, cultural, value changes. These cultural and spiritual norms for sustainability need to be communicated in ethical discourses with specific rules for the validity of norms. Values, visions and norms do not remain individual beliefs but need to be communicated and defended in the ecological discourse to guide social practices of changing resource use, consumption and lifestyles. Environmental values and norms imply often ideals and convictions in similar forms as utopian thinking, and with that return the non-intended consequences of such thinking

in the ecological discourse - sectarianism, speculation, construction of ideal societies, and attempts to “emigrate” from society, in sectarian projects, isolated communities, and new forms of total institutions.

The normative ideas and reflections include contrasting views of humans, nature and society, worldviews and paradigms, dispersed in the ecological, ethical, religious and philosophical discourses in different cultures and countries. It seems a simplification to construct overarching ideas of sustainability in this fragmented landscape of cultural and civilizational diversity, new global ethics that should unite all competing religions and cultures, as if these ethics could develop independently from the heterogeneous cultures in which humans live. Simplified assumptions about global orders are also found in science, for example, in Becks research about the risk society that should advance from national to cosmopolitan perspectives. This has already been criticised (e.g., Frödin 2013) as a false dichotomy of national and cosmopolitan views. It is doubtful whether the knowledge requirements for sustainability transformations can be reduced to cosmopolitan views and global ethics with ideas as that of respecting diversity. Ideas of global ethics, global cultures, and global governments seem more wishful thinking than transformation projects when they are not controlled and guided by the available knowledge about society and nature. So far only the modern economy or the world market is a global system, whereas political and cultural action happens in more difficult situations of diversity and multiplicity. Universal constructions of human rights, international laws and forms of politics coexist with different forms and relations of power in modern society that continues to be divided in national political and governmental systems. The long process of nation-building is not yet finished when the transformation of national societies has started - one of the many forms of dissimultaneity in the sustainability process; further ones exist in the cultural and religious orders that react in different ways to the rapid global social and environmental change processes.

Jenkins, reviewing the debate on spiritual practices of sustainability, opted for religious ethics, more in conjectures than in arguments: spiritual and value commitments may motivate change and transformation. *“Perhaps the roots of globalizing economic and technological systems lie in a moral consciousness profoundly shaped by religion. ... religious metaphors and spiritual practices have unique capacities for interpreting life’s complexity and generating holistic responses. If part of the challenge of sustainability is to understand the mutual relations of humanity and nature within a wider worldview, then religions may have useful resources. If widespread environmental degradation indicates an alienation of human personhood from the rest of the living Earth, then spiritual practices may help heal this division and reconcile humans to their ecological web”* (Jenkins 2009: 383). The effort to broaden the debate and creating a place for spiritual thinking in ecology ends in unclear reflections; it leaves open how scientific, spiritual and practical thinking and knowledge connect to generate sustainability action. For such action the knowledge about the socio-cultural and socio-ecological transformation to sustainability and the beliefs about a global order need to be connected.

Not all beliefs and visionary ideas support the sustainability transformation which requires forms of action under specific historical, local, social conditions. These can be motivated with many different individual beliefs and worldviews, but they need to be integrated with available knowledge about society and nature for different disciplines. To integrate scientific knowledge, normative ideas and spiritual thinking, it can be useful to develop mediating discourses in which consensus about normative principles of sustainability can be developed without unrealistic attempts to reconcile different ethical, religious and belief systems. Examples for such mediating discourses where positive knowledge, mundane norms and transcendental beliefs can be combined and communicated in different, theoretical and practical forms include the discourses of new normative orders in modern society (Forst and Klaus 2011), the discourse ethics by Habermas (1991), and the civilizational analysis of Arnason (2003). Such approaches can be applied in the sustainability debate, to support the intersubjective communication of values and beliefs in sustainability debates. Less useful seem traditional forms of spiritual thinking and reflecting our highest values and beliefs and worldviews, creating new rituals to alleviate the alienation from the living earth, or reviving respect for God's creation (Jenkins, 2009: 384).

The social and cultural subjects of the sustainability process, inexactly described by Jenkins as individuals and communities, need to be analysed further. Not all spiritual communities can be seen as representing the common good and common interests of humankind; communities follow different views and beliefs, are or particularistic and often confronting and competing in their reasoning. Beyond the scientific and the normative-spiritual knowledge sources of sustainability further knowledge integration and synthesis are required. It is difficult to find such new forms of action, but the synthesis of natural scientific, social-scientific and local or everyday knowledge enables forms of action which can be connected with forms of normative thinking beyond the spiritual practices of local communities. Difficulties remain of syntheses between contrasting and contradicting forms of knowledge and thinking. Interdisciplinary knowledge production and integration is weakly developed with regard to exact methods of knowledge synthesis and dealing with contradictions between knowledge forms, worldviews, paradigms and theories.

Ethically motivated sustainability debates, including that in public policies and in many environmental movements, show often lack of connection of the knowledge components mentioned above, and with regard to scientific knowledge; they lack especially social-scientific knowledge about possibilities to transform societal systems. These debates tend to create new forms of civil religion and esoteric thinking, oriented to religions and philosophies of the Western Christian tradition or other religions and worldviews among which that of Buddhism and of indigenous people gained importance in the ecological discourse, in ideas to create a new harmony of humans and nature which simplify the problems of sustainability transformation extremely, becoming inefficient when they are not combined with scientific and practical knowledge. The concrete causes and sources of environmental disruption and lack of sustainability in modern society are caused by organised practices of economic production that is only loosely connected to specific values or forms of belief - if connected at all to these. The older controversy between

anthropocentrism and ecocentrism resurfaces in the spiritual and ethical discourses, without solving the knowledge problems in the sustainability process. Further synthesis of knowledge is required to develop ethics of stewardship for the sustainability debate in an interdisciplinary knowledge basis for sustainability as shown by Chapin III et al (2009, 2010).

