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Seven Dimensions of 'Sustainability Transition':

Temporal, Spatial, Scientific, Societal, Economic, Political and Cultural[1]

© **Hans Günter Brauch**

Chairman, Peace Research and European Security Studies (AFES-PRESS)
Editor, Hexagon Series on Human, Environmental Security and Peace
PD Dr. Hans Günter Brauch, Alte Bergsteige 47, 74821 Mosbach, Germany

Abstract

This paper contextualizes the emerging debate on sustainability transition (ST) in the context of seven dimensions. The paper is structured in 12 parts. After the introduction that outlines the goals, objectives, the thesis and structure of the paper, the second part discusses five historical times (geological, technical, political, conjunctural and short-term events) and the three previous great transformations (technical, industrial, IT revolutions) while the third part reviews 25 years of policy and scientific debates on the goal of sustainable development (SD) and the fourth addresses the emergence of the scientific and policy debates on ST since 2005. The following seven parts briefly review the Temporal (5), Spatial (6), Scientific (7), Societal (8), Economic (9), Political (10) and Cultural (11) dimensions of ST. The concluding part (12) addresses the obstacles to ST and points to a need for overcoming old mindsets and worldviews. It takes up the argument of Oswald Spring and Brauch (2011) on two opposite worldviews, mindsets and coping strategies of either continuing with a business as usual (BAU) or moving towards a fourth sustainability revolution (FSR) and argues for the latter to avoid a neo-Malthusian and Hobbesian dead end that may result in a militarization of the security impacts of GEC and global climate change as well as the Cornucopiean dead end of geoengineering. The paper suggests a dialogue on the linkages between goals, processes and strategies of ST and the normative goal of a sustainable peace that requires an intensive multidisciplinary dialogue, most particularly between the environment and the peace and security studies communities.

Keywords: Sustainability transition, sustainable peace, temporal, spatial, scientific, societal, economic, political and cultural dimensions

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Seven Dimensions of 'Sustainability Transition':
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1. Introduction: Goals, Objectives, Thesis and Structure

The concept and the new research field of 'sustainability transition' have gradually evolved since 2005 when the Dutch *Knowledge Network on Systems Innovation and Transition* (KSI) combined different approaches of "complex systems analysis, a socio-technological and a governance perspective". It relies on research that has evolved since the 1990s when "innovation and technology scholars … started to address environmental innovation and sustainability transitions more explicitly" (van den Bergh et al 2011) to which research from the *technological innovation systems approach* (TIS) and the *multi-level perspective* (MLP) has contributed (Coenen/Truffer 2012: 4-5).

This research effort resulted since the first Amsterdam conference in 2009 on sustainability transitions in the establishment of the '*Sustainability Transitions Research Network* '(STRN), the 'Routledge Studies in Sustainability Transitions' (2010) and the '*Environmental Innovation and Sustainability Transitions*' (EIST) Journal (2011), and in a WBGU Report on a 'Social Contract for Sustainability' that is based on a proposal by Clark, Crutzen and Schellnhuber who called for a new paradigm of a 'Science for Global Sustainability' (2004). Coenen, Benneworth and Truffer (2012) argued that "the literature on transitions towards sustainable socio-technical systems 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". The KSI-sponsored website on 'sustainability transitions' claims that

> Sustainability transitions are one of the great challenges of the 21st century. Both scientists and politicians agree on the fact that our system is in need of fundamental transformation. After WW II the Western world realized in a few decades a welfare state with prosperity for most people. But around 1970 a growing number of groups expressed strong concerns about the social and environmental risks which have come along with that progress. Food crises, climate crises, financial and economic crises increased the sense of urgency. It is certain that sustainable development will require a set of deep structural changes of modern societies. Such processes of change are called transitions and take time, lots of time.[2]

The scientific concept of 'sustainability transition' combines a goal of a sustainable development with a process of a long-term transformative change of which several occurred through-out earth and human history. The physical and societal impacts of Global Environmental Change (GEC) and Global Climate Change (GCC) were triggered by the industrial revolution (1750-1890/1920) that was launched by Watt's invention of the steam engine and the massive use hydrocarbon sources of energy (coal, oil and natural gas). The ongoing second technological revolution started with Edison's invention of electricity, with a fundamental change in the communication and transportation systems and since WW II with the rapid evolution of new information technologies that enabled modern globalization processes possible.

The evolving scientific discourse on 'sustainability transition' is closely linked to a separate and unrelated discourse on the securitization of global environmental and climate change (Brauch 2009; Scheffran/Brzoska/Brauch/Link/Schilling 2012) that addresses possible security consequences of the anthropogenic interferences into the earth system as 'threat multipliers' (EU 2008; UNGA 2009; UNSG 2009).

[2] See: "Sustainability Transitions.com book series & blog", at: < http://www.sustainabilitytransitions.com/en/background > (29 May 2012).

The parallel discourse on 'sustainability transition' addresses both the causes and the impacts of GEC and GCC by facing and coping with both and avoiding the projected societal consequences of dangerous or catastrophic climate change and of possible tipping points in the climate system (Lenton et al. 2006). Thus, 'sustainability transition', in the words of the report of the UN Secretary-General can become a 'threat minimizer' in six pathways to sustainable development this report referred to i) adaptation, ii) economic development, iii) governance, iv) capacity building, v) mitigation and vi) conflict prevention.

From this perspective the goal of 'sustainable development' and the perspective on 'sustainability transition' refer to a much wider research agenda than the relatively narrow focus on environmental and technological innovations that is a primary focus of many researchers in the STRN. The process of 'transition' refers to multiple long-term evolutionary and revolutionary transformative changes that point to five different historical times with different transformative results that must be distinguished. I address them with four hypotheses:

1. We are in the midst of a global transition in earth history that was triggered by the first industrial and the second technological revolution of energy, communication, transportation and information technology resulting in significant anthropogenic transformation of the earth system that has been coined by Paul J. Crutzen (2002, 2011) as the transition from the 'Holocene', the period since the end of the glacial period 12.000 years ago, to the 'Anthropocene' that started with the increasing human interventions into the earth system and that resulted in a rapid increase in GHG emissions in the atmosphere.
2. The impacts of the transformations of these processes have resulted in a complex global environmental change and an anthropogenically-induced climate change besides the increasing destruction of biodiversity that has resulted in an exponentially growing accumulation of GHG in the atmosphere that have also affected almost all environmental services.
3. The societal impacts of the physical effects of 'anthropogenic global climate change' and of biodiversity loss may result in major international, national and human security dangers and concerns that have been discussed since 2000 from different scientific worldviews, schools and political mindsets on the national and international level.
4. Since 2005 an alternative discourse on 'sustainability transitions' or on 'transitions to sustainable development' is evolving that addresses new directions in the 'study of long-term transformative change' that should also focus on resilient societies.

Seven discourses or dimensions on 'sustainability transitions' will be briefly reviewed and assessed in this text: the i) temporal, ii) spatial, iii) scientific, iv) societal, v) economic, vi) political and vii) cultural. Before these emerging debates will be addressed this new proposed long-term transition towards a sustainable world has to be contextualized in order to avoid both the societal effects of a 'dangerous' or 'catastrophic' climate change through fundamental changes in time and space, in human values, behavior, production and consumption patterns. Humankind and policymakers face a fundamental choice of either ignoring the change in the interactions between the human and earth system and postponing policy decisions to their successors or to the next generation by adhering to worldviews and mindsets determined by categories of '*business-as-usual*'(BAU) or to move towards an alternative paradigm (Oswald Spring/Brauch 2011). The next part offers a historical framework for the contextualization of past long-term transformative changes since the end of the last glacial period, called the Holocene in geology and geography.

2. Five Historical Times and Past Grand Transformations

In earth and human history since the end of the last glacial period, when human civilization and high civilizations gradually emerged, we distinguish among five historical times. This

argument is inspired by Braudel's (1946, 1969, 1972) three historical times of the history of structures (*histoire de longue durée*), of repetitive cycles (*histoire de conjuncture*) and of events (*histoire événements*). I distinguish among five historical times:

a) the *geological times* of earth history and focus on the ongoing transition from the Holocene to the Anthropocene;

b) the *time of the so far three technical revolutions* or great transformations of the
   i. Neolithic or agricultural revolutions;
   ii. of the (first) industrial revolution (1750-1980/1920) (Osterhammel 2009); and of the
   iii. technological energy, communication, transportation and IT revolution (1980/1920-today) with an intensive use of fossil energy, communication (telephone, radio, TV, IT), transportation (car, sea carriers, aircraft), computers and global financial flows resulting in a globalization process and in multiple challenges to national sovereignty, risks to biodiversity and new threats due to possible abrupt and chaotic changes.

c) the *time of changes in national and international order* due to revolutions and the outcome of major wars, e.g. in modern times due to the American (1776), French (1789), Soviet (1917), Chinese (1945-49) revolutions and the international orders of Vienna (1815), Versailles (1919), Yalta and San Francisco (1945), and the new international disorder since the end of the Cold War (Brauch 2008);

d) the *time of repeating economic* (business cycles) and *political cycles* (duration of political presidencies or election periods of parliaments); and

e) the *short time of major political, societal or economic events* that only in rare cases (as structure changing events) were instrumental for major changes in national and international order.

