Global Sustainability & Human Prosperity

– contribution to the Post-2015 agenda and the
development of Sustainable Development Goals

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Foreword

This discussion paper looks into the links between human wellbeing and the biosphere, and describes why and how these links should influence the formulation of the future global Sustainable Development Goals. It explores what we can learn from the Millennium Development Goals (MDGs), and how existing international agreements can be reflected in the Post-2015 MDG process. The paper also seeks to contribute to the elaboration of targets, including process-oriented targets and scalable indicators suitable for a rapidly changing world.

It is a follow-up to an earlier discussion paper, “Human prosperity requires global sustainability – a contribution to the Post-2015 agenda and the development of Sustainable Development Goals,” that was commissioned by the Swedish Government Office for the Nordic Environment Ministers’ meeting in Jukkasjärvi on 7th February, 2013. The Stockholm Resilience Centre was then asked by the Nordic Environment Ministers to further elaborate on this issue and exemplify some aspects and conclusions set out in that first document.

This discussion paper, finalized in October 2013, therefore highlights its perspectives, approaches and frameworks through concrete examples and case studies. It will be relevant for a number of processes in which the Nordic countries are currently engaged, such as:

- High-level Panel on Post-2015 Development.
- Open Working Group on Sustainable Development Goals.
- Sustainable Development Solutions Network (SDSN).
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

It has also contribute as a background document to two international meetings. First, an international workshop for scientists, government experts and stakeholders on “Planetary boundaries and environmental tipping points: What do they mean for sustainable development and the global agenda?” was held on the 4–5th of November 2013 in Geneva, Switzerland, organised by the Ministry of the Environment of Finland in cooperation with the Ministries of the Environment in Norway, Sweden and Denmark, United Nations Environment Pro-

gramme (UNEP) and the Stockholm Resilience Centre with the support of the Nordic Council of Ministers.

Later, on the 2–4th of December 2013, there was a *Multistakeholder Dialogue on Integrating Social-Ecological Resilience into the New Development Agenda* in Medellín, Colombia. The Dialogue was organised jointly by the Alexander von Humboldt Institute for Research on Biological Resources, the Ministry of Environment and Sustainable Development of Colombia, and the Stockholm Resilience Centre, with the full support of the Governments of Colombia and Sweden, and in consultation with the CBD Secretariat.

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1. Introduction

Over the last two hundred years, the human enterprise has undergone a period of rapid expansion as if the world we live in had unlimited capacity for growth in the material economy. The bulk of current concepts and models of the global economy were developed during this same period, when the human population still had a small impact on the natural environment. In this “empty world” context, the limiting factor to improving human well-being was *labour* and the *built and manufactured capital* such as houses, roads and factories. *Natural capital* – our ecological life support system – as well as our *social capital* – our myriad relationships with each other – were not viewed as constraints to development. In effect, classical models of the economy viewed social and natural capital as limitless (Costanza *et al.* 2012). It made sense in this context, not to worry too much about environmental and social “externalities,” effects that occurred outside the market, since they could be assumed to be relatively small and ultimately solvable.

In contrast, we now live in an increasingly interconnected and highly populated world, where the environmental impacts of human development extend globally. The current era is now widely described as the “Anthropocene” (Crutzen 2002, Steffen *et al.* 2011), recognizing that human activities are now the major driver of environmental change, including the climate system, the water cycle, and the distribution of living species and dynamics of ecosystems. The human impact extends across all scales from the local to the global. Over the past 50 years, humanity has moved from being a “small world on a large planet” to becoming a “large world on a small planet,” transforming the planet’s atmosphere, oceans, ice sheets, waterways, forests, and biodiversity in ways that could undermine development through exceeding boundaries that determine the planet’s ability to support human development (TEEB 2010, GEO5 2012, Rockström *et al.* 2009).

Now we have to think differently about the relationship between humans and the rest of nature. It is evident that in order to improve human well-being and social equity, while at the same time reduce environmental risks and ecological scarcities (UNEP 2011), we need a new vision for sustainability and the economy that is better adapted to the new conditions. A deeper understanding of what really does contribute

to sustainable human wellbeing is required, an understanding that goes beyond viewing poverty as merely the condition of having a low monetary income, recognizing the substantial contributions of natural and social capital, which in many countries already are important limiting factors for improving human wellbeing (Griggs *et al.* 2013).