Earth Stewardship as described by Chapin et al is supposed to be a social-ecological perspective for sustaining life in rapidly changing society and nature. Knowledge for global stewardship should be generated in cooperation of physical, biological, and social scientists – in global partnerships and in contact with other actors, including citizens and people in communities of faith, professions, planning and restoration, policy and management. Whereas in the past stewardship focused on local resource management globally, today the earth as one global social-ecological system (SES) needs to be managed as a consequence of the rapidly increasing environmental change. This change is described as globalisation of economy, culture and ecology that modifies the life support system of the planet. Sustainable management of resources is no longer possible as managing systems so that they remain the same as in the past; it becomes management of system that are under continuous change, influenced in manifold ways by humans. For this purpose the authors design an integrated social-ecological framework that should allow to use knowledge from many different natural and social-scientific disciplines, in difficult syntheses where disciplinary differences in terminology, methods and knowledge practices create communication problems (Chapin III et al 2009: 3ff).

Whereas this approach has significantly advanced in interdisciplinary knowledge integration, it shows, as an approach developing from ecological knowledge, deficits in the use of social scientific knowledge about the functioning of societal systems. Inter- and transdisciplinary communication of knowledge is somewhat inexactly described with regard to psychology of perception and communication. At this point resurface assumptions from traditional ethical thinking: that joint beliefs and positive common ideas will create the action necessary for achieving sustainability.

(3) Human ecology

(a) Human ecology as philosophy: Christensen (2014) described the philosophical character of human ecology with the arguments: the concern of human ecology for sustainability and equity helps people in problematic human-environment interactions to find a more sustainable balance between the moral claims of others and their own needs and desires, or, in a traditional philosophical terminology, a balance between virtue and happiness. This implies to include philosophy in the practice of human ecology, aiming to provide an account of what it means to be a rational human animal, specifying the idea to live well without prescribing a specific form of life. The philosophical character of human ecology is generally described by the author as multi-, inter- and transdisciplinary knowledge process and as fusion of biological and social sciences; such knowledge integration is not necessarily connected to or guided by philosophical considerations, except in a limited sense of epistemological reasoning.

Christensen, being aware of the disconcerting view of human ecology as multi-, inter- and transdisciplinary, seeks a solution in philosophy as complementary to disciplinary knowledge practices and in an attempt to apply it for the reflection of concrete problems discussed in the ecological discourse, for example, the analysis of consumption or of production in late modern capitalist society for which he refers to the critical theory of the Frankfurt School. The way from critical philosophy through political economy of capitalism to present human and social ecology was long and complicated. Whether it is useful for the purpose of critical reflection of modern forms of life and production to return to philosophical terminology and thinking may be doubtful. Too much seems to be expected from philosophy for the integration of different knowledge components which requires more non-philosophical and interdisciplinary knowledge and thinking. More than adopting philosophical terminology it may be necessary in human ecology to criticise and modify it in the analysis of present forms of life in a sustainability perspective.

(b) Human ecology beyond philosophy: Pluri- and interdisciplinary knowledge syntheses based on social- and natural-scientific research are more systematically discussed for the purpose of sustainability analysis in Allen et al (2008) where knowledge from human ecology and economics is integrated in a new framework. This framework includes four knowledge-related components of belief systems, social agreements (practices of structuring human interaction through cultures, rules and norms), human populations (including demographic processes), and physical environments and resources. Knowledge integration remains loosely structured in this framework, an interdisciplinary theory is not elaborated. Global sustainability concerns are discussed in a long time perspective, connecting the time scales of sociocultural and biological evolution. Furthermore, humanities and belief systems are connected with economic analyses, to unfold a historical and dynamic perspective of analysing changes in economic systems, and to emphasise global systems in a perspective of world ecology where spatial units at lower scales appear as “sub-ecologies” (Allen et al 2008:10f). Regarding transitions to sustainability the authors do not formulate a theory but suggest for the analysis of different transition paths to specify the structural or systemic components in their framework. Lose frameworks of this kind do not replace theoretical and systems analyses; they are useful to structure empirical research and guide knowledge integration – similar to the multitier framework formulated in the social ecology of Ostrom (2009) in an inductive process of knowledge integration and generalisation.

To advance beyond normative orientations for integrating nature and society, to find balances of positive and normative knowledge for sustainability analyses, to develop knowledge integration through theoretical structuring, and to deal methodologically with contrasting and contradicting knowledge about SES, are continuous epistemic problems for which methodologies of knowledge integration need to be developed, in human and social ecology as in all interdisciplinary research. The formulation of a “systems approach to sustainability” (Duball and Newell 2015) advances towards more theoretical synthesis, without generating a final theoretically systematised perspective of knowledge synthesis. The authors use as integrating framework the dynamical theory of complex systems. The purpose of a theoretical framework constructed from systems

dynamics is to draw together concepts and principles from different disciplines, cultures and life experiences for a shared framework in human ecology. The preceding framework of Boyden and his reflections are used, for example, his criteria for structuring information about different forms of nature-culture systems analysed in human ecology, or for analysing, visualising and communicating about interactions between different aspects of natural and cultural systems. Considerations about sustainability enter in this framework from the analyses of system dynamics carried out in the “limits-to growth”-report for the Club of Rome in 1972, or the analysis of population dynamics by Ehrlich and Holdren (Duball and Newell 2015: 96 ff, 111ff).

The theory developed, taking up and systematizing core ideas from the discourse of new human ecology since the 1970s, is more a conceptual framework from older systems thinking. It helps to organise knowledge exchange and integration, less to formulate a theory explaining the systemic forms of nature-society interaction. Duball and Newell highlight the intention to support the spreading and communication of human ecology in the practices of knowledge dissemination and application, in spheres of environmental studies, policy and practice. This can be seen as prioritising the - obviously simpler - second step of dissemination of knowledge over the first one of integration of knowledge through elaborating systematically, methodologically and theoretically a perspective and theory for analysing nature-society interaction. Such a theoretical perspective that can be sued for a critical reflection of the sustainability discourse is rather found in the new social-ecological research that brought advances in the study of societal metabolism and metabolic regimes and analyses of the dynamics of interaction society and nature at different historical times. The framework of Duball and Newell remains in this regard rather conventional with its orientation to the history of human ecology. It seems that the renewal of the sustainability discourse requires more efforts of knowledge generation than that of integrating knowledge in a unifying framework of human ecology: connecting the human ecological discourse to the broader discourse of sustainability and its further knowledge sources. Before possibilities of further knowledge integration can be discussed, the critique of sustainability emerging in the ecological discourse needs to be dealt with.