A major new field of 'transition studies' has emerged in political science since the end of the Cold War focusing on the transition of previously state socialist political, economic and societal systems towards Western type market economies. From this still dominant 'transition research' in political science and international relations, the emerging scientific discourse on a needed future transition to sustainability fundamentally differs referring to major transformations in the scientific, societal, economic, and political systems, which imply a radical cultural transformation with the policy goal to avoid dangerous and catastrophic changes in climate, soil and water together with a rapid increase of biodiversity losses.

The impacts of the of the last two technical revolutions, of the industrial revolution (1750-1890/1920) and the technological and IT revolution (1880/1920-present) have resulted in a major intervention of human processes into the earth system that can be measured since the beginning of the industrial revolution in an exponential increase of the accumulation of greenhouse gases in the atmosphere that did not occur in millions or hundred thousands of years of climate variability with even higher variations in global average temperature and in sea levels than are presently projected by different climate models until 2100.

The emerging scientific debate on 'sustainability transition' addresses multiple scientific, societal, economic, political and cultural needs to reduce GHG emissions not only by legally binding *quantitative emission limitation and reduction obligations* (QELROs) as in the framework of the Kyoto Protocol (1997) that have so far failed to achieve the proclaimed goals due to a lack of political willingness and capability to implement these legal obligations and policy declarations during the past two decades. A continuation of the prevailing worldview and mindset of 'business-as-usual' may lead increasingly to 'dangerous'(+4°C world) or even 'catastrophic' climate changes and major human catastrophes during this century if the global average temperature should rise by 4-6°C above preindustrial average temperatures by end of the 21st century.

3. The Goal of Sustainability and the past 25 Years of Policy and Scientific Debates on Sustainable Development

3.1 The Political Concept of Sustainable Development

According to *Webster's New Twentieth Century Dictionary* (McKechnie [2]1983: 1838) the adjective 'sustainable' refers to being "capable of being sustained, maintained, maintainable" and according to the *Shorter Oxford English Dictionary* (OUP [5]2002; vol. 2: 3129) the term 'sustainable' refers to being "able to be maintained at a certain rate or level", and specifically with regard to "economic activity, development and agriculture" to "not leading to depletion of resources or degradation of the environment".

The *Encyclopedia Britannica* (15th Edition, 1999) lacked any entry on sustainable development, while the last edition of the *Brockhaus Enzyklopädie* (21st ed., vol. 19: 233-237) introduced it as a "guiding principle of international politics and of movements of civil society that aims at a permanent and just management of the earth". This lead article introduces 'sustainable development' as a "global civilization process that improves the situation of life of the present generation (development) without simultaneously endangering the opportunities of life for future generation (maintaining the social, economic and natural foundations of society". From an ethical perspective this article points to both considerations of 'intragenerational' and 'intergenerational' justice and equity.

This concept was originally synonymous with 'sustainability', which was first used in forestry with regard to a "sustained yield" since 1713 but its reference to "a balance between resource consumption and reproduction" was used in forestry since the 12th century. The sustainability concept was already used in 400 BC, when Aristotle referred to a similar Greek concept as household economics. The term 'sustainable' was first used in its modern meaning by the Club of Rome in its report on *Limits of Growth* (Meadows/Meadows/Randers/Behrens III 1972; Meadows/Meadows/Rander 1992/1993), which used the word 'sustainable' for describing the desirable "state of global equilibrium", arguing that they were "searching for a model output that represents a world system that is: 1. sustainable without sudden and uncontrolled collapse; and 2. capable of satisfying the basic material requirements of all of its people" (Meadows et al 1972).[3]

Since the publication of the Brundtland Commission (1987) report sustainable development has become a key concept guiding both policy and scientific debates for the past quarter century. This report defined sustainable development as a form of development that "meets the needs of the present without compromising the ability of future generations to meet their own needs".[4] In its definition, this term comprises two other concepts of "'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" (Brundtland Commission 1987). For the Brundtland Commission "sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations".

The United Nations 2005 World Summit Outcome Document refers to sustainable development as the "interdependent and mutually reinforcing pillars" of sustainable develop-

[3] See Wikipedia: "Sustainable Development" (28 May 2012).
[4] United Nations, 1987: "Report of the World Commission on Environment and Development" (New York: UN).

ment as economic development, social development, and environmental protection.[5] The 'outcome document' of the second earth summit (Rio+20) of 22-24 June 2012 addressed the "green economy in the context of sustainable development and poverty eradication" that offers a comprehensive be list of proposals made since the first Rio earth summit (1992) but lacks any legally binding political obligation.[6]

3.2 Milestones in the Policy Debates on Sustainable Development

Issues of the environment, of global environmental change and of sustainable development have not been addressed in the United Nations Charter (1945). Environmental science and environmental movements have gradually emerged since the mid and late 1960s and national environmental ministries and international organizations have been established since the 1970s. The first international conference of major state representatives occurred in June 1972 in Stockholm that agreed for a mandate for setting up the *United Nations Environment Programme* (UNEP) in Nairobi in 1972.

UNEP had so far five executive Secretaries from Canada (Maurice Strong, 1972-1975; Elizabeth Dowdeswell, 1992-1998), Egypt (Mostafa Kamal Tolba, 1975-1992) and Germany (Klaus Töpfer, 1998-2006; Achim Steiner, 2006-present). After UNCED in Rio de Janeiro in 1992 the *United Nations Commission on Sustainable Development* (UNCSD) and the *Global Environmental Facility* (GEF) were established independent of UNEP.

The United Nations' *World Commission on Environment and Development* (WCED), chaired by Gro Harlem Brundtland, was appointed by UN Secretary-General Javier Perez de Cuellar in December 1983 based on UN General Assembly Resolution 38/161 on the "Process of Preparation of the Environmental Perspective to the Year 2000 and Beyond". Its report was released in October 1987 before the Commission was replaced by *Center for Our Common Future* that started in April 1988. The Report's three main conceptual pillars of sustainable development include economic growth, environmental protection and social equality.[7]

The *United Nations Conference on Environment and Development* (UNCED) in June 1992 was the second major international state conference since Stockholm that resulted in the signing of the *UN Framework Convention on Climate Change* (UNFCCC) and of the UN *Convention on Biodiversity* (CBD) and the adoption of the Agenda 21 and a mandate for negotiating a *UN Convention to Combat Desertification* (UNCCD) that was signed in 1994. The *United Nations' Commission on Sustainable Development* (UNCSD) was established by the UNGA in December 1992 to ensure effective follow-up of UNCED in Rio. UNCSD as the high-level forum for sustainable development within the United Nations system reviews progress in the implementation of Agenda 21 and of the Rio Declaration on Environment and Development and provides policy guidance for the Johannesburg Plan of Implementation (JPOI) at the local, national, regional and international levels.

As a commission of the UN *Economic and Social Council* (ECOSOC), CSD has 53 member States and meets each year for two sessions in seven 2 year cycles (2003-2017) that address specific issues. UNCSD is supported by the *Division for Sustainable Development* (DSD) that is an authoritative source of expertise within the United Nations system on sustainable development and acts as its substantive secretariat addressing the implementation of Agenda 21, the Johannesburg Plan of Implementation and the Barbados Program of Action for Sustainable Development of Small Island Developing States. Its primary goal is the "integration of the social, economic and environmental dimensions of sustainable

[5] United Nations, 2005: "2005 World Summit Outcome Document", at: < http://www.who.int/hiv/ universal access 2010/worldsummit.pdf>.
[6] UNGA, 2012: Draft resolution: *The Future We Want*, A/66/L.56 (24 July 2012).
[7] See Wikipedia: "Sustainable Development" (28 May 2012).

development in policy-making at international, regional and national levels; wide-spread adoption of an integrated, cross-sectoral and broadly participatory approach to sustainable development; measurable progress in the implementation of the goals and targets of the Johannesburg Plan of Implementation". Major milestones in the work of the UNCSD have been: i) the Brundtland Commission Report (1987), ii) Agenda 21 (1992), iii) Barbados Plan of Action (1994), iv) the Program for the Further Implementation of Agenda 21 (1997), v) the adoption of the MDGs (2000), vi) the Johannesburg Plan of Implementation (2002) and vii) the Mauritius Strategy of Implementation (2005).

In 2000 a summit meeting of the UNGA in New York adopted the Millennium Declaration with eight *Millennium Development Goals* (MDG) to be achieved by 2015 with goal 7 focused on ensuring 'environmental sustainability'.[8] In 2002 the *United Nations Conference on Sustainable Development* (UNCSD) reviewed the achievements and shortcomings adopting the *Johannesburg Declaration on Sustainable Development* and a *Plan of Implementation of the World Summit on Sustainable Development*. As the outcome of the Earth summit in June 2012 in Rio de Janeiro the conference approved an outcome document on "The Future We Want".[9]

3.3 Scientific Debates on Sustainable Development and on Sustainability

Waas, Verbruggen and Wright (2009: 629) noted that "since the 1990s, universities worldwide have increasingly embraced the sustainable development movement. More than 1000 academic institutions worldwide have signed international declarations towards implementing sustainability through environmental literacy initiatives; curriculum development; research; partnering with government, non-governmental organizations and industry in developing sustainability initiatives; and 'greening' physical operations."

