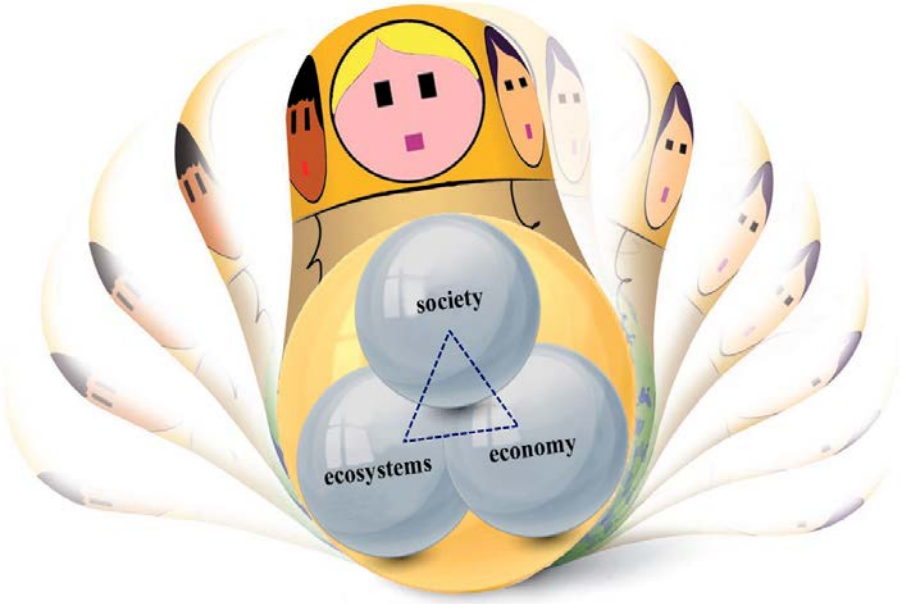
# Sustainable systems in the post-2015 development agenda: Keeping societies, economies and ecosystems resilient

**Contribution of the**
**International Expert Group on Earth System Preservation**
**(IESP) to the post-2015 Sustainable Development Goals**

**General obligation**

**Humankind ought to take readily applicable measures capable of keeping societies, economies and ecosystems resilient**




October 2013

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## Overview of the proposed goals and targets

Goal 1**: Foster the resilience of societies**

- Target 1.1 Improvement of cognitive understanding of societal systems and dissemination of the respective knowledge achieved.
- Target 1.2 Guarantee of equal rights and social justice independent of gender, race, religion or ethnicity.
- Target 1.3 Alleviation and eventual eradication of poverty.
- Target 1.4 Development of innovative methods of building the capacity to overcome global threats.
- Target 1.5 Implementation of the Human Right to Water and Sanitation (HRWS) through generally accepted measures based on the principle of progressive realization.
- Target 1.6 Reduction of population growth through voluntary means.
- Target 1.7 Development of guidelines for human behavior based on moral values and ethical behavior specially focused on natural resources and the environment.
- Target 1.8 Reduction of the vulnerability of complex societal systems (urban agglomerations, communication and mobility infrastructures, and industrial societies) to climate change.
- Target 1.9 Innovation in the modeling of socio-technical systems as nonlinear complex systems for better understanding and guidance of societal and technical development.

Goal 2: **Foster the resilience of economies**

- Target 2.1 Improvement of international cooperation.
- Target 2.2 Enhancement of the resilience of economic systems through development of incentives favoring small and medium size enterprises (SMEs).
- Target 2.3 Enhancement of the resilience of farming and food supply systems through support of production and distribution schemes serving consumers and preserving local land ownership.
- Target 2.4 Development and implementation of technologies for water conservation, pollution reduction, and recycling that will meet the increasing demand for water for human use and maintenance of aquatic ecosystems.
- Target 2.5 Pursuit of a new economic paradigm that favors qualitative growth over maximum production and revenue.
- Target 2.6 Development of innovative technologies serving local demands and their application in rural areas.
- Target 2.7 Improvement of general public understanding of the contribution of individuals to environmental degradation and ecosystem shifts and the obligation of each person to cooperate in the efforts to reverse detrimental developments.
- Target 2.8 Improvement of risk dynamic modeling of economic and financial systems for the purpose of managing unforeseen developments.