2.2 Critique and renewal of the sustainability discourse

A widespread critique of the debate of sustainable development in the environmental discourses in science and policy referred to the insufficient clarification of the relations between economic growth and conservation or protection of the environment. In the practice of the sustainability discourse the possibility of neoliberal, growth-based mainstreaming of the idea was kept open. The debate *“did not question the ideology of economic growth and did not adequately challenge the consumer culture criteria of sustainability have never been formulated, thus leaving the back door open to advocates of economic growth and progressive secular materialism to hijack the concept of sustainable development for their purposes. The pre-1970 ecological thinking has been watered down*

to once again make the material demands of the human species the primary test of what should be done with the Earth.” (Du Pisani 2006: 93).

In the more recent sustainability debate similar critical perspectives can be found, some going further and beyond the horizon of political and worldview-debates connected to ecological thinking (e.g., the debates in human, social and political ecology shown below). The efforts to renew and broaden the idea of sustainability included

- the transition and transformation research (Leach et al 2012),
- the cultural (re-)contextualisation of sustainable development (Worldwatch Institute 2013), and
- the theoretical elaboration of possibilities of social-ecological transformation of nature-society interaction in late modern, globalising society (Krausmann et al 2009).

As a consequence of these efforts in re-thinking and re-contextualising sustainability, a series of contrasts and contradictions to be dealt with in the sustainability process came to the forefront. This requires the elaboration of a theoretically clarified concept of socio-ecological transformation. Beyond the normative formulations of commitments and goals in the political discourse of sustainable development, develops a second debate about process models for achieving sustainability in complex processes that combine policy reforms and societal transformation. These process models go beyond the debates of intra- or inter-generational solidarity and (re-)distribution of natural resources, showing the conditions under which societal transformation needs to start and the problems to be dealt with in the sustainability process more clearly:

- the incompatibility between continued (exponential) economic growth and sustainable use of natural resources;
- the continuing development gaps between the global North and South, the rich and the poor countries and economies in modern society;
- the contrasts between governmental sustainability policies and social realities that show the lack of progress towards sustainability in most countries and the continuing intensification of resource use (since the trends assessed ten years ago in the Millennium Ecosystem Assessment not much improvement has happened, as analyses of ecological footprints and material and energy flow assessment show);
- the increasing and more violent conflicts that emerged after the collapse of East European socialism with the East-West confrontation in the cold war and its risk of nuclear war; the new world order is not so much affected by a “clash of civilisations” as described by Huntington, but shows mainly the conflicts resulting from impoverishment and austerity policies in many countries of the world, not only in the South (the “managed decline” of societies);
- the contrasts between harmonistic global ethics and dividing realities of sustainability policies and practices found (environmentalism of the rich in contrast to environmentalism of the poor);
- the contrasts between universalism and particularism of cultural and civilizational processes and orders, particularism, here connecting to the

cultural specificity of the manifold forms of sustainable development as societal process that cannot be reduced to global policy and governance. This requires complicated form of multi-scale governance.

These challenges and the necessity to develop new ideas in sustainability research and thinking are controversially discussed. Sustainable development thinking is especially challenged in a controversy that seems to indicate a final crisis of the idea. This controversy in ecological research is about the question whether the complexity of systems, limits of knowledge, and problems in integrating society and nature can be dealt with in global governance. In the broader sustainability debate the support from ecological knowledge is breaking away before the transdisciplinary integration of knowledge about transformation to sustainability is realised and practical success is achieved in redistributing resources. The decisive step of collective learning and change on the way towards sustainability did not happen, and now the idea of sustainability becomes to be seen as an impossible goal that should be given up. In the renewal of the sustainability discourse and process competing ideas and contrasting arguments can be expected, showing sustainability and sustainable development as examples of “continually contested concepts” (Collier et al 2006), with different interpretations. New in this situation is that the support so far decisive for achieving sustainability, the support through ecological knowledge, is no longer sure.

From ecology come voices to give up the idea of sustainable development as misleading or unrealistic, for reasons that it is either too late to initiate the necessary global transformation of society (articulated especially in critical voices at the Johannesburg Summit in 2002), or that the sustainability transformation is too complex to be managed and governed by society (articulated in the more recent ecological debates, connected to the rapidly developing resilience discourse).

3. New ecological critique of sustainability and transformation research

3.1 The resilience debate as modification of sustainability thinking

The career of the concept of resilience, in different variants of ecological, social and social-ecological resilience (Folke 2006) brought during the past decade new approaches in environmental research that seemed to complement the sustainability perspective through a further one, describing another form of dynamics in coupled social and ecological systems (SES). But resilience brought also re-interpretations of the development of SES that ignore long-term perspectives of transformation: sustainability tends to be melted with resilience in cyclical changes, reducing development to adaptation and coping with stress, disturbance and catastrophes, finally becoming disaster management. When the transformative perspective of sustainability is replaced through the adaptive perspective of resilience as disturbance-driven change in SES, resilience tends to become the “disastrous subject” as which it has been criticised in the broader debate (Reid 2012). The discussion of sustainability and sustainable

development oscillates between the alternatives to modify the concept for future use (Blowers et al 2012) and the suggestion to renounce to the concept (Benson and Craig 2014).

(1) *Blowers et al 2012*: The sceptical debate about sustainability as interdisciplinary and integrating concept for science, policy and practice of resource management was opened by Blowers et al with questions that indicate growing doubts about the use of the concept sustainability, asking *“Is it merely a routine recognition of a normative concept that is now pretty much axiomatic for environmental scientists and policy makers alike? Or, does the concept still retain sufficiently positive, purposive and practical connotations to fulfil its presumed role as an overarching goal of scientific understanding and political policymaking? The answer is, we suspect, a bit of both of these. It all depends on perspective, on value and viewpoint”* (Blowers et al 2012: 1). Referring to the climate change debate, the authors conclude that sustainable development as a process and concept is no longer a practical guide or goal for future policies. The concept needs to be re-thought to meet future requirements of development which includes the protection and conservation of environmental resources and shifts in behaviour through greater equality and widespread political participation. (Blowers et al 2012: 8)

The critical assessment can be understood to react to the widely known deficits of national and international sustainability policies and programmes. Possibilities to develop the concept of sustainability further and to renew it with improved knowledge so that the perspective of transformation can be maintained are kept open. However, the inclination to reduce sustainability to a normative goal of political action, appearing in these formulations, makes it easy to reject the term as insufficient in science and research. The continuing debate showed, that this happened, with further arguments that claim to be derived from ecological knowledge and its limits.