In 1980, seven years before the Brundtland Commission report, IUCN – The World Conservation Union, in a report on *Caring for the Earth* defined sustainable development as "improving the quality of human life while living within the carrying capacity of supporting ecosystems", where sustainability is understood as "a characteristic of a process that can be maintained indefinitely" (Trzyna 1995: 15)." For Viedermann (1995) it is a "vision of the future that provides us with a road map and helps to focus our attention on a set of values and ethical and moral principles by which to guide our actions" (Trzyna 1995: 17). For him sustainable development is multidisciplinary, a social process and a moral principle.

A quarter century after 'sustainable development' was introduced as a political and politicized concept, no agreed definition exists neither in the political realm nor in different scientific disciplines that have since employed this concept. In the *Encyclopedia of Global Environmental Change*, Peter N. Duinker (2002, vol. IV: 411) noted that "despite the elusiveness of a robust and practical definition (Munn 1992), scores of definitions have since been proposed". Rees (1990) defined sustainable development as 'positive socio-economic change that does not undermine the ecological and social systems upon which communities and society are dependent. Its successful implementation requires integrated policy, planning, and social learning processes; its political viability depends on the full support of the people it affects through their governments, their social institutions and their private activities.'

According to Duinker (2002: 411) the discussions have also focused on the meaning of the key concept of sustainability (Brown et al 1987; Dovers 1990; Shearman 1990) "with no clear, widely accepted definition in sight". Robinson, Francis, Legge and Lerner (1990) defined sustainability as "the persistence over an apparently indefinite future of certain

[8] UN: *The Millennium Development Goals Report 2011* (New York: UN, 2011): 50.
[9] UNGA, 2012: Draft resolution: *The Future We Want*, A/66/L.56 (24 July 2012).

necessary and desired characteristics of the socio-political system and its natural environment". For Brown, Hanson, Liverman and Merideth (1987) sustainability relies on these demands: "(a) continued human life on earth, (b) long-term maintenance of biotic resources and agricultural productivity, (c) stable human populations, (d) limited growth economies, (e) emphasis on local scale self-reliance and (f) continued environmental quality".

In the same *Encyclopedia of Global Environmental Change* Eban Goodstein (2002; vol. 5: 26-29) discussed sustainability in the context of economics and global environmental change where she distinguished between the short time horizons of market systems and sustainability and the neoclassical view of sustainability, which the author contrasted with an ecological view that emphasized the precautionary principle (Goodstein 2002: 29).

The theme of 'sustainability transition' was addressed in a major report of the US National Research Council (NRC 1999: 2) on *Our Common Journey: A Transition toward Sustainability*, which reinvigorated "the essential strategic connections between scientific research, technological development and societies' efforts to achieve environmentally sustainable improvements in human well-being". The report aimed at "internationally sanctioned goals for human welfare and environmental protection over the next two generations" whose realization would require "social learning". The report argued that the primary goal during "the next two generations should be to meet the needs of a much larger but stabilizing human population, to sustain the life support systems of the planet, and to substantially reduce hunger" (NRC 1999: 3-4). If current trends would continue the prospects for sustainability could seriously be undermined and life support systems "will be dangerously degraded, and the numbers of hungry and poor will increase". The NRC study concluded:

> Over longer time periods, unmitigated expansion of even these individual problems could certainly pose serious threats to people and the planet's life support systems, Even more troubling in the medium term, however, are some environmental threats arising from multiple, cumulative, and interactive stresses, driven by a variety of human activities. These stresses or syndromes, which result in severe environmental degradations, can be difficult to untangle from one another, and complex to manage. Though often aggravated by global changes, they are shaped by the physical, ecological, and social interactions at particular places, that is, locales or regions. Developing an integrated and place-based understanding of such threats and the options for dealing with them is a central challenge for promoting a transition towards sustainability (NRC 1999: 8).

The report suggested to integrate knowledge and action and proposed these priorities for research on sustainability science: a) "to develop a research framework that integrates global and local perspectives to shape a 'place-based' understanding of the interaction between environment and society"; b) "initiate focused research programs on a small set of understanding questions that are central to a deeper understanding of interactions between society and the environment", and c) "promote better utilization of existing tools and processes for linking knowledge to action in pursuit of a transition to sustainability".

On the eve of the 21st century, the US NRC report listed among the priorities for action in the new century: 1) "accelerate current trends in fertility reduction"; 2) accommodate an expected doubling or tripling of the urban system in a habitable, efficient, and environmentally friendly manner"; 3) "reverse declining trends in agricultural production in Africa sustain historic trends elsewhere"; 4) "accelerate improvements in the use of energy and materials"; 5) "restore degraded ecosystems while conserving biodiversity elsewhere"; and 6) "integrated approaches to research and actions at the regional scale related to water, atmosphere and climate, and species and ecosystems" (NRC 1999: 10-14).

This visionary report of the NRC on *Our Common Journey: A Transition toward Sustainability* is organized in 6 chapters that focus on 1) common concerns and differing emphases on sustainable development, 2) on trends and transitions, 3) on exploring the future,

4) on environmental threats and opportunities, 5) on reporting on transition and 6) integrating knowledge and action. The NRC (1999: 281) report suggested four interlinked, research-based components of sustainability science: a) social systems research, b) biological systems research, c) technological systems research and d) geophysical systems research.

In 2010 a book series on sustainability transitions was launched and the German Advisory Council on Global Change (WBGU 2011) published a report on *A Social Contract for Sustainability* that looked into both "Earth System Megatrends" and "Global Economic and Social Megatrends" focusing on changing values, the great transformation as a heuristic concept, on its technical and economic feasibility, on transformative governance, on agents of transformation and it offered many recommendations on a) the challenge low-carbon transformation, b) a new social contract, c) ten measure bundles with major strategic leverage, and d) on the composition on measure bundles. The WBGU report concluded with many specific recommendations on i) research for transformation, ii) education for transformation, and iii) recommendations with concrete research priorities in the three transformation fields.

From a different perspective, Rosa and Dietz (2010: 1-2) addressed the "Global transformations: PaSSAGE to a New Ecological Era" assessing "our state of knowledge about the dynamics of coupled human and natural systems, with an emphasis on their human dimensions". They defined *global environmental change* (GEC) in the context of coupled human and natural systems (CHANS) based on the assumption that both do not only interact but form "complex feedback loops" (Liu et al. 2007a, 2007b). A report on *Global Environmental Change. Understanding the Human Dimensions* (Stern/Young/Druckman 1992) had referred to five key social variables or GEC drivers: 1) population growth, 2) economic growth, 3) technological change, 4) political-economic institutions, and 5) attitudes and beliefs. They analyzed the impact of anthropogenic forces on an "accelerated Pace, Scale, and global Spread of environmental impacts" [PaSSAGE]. Rosa and Dietz (2010: 13) argue that autocatalysis, globalization, and the interconnectedness of ecosystems (AGE) around the globe drive GEC in the Anthropocene era (Crutzen/Stoermer 2000). The study by Stern, Young and Druckman (1992) referred to population, consumption and technological efficiency as key drivers of GEC.

Rosa and Dietz (2010: 31-37) distinguish different research traditions and directions in Europe and Latin America compared with the USA and Canada. From a European tradition "humans are neither passive recipients of environmental knowledge and options, nor merely objects to be studied via scientific methods … Rather, this tradition notes that values, beliefs, attitudes, and stories about the environment are all actively – and in many cases, strategically – constructed". Therefore, "they become the focus of investigation, not the 'objective' conditions of nature" that is well represented in Beck's (2010) risk worldview. From a different perspective, North American scholars have addressed issues of a *Structural Human Ecology* (SHE) focusing on "population size and consumption as key factors resulting in environmental impacts" (Dietz/Rosa/York 2010) with a special focus on land use cover and change (LUCC), institutional structures and practices, international environmental regimes, common pool resources, and ecological consequences: vulnerability.

In their concluding chapter Rosa and Dietz (2010a: 304ff) point to the following prospects for future research in the US, taking the research priorities of the NRC/NAS Report (Stern/Young/Druckman 1992) into account that address reactive vs. proactive framings, climate assessment and models, nonlinear dynamics and tipping points. While the "past consensus in the human dimensions community focused on vulnerability, adaptation, and response" Rosa and Dietz (2010a: 311) suggested "a reinvigorated effort to integrate social science research with research in the biological and physical sciences" and "that research and policy formulation be reprioritized to focus on prevention and mitigation, not just adaptive response strategies".

However, the two reports (NRC 1999, WBGU 2011) and the *Routledge Series on Sustainability Transitions* but also the debate on the human dimensions of GEC and on the interactions between human and natural systems did not address the international dimension of peace and security and the functional normative equivalent to sustainable development that has been referred to as sustainable peace (Keating/Knight 2004). The emerging debate in peace and humanitarian studies on 'sustainable peace' issues in most cases did not discuss global environmental challenges. Thus, the proposal to address both themes of 'sustainability transition' and 'sustainable peace' enters new ground (Brauch/Oswald Spring 2009).