Goal 3: **Encourage the self-regulation processes of ecosystems**

- Target 3.1 Curtailment of clear cutting of tropical and boreal forests as well as draining of wetlands.
- Target 3.2 Preservation, increased attention, and monitoring of aquatic ecosystems.
- Target 3.3 Development of domestic regulations as well as international agreements and treaties to protect glacier regions (Arctic, Antarctic, Himalayan and others) from economic exploitation.
- Target 3.4 Protection of sensitive areas requiring their safeguarding by the public and through internationally binding law.
- Target 3.5 Advancement of organic farming to further develop sustainable agriculture.
- Target 3.6 Worldwide banishment of discharge of untreated sewage and other waste materials into natural ecosystems.

Goal 4: **Safeguard and strengthen the resilience of the eco-social triad**

- Target 4.1 Investment in research to better understand the interdependencies between the sub-systems of the eco-social triade.
- Target 4.2 Maintenance and enhancement of the resilience of the eco-social triade as an important goal in decision making from the earliest stage.
- Target 4.3 Management and understanding of the complexity of the relevant eco-social systems within our societies by developing and applying new inter- and trans-disciplinary approaches and methods.
- Target 4.4 Recognition of the value of ethical behavior focused on natural resources and the environment.
- Target 4.5 Cross-sectoral approaches to water, food, energy production, and ecosystem management as the basis of advanced water resources management.
- Target 4.6 Enhancement of the resilience of the eco-social triad to mitigate impacts of droughts and floods.
- Target 4.7 Improvement of the handling of huge amounts of data (“big data”) as well as information and communication networks because of the increasing complexity of eco-social and socio-technical systems.

## Explanations

General obligation:

**Humankind ought to take readily applicable measures capable of keeping societies, economies and ecosystems resilient.**

The purpose of sustainable development is to develop strategies that will minimize the likelihood of ecosystems and their functions as well as human societies and their economies to collapse. To prevent collapse, a new balance must be found that takes into account the three dimensions of sustainability science: society, economy and environment.

Collapse prevention is achieved by keeping the eco-social triad and its subsystems, namely ecosystems, societal systems and economic systems, in the state of resilience [1].

Resilience is maintained as long as the sub-systems as well as the eco-social triad keep their ability to cope with and eventually adapt [2] to changes of ambient conditions so that the overall system functionality and integrity are preserved. Following the resilience theory [1] continuous revolving of the adaptive cycles – for both natural and man-made systems – is the fundamental process of resilience preservation. Thus, careful management of adaptive cycles appears to be a promising method of keeping societal and economic systems resilient.

In the case of ecosystems, adjustment to changing ambient conditions is driven by self-regulation processes. Most likely, those processes were responsible for the development of life on Earth over the past 2 billion years [3, 4]. Assuming the correctness of this hypothesis, humankind is well advised to avoid interference with or even elimination of natural self-regulation processes. This applies particularly to very large ecosystems like the oceans, the atmosphere and the global Gaia-system.

In social and economic systems self-regulation is to a large extent replaced by intentional actions based on fundamental knowledge, accumulated experience and wisdom, will, sense of responsibility for the whole and courage. Gain of advanced knowledge (science), transfer of knowledge and skills (education and training), encouragement of creativity as well as internalization of moral values must be guiding principles for setting sustainable development goals and respective targets and for materializing targets.

The global problems initiated by humankind (e.g., loss of ecosystem function, increasing demand for energy, water, food, shelter and mobility, rapid urbanization, spread of luxury nutrition, overshooting financial markets) are fundamentally interdisciplinary and will require interdisciplinary studies in systems science. In socio-technical systems, information and communication technology is growing together with societal infrastructures (e.g., smart grids, smart cities), to manage the complexity of human civilization [5]. New integrative research and teaching centers must be founded, to train students in interdisciplinary networking and to cooperate in interdisciplinary teams. Interdisciplinary teams committed to solve problems are also demanded in industry, economy, and governmental institutions.

## Goal 1: Foster the resilience of societies


### Target 1.1

**Improvement of cognitive understanding of societal systems and dissemination of the respective knowledge achieved.**

Investment in research at the interface between social and economic sciences, engineering, the physical and biological sciences, and the humanities is necessary. The knowledge gained will enable societies to prevent or positively respond to detrimental impacts resulting from changes in ambient conditions. Coping with and eventually adapting to changes of ambient conditions must be understood as an important advantage by both the public and decision makers.