(2) *Benson and Craig (2014)* refer to a diagnosis of irreversible damages to the global ecosystem and draw the conclusion to renounce to sustainability. This conclusion is less based on a critical examination and assessment of the sustainability concept with regard to its potential improvements or theoretical elaboration, but derives from a reductionist view of sustainability as political goal. *“It is time to move past the concept of sustainability. The realities of the Anthropocene warrant this conclusion. They include unprecedented and irreversible rates of human induced biodiversity loss, exponential increases in per-capita resource consumption, and global climate change. These factors combine to create an increasing likelihood of rapid, nonlinear, social and ecological regime changes. The recent failure of the Rio+20 provides an opportunity to collectively re-examine - and ultimately move past - the concept of sustainability as an environmental goal. We must face the impossibility of defining - let alone pursuing - a goal of ‘sustainability’ in a world characterized by such extreme complexity, radical uncertainty and lack of stationarity. ... we propose resilience thinking as one possible new orientation and point to the challenges associated with translating resilience theory into policy application.”* (Benson and Craig 2014: 777)

The authors affirm that they do not want to criticise the ethical nature of the sustainability idea. Sustainability remains a valuable idea as an overarching principle for global ecological ideals of intergenerational solidarity of resource use, but they doubt whether it is useful as a goal of environmental governance (Benson and Craig 2014: 779). This reasoning can be criticised either for a shortcut view of global governance, or for a neglect of knowledge available from social-scientific research about the transformation of societies and their interaction with nature. The reduction of sustainability to an ethical goal or norm, to a general and inexact principle of collective action, makes such a conclusion possible. The analysis of problems of societal resource use practices and growth that motivated sustainability as idea to guide to changing practices of resource use is bypassed. The critique is not based on arguments specific for sustainability, but applies a general argument referring to system complexity that can easily be used to deny possibilities of transformative action, willingly or not supporting reasoning of the kind of environmental scepticism. A similar argument is found since long in ecological research: humans are not able to manage ecosystems because of the complexity and dynamics of the systems that exceed human knowledge and foresight capacity. If not specified further to investigate the limits of societal transformation according to present knowledge, the argument is not sufficient to reject the idea of sustainability, neither theoretically, nor practically. The rapidly growing environmental research and the research about prior transformation of societies and modes of production provide knowledge and arguments against such reasoning. The intensive discussion and research on management or governance of ecosystems and SES, including global climate change and earth system governance, provides three arguments against the conclusion that the idea of sustainability should be given up.

(1) Specifying the limits of knowledge and creating interdisciplinary knowledge syntheses to shift the limits: Given complexity, nonlinearity, surprise and unexpected regime shifts in ecosystem development, it is still not consequent to conclude sustainability is a useless concept for guiding scientific research and knowledge synthesis for identifying possible ways of societal transformation. Rather the point to be made in the critical review of the scientific and political sustainability discourses is, that sustainability is necessary to supplement resilience through a wider perspective, aiming at scientifically reflected strategies of societal transformation that are also required in a situation of potential catastrophes and societal collapse. Transformation implies fundamental system changes to reduce the overuse of natural resources and the functional disturbance of ecosystems and global geochemical cycles of matter, which requires beyond resilience another, long-term perspective of societal transformation. It is for the first time in human history that environmental problems are connecting to global change and planetary boundaries of resource use are approaching. This requires the connection of different arguments: the critique of economic growth, growth of resource use, and consumerism; managing resource use within the limits of global biocapacity; and maintaining life-supporting ecosystem functions. If this is not attempted through sustainability governance and the growth processes continue, changes will happen in form of non-governed and unwanted transformation through catastrophes, where nature, ecosystems and global change enforce a kind of sustainability in the brutal forms of

economic, societal and ecosystem collapse, as discussed since long in the “limits to growth”-discourse. Increasing environmental problems, conflicts and catastrophes do not justify a reasoning of the kind nothing else can be done but adaptation to disturbance.

The late socio-ecological research of Ostrom (2007) needs to be discussed further at this point: the development of a science of complexity to be able to limit the probability of catastrophic transformation through governance, regulation and mediated transformation. The possibilities of social-ecological transformation are not discussed further by Benson and Craig, although a series of ideas and principles are known from interdisciplinary research about earth stewardship, and in social and political ecology. Re-interpreting sustainability as social-ecological transformation seems one perspective to develop ideas for coping with disasters, but developing additional ideas to adaptive change and disaster management. The limited perspective of adaptive cycles, the ecological model that summarizes the perspective of change in terms of resilience, assuming it is the only and decisive knowledge for environmental change, ignores further knowledge and bypasses the search for sustainability strategies through interdisciplinary broadening of the ecological knowledge base. Without that resilience thinking seems to achieve its limits and turns in a plea for giving up the search for possibilities of societal transformation.

(2) *Separating qualitatively different arguments and forms of change*: Two forms of arguments against sustainability should be discussed separately,

- “*too complex*” implying that complexity, uncertainty and nonlinear changes make it impossible to define sustainability, and
- “*too late*” implying the failure of sustainability to become a workable goal for environmental policy.

The two points do not necessarily go together, and different arguments can be found to cope with both assertions. Both should be discussed and responded on the basis of knowledge available about social and ecological change and transformation. The complexity argument can be transformed into one of seeking adequate forms of reducing the complexity through research (in which system-specific forms of complexity for social and ecological systems need to be analysed) and experimental forms of management as in adaptive management. The argument “too late” can also be modified and specified, as it seems to be constructed with a narrow concept of management that is not sufficiently differentiated and broadened to include long-term transformation processes with different components of intervention with different time horizons (management, governance, adaptive management/governance, transition and transformation).