In the preface to a compilation on *Sustainable Development: Implications for World Peace* Rocha Magalhães (1997: xi-xiii) argued that "sustainable peace cannot arise from an effort which ignores the broader questions of development". The conference in 1996 from which this volume emerged addressed four sets of questions: 1) which conflicts are due to a lack of sustainable development (poverty, inequality, lack of natural resources); 2) "in what way does the peace process contribute to the promotion of sustainable development"; 3) "how can sustainable development remove the causes of conflict at the local, regional and international levels"; 4) "What does all of this mean in terms of implications for peace and development policy". Ronnie D. Lipschutz (1997: 36) discussed the conceptual linkages between "Peace and Sustainable Development: Why? When? How? for Whom?" and concluded that

> Peace is not simply bringing an end to war: its sustainability also depends on a social consensus over the *terms* of peace. Sustainable development is not simply making the resources last: it depends on having in place a social organization that is based on a framework that helps to facilitate social consensus and peace. This does not mean off course, that global peace or governments are irrelevant; they are a very necessary part of a comprehensive formula. It does not mean, however, that if sustainable development is to become more than a mantra, it must address the specific needs of people in specific communities through their own collective and collaborative efforts.

This brief review of four bodies of scientific literature on: a) sustainable development as a concept, policy guideline and process, b) sustainable transition referring to the global transformation of present values, attitudes and behavior as well as of the energy, production, consumption, transportation sector, urbanization and habitat, c) on the human dimension of global environmental change research, and d) on the conceptual debate on peace and security, most particularly on 'sustainable peace' and 'human security'.

These four scientific issue areas have been addressed in different and highly specialized scientific communities in their own journals or book series. This emerging project addresses the linkage between goals and processes of multiple transformations implementing the political guidelines of sustainable development and their potential impacts on international and national policies focusing at peace (goal) and security (means). This requires a (re)conceptualization of both peace and security and conceptual, theoretical and empirical analyses on these complex linkages during past global transformations and possible future developments and scenarios.

4. The Emergence of the Scientific and Policy Debates on 'Sustainability Transition'

The scientific discourse during the past two decades has focused in the natural sciences on the emergence of earth systems analysis (ESA) or earth systems science (ESS), on 'sustainability science' (SuS) involving both the natural and social sciences and on approaches on 'sustainability transitions' (ST) primarily in the social sciences. The related policy debate has addressed proposals for a global green deal and for green growth that are increasingly being addressed by inter- and supranational organizations, such as UN, UNEP, OECD and the EU.

This part reviews the recent developments and trends in the scientific debate on 'sustainability transitions' since the Amsterdam conference (2009) when the 'Sustainability Transitions Research Network' (STRN) was established that has focused on "persistent sustainability problems in such sectors as energy, transport, water and food" from the perspective of "various scientific communities".[10] The STRN defined transitions research as

> a new approach to sustainable development (SD) and is drawing on … complexity theory, integrated assessment, STS, innovation studies, history, governance studies, reflexive modernization, but is also developing its own core set of questions and theories. … We have learned that … technical changes need to be seen in their institutional and social context, generating the notion of 'socio-technical (s-t) systems', which are often stable and path dependent, and therefore difficult to change. Under certain conditions and over time, the relationships within s-t systems can become reconfigured and replaced in a process that may be called a system innovation or a transition.

The STRN noted that "transitions to sustainability may turn out to be strongly context specific: dependent on the configurations of sectors and need areas, on national policy contexts and cultural aspects as well as on specific political contexts". It thus explored "the varied governance challenges that transitions to sustainability imply in different contexts".

> What is currently missing however is a network program that brings together researchers with a common interest in sustainability transitions but from a variety of different research fields: industrial transformation, innovation and socio-technical transitions; integrated assessment; sustainability assessment; governance of SD (political science); policy appraisal community; researchers working on reflexive governance; the resilience community; the ecological economics community; groups of energy-, environment- and sustainability- modelers; and a core sustainability transitions community. The network aims to do sustainability transitions research covering a variety of domains including energy, mobility, housing, agriculture, water and the build environment. Research is organized around seven themes: (a) synthesizing perspectives and approaches to transitions; (b) governance, power and politics; (c) implementation strategies; (d) civil society, culture and social movements in transitions; (d) firms and industry; (e) geography of transitions; (e) modeling of transitions.

The first volume in the Routledge Studies in Sustainability Transitions by Grin, Rotmans and Schot (2010) addressed "New Directions in the Study of Long Term Transformative Change" combining "three perspectives on transitions to a sustainable society: complexity theory, innovation theory, and governance theory". The authors

> seek to understand transitions dynamics, and how and to what extent they may be influenced. … This implies that our world has to overcome the undesirable side effects of the ongoing 'modernization transition,' which began around 1750. However, the transition to sustainability has to compete with other developments, and it is uncertain which development will gain the upper hand. … The authors … closely address the need for transitions, as well as their dynamics and design. Thereby they concentrate on historical cases as well as on contemporary examples.[11]

The Environmental Innovation and Sustainability Transitions' (EIST) Journal "offers a platform for reporting studies of innovations and socio-economic transitions to enhance an environmentally sustainable economy and thus solve structural resource scarcity and environmental problems, notably related to fossil energy use and climate change. This involves attention for technological, organizational, economic, institutional and political innovations as well as economy-wide and sector changes, such as in the areas of energy, transport, agriculture and water management." The journal focuses on "social, economic, behavioral-psychological and political barriers and opportunities as well as their complex

[10] See at: <http://www.transitionsnetwork.org/files/STRN_research_agenda_20_August_2010(2).pdf >

[11] See at: <http://www.sustainabilitytransitions.com/book/transitiontheory> and <http://www.routledge.com/books/details/9780415876759/ >.

interaction".[12] The WBGU Report on a 'Social Contract for Sustainability' (2011) argued that the transformation to a low-carbon society

> can only develop if subsidies for fossil energy carriers … are abolished. … Climate protection is, without a doubt, a vital fundamental condition for sustainable development on a global level. … Sustainable development means more than climate protection, though, as the natural life-support systems also include many other natural resources, such as fertile soil and biological diversity.
> The transformation into a sustainable society requires a modern framework to allow … almost nine billion people to lead ‚the good life', both in terms of living with each other, and living with nature: a new Contract Social. … Science plays an essential role here, as for the first time in history, a profound transition does not need to be caused by imminent necessity, but by precaution and well-founded insight. … The social contract also represents a special agreement between science and society. … It is also about a new culture of democratic participation. … The WBGU also highlights the fact that a low-carbon transformation can only be successful if it is a common goal, pursued simultaneously in many of the world's regions. Therefore, the social contract also encompasses new ways of shaping global political decision-making and cooperation beyond the nation state.[13]

This Report proposed specific measures for the energy sector, land-use changes and global urbanization that could accelerate and extend the transition to sustainability.

1. The state should show conscious awareness of its enabling and proactive role to advance global decarbonization. However, this can only be legitimate if it goes hand in hand with offering its citizens far more extensive opportunities for participation.
2. A European energy policy aiming for a fully decarbonized energy system by 2050 at the latest should be developed and implemented at once. … One top priority for any development policy should be to provide access to sustainable energy to the 2.5 to 3 billion people in developing countries currently living in energy poverty.
3. A huge effort should be made to steer the world's accelerating urbanization towards sustainability.
4. Land-use can and should become climate-friendly, in particular forestry and agriculture.
5. Financing of the transformation and the massive investments required should increasingly rely on new business models that help to overcome current investment barriers.
6. Within international climate policy, states should continue to work towards an ambitious global treaty. At the same time, multilateral energy policy must promote the worldwide transfer of low-carbon technologies.[14]

The WBGU Report proposed that "research and education are tasked with developing sustainable visions, in co-operation with policy-makers and citizens; identifying suitable development pathways, and realizing low-carbon and sustainable innovations". It suggested that

> during the establishment of low-carbon energy systems, the challenge lies in ending energy poverty in developing countries whilst also drastically, and quickly, mitigating global CO_2 emissions from the use of fossil energy carriers. … This requires efficiency improvements and lifestyle changes in many areas of people's everyday lives. … The WBGU recommends a strategy that relies primarily on an accelerated use of renewable energies. … Carbon, capture and storage (CCS) … is a necessary climate protection measure for countries that continue to rely on the use of fossil energies in the interim. CO_2 sequestration could also become an important technology at a later stage. ... Transformation costs can be lowered significantly if joint decarbonization strategies are implemented in Europe.[15]

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[12] See the overview page at: < http://www.wbgu.de/en/flagship-reports/fr-2011-a-social-contract/ >; the English summary at: < http://www.wbgu.de/fileadmin/templates/dateien/veroeffentlichungen/hauptgutachten/jg2011/wbgu_jg2011_kurz_en.pdf > and the complete English text: <http://www.wbgu.de/en/flagship-reports/fr-2011-a-social-contract/ >.

[13] See at: <http://www.wbgu.de/en/flagship-reports/fr-2011-a-social-contract/ >, see also the press release at: <http://www.wbgu.de/en/press-appointments/press-releases/2011-04-07-press-release/ >.

[14] See press release at: < http://www.wbgu.de/en/press-appointments/press-releases/2011-04-07-press-release/ >.