### Target 1.2

**Guarantee of equal rights and social justice independent of gender, race, religion or ethnicity.**

Providing individual freedom for men and women will likely drive eradication of poverty. It will safeguard social structures, prevent violence, and preserve traditions, local dialects, arts as well as religious beliefs – all of them to be considered as preconditions of societal resilience.

### Target 1.3

**Alleviation and eventual eradication of poverty.**

Eradication of poverty is to be understood as prerequisite of societal resilience. The principle of societal fairness and equitability needs to be prioritized. Comprehensive measures including disaster reduction and promotion of humanitarian assistance are to be implemented in national and international policy.

### Target 1.4

**Development of innovative methods of building the capacity to overcome global threats.**

Worldwide reestablishment of behavioral norms based on moral values and the will for taking care of community affairs complemented by the building-up basic knowledge and skills of people to master complex ecological, societal and economic problems is considered the key for sustainable development. Thus, investment in innovative educational methods encompassing building responsibility as well as implementing knowledge and skills is considered crucial.

Education should also be focused on ecosystem function and services, and inherent non-monetary values of nature and life. Equally important is building the competence in solving environmental problems taking into account all three dimensions of sustainability and their interrelationship [6]. Meaningful sufficiency should be stressed over excessive efficiency.

Long-term strategic objectives for improving the quality and efficiency of education and training are to be considered as a prerequisite of creativity and innovation, including entrepreneurship. Education for sustainability should go beyond adding the concept of sustainability in the curriculum [7] but include proper onsite training with the specific aim of solving local and regional problems. To be able to maintain resilience solutions are required in addition to descriptions of the problems we are facing.

Target 1.5

**Implementation of the Human Right to Water and Sanitation (HRWS) through generally accepted measures based on the principle of progressive realization.**

Implementation of the HWRS approach to stabilize societies and economies is the responsibility of local through national government. Basic needs and services, such as drinking water supply and sanitation, are best provided by the public sector (public service) and supported through taxes and/or adequate fees/charges. The technical systems required should be developed and consequently established step-by-step [8] in relation to local economic conditions.

Target 1.6

**Reduction of population growth through voluntary means.**

According to fundamental principles of nature there is no "eternal" growth. In nature, growth is limited by death and decay. Cycling and recycling are fundamentals of nature and ecological function. During the past decades advances of science, technology and medicine led to dysfunction of the natural adaptive cycle and thus to a nearly exponential growth of the human population and the corresponding demands for food, water and raw materials overshooting the carrying capacity of the Earth [9, 10]. Growth of human population must be slowed down by generally acceptable and measurable actions while maintaining socialization of children and community life [11].

Target 1.7

**Development of guidelines for human behavior based on moral values and ethical behavior specially focused on natural resources and the environment.**

Disregard of conditions required for the functioning of ecosystems in favor of short term individual economic and societal interests threatens the resilience of all systems involved and counteracts sustainable development. Evaluation of a variety of approaches to impart knowledge that encourages individual moral responsibility for resource conservation and environment protection is necessary.

Target 1.8

**Reduction of the vulnerability of complex societal systems (urban agglomerations, communication and mobility infrastructures, industrial societies) to climate change.**

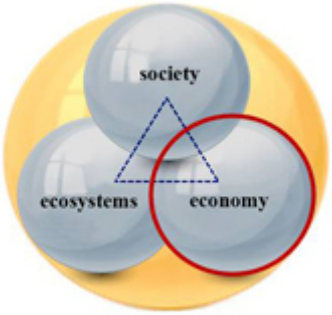
It is crucial for industrialized countries to better understand their vulnerability as well as the adaptability of complex social structures and networks to climate change in order to be able to make robust decisions towards self-protection. For the greatest part of history on Earth, *Homo sapiens* has lived in small groups and adapted culturally to climate change. Its cultural capacity to create new ecologic niches has enabled the spread of human societies to all landmasses on the globe. Human adaptability created a great variety of cultures, making humankind as a whole resilient to changes in the global ecosystem. Today, as a global society emerges, mass extinction of species is paralleled by a loss of cultural diversity. This raises serious concerns about the human capacity to adapt to global change in future.