1.1 The Problem

The Post-2015 agenda and the development of Sustainable Development Goals (SDGs) provide a global window of opportunity to address the above identified social needs and environmental pressures together. The experiences of the Millennium Development Goals (MDGs) demonstrate that concerted attention to global problems does yield positive results (UN 2013) raising awareness and political accountability worldwide. While the MDGs have been successful in focusing attention on a range of issues linked to extreme poverty, such as hunger, gender inequality, and disease, the MDGs have not succeeded in linking global sustainability to poverty alleviation and human wellbeing since the environmental dimensions have been largely disconnected from the social and economic. In developing the SDGs, it is therefore important to move beyond the MDGs and in a much deeper way link the social and economic dimensions of development with environmental dimensions, incorporating the full spectrum of humanity's collective assets including social and natural capital at local, regional, national, and global scales.

1.2 Solution

Ecological and social systems are increasingly viewed as interlinked and inseparable (Folke *et al.* 2011). We therefore argue that the twin priorities for the formulation of SDGs must be the protection of the biosphere – society's "life-support systems," and the reduction of poverty as an essential part of a fair and just global society.

The SDGs must go beyond the usual disciplinary division of sustainability into separate social, economic and environmental goals (the "three pillars"), because society, the economy and our environment are intrinsically interdependent. Hence, we recommend that goals should be built around integrated themes such as thriving livelihoods, food security, water security and clean energy.

The goals should also avoid becoming a piecemeal collection of single issue objectives, but instead ensure that the sum of the parts really does contribute to global sustainability (Griggs *et al.* 2013, Norström *et al.* 2013). This requires a deeper analysis of the multiple interconnections, trade-offs and synergies between SDGs. For example, SDGs should be designed to focus on the role of natural capital and ecosystem services *within* (not alongside) economic development and poverty reduction. This in turn requires a greatly enhanced and much more widespread awareness and learning in society of the multiple benefits that humanity obtains from ecosystem resources and processes.

Finally, we suggest that measuring progress on the targets for the SDGs must require an agreed set of scalable indicators that should be inclusive, building data and knowledge from local to national, regional and international levels. Given the rapidity of many global changes (such as ocean acidification, ice-sheet melting, and altered regional climates linked to intense urbanisation), the targets should be based on the latest research on the dynamics of the Earth system and benefit from learning processes and early warning and monitoring activities emerging in multiple knowledge systems.

2. Living in the Anthropocene: human well-being and the biosphere

To understand the sustainability challenges in the Anthropocene, we need to understand both the extent of human impact on the global environment, and the role of the biosphere in supporting human wellbeing. The *ecosystem services* and *planetary boundaries* concepts provide important framings for this understanding and action. The former focuses on the benefits humans gain from the biosphere, while the latter concept emphasizes the impacts of human activity on the biosphere and proposes precautionary limits for these. In this section, we describe these concepts and explain how they can be used to develop global sustainable development goals.

2.1 The Anthropocene – age of humans

For millions of years our planet's atmosphere, oceans, land-masses and biological life have formed a complex system of processes which have interacted and co-evolved. Earth has experienced many periods of abrupt change throughout its history, driven by astronomical and geological forces, such as changes in the Earth's orbit around the sun or Earth's tectonic changes. Over the past several thousand years, human activities have increasingly affected this global system.

In this context, the Holocene epoch (the present geological era starting 10,000 years ago) has been a climatically and ecologically stable period, in sharp contrast to the rather large and rapid fluctuations in the preceding period (Figure 1 shows how global temperature has changed over the last 100,000 years). Despite some natural environmental fluctuations, complex feedback mechanisms involving processes in the atmosphere, the biosphere and the oceans have kept climatic variations within a narrow range. For instance, global temperatures have varied by just plus or minus 1 °C in the last 10,000 years. The relatively stable environment of the Holocene enabled humanity's development of agri-

culture and complex societies. Humans increasingly invested in settlements and food production, and managed their environment rather than merely exploiting it.

Within the last century, humanity has become a dominant force for planetary change (Steffen *et al.* 2011). Humanity's recent influence on the Earth has reached such a magnitude that there is growing scientific consensus that we have entered a new geological epoch, the "Anthropocene" (Crutzen 2002, Steffen *et al.* 2007), derived from the Greek word "Anthropos" meaning "Man". Today, humans are changing the composition of the Earth's atmosphere (IPCC 2013), have modified or transformed most of the Earth surface (Ellis and Ramankutty 2008), substantially altered the flows of water (Vörösmarty *et al.* 2010), changed elemental cycles and flows of mineral resources (Steffen *et al.* 2004), and radically changed the distribution of plants and animals (MA 2005). By many measures, the changes humanity has caused in the last 50 years are now at or beyond the variations seen through the entire Holocene.