As necessary as it is to avoid the reduction of sustainability to resilience, it is to connect both ideas and perspectives with interdisciplinary and broadened scientific knowledge. To combine the different perspectives seems to open more alternatives than the ones seen by Benson and Craig. Limits of knowledge can be achieved within one paradigm, perspective or theory, as within resilience that is too much oriented towards ecological knowledge and concepts about the functioning and change of ecosystems. Not only future research and new knowledge, also interdisciplinary broadening and use of knowledge

about social systems, societies and SES, can open more alternatives in terms of sustainability than a limited ecological perspective of resilience. Such broadening happens in various forms in interdisciplinary human, social and political ecology.

(3) *Knowledge forms, changes and improvements:* The sustainability discussion should not be reduced to that what is known in terms of empirical knowledge about society, ecosystems or SES at a given point in time in environmental research. This knowledge has grown rapidly in recent decades, especially through interdisciplinary environmental research, and this knowledge growth and improvement continues, for example, regarding the planetary boundaries of resource use. So far also the construction of limits of knowledge seems to be happen in simplified forms – primarily regarding knowledge from empirical research done in specialised and disciplinary forms. The manifold forms of scientific and other knowledge, empirical and theoretical knowledge, technical and normative knowledge, managerial, local, practical knowledge, and other forms, give rather support to arguments of the kind there are no final limits of knowledge, only such at a given point in time and state of research, and the limits are specific for each of the knowledge forms mentioned. Limits of knowledge in single disciplines can be shifted already through interdisciplinary combination of knowledge. Drawing conclusions about limits from the always insufficient positive knowledge describes rather the dilemmas of environmental and other research as, for example, formulated in the “post-normal science”-hypothesis of Funtowicz and Ravetz (1993). Only in certain phases of the development of modern society there may be impasses where resilience and sustainability seem to melt down to disaster management, where there is no progress in transformation towards sustainability, be it because of lack of support, inadequate strategies, or lack of knowledge about how to break such vicious circles as described by Fischer et al: *“the global sustainability deficit is not primarily the result of a lack of academic knowledge. Rather, unsustainable behaviors result from a vicious cycle, where traditional market and state institutions reinforce disincentives for more sustainable behaviors while, at the same time, the institutions of civil society lack momentum to effectively promote fundamental reforms of those institutions. Achieving more sustainable behaviors requires this cycle to be broken.”*(Fischer et al 2012). This idea can be developed further with more specific arguments for seeking and initiating transformation to sustainability. The negatively reinforcing changes of different system types, of different origins, with different reasons and causes, need to be specified and diagnoses of limits of knowledge need to be assessed critically. Accepting a variety of knowledge limits at a given time, the idea of sustainability and transformation to sustainability does not need to be given up. Furthermore, the argument of lack of knowledge does not necessarily translate into impossibility of action or governance. With the rapidly increasing environmental research in the past decades grew also experience and knowledge how to deal with lack of knowledge. Environmental research seems specialised to find out new possibilities to deal with complexity and lack of knowledge. The research on global change, resilience or sustainability gives paradigmatic examples for dealing with ignorance.

The 21st century with catastrophic trends in global change - population growth, economic decline, biodiversity reduction, climate change, civil wars and wars because of access to natural resources - may appear in the history of modern society as a prolonged phase of a “blocked society” (Crozier). Because of vicious circles of development and (too) many problems which exceed the capacity of society to develop without transformation “the future cannot begin” (Luhmann 1976). There is also evidence that the market-based strategies of growth-based development tend towards maintaining such blocked development, not seeking ways out of development traps, path dependence and other dilemmas of economic development. Moreover, a neo-Malthusian perspective of global “overshoot and collapse” that is part of the ecological discourse since the “limits to growth”-reports of the Club of Rome in the 1970s seems to block with its arguments the search for new solutions, thus supporting arguments of catastrophic change and doomsday prophecies. But this perspective provides arguments for change that can become part of a transformation perspective: arguments against growth (not reduced to population growth as the only or main cause of achieving limits), for reduction of resource use, not using dangerous technologies of production and resource use, for control of population growth, for redistribution and sharing of resources. All these arguments remain valid with regard to sustainable development. Qualitatively different causes of reaching limits need to be investigated further – economic growth that is caused by the institutional mechanisms of market economy and modern capitalism; population growth that follows demographic dynamics of different kind; growth of natural resource use that follows from high consumption levels and specific lifestyles; and limits of biocapacity or functional disturbance of ecosystems that follow again different dynamics. That all these reasons and causes are connected in vicious circles and reinforcing each other makes it difficult to break the circles, but does not yet provide arguments for the impossibility of transformation, simplification of the causality, or non-manageable complexity. Also when catastrophes and nonlinear environmental change can be expected, this is not an argument of the kind that the future is programmed through turbulences that cannot be influenced or changed. Complexity is an anti-deterministic concept, but the consequences drawn from ecosystem complexity seem to come close to determinism in the form of “overshoot and collapse.” The future development of society and SES is not programmed for ever more resource use and pollution – and neither the disastrous economic growth nor the disastrous subject of resilience should be able to block thinking and research about breaking path-dependence and transformation of development paths that are required for sustainability. To exclude the possibility of path transformation can happen when too much is taken for granted, in terms of limits of knowledge; path transformation may be “forgotten” because it is, more with practical reasoning than with scientific knowledge, be seen as unrealistic. Reification, objectification and ideologies are not excluded from ecological thinking or from science more generally. Knowledge that can help to find possibilities of path transformation can be found in social-scientific research and theories of modern society, to a large degree ignored in the ecological and resilience discourse; this knowledge should be introduced in the sustainability discourse.

Efforts to clarify the interrelations between resilience and sustainability have not yet brought sufficient clarity that may be possible with interdisciplinary analyses of SES. Insufficiently formulated, interpreted and integrated notions of resilience and sustainability create continuous difficulties, as the attempt of Wang et al (2015) with the “triple morphogenesis”- approach shows that is stuck in the conceptual integration of the concept of adaptation, transition and transformation in the resilience concept. Similar difficulties appear in other attempts (e.g., Olsson et al 2014) to reconstruct sustainability transformations in a resilience perspective. The development of transformation research shows ways out of this dead end.