Target 1.9

**Innovation in the modeling of socio-technical systems as nonlinear complex systems for better understanding and guidance of societal and technical development**

Self-organizing and resilient systems are driven by nonlinear dynamics of complex systems. One of the main insights of nonlinear dynamics is the emergence of systemic risks caused by the interactions of a wide variety of factors and players. The emergence of systemic risks from complex systems dynamics is a challenge for control tasks in engineering sciences as well as regulation and governance in social systems. Modeling in systems science with early warning systems in the technical and natural sciences as well as economics and politics is needed.

## Goal 2: **Foster the resilience of economies**




Target 2.1

**Improvement of international cooperation.**

Global challenges such as meeting energy, water and food demands, mitigating climate change impacts, and protecting ecosystems including their environment can hardly be solved by unilateralism. Intensified international cooperation is to be understood as a key measure in keeping economies resilient.

Target 2.2

**Enhancement of the resilience of economic systems through development of incentives favoring small and medium size enterprises (SMEs).**

Presumably, highly diversified clusters of SMEs are less vulnerable against unforeseen changes of ambient conditions (political regime changes, changes of the financial market, changes of "fashion", occurrence of natural disasters etc.) compared to concerns and alliances since large companies are often unwieldy and slow to act.

Target 2.3

**Enhancement of the resilience of farming and food supply systems through support of production and distribution schemes serving consumers and preserving local land ownership.**

Large-scale crop and livestock farming is known to provide economic advantages with respect to production costs. Where large-scale farming serves primarily foreign markets, vital requirements of local communities are often disregarded and local resources (water, soil, healthy environment, wellbeing of local people) may be over-exploited. As a result, local economic and environmental systems become tremendously vulnerable.

Target 2.4

**Development and implementation of technologies for water conservation, pollution reduction, and recycling that will meet the increasing demand for water for human use and maintenance of aquatic ecosystems.**

Water is an essential resource for the production of virtually all goods and services on our planet. It is also a limited resource. Consequently, the allocation of water and investment in water management and water usage is key for setting the future development trajectory [11].

The global demand for water, food and energy is likely to increase in the 21$^{st}$ century. Water scarcity is widely considered as a top global threat. To meet the projected growth of demand without undermining our planets carrying capacity, it is critical to make significant improvements in water supply of domestic, industrial and agricultural operations.

Target 2.5

**Pursuit of a new economic paradigm that favors qualitative growth over maximum production and revenue. Research institutions should develop alternative economic models balancing private and social interests. The GDP as indicator needs to be replaced.**

The "traditional" economic paradigms, in particular neo-liberalism, financial systems and globalized markets, are the key drivers of unevenness between wealth and poverty, global change and environmental degradation. A long term change, through international regulations, to economic systems based on societal justice is a key target.

Target 2.6

**Development of innovative technologies serving local demands and their application in rural areas.**

Governments should ensure that certain percentage of tax collected is invested on the R&D of technologies applicable in rural areas. For example, many power plants fed by renewable materials should preferentially be built in rural areas. Developing these plants will be useful in creating job opportunities and long term economic growth in rural areas. Effective tax planning is a perquisite in the current economic situation, for diverting tax incentives towards the renewable energy sector. This will safeguard sustainable development at large [12].

Target 2.7

**Improvement of general public understanding of the contribution of individuals to environmental degradation and ecosystem shifts and the obligation of each person to cooperate in the efforts to reverse detrimental developments.**

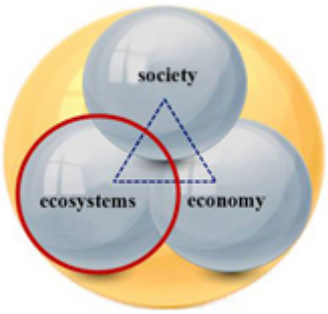
It is important to develop awareness programs highlighting the role of each individual in counteracting unfavorable climate changes. Understanding must be developed that everybody on Earth has contributed to the evolvement of global threats such as climate change, loss of ecosystems and societal instabilities. Accordingly, the responsibility to overcome global threats cannot be left to others. Everybody has to contribute.