[15] See press release at: <http://www.wbgu.de/en/press-appointments/press-releases/2011-04-07-press-release/ >.

The policy debate auggested a 'new global green deal' for a green growth (UNEP[16], OECD (2011, 2011a), UNCSD) in the debates prior to Rio+20 in June 2012[17], two decades after the UN Summit on Environment and Development (UNCED) and a decade after the UN Summit on Sustainable Development (UNSSD.

The scientific discourse and the policy debates closely interacted. While the policy debate since the Brundtland Commission Report (1987) has partly triggered funding for new scientific institutions and research projects, the scientific debate has since moved much further from developing an approach to zero growth, to a reduction of the overuse of nature and the recuperation of the crucial ecosystem services for humans and nature. In the global public and policy debate there has been an overemphasis on GHG emissions while the mayor destruction of biodiversity and the negative impacts on ecosystems were often ignored.

Also a 'climate paradox' of some G8 countries has emerged (Brauch 2012), which declared from 2007 to 2011 their intention to reduce their GHG by 80% by 2050 while they had failed to achieve their commitments under the UNFCCC and the Kyoto Protocol until end of 2012 due to a lack of political will and ability to implement long-term declaratory policies postponing the tough decisions to the next generation.

The weak performance and implementation of quantitative GHG emissions reductions will most severely affect the highly socially and environmentally vulnerable developing and least developed countries while the economic losses due to hazards were the highest in developed countries due to insurance. It is projected that many of these countries with a continued high population growth, a high level of people below the poverty line will also have a low level of resilience and limited capabilities for adaptation and mitigation during the 21st century.[18]

5. The Temporal Dimension of Sustainability Transition

As the previous "great transformation" (Polanyi 1944) due to the industrial revolution, the debate on 'sustainability transition' refers to another long-term but a far more comprehensive transformative change. With regard to the "policy implications of sustainability transitions" Voß et al. (2009) pointed to a long-term orientation of policy frameworks arguing that

> Sustainability transitions typically span over several decades and are therefore at odds with the usual spans of attention prevalent in political processes … In order to support long-term structural shifts, policies have to interact with many transformative changes as they unfold. Long-term policy design thus needs to be flexible, adaptive and reflexive (Voß et al 2009).[19]

The temporal dimension of past long-term transformative change have been analyzed by archaeologists and historians who have worked on the agricultural and Neolithic revolutions from 10.000 to 6.000 years BP during the early phases of the Holocene when permanent settlements (villages, towns), new forms of systems of rule, governments, high civilizations and also organized forms of violent conflicts (wars) gradually emerged. Until 1750 these economies relied on a preindustrial solar energy system (Sieferle 1997; Smil 1994).

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[16] See UNEP: "Green Economy" page; at: <http://www.unep.org/greeneconomy/>; "Global Green New Deal. Policy Brief"; at: <http://www.unep.org/pdf/A_Global_Green_New_ Deal_Policy_Brief.pdf>; "'Global Green New Deal' - Environmentally-Focused Investment Historic Opportunity for 21st Century Prosperity and Job Generation"; at: <http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=548&ArticleID=5957&l=en>.

[17] "Rio +20 United Nations Conference on Sustainable Development"; at: http://www.uncsd2012.org/ and the final document: UNCSD: The Future we Want (Rio de Janeiro: 24 June 2012); at: <http://daccess-dds-ny.un.org/doc/UNDOC/LTD/N12/436/88/PDF/N1243688.pdf?OpenElement >.

[18] See Hans Günter Brauch: *Climate Paradox of the G8- Legal Obligations, Policy Declarations and Implementation Gap*. First Sustainability Transition and Sustainable Peace Workshop UNAM/CRIM and AFES-PRESS, Morelos, 1^0-12 September 2012.

[19] See: Coenen and Truffer (2012: 6).

During the 19th century the industrial revolution was closely linked to a knowledge revolution with a fundamental transformation in science and technological development, in the energy system, in production and consumption, in human settlements, mobility and communication that resulted in changes of the system of rule, societal participation (Polanyi 1944), but also in a mass mobilization of society and the economic system for warfare during the first world war (Osterhammel 2009). Since 1865 the rapid industrialization in the USA resulted in transformation of the economic sources of political and military power prior (Kennedy 1987).

The third technological revolution started with Thomas Edison's discovery of the electric bulb (1979), the invention of the telephone by, of the automobile (1885), and with the computer (1941) that triggered fundamental transformations in the communication, transportation and information technology that initiated long-term and comprehensive transformative changes which also had an impact on the transitions processes of national and international order.

So far the evolving discourse on 'sustainability transitions' has been relatively narrow lacking both such a longer-term historical dimension but also a spatial dimension that may explain why past transitions have occurred first in certain regions (e.g. with the development of wheat in Ethiopia, of rice in China and Maize in Mexico) and why the industrial and the technological revolutions and transitions emerged first in Europe and North America.

6. The Spatial Dimension of Sustainability Transition

Within the evolving discourse on sustainability transition, the proposal of a spatial dimension by Coenen, Benneworth and Truffer (2010, 2012) was more limited who argued that

> An explicit analysis of the geography of transitions contributes to the extant transitions literature in a variety of ways. Firstly it provides a contextualization and reflection on the limited territorial sensitivity of existing transitions analysis. … Secondly, it explicitly acknowledges and investigates a variety of transition pathways. Thirdly, it encompasses not only greater emphasis but also better conceptual and theoretical devices for understanding the international, trans-local nature of transition dynamics.

More recently, Coenen and Truffer (2012: 1) claimed that

> environmental innovations and sustainability related initiatives have received increasing attention in the recent economic geography and regional studies literature. In how far sustainability concerns might also lead to fundamental transformations in technologies, industries and life styles (so-called sustainability transitions) has however found much less resonance. … These approaches mostly disregarded spatial aspects of sustainability transitions until recently.

They suggested that future research should combine both traditions in sustainability related research in Regional Studies. Since 1990 they distinguished between two main trends in sustainability transition studies focusing on the technological innovation systems approach (TIS) and on the multilevel perspective (MLP) that both relied on Innovation and Technology Studies (Coenen/Diaz Lopez 2010)". The MLP, Coenen and Truffer (2012: 6) argue,

> critiques the overly narrow focus on innovation success prevalent in much of the innovation system literature (Geels 2004). This framework was elaborated based on detailed historical accounts of sector and technology formation processes. The resulting semi coherent constellations of technological artifacts, infrastructures, regulations, user practices are captured by the notion of the sociotechnical regime (Geels 2002).

Coenen and Truffer (2012: 8) noted that the emerging sustainability transitions research is lacking a spatial dimension. "One of the very salient weaknesses is related to the treatment of space in socio-technical systems studies (Hodson/Marvin 2010; Smith et al 2010; Truffer 2008; Cooke 2010). Scholars in Urban Studies for instance have explicitly explored the role of cities in low carbon transitions (Bulkeley et al 2010) and detailed some of the many different ways of thinking about the roles of cities in the context of sustainability transitions."

Coenen and Truffer (2012: 8) concluded in a review on sustainability concerns that

> regional studies provide some building blocks on which a more elaborate concept of geographies of transition could build. … The major weaknesses being that technologies and sectoral (trans-) formation processes rarely receive very explicit consideration. Either there is a strong focus on institutional change at the expense of technological change, regional production structures at the expense of consumer and citizen related processes or alternatively a strong but singular focus on (experimental) policies for regional sustainability. The complementarities between regional studies and transitions studies therefore warrant some further scrutiny.

However, regional studies usually only look at the lower level of the geographic scale, while international relations address the more abstract level of the relations among states, societies and economies, thus linking international with transnational relations, including negotiations towards achieving policy declarations on decarbonization of the economy and a shift towards green growth. The discussion on 'sustainability transition' has so far focused primarily on the micro-level of socio-economic and societal and technological innovations and did not address the impacts of strategies and policies within a business-as-usual worldview or mindset and an alternative sustainability perspective on international peace and security.

A continuation of the consumption of fossil fuels will not only raise GHG emissions but also increase the demand for nonrenewable energy sources, increase their price and possibly result in military conflicts on the access and control of hydrocarbons. Policy scenarios may be foreseeable that strategies, policies and measures oriented at a long-term-transformative change towards sustainable development may enhance the prospects for international cooperation, of peace with security and of the long-term vision of a positive or sustainable peace?

7. Scientific Dimension of Sustainability Transition

The development of new scientific and technological knowledge is crucial for initiating processes that call for multiple transitions towards sustainability. With their paper on "Science for Global Sustainability: Toward a New Paradigm" Clark, Crutzen and Schellnhuber (2004: 3) provided the conceptual context for the Dahlem Workshop on "Earth Systems Science and Sustainability" (2003) in which they pointed to "the need for harnessing science and technology in support of efforts to achieve the goal of environmentally sustainable human development in the Anthropocene". They noted the great transformation during the 20th century that resulted in an increase of cropland by a factor of two, of world population by a factor of 4, water use by a factor of 8, energy use by a factor of 16 and industrial output by a factor of 40 (based on McNeill 2000, 2009).