3.2 The development of transformation research

The change of sustainability and sustainable development to theoretically reflected ideas has advanced with two terms: that of transition, which is often understood as a more limited, reformist notion of change, and that of transformation as a fundamental change of social-ecological systems.

“Transformative approaches go far beyond keeping the main functions of a given socio-ecological system intact by adjusting to changing conditions ... They aim instead to alter the fundamental attributes of a system, such as the economic mode of production, political institutions, ideologies, societal norms, everyday life, ecology ... and so-called ‘social natures’, i.e. combined socio-ecological assemblages that are spatially, temporally as well as socially and materially produced, a result of power relationships and cultural meanings ... Transformations involve non-linear processes, because they deal with dynamic multidimensional and complex systems and understand social innovation as a key driving force of such processes ... They involve multiple scales and system levels, from the local to the regional, national and international levels, and functional levels such as the markets, states and civil society”(Asara et al 2015). The development of the transformation concept in this sense happened stepwise, with the concepts of transition, great transformation, transformative agency towards a theoretically formulated concept of social-ecological transformation.

(1) *Transition research:* Transition to sustainability developed in studies that took a sociotechnical perspective (Smith et al 2005) or a micro-social perspective of social change (Fischer-Kowalski and Rotmans 2008). Transition may be seen as a less theoretically elaborated concept, more prone to empirical research and less system-specific with regard to the dynamics of different forms of social, technical and ecological systems. It may require a more theoretically elaborated complementary concept of transformation. The research on transitions *“has made a considerable contribution in understanding the complex and multi-dimensional shifts considered necessary to adapt societies and economies to sustainable modes of production and consumption. However, transition analyses have often neglected where transitions take place, and the spatial configurations and dynamics of the networks within which transitions evolve. A more explicit spatial perspective on sustainability transitions ... provides a contextualization on the limited territorial sensitivity of existing literature. Secondly, it explicitly acknowledges*

and investigates diversity in transition processes, which follows from a 'natural' variety in institutional conditions, networks, actor strategies and resources across space. Thirdly, it encompasses not only greater emphasis but also an opportunity to connect to a body of literature geared to understanding the international, trans-local nature of transition dynamics" (Coenen et al 2012: 968).

This reasoning summarises the broader discourse and research about spatial scales and their diversity in sustainable development, approaching more realistic perspectives in global sustainability policies. It does so in a somewhat limited perspective of economic geography. The institutional embeddedness of development processes, their specific territorial conditions, and the multi-scalar forms of socio-technical trajectories highlighted by the authors show the direction of advances in the debate. Markard et al (2012: 956) discuss as core concept of transitions research that of socio-technical transitions as *"processes that lead to a fundamental shift in socio-technical systems", including "far-reaching changes along different dimensions: technological, material, organizational, institutional, political, economic, and socio-cultural"*. This concept is more as an empirical description of the multi-dimensional processes than a theoretical conceptualisation, but refers to important factors influencing sustainability transformations, for example: broad ranges of actors, long time-spans of decades, and the development of new products, services, business models, and organisations. The view of economic innovation in business processes in this perspective can be developed further in more interdisciplinary theoretical analyses.

Similar in the focus on spatial perspectives, but specific with regard to "distance of action" or "telecoupling" is the framework of Liu et al, highlighting that little attention has been paid to *"the impacts of distant interactions on sustainability in multiple places. ... they are usually treated as exogenous variables and feedbacks have rarely been considered."* The authors suggest telecoupling as an umbrella concept with *"five major interrelated components, i.e., coupled human and natural systems, flows, agents, causes, and effects. ... The framework can help to analyze system components and their interrelationships, identify research gaps, detect hidden costs and untapped benefits, provide a useful means to incorporate feedbacks as well as trade-offs and synergies across multiple systems (sending, receiving, and spillover systems), and improve the understanding of distant interactions and the effectiveness of policies for socioeconomic and environmental sustainability from local to global levels."* (Liu et al 2013: abstract). This framework enables to identify certain conditions and forms of socio-ecological transformation, but lacks a theoretical systems analysis of interacting SES.

(2) *Another great transformation (WBGU 2011)*: The Scientific Council Global Environmental Change of the German government has elaborated in its recent expertise (WBGU 2011) the concept of another great transformation that is required to achieve sustainability, making use of Polanyi's terminology. The new transformation to happen in 21st century is characterised by two novel qualities: it requires governance mechanisms to plan and influence that what cannot be planned, and it should happen, in difference to earlier transformations of society, in short times of several decades (it is not a slow evolutionary change, over long time, but shows accelerating evolution where

social and ecological change overlap and connect). The transformation is described as the sustainable global rebuilding of economy and society. It includes different fields of transformation such as production, consumption and lifestyles, and it requires as precondition to reduce the human-made global climate change to a minimum that prevents further unwanted and catastrophic change of nature and society through the climate mechanism that is manipulated through the global economy. The transformation is compared in its historical significance to the great transformations of neolith time (agriculture) and of modern time (industrialisation). Although hardly referring to knowledge from human and social-ecological research, the expertise is in parts compatible with the theoretically elaborate conception of social-ecological transformation resulting from social ecology and it supports the re-thinking of sustainability as such a transformation.

In the international discourse of sustainability similar adoptions of the term “great transition” or “great transformation” can be found that require further theoretical clarification through social-ecological concepts and knowledge. More systematic elaborations of historically and culturally situated concepts of social-ecological transformation can be found in human ecology (e.g., Duball et al), social ecology (e.g., Fischer-Kowalski et al: societal metabolism), and political ecology (e.g., Martinez-Alier 1995). A step towards the unfolding of a perspective of transformation of SES is done with the concept of transformative agency by Westley et al (2013).