Target 2.8

**Improvement of risk dynamic modeling of economic and financial systems for the purpose of managing unforeseen developments.**

In economy, there is no single causal model as a definitive mapping of reality. Entire classes of possible stochastic models with different weights must be considered. These models must be combined with a data-driven methodology and insights in the factual human behavior and its diversity. Therefore, psychological and sociological case studies of human behavior under risk conditions (e.g., stakeholders at stock markets) are necessary. It is important to increase understanding of bounded human rationality.

## Goal 3: **Encourage the self-regulation processes of ecosystems**




Target 3.1

**Curtailment of clear cutting of tropical and boreal forests as well as from draining of wetlands.**

On a major part of the Earth's surface natural ecosystems have been totally replaced by artificial biological systems to provide food and fiber to people. Due to the loss of biodiversity, such systems lack resilience that is inherent to natural ecosystems; in the short-term they can be maintained in a quasi-resilient state through human interference. But there still remain vast ecosystems on Earth including boreal and tropical forests and large wetlands that operate in the natural regime, retain much of their integrity and continue to provide regional and global ecosystem services, including the regulation of the terrestrial water cycle. These systems are to be protected and intensively studied to better understand their significance.

Target 3.2

**Preservation, increased attention, and monitoring of aquatic ecosystems.**

Global warming directly affects the water temperature and large-scale currents impacting in turn the oceanic ecosystems and global climate. Pollution of oceans is increasing and affecting the biota considerably (e.g. fish production). Further, the disintegration of the biogeochemical fluxes in the ocean may become a more significant factor in global change than the direct pollution by modern fossil fuel emissions. Of particular concern are changes in the global vertical transport of organic and inorganic life-important elements such as carbon and nitrogen.

Preservation of marine ecosystems must focus on reduction of human-induced damage to the marine ecosystems and restoration of damaged ecosystems. This also includes preservation of valuable marine species, both physically and biologically. Conservation programs for marine ecosystems must combine scientific principles derived from marine biology, oceanography, and fisheries sciences, as well as human factors such as demand for marine resources and marine law, economics and policy.

Target 3.3

**Development of domestic regulations as well as international agreements and treaties to protect glacier regions (Arctic, Antarctic, Himalayan and others) from economic exploitation.**

Glaciers, the Earth's largest freshwater reservoir, have begun melting at very high rates in recent decades. Climate change has made glacial ecosystems more vulnerable. In addition to negative consequences in the downstream and surrounding region due to high melting rates, a large number of plants and animals will become extinct. Protection of glacial ecosystems functions is crucial to avoid disastrous consequences for these fragile ecosystems and most likely for the global system as a whole.

Target 3.4

**Protection of sensitive areas requiring their safeguarding by the public and through internationally binding law.**

Ecologically sensitive regions and natural parks must receive rigorous protection because of their recognized natural, ecological and/or cultural values. Until now many protected areas are shown on maps but are without implementation of the needed protection measures. Unsustainable exploitation of protected areas should be stopped, All activities within the protected areas, including local use and ecotourism, need to be painstakingly monitored for their compliance to sustainability guidelines.

Target 3.5

**Advancement of organic farming to further develop sustainable agriculture.**

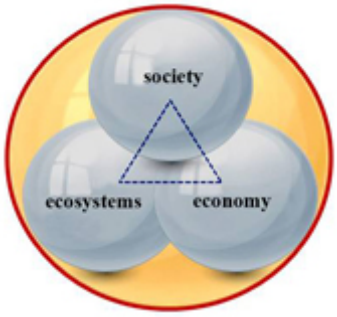
Further development and implementation of sustainable agriculture is important concerning both, terrestrial ecosystems and societies. Intensive agricultural practices generally involve excessive use of herbicides, pesticides and fertilizers. The excessive use of herbicides to control weeds, fertilizers to accelerate and increase crop growth and pesticides to control insects has resulted in negative environmental impacts such as soil degradation, groundwater pollution and biodiversity reduction. Sustainable agriculture promotes farming practices and methods that are profitable, environmentally sound and good for communities.