In 1999, the US National Academy of Science noted that the present trends are projected to increase into the 21st century and that "many human needs will not be met, life-support systems will be dangerously degraded, and the number of hungry and poor will increase" (NRC 1999: 101), but the NAS also argued that "a successful transition toward sustainability is possible over the next two generations" but that his would require "significant advances in basic knowledge, in the social capacity and technological capabilities to utilize it, and in the political will to turn this knowledge to action" (NRC 1999: 160). Clark, Crutzen and Schellnhuber (2004:) discussed both the opportunities and challenges in facing and coping with these impacts of GEC and GCC that were addressed in the Amsterdam Declaration (2001) calling for The *Earth System Science Partnership* (ESSP) that has evolved during the past decade (Leemans/Rice et al. 2011).

Clark, Crutzen and Schellnhuber (2004: 1-28) further noted that that since the 1950s several transitions have occurred in how society views the relationships among environment, development, and knowledge, but that "only very recently, however, has it become evident that the Anthropocene crisis forces humanity to manage consciously a transition toward su-

stainable use of the Earth". They argued that in the aftermath of the Johannesburg Summit (2002) one outcome was "the realization that the range of organized, disciplined, reflective activity needed for intelligently and effectively guiding a sustainability transition was much broader than what is conventionally subsumed under the term of 'science'." They considered the earth systems science as a key promoter of such a transition, what requires a change in the scientific world view and orientation recognizing that sustainable development is a knowledge-intensive activity. They pointed to a growing consensus "that management systems for a sustainability transition need to be systems for adaptive management and social learning". They argued that 'Wissenschaft' can contribute information, incentives and institutions by mobilizing the right knowledge, by integrating knowledge, by balancing flexibility and stability and contributing infrastructure and capacity.

In conclusion, they suggested "A New Contract for Planetary Stewardship", linking science and society that was taken up in 2011 in he WBGU's Flagship Report suggesting "A Social Contract for Sustainability" and they summarized their argumentation in this statement:

> We are currently witnessing the emergence of a new scientific paradigm that is driven by unprecedented planetary-scale challenges, operationalized by transdisciplinary centennium-scale agendas, and delivered by multiple-scale co-production based on a new contract between science and society.

From the perspective of international relations, ecology, geography this may require from the natural sciences a readiness to bring international, and peace and security considerations into their analysis, as well from the social sciences a readiness to consider the results of ESS and ESA in their own analyses, what has stimulated Brauch, Oswald Spring and Dalby (2011) to call for a new "Political Geoecology for the Anthropocene". The scientific discourse on 'sustainability transition' must be broadened from its narrow initial focus as it has evolved since the Amsterdam conference in 2009 towards a wider scope that comprises all seven dimensions of 'sustainability transition'.

8. Societal Dimension of Sustainability Transition

Political, economic and societal strategies for 'sustainability transition' cannot be implemented against the wishes, values and preferences of the people concerned. Such a long-term and global transformative change requires not only 'hard' changes in the production, energy, transportation systems and in human settlements and habitats but also many 'soft' changes in human values, belief systems, worldviews and mindsets.

The societal dimension of the scientific discourse on sustainability transition has so far focused, i.a. on the needed change in human values, perception and behavior resulting in new lifestyles, ways of life and consumptive patterns. These goals have been promoted by leading scientists, selected policymakers and by religious and social movements, such as for example the simplicity movements that have called for a simple lifestyle without negative effects on nature.

The WBGU (2011: 67) argued that "the necessary transformation into a low-carbon society already corresponds to some of the prevalent attitudes and value systems in many of the world's countries ... Secondly, that the transformation can therefore be viewed as a positive factor in the sense of increasing subjective life satisfaction for large parts of the population." The WBGU noted "that the terms 'values', 'attitudes' and 'opinions' have different meanings in psychology, sociology and political sciences" (see Häcker/Stapf 1994).

1. Personal and cultural values: According to Kluckhohn (1951), values are a shared perception of something worth having or striving for. Cultural values therefore refer to something that has evolved socio-culturally, something that exists independent of individuals. Personal values, on the other hand, refer to the subjective concepts of desire and specific value orientation. Personal

values or value orientation therefore describe the individuals' relatively stable preferences with regard to different values (Häcker/Stapf 1994).

2. Attitudes: Contrary to the rather abstract 'values' and 'value systems', attitudes relate to certain objects, people (groups), ideas and ideologies, or specific situations (Häcker/Stapf 1994). Attitudes represent evaluation and action tendencies with regard to attitude objects, and are usually stable in the medium-term. They are therefore neither long-term value systems, nor short-term intentions.
3. Opinions: Are generally considered to be the verbalization of attitudes and values (Rokeach 1968). Attitudes are usually measured by several items, i. e. asking carefully selected questions and statements which are indicators for certain attitudes to evaluate one attitude object, thereby ensuring that the results are reliable.

Ingelhart's (1977, 1998) work on value change has addressed the emergence of postmaterialist values since the end of World War II that found an expression in the "emergence and increasing power of new social movements … as the expression of a wider cultural value change (Inglehart 2008)" (WBGU 2011: 69). However, this observed value change and the global contextual change since 1989 did not affect the prevailing worldview and the mindset of many policymakers. While during the 5th wave of the World Value Survey (WVS 2010) close to 80% of the surveyed US population saw global warming or the greenhouse effect as serious or very serious, nevertheless President Obama has failed so far to have any climate change legislations adopted (Klein 2011). This implies a high volatility of the WVS and that the values did not result in any major behavioural change and did not matter politically given the strong economic and ideological interests of the climate change opponents and sceptics.

For a behavioural change towards a sustainability transition a temporal change in public preferences and attitudes is not sufficient, rather fundamental changes in human behaviour is needed that may imply major changes in lifestyles, consumptive preferences and patterns that result in a lower ecological footprint and in a reduction of the individual carbon emissions. However, this cannot only be achieved by changes on the demand side but also requires major change in the supply side with regard to green and renewable energy systems, public and low carbon transport systems and products with a much lower carbon footprint.

New social movements and political parties may contribute to creating both awareness and positive political frameworks for a change in the lifestyles and the preferred way of life of a majority of the people. Thus, changing the 'soft' human and societal side of 'sustainability transition' may be as difficult if not even more difficult than changing the socio-technological framework on which most of the research have so far focused. The WBGU (2011: 78-79) further argued that

> For the transformation of economy and society towards sustainability, the political, economical and technological path dependency is also a significant barrier (Liebowitz/Marjolis 1995; Pierson 2004). An existing system of institutions (norms, contracts negotiating and decision-making modi, etc.), but also of technologies and infrastructures, can hinder far-reaching social changes. Already existing technologies, infrastructures and socio-cultural patterns can produce these kind of lock-in effects, restricting the behaviour and the development potential over several investment cycles (Freeman 1992). … In politics and the economy, path dependent processes and developments frequently result in mistakes becoming the established norm, and the continued absence of learning effects. ... Clinging to past thought and action patterns can lead to an 'objective' pressure to change, which merely results in modification, rather than transformation of the status quo, delaying the replacement of the fossil-nuclear energy system with a sustainable energy system even further.

While new scientific results and new publicly shared knowledge does not change values, attitudes, preferences and behaviour, the enduring change of these soft factors requires simultaneous changes in the hard factors of the economic system and production and consumption process and in the policy process.

9. Economic Dimension of Sustainability Transition

Besides the energy sector that accounts for 2/3 of GHG emissions, land-use change due to deforestation and agriculture contribute ¼, therefore, the WBGU (2011: 109) argued that:

> central elements of the transformation into a sustainable and climate-friendly society are the comprehensive decarbonization of the energy system, as well as significant energy efficiency improvements, particularly in end-use efficiency. … These include … facilitating economic development through universal access to safe and modern energy, improving long-term supply security, and a de-escalation of international conflicts with regard to energy resources, positive effects on employment in structurally weak regions, and the reduction of many of the current systems' negative effects on the environment … Building the transformation-relevant technology and infrastructure requires substantial investments. ... In the long run … these initial investments will be more than compensated by … reduced fuel and security costs, less damage to the environment, and avoidance of costs associated with adapting to climate change, and with the consequences of climate change (WBGU 2011: 109).

According to the IPCC's (2011) *Special Report on Renewable Energy Sources and Climate Change Mitigation* (SRREN) and the WBGU's (2011: 119) assessment "the sustainable potential of renewable energies is fundamentally sufficient to provide the world with energy". According to the IPCC (2011: 15): "There are multiple pathways for increasing the shares of RE across all end-use sectors." This applies specifically for the transportation, building and agricultural sectors and requires long-term integration efforts including

> investment in enabling infrastructure; modification of institutional and governance frameworks; attention to social aspects, markets and planning; and capacity building in anticipation of RE growth. Furthermore, integration of less mature technologies, including biofuels produced through new processes … fuels generated from solar energy, solar cooling, ocean energy technologies, fuel cells and electric vehicles, will require continuing investments in research, development and demonstration (RD&D), capacity building and other supporting measures.