(3) *Westley et al - a theory of transformative agency in SES*: The authors reviewed the literature on leadership in coupled SES and on institutional entrepreneurship in complex adaptive systems to develop a new theory of transformative agency in SES. They argue, although *“there is evidence of the importance of strategic agency in introducing innovation and transforming approaches to management and governance of such systems, there is no coherent theory to explain the wide diversity of strategies identified. Using Holling’s adaptive cycle as a model of phases present in innovation and transformation of resilient socialecological systems, overlaid by Dorado’s model of opportunity context (opaque, hazy, transparent) in complex adaptive systems, we propose a more coherent theory of strategic agency, which links particular strategies, on the part of transformative agents, to phases of system change”*(Westley et al 2013:1).

As with the examples from transition and transformation research discussed before, it seems that the available concepts and approaches in ecology and systems theory - resilience, adaptive cycles and complex systems theory - are not sufficient to develop a theory of social-ecological transformation, rather try to bypass such a theory. Such a theory requires more concrete knowledge about the historically specific structures, processes and dynamics in modern society and the modern economic world system. Such knowledge was formerly developing in political economic research and critical theory of society, and is today renewed in social ecology in the analysis of societal metabolism, global resource flows and world ecology. Starting from that research it seems possible to elaborate a theoretically based, historically specific concept of social-ecological transformation to sustainability.

4. Perspectives of sustainability - the future in terms of socio-metabolic transformation

In difference to the more inexact concepts of transformation and loosely integrated interdisciplinary approaches discussed so far, the following approaches specify the concept of social-ecological transformation, transferring it from a metaphorical notion to a theoretically elaborated concept that can be applied in global scenarios.

(1) *Social-ecological research on societal metabolism and metabolic transitions:* Krausmann et al (2009) summarize their study about global socio-metabolic transition, the past and future trajectories, with the concept of socio-metabolic regimes (Box 1).

Box 1: The industrial socio-metabolic regime

Socio-metabolic regimes “represent dynamic equilibriums of society-nature interactions, and are characterised by typical patterns of material and energy flows (metabolic profiles). ... industrialization is analysed with “a global dataset on the socio-economic metabolism of 175 nations for the year 2000, including data on the domestic consumption of materials and energy as well as physical trade flows. We group the countries into 6 clusters differentiated by economic development and population density, reflecting both the historical path of (agrarian) development and resource endowment. These country clusters can be characterized by specific metabolic profiles and differ widely in terms of material and energy use. Our analysis reveals that per capita material and energy use in industrialized clusters is higher than in developing regions by a factor of 5 to 10. However, per capita use of natural resources differs significantly among industrialized clusters, with more densely populated countries being at the lower end. Our data show that a large fraction of the global population displays a metabolic profile somewhere in between the pattern typical for the agrarian and the industrial regime, often much closer to the agrarian regime. We conclude that the socio-metabolic transition from an agrarian to an industrial regime is an ongoing process with important consequences for future global material and energy demand. Taking a transition between regimes and the currently prevailing metabolic characteristics of this transition as given, the global energy and materials demand is likely to grow by a factor of two to three during the coming decades” (Krausmann et al 2009:637). The most critical result is that for high-density developing countries as China and India, where the anthropogenic material and energy burden per unit of land area is higher than in industrial Europe, with expected further increases that surpass carrying capacities.

The growth of industrial metabolism “is a major driver of global environmental change. We present an assessment of the global use of materials since the beginning of the 20th century based on the conceptual and methodological principles of material flow accounting.” The authors “compiled a quantitative estimate of annual global extraction of biomass, fossil energy carriers, metal ores, industrial minerals and construction minerals for the period 1900 to 2005. ... during the last century, global materials use increased 8-fold. Humanity currently uses almost 60 billion tons ... of materials per year” After the second world war happened “rapid physical growth, driven by both population and economic growth. Within this period there was a shift from the dominance

of renewable biomass towards mineral materials. Materials use increased at a slower pace than the global economy, but faster than world population. As a consequence, material intensity (i.e. the amount of materials required per unit of GDP) declined, while materials use per capita doubled from 4.6 to 10.3" tons per year. "While biomass use hardly keeps up with population growth, the mineral fractions grow at a rapid pace. We show that increases in material productivity are mostly due to the slow growth of biomass use, while they are much less pronounced for the mineral fractions. So far there is no evidence that growth of global materials use is slowing down or might eventually decline and our results indicate that an increase in material productivity is a general feature of economic development." (Krausmann et al 2009a: 2696)

Sources: quoted

The global analyses of resource use show the necessity to deal in the sustainability process with economic growth and intensification of resource use at the level of the economic world system and its form of societal metabolism that is neglected in the ecological debates of resilience and sustainability. It seems evident that the systemic mechanisms inherent in the system structures of the modern economic world system require critical discussion with social-scientific knowledge about the possibilities of reducing growth; the dynamics of capitalist accumulation processes cannot be understood from ecological analyses alone that show only the quantitative dimensions of growth, and not from consumer-oriented appeals for reduced consumption.

(2) *Political-ecological research on ecological distribution conflicts, climate change adaptation, and biofuel production (Martinez Alier 1995, Brunnengräber et al 2008; Leopold and Dietz 2012):* These perspectives can be integrated in a more encompassing human ecological perspective- Political-ecological analyses include systems analyses of SES and analyses of sustainability transformation in terms of social or collective action and transformative agency. As the social-ecological research discussed before, they study the societal metabolism that changes nature, depending on the appropriation, use and transformation of nature through natural resource use that happens today in global production and consumption. Social practices of natural resource use are historically and socio-culturally specific, shaped by the social structures, political and economic institutions, power relations and cultural specificities in a given country, economy or society. The study of these institutional patterns and their change is necessary for the formulation of strategies for sustainable development or socio-ecological transformation. It is not sufficient for such strategies to study ecosystem processes and changes; the institutional transformation of natural resource use can only be understood from more systematic and theoretical analyses of societal and economic systems. In integrated analyses of societal systems, SES, and action strategies the simpler forms of empirical analyses of SES - as spatially specified bio-geo-physical systems and social actors and institutions connected with it - are reformulated in terms of a theory of nature-society interaction that develops from social-ecological and political-ecological research, although it is not yet systematically elaborated. The requirements of reformulating and improving strategies of socio-ecological transformation to sustainability give a practical reason to develop such an interdisciplinary theory. The theoretical analyses of SES-

dynamics can be connected with global scenario analyses as one form to apply the knowledge in the formulation of sustainability strategies.