In the Anthropocene, sustainability depends critically on acting locally while recognising and understanding global interactions, *and* acting globally to secure living conditions and livelihoods at local scales.

In the Anthropocene, the new challenge for humanity is to become planetary stewards of our own future. This stewardship must go beyond the management of the local environment. Scientific knowledge about past changes and current pressures allows the identification of planetary boundaries, which the global sustainability targets should recognise and respect. Flourishing within planetary boundaries requires a global perspective, and substantial innovations and technical advancement (Westley *et al.* 2011). Unless the transition from today's unsustainable pathway to one of global stewardship is carefully navigated at all scales, we may risk pushing the global system back into the pattern of violent fluctuations in temperature characterizing most of the last 100,000 years (Fig. 1) with likely catastrophic consequences for human wellbeing and civilizations as we know them.

Fig. 1. Earth's temperature trend through the last glacial cycle and selected events in human history (image from Rockström et al. 2009)

The Holocene is the most recent ~10,000 years. ΔT (right axis) is the difference in temperature from present day, calculated using $\delta^{18}\text{O}$ measured in ice-core (left axis) as the indicator of temperature.

2.2 Ecosystem services: human dependence on the biosphere

All human activities that generate wealth and support progress and development are ultimately founded on local management of the natural resources and ecosystems of Earth's biosphere. The "Anthropocene reality" will therefore have multiple and substantial consequences for human wellbeing, and the continuing capacity of ecosystems to deliver the ecosystem services on which our wellbeing depends. Natural ecosystem processes support and enriches human lives and contributes to economies in a wide range of ways. This dependence is increasingly conceptualised as "ecosystem services" (MA 2005, TEEB 2010).

The ecosystem services concept draws attention to the essential benefits that natural ecosystems provide to people. As many ecosystem services are not sold on markets they tend to be undervalued by conventional economics, and can be overlooked in decision-making. Thus apparently economically rational degradation of ecosystems can result in significant losses in human welfare (e.g. Folke *et al.* 2011). The ecosystem services concept makes the economic case for conserving nature, and aims to improve the efficient use of ecosystems to support human wellbeing.

Ecosystem services reflect a human-centred view of ecology. The Millennium Ecosystem Assessment (MA 2005) used a generalised definition: "the benefits people obtain from ecosystems." It distinguished a) provisioning services, such as food production; b) regulating services,

that maintain a benevolent environment and protect against environmental disturbance, such as flood defence; c) cultural services that are reflected in religious, recreational or cultural values and practices; and d) supporting services, comprising the underlying ecological structures and processes on which all other services rely (Figure 2, Appendix 1). These four categories have been widely adopted in both research and policy. Alternative framings have also been suggested that allow more specific distinction between ecological processes, intermediate services, final potential services, goods (which may incorporate human inputs such as labour or capital) and actual benefits to people in terms of improvements in wellbeing. These distinctions are proposed to avoid double-counting in the economic valuation of ecosystem services (Fisher *et al.* 2009), and for conceptual clarity when assessing the contribution of ecosystem services to human wellbeing (example Figure 3).

Fig. 2. Categories and examples of ecosystem services (TEEB 2010)

Based on MA and TEEB classifications with icons designed by Jan Sasse for TEEB

Illustration: J. Lokrantz/Azote.

2.2.1 Biodiversity and ecosystem services

Biological diversity has multiple roles in ecosystem functions and the generation of services. Three major roles have been identified. A high level of diversity often leads to: 1) an increase in productivity due to complementary traits among species for resource use, and productivity

itself underpins many ecosystem services, 2) an increase in response diversity (a range of traits related to how species within the same functional group respond to environmental drivers), resulting in improved maintenance of ecosystem functioning as the environment changes, and 3) some protection against “ecological surprises,” the idiosyncratic effects due to keystone species properties and unique traits-combinations which may result in a disproportional effect of losing one particular species compared to the effect of losing individual species at random (see Kumar, 2010).

Fig. 3. The multiple benefits to urban inhabitants of a single tree

Illustration: J. Lokrantz/Azote.