The IPCC's SRREN Report (2011) addressed the linking between renewables and sustainable development, arguing that "historically, economic development has been strongly correlated with increasing energy use and growth of GHG emissions, and RE can help decouple that correlation, contributing to sustainable development (SD)." Renewables can also make a significant contribution to global mitigation efforts, given that "a significant increase in the deployment of RE by 2030, 2050 and beyond is indicated in the majority of the 164 scenarios reviewed" in SRREN. The IPCC further argued that "individual studies indicate that if RE deployment is limited, mitigation costs increase and low GHG concentration stabilizations may not be achieved". And that „a transition to a low-GHG economy with higher shares of RE would imply increasing investments in technologies and infrastructure".

As the increasing consumption of fossil fuels was the major cause for the increase of GHG emissions in the atmosphere from 279 ppm in 1750 to 396.8 in February 2013, a drastic increase of the global share of RE is a necessary but not sufficient policy for coping with GHG emissions. The goal of a gradual and comprehensive decarbonization of the economy requires major improvements in energy efficiency and a great transformation in many economic sectors. These comprehensive concerns have motivated national and international policymakers to call for a 'global green deal' and for policies of sustainable production and consumption, for a sustainable zero growth, for green growth and even for a degrowth.

Besides the fundamental transformation of the energy sector, the WBGU Report (2011) proposed an intensification of policies of sustainable production and consumption and major initiatives in buildings, living and land-use planning, in mobility and communication and in food requiring both a climate-compatible agricultural management and a change in dietary habits. Initiating and intensifying the process towards a low-carbon society and economy

requires major investments and new and additional financial resources, such as phasing out fossil energy and agricultural subsidies, taxation of international transportation and international financial transactions, development assistance and financing via the carbon market. B Besides the decarbonization of the world economy, „overcoming energy poverty“ and „to provide universal access to modern, clean and safe energy in the form of electricity or gaseous energy carriers by 2030“ is the second major challenge for a sustainable energy transition.

Initiating sustainable transformation in cities with the highest energy growth potential can become a major force of innovation and investment in new infrastructure. This requires new governance actors (Corfee-Morlot et al. 2009) who can reduce traffic by a “spatial integration of urban functions”, thus “achieving a high quality of life for inhabitants”. Further, “energy infrastructure integration (CHP technology, heating and cooling systems, smartgrids, electromobility, etc.) can benefit considerably from the spatial density” (WBGU 2011: 173). While “land-use systems cannot become completely emissions-free”, nevertheless “a significant contribution from land use” is needed, including “stopping deforestation and switching to sustainable forest management, as well as the promotion of climate-friendly agriculture and dietary habits” (WBGU 2011:173).

10. Political Dimension of Sustainability Transition

The political dimension on ‘sustainability transition’ has been extensively discussed and many approaches, analysis and proposals have been submitted so far. Grin (2010: 223) suggested that the transition to sustainable development can no longer rely on centralized government institutions of political administrative steering, given the “more prominent role of the interactions between the state, market, and society”. Grin argued that a governance perspective “allows us to consider transition management, strategic niche management and interrelated processes in the real world”, due to three reasons: 1) a “historical contextualization of the transition towards a sustainable society in late modernity”; 2) an emphasis “not only the nature of transitions as profound changes … but also how these changes in practices and structure in a particular domain are influenced by long-term, societal trends exogenous to that domain”, and that “it pays attention to dealing with the politics intrinsic to transitions and systems innovation”.

Grin (2010: 237) reviewed the contemporary processes of institutional change in modern societies with regard to a) structural changes affecting the polity that deal with institutional transformations between the four key actors, the state, market, society and science; b) structural changes in innovative systems including the development and use of new technologies, and c) the emergence of new, often transnational, arrangements for corporate governance. But this perspective lacks an analysis of the fourth transformation of international politics of peace and security comparing the international, regional and global impacts of a continuation of business-as usual policies and of the alternative sustainability paradigm. Based on the first three levels, Grin (2010: 247) argued that “at the regime level, major processes of transformations go on in the institutions of state, market, civil society and knowledge, and their mutual alignment.” Grin interpreted these changes as the result of two processes resulting from: a) “influences on the regime from landscape-level trends, such as globalization, individualization, Europeanization and the politicization of side effects, as well as derived trends such as privatization and liberalization;” and as the responses to b) “the challenges these practices have come to face during the past two decades as a consequence of feedback processes.”

Focusing primarily on the structural change in innovative systems, Coenen and Truffer (2012: 6) argued that in sustainability transition research

> explorative scenarios, experimentation and learning … constitute important elements in specific policy programs. An early example of a reflexive policy framework that built on earlier work of Constructive Technology Assessment (Schot 1992) has become known as Strategic Niche Management (Hoogma et al. 2002; Schot/Geels 2007). … Other contributions have worked out foresight based scenario methods to identify potential development trajectories for entire countries (Elzen et al. 2004), sectors (Truffer et al. 2008), technological fields (Markard et al. 2009; Raven et al. 2009) or firm level strategic planning processes (Stoermer et al. 2009; Truffer et al. 2010). A more encompassing policy framework has later been developed in the Netherlands under the label of Transition Management (Kemp/Rotmans 2009; Voß et al. 2009; Kern/Smith 2008), … which comprises five main procedural elements: (1) Establishing a transition arena (i.e. a broad constituency of representatives from industry, politics, and society that accompany the ongoing planning and implementation process), (2) developing a vision of a future sustainable sector structure, (3) identifying pathways towards these future states by means of backcasting methods, (4) setting up experiments for particularly interesting development options and (5) monitoring, evaluation and revisions (Loorbach 2007).

A different approach was taken in a study by Roeland J. in 't Veld (2011: xv) for the Institute for Advanced Sustainability Studies (IASS) on *TRANSGOVANCE. The Quest for Governance of Sustainable Development* that suggested to decision-makers in politics, business, science, civil society and the media to create governance arrangements beyond traditional borders and that "sustainability requires transgovernance", where action is based on thinking: 1) beyond classical governance style and towards a culturally sensitive metagovernance for sustainable development, and b) beyond disciplinary scientific research, towards more transdisciplinarity. This approach implies major changes in and between democracy, science and media.

For rethinking sustainability governance, Roeland J. in 't Veld (2011: 17) referred to these crucial concepts: "knowledge democracy, cultural diversity, planetary boundaries and reflexivity, as well as structural changes through emergencies" and he formulated his insights on the linkages among these concepts in proposals for ten sustainability governance themes:

1. Developing societal networks that trespass the traditional boundaries of governance arrangements, involving private and public actors: 'co-decentral' arrangements;
2. Conditions for better long-term decisions;
3. A new diplomacy for international agreements;
4. Conditions for a more transdisciplinary science system;
5. Checks and balances in science communication;
6. Upgrading the relevance of city initiatives;
7. Nation states in a new role of process architect;
8. Crowds sourcing and volatile publics;
9. creating space for new institutions, and allowing for old institutions to be phased out or to be transformed into new ones;
10. Measuring progress through metrics which are to be found in dialogue-style search procedures.

These two studies by Grin (2010) and in 't Veld (2011) link the intensive scientific debate on global environmental and climate governance to the process of sustainability transition. From a US perspective, John C. Dernbach (2008) discussed legal aspects of "Navigating the U.S. Transition to Sustainability" arguing that

> Sustainable development would require the United States to maintain and improve human prosperity while at the same time greatly reducing its consumption of energy, materials, water, and land. … Because achieving sustainable development is a significant learning experience, the United States will need to employ a form of governance—reflexive governance—that requires constant learning and supportive citizens and stakeholders who are also working to ensure sustainability in their own activities. The two basic problems reflexive governance must address are the multigenerational nature of the effort and the need for across-the-board integration of environmental considerations into decision-making. The suggested legal structure includes a required national strategy, long-term and short-term goals, better integration of environment into

decision making across and among various levels of government, public education and engagement, a broad range of legal and policy tools, feedback mechanisms to foster learning, and designated governmental entities for coordinating or managing this effort as well as providing an independent review of their efforts (Dernbach 2008).

Several studies addressed the governance aspects and perspectives of sustainability transition (Loorbach 2007). But no specific proposal on the international governance for sustainability transition was adopted in the outcome document of Rio+20.

11. The Cultural Dimension of Sustainability Transition

While many studies in the emerging scientific debate on sustainability transition have focused on issues of technological innovation in relevant industrial sectors, especially on energy, and on governance aspects, the societal and cultural dimension has been less prominent. In the social and political sciences there has been an intensive debate on postmodern values and value changes (Inglehart 1977) and on the changes of attitudes and preferences towards sustainability (Raskin et al. 2002; Leiserowitz et al. 2006). The WBGU (2011: 67) used values as "a shared perception of something worth striving for", where cultural values refer "to something that has evolved socio-culturally". It stated that "attitudes relate to certain objects, people (groups), ideas, and ideologies, or specific situations (Häcker/Stapf 1994). In contrast to short-tem intentions and long-term value systems, attitudes "represent evaluations and action tendencies with regard to attitude objects, and are usually stable over the medium-term" while opinions are understood as "verbalizations of attitudes and values".

The WBGU (2011: 77) argued based on Leiserowitz et al. (2006) that various barriers prevent "value systems from impacting on behaviour, at both individual and social or structural level" and that a change in behaviour requires "a material and cognitive basis". A transition towards sustainability is structurally constrained by the prevailing path dependence and the extensive high carbon infrastructure and its political and electoral influence.