Target 3.6

**Worldwide banishment of discharge of untreated sewage and other waste materials into natural ecosystems.**

Disposal of untreated urban sewage into rivers and lakes is common in developing countries. Disposal of excess amount of untreated sewage not only creates human health risk but damages the self-regulation capacity of aquatic systems. To maintain sustainable aquatic ecosystems, both innovative wastewater treatment technologies and the development and dissemination of public awareness programs are needed.

## Goal 4: **Safeguard and strengthen the resilience of the eco-social triad**




Target 4.1

**Investment in research to better understand the interdependencies between the sub-systems of the eco-social triade.**

Interdisciplinary and transdisciplinary basic and applied research is likely to provide a sound basis for implementing sustainable political measures to keep the eco-social triade resilient. In particular, cross-cutting research projects need to be supported. As important as gain of knowledge is building the capacity to solve ecological problems [13].

Target 4.2

**Maintenance and enhancement of the resilience of the eco-social triade as an important goal in decision making from the earliest stage.**

Consensus must be reached that sustainable development strategies serve ecosystem health and, hence, the well-being of people on Earth.

Target 4.3

**Maintenance and enhancement of the complexity of the relevant eco-social systems within our societies by developing and applying new inter- and trans-disciplinary approaches and methods.**

Efforts must be undertaken to extend the knowledge of qualitative and quantitative dynamic network models and analysis of the human-environment nexus to find leverage points for effective intervention, and to transfer such insights into practice.

Target 4.4

**Recognition of the value of ethical behavior focused on natural resources and the environment.**

Short term individual, economic and societal interests often override the need to maintain conditions required for the well-functioning of ecosystems threatening the resilience of all systems involved and counteracting sustainable development. The evaluation of different approaches to impart knowledge that encourages individual ethical responsibility towards the environment is necessary.

Target 4.5

**Cross-sectoral approaches to water, food, energy production, and ecosystem management as the basis of advanced water resources management.**

Management of water basins requires a cross-sectoral approach to identify and overcome challenges around water, food and energy provision [14]. The current state of nature based and engineered water infrastructure, operation and technology application is to be scrutinized. Innovative measures and tools are to be developed which enhance functionality and sustainability while balancing environmental, social and economic situations peculiar for the region to be served. Cross-sectoral thinking is required to deal with challenges around water, energy and food production efficiencies, trade-offs, and impacts.

Target 4.6

**Enhancement of the resilience of the eco-social triad to mitigate impacts of droughts and floods.**

Water-related disasters are the worst and most recurrent of all natural and anthropogenic adversities, posing major obstacles to human security and sustainable development [15]. Sustainable development of the eco-social triad is to be understood as a key factor in lowering the exposure to water risks.

Target 4.7

**Improvement of the handling of huge amounts of data ("big data") as well as information and communication networks because of the increasing complexity of eco-social and socio-technical systems.**

Beyond transactional data stored in relational databases, there are less structured data of weblogs, social media, email, sensors, and photographs that can be mined for useful information. Big data means an amorphous and messy mass of structuralized, less structuralized and un-structuralized data which are mined by big data algorithms (e.g. Google) for predictions. In 2009, Google could predict the emergence of an epidemic many weeks before public health officials could react. In economy, big data technology is used to calculate probabilistic profiles of products and clients. In eco-social an eco-technical systems, they should be tested as early warning procedures.

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Presented to the Sustainable Development Goals e-Inventory
on behalf of the authors and contributors

Munich on the 14th of October, 2013

Prof. Dr.-Ing., Drs h.c. Peter A. Wilderer
Chairmain of IESP

## IESP in brief

The International Expert Group on Earth System Preservation is a global network of scientists, decision makers, and members from governmental and non-governmental organizations. Its purpose is to contribute to advances in Earth system science through thematic-based conferences, workshops, seminars, lectures and publications. It serves as a liaison between experts, decision makers and the public to promote a mutually, beneficial exchange and to provide access to current scientific knowledge. Its activities contribute to policy debate by providing a common platform for discussion on sustainable development of ecosystems, economic and societal systems and their interrelationships. The IESP network has more than 50 international members from the fields of sustainability research, energy engineering and environmental sciences, natural resource technology, environmental engineering, climate dynamics, risk assessment, industrial ecology, political sciences, economics, and more. The network works with organizational staff located on the campus of the Technical University Munich in Garching, Germany.