(3) *Global scenarios* are methodologies to deal with knowledge, uncertainty and ignorance in the formulation of forms of possible futures and alternative ways to sustainability (e.g., Raskin et al 2010). Sustainability as transition to an unknown future society can make use of scenario analysis to explore and assess different forms of transformation. However, improved ideas and knowledge are not generated through the use of the scenario method alone, but through the broadening of the knowledge base from which scenario variants are elaborated. The future is unknown, but it is influenced through the knowledge and the governance processes done at present. This can show *“the risks of conventional development approaches and the real danger of socio-ecological descent. ... a Great Transition scenario - turning toward a civilization of enhanced human well-being and environmental resilience - remains an option, and identifies a suite of strategic and value changes for getting there. A fundamental shift in the development paradigm is found to be an urgent necessity for assuring a sustainable future and, as well, a hopeful opportunity for creating a world of enriched lives, human amity, and a healthy ecosphere”* (Raskin et al 2010). With that reason the sustainability debate seems to have reached the point where for the future discussion two variants can be separated:

- changing to simpler, less resource intensive consumption as in the past and in earlier phases of modern society (the critical argument against modern consumerism, for example in the report of the Worldwatch Institute 2013), that does not systematically investigate the systemic determinants of resource use and consumption generated through the mode of industrial production and the global economic system; and
- analysis of resource use and consumption that takes into account the limited individual choice of life- and consumption styles in modern economy and society and the arguments of transforming society and its interaction with nature, that sets natural resource use and consumption in a more elaborate form of systems analysis of SES.

These variants do not exclude each other logically, but present the arguments of reducing and changing natural resource use practices in different and contrasting forms. The global scenario debate oscillates between the two forms of analysing consumption that can be specified integrated, analysing more systematically the social structuring of resource use and consumption. Then the actor and the system perspective can be synthesised and both be used in a more coherent perspective that takes into account as well the possibilities of individual consumers to change their lifestyles, as the dependence of consumption forms from the systems of modern society and economy and their interaction with nature, which would require transformation strategies. That integrated perspective converges to the analysis of sustainability as social-ecological transformation developing in recent social ecology and interdisciplinary analyses of capitalist world ecology.

What can be said about the possibilities of social-ecological transformation can be build up from successive steps of connected interdisciplinary analyses including

- the systems analysis of modern society, economy and its interaction with nature;
- the different social and ecological processes that need to be connected to influence the use of natural resources to break the vicious circle of resource use in modern globalising society;
- the different possibilities to influence these processes: whether and how they can be influenced and steered through policy and governance, or influenced in other forms (indirect steering);
- the different time horizons of processes of change, adaptation and transformation; and
- the means of influencing transformation as long term, phase process at different stages of the transformation (including policy instruments).

5. Conclusions

Sustainability, although not necessarily the misleading notion of sustainable development, is still and continues to be a useful idea for environmental policies and natural resource management, although it is now marked with considerable doubt and uncertainty from ecological knowledge, or sometimes simply with the reasoning it is an overused and outdated idea.

Historical analyses of the sustainability problems and the societal metabolism in different historical forms of human societies helped to describe the specific global sustainability problems today that are connected to global environmental change and the industrial socio-metabolic regime. Such historical analyses developed in human and social ecological research and in environmental history. The global dynamics of societal change, highlighted in the construction of global scenarios (Raskin et al 2010), refer to such analyses, showing how processes of social and environmental change became global and more complex. In future, in new strategies of sustainability transformation, the interaction of society and nature needs to be regulated at all levels from the local to the global, for which more complex governance models are required. The unfolding of this new sustainability perspective in the critical analysis and discussion of sustainability above had as consequence another view of sustainable development, as social-ecological transformation of modern society and its interaction with nature. In this perspective the concept of sustainability is developed further with interdisciplinary knowledge, without ignoring the limits of the concepts and of scientific knowledge.

Presently we cannot imagine the sustainable society of the future. Scientific knowledge can only help to make better informed guesses about what can happen in future. The future remains as unknown for the people acting to achieve it, as the industrial society for the people - including scientists - who started some hundred years ago to build a modern society. Their knowledge and practices of social action were used for solving

practical problems, without knowing that they build the future industrial society by solving the resource problems of their feudal societies that cumulated in the energy (wood) problems of medieval society caused by regional deforestation. The people 10 000 or more years ago acted in a similar situation when they began agriculture and domestication of animals in different parts of the world. Their practical problem solving in terms of food production happened mainly for the reasons of adapting to resource scarcity and growing human population, but it had the consequences of transforming society. In that great transformation to agriculture developed social and economic institutions that are until today basic components of modern society – agriculture, state, and urban settlement. The changes in the earlier socio-ecological transformations in history, also called “Promethean revolutions” (Georgescu-Roegen), included improved social and economic sustainability through the development of new institutions (settlements) and improvements in food production through more intensive use of natural resources. Whether these changes were also ecologically sustainable is more difficult to say – they implied as well environmental destruction at local levels (deforestation, ruin of fertile soils) as successful adaptations to environmental conditions and long-term maintenance of ecosystems, especially agro-ecosystems. All socio-ecological transformations in human history and in the use of natural resources implied changes in society and in nature, although not of the dimensions and velocity as in the industrial epoch that marks the beginning of “the Anthropocene”.

Returning with these reflections to the present discussion about sustainability, it can be assumed: *the process of social-ecological transformation to sustainability is not a short one, but one of several generations or centuries*. It needs to be learned on the way of transformation how to approach, continually improve and finally achieve sustainability as a “moving target”. The process cannot be planned as a whole; it is threatened by environmental catastrophes as consequences of global environmental change, and it requires more interdisciplinary knowledge practices that include the use of social-ecological knowledge. Human, social and political ecology, the trinity of interdisciplinary knowledge practices for reconstructing sustainability transformation, are no privileged approaches with exclusive scientific knowledge about the transformation. Their only advantages are that they integrate and synthesise knowledge more systematically, include more knowledge from different disciplines, and focus on the interaction of society and nature, for different types of society, in historically specified perspectives.

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