The analysis of the so-called soft aspects of sustainability transition, e.g. of the constraints, obstacles and barriers to a change in opinion, attitudes, value systems and behaviour require the expertise of sociologists, social psychologists and anthropologists but also of political scientists that include an analysis of cognitive perceptual and evaluative barriers due to established worldviews and mindsets (Oswald Spring/Brauch 2011).

12. Addressing the Obstacles to Sustainability Transitions: Overcoming Old Mindsets and Worldviews

Oswald Spring and Brauch (2011) argued that in the Anthropocene humankind is confronted with opposite ideal type visions of the future:

- Business-as-usual in a Hobbesian world where economic and strategic interests and behaviour prevail leading to a major crisis of humankind, in inter-state relations and destroying the Earth as the habitat for humans and ecosystems putting the survival of the vulnerable at risk.
- The need for a transformation of global cultural, environmental, economic (productive and consumptive patterns) and political (with regard to human and interstate).

Both visions refer to totally different coping strategies with GEC:

- In the first vision of business-as-usual cornucopian perspectives prevail that suggest primarily market mechanisms, technical fixes, defence of economic, strategic and national interests with adaptation strategies that are in the interest of OECD countries.

- In the alternative vision of a comprehensive transformation a sustainable perspective has to be developed and implemented into effective new strategies and policies with different goals and means based on global equity and social justice.

The consequences of both opposite scientific visions and competitive policy perspectives are:

- The vision of business-as-usual with minimal reactive adaptation and mitigation strategies will most likely increase the probability of a 'dangerous climate change' (Schellnhuber/ Cramer/Nakicenovic/Wigley/Yohe 2006) or catastrophic GEC with both linear and chaotic changes in the climate system and their socio-political consequences that represent a high-risk approach.
- To avoid these consequences the alternative vision and sustainability perspective requires a change in culture (thinking on the human-nature interface), worldviews (thinking on the systems of rule, e.g. democracy vs. autocracy and on domestic priorities and policies as well as on interstate relations in the world), mindsets (strategic perspectives of policy-makers) and new forms of national and global governance.

This alternative vision refers to the need for a "new paradigm for global sustainability" (Clark/Crutzen/Schellnhuber 2004), for a "transition to [a] much more sustainable global society" (Raskin/Banuri/Gallopin/Gutman/Hammond/Kates/Swart 2002), aimed at peace, freedom, material well-being and environmental health. Changes in technology and management systems alone will not be sufficient, but "significant changes in governance, institutions and value systems" are needed, resulting in a fourth major transformation after "the stone age, early civilization and the modern era". These alternative strategies should be "more integrated, more long-term in outlook, more attuned to the natural dynamics of the Earth System and more visionary" (Steffen/Sanderson/Tyson/Jäger/Matson/Moore III/Old-field/Richardson/Schellnhuber/Turner II/Wasson 2004: 291-293). These many changes suggested above by natural scientists require a 'Fourth Sustainability Revolution'.

12.1 Results of Business as Usual: The Climate Paradox

This author argued that both highly-industrialized countries (G-8, Canada, USA, Japan) and rapidly industrializing threshold countries (G-20) that account for more than 80% GHG emissions face a 'climate paradox' due to their inability to implement their legal commitments or policy declarations. However, the different performance of the climate laggards and new climate change leaders document that different political cultures in Europe and North America have influenced the different policy performance (Brauch 2012).

12.2 The Neo-Malthusian Dead End: Securitization to Militarization

Hobbesian pessimists, who are concerned about the national security implications of global environmental and climate change that are being interpreted from the dominant realist policy mindset, have used this argumentation to adjust their force structure to cope with these challenges. From a national security perspective the securitization of climate change impacts as a 'force multiplier' may result in a militarization.

12.3 The Cornucopian Dead End of Geo-engineering

From the opposite 'cornucopian' perspective, the solution to the challenges posed by global environmental and climate change may be technical fixes that have been offered by those who call for macro-scale projects of geo-engineering.

12.4 Towards a Sustainable Transition with Sustainable Peace

The prevailing policy mindset that favoured policy solutions based on assumptions of 'business as usual", has resulted in a comprehensive paralysis of global multilateral climate

governance at Copenhagen (2009), Cancun (2010), Durban (2011), and Doha (2012). The Neo-Malthusian national security perspective on the security implications of climate change may result in a militarization while the Cornucopian perspective believing that market mechanisms and technical fixes could cope with the impacts of anthropogenic climate change may lead to other severe global challenges. Based on the possible negative outcomes of both perspectives, these questions emerge:

1. Which conceptual linkages exist between the discussion on sustainable development (ecology) and a sustainable peace (peace research)?
2. Which possible consequences of non-action and of a postponement of decisions can be foreseen in the area of global environmental change (water, soil, climate change, biodiversity) for international peace and security – from the perspective of states and international organizations as well as of human security?
3. May policies of ecological non-action and of the postponement of decisions become a serious threat to international peace and security during the 21st century that increase the intensity of anthropogenic climate-induced natural hazards and disasters that may pose for billions of people an issue of survival?
4. May anticipative learning and a forward looking public and global discourse on the necessary long-term transformative change contribute to a sustainable development and counter new threats for international peace and security in a preventive manner?

12.5 Concluding Remark on Seven Dimensions on Sustainability Transition

This paper has argued for a wider or a macro approach to the study of sustainability transition that tries to bring several scientific disciplines and communities into a dialogue, natural scientists, especially climate specialists, geographers, political scientists, economists, sociologists, social psychologists, anthropologists, the socio-technical community, the governance community, ecologists and peace researchers.

The ‘temporal dimension’ of long-term transformational change adds to Braudel’s three times of long-term (geography), medium-term (conjunctural, economics) and short-term (events, history) the very long-term of geology and earth history, the shortening time-span of the so technical revolutions, and the political time of changes in ‘international order’ and ‘system of rule’ on the national level. The human intervention into the earth system since the industrial revolution has caused a fundamental change in earth history from the ‘Holocene’ to the ‘Anthropocene’ that has triggered the need for a sustainability transition to avoid that a militarization of the impacts of climate change may lead to major violent conflicts during the 21st century and beyond. Thus, the suggested debate on the linkage of sustainability transition with the normative debate on a sustainable peace follows the precautionary principle and calls for proactive policies that may result in a reduction of future resource conflicts on scarcer and more expensive fossil energy sources.

The ‘spatial dimension’ of sustainability transition takes up the suggestion to bring different scales – and thus also a geographic perspective in – from the micro level of individual human beings and local communities to the regional, national, continental and global level.

The ‘scientific dimension’ refers to the call of several scientists (Clark/Crutzen/Schellnhuber 2004) for a need of a new scientific revolution by moving to a major paradigmatic shift towards a new scientific worldview, as has occurred in Europe during the 17th century with the transition from the ‘Ptolemaic’ worldview of astronomy that the sun was circling around the earth to the modern worldview developed by Nikolaus Copernicus, Galileo Galilei, Johannes Kepler, Tycho Brahe and others that the world was circling as a planet around the sun. The report by Stern, Young and Druckman (1992), the NRC report (1999) and the WBGU report (2011) have all addressed the need for a closer conceptualization of the

interfaces between knowledge and action and submitted many proposals for research and education for the transformation process as a contribution of the knowledge society

The ‘societal dimension’ refers to the role of society, especially of societal actors and processes, in the needed transition towards the policy goal of a sustainable development path. societal groups (social movements, nongovernmental organizations, trade unions, political parties) can both be an accelerator due to a social learning process but it can also delay and obstruct needed political decisions and societal action. As transmitters of the new scientific knowledge both the education system and the media play a crucial role. Societal groups, perspectives and actors directly impinge on the economic dimension (as the demand side) and the political system as the supplier of legitimacy though elections in democratic societies.

The ‘economic dimension’ of sustainability transition (as the supply side) is crucial as it applies the scientific knowledge into new products that may significantly change societal processes. The consciousness and the convictions of the economic elites regarding sustainability considerations are a major determinant of investment decisions. Scientific knowledge may be translated in the economic sector to new forms of sustainable production and new products that make a sustainable consumption possible.

The ‘political dimension’ links the scientific, societal and economic dimensions by allocating the financial resources that make the development of new knowledge possible but in democratic societies it needs the support of the electorate. The political elite can be a leader towards a sustainability transition but it can also be forced to become a laggard if the parliaments do not approve the budget, national laws, regulations and the international treaties that offer a financial and legal framework for the long-term process of sustainability transition. With regard to issues of global environmental change and global climate change basic differences in the political culture have developed during the past decade between EU countries, the US, Canada, Japan, Australia, and South Korea.

The ‘cultural dimension’ influences the opinions, attitudes, cultural values and finally also the behaviour of individual human beings, of local, ethnic and religious communities and of societal groups. Cultural values significantly influence the worldview of societal actors in science, business, politics and the society and thus have a major impact on the conceptual filters and the mindsets of policy makers.

Research on sustainability transition must focus both on the ‘soft factors’ that enable, accelerate or delay and impede the adoption and implementation of such goals, and on the ‘hard factors’ of environmental innovations for sustainability transition that have been addressed from a socio-technical perspective. The governance perspective links the knowledge on the soft and the hard factors for a sustainability transition.

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