The TEEB project made the conclusion that

“There is clear evidence for a central role of biodiversity in the delivery of some – but not all – services, viewed individually. However, ecosystems need to be managed to deliver multiple services to sustain human well-being and also managed at the level of landscapes and seascapes in ways that avoid the passing of dangerous tipping-points. We can state with high certainty that maintaining functioning ecosystems capable of delivering multiple services requires a general approach to sustaining biodiversity, in the long-term also when a single service is the focus.” (Kumar 2010).

The degree to which an individual benefits from biodiversity and ecosystem services depends on a range of mechanisms of access including so-

cial relationships, institutions, capabilities, rights and various capitals (Ribot and Peluso 2003). Thus, the best opportunities to improve the wellbeing of poor people may be achieved through more secure and equitable access to ecosystem services, rather than through increasing flows of ecosystem services. Ecosystem services and poverty alleviation will be treated more in detail in section 2.5.

Three examples of the role of biodiversity and ecosystem services for human well-being and sustainable development

Box 1 – Ecosystem services and poverty alleviation in coastal East Africa are affected by global changes

Coastal ecosystems in Kenya support the livelihoods and wellbeing of a range of different types of people through a range of ecosystem services. For example, coral reefs, mangroves and seagrass beds provide fish for food and protect coast-lines for habitation and development. In turn these “provisioning” and “regulating” ecosystem services support human wellbeing through earnings for small-scale fishers and tourism employees, the cultural identity of local peoples and the aesthetic enjoyment of visitors.

These ecosystem services contribute differently to the wellbeing of different stakeholders as people differ in their ability to access benefits and their priorities and needs. These are influenced by their culture, wealth, gender and other characteristics as well as formal rights of access. For example, poorer fishers who cannot own a boat or expensive fishing net, work as hired labour, and earn a small proportion of the profits from the fishery. Meanwhile the fish trade is organised by gender with men buying more valuable types of fish for higher value markets, including tourist hotels, while women buy smaller cheaper fish and process it to sell to local people. Employment in the tourism industry is dominated by immigrants to the region who have good business and language skills.

Changes in the management of these ecosystem services leads to trade-offs between different services. For example the establishment of a marine park sacrifices some fisheries benefits to improve the value of tourism. However, because people vary in their ability to access benefits such interventions also have a distributional effect creating winners and losers. For example if the number of people fishing was reduced, individual catches and the size of fish would increase, offering higher earnings for remaining fishers. However to achieve this change requires displacing some fishers from the fishery, and reducing the supply of small cheap fish that support female traders’ livelihoods.

These coastal systems also illustrate how ecosystem services which contribute locally to people’s wellbeing are connected to global planetary boundaries and global connections. Global climate change is showing impacts in the region: coral reefs in Kenya have begun to suffer from “coral bleaching” due to increasing seawater temperatures which can kill the living corals that form the basis of the ecosystem. The local system is also connected to the global economy as fish products from local fisheries are increasingly fed into global trade.

Source: Daw *et al.* 2011.

Box 2 – Stewardship of the biosphere in the urban era

We are entering a new urban era where cities increasingly become a central nexus of the relationship between people and nature. On a global scale, cities are crucial centres of demand for ecosystem services and sources of environmental impacts. Approximately 6% of the urban land projected to be present in 2030 is forecast to be built just in the period 2000–2030 (Elmqvist *et al.* 2013). Urbanization thus not only presents challenges for global sustainability, but also numerous opportunities. In the next two to three decades, we have unprecedented chances to vastly improve global sustainability through designing systems for increased resource efficiency, as well as for exploring how cities can be responsible stewards of biodiversity and ecosystem services both within and beyond city boundaries.

Although cities often strive to optimize their resource use, increase their efficiency, and minimize waste, they can never become fully self-sufficient. Therefore, individual cities cannot be considered “sustainable” without acknowledging and accounting for their dependence on ecosystems, resources and populations from other regions around the world (McGranahan and Satterthwaite 2003, Seitzinger *et al.* 2012). Consequently, there is a need to fundamentally revisit the concept of sustainability, as its narrow definition and application may not only be insufficient, but can also result in unintended consequences such as the “lock-in” of undesirable urban development trajectories (Fig. 4).

An example is represented by one of the most critical resources, the provision of freshwater. Urban areas depend on freshwater availability for residential, industrial, and commercial purposes; yet, they also affect the quality and amount of freshwater available to them. Water availability is likely to be a serious problem in most cities in semiarid and arid climates. Currently 150 million people already live in cities with perennial water shortage. By 2050, population growth is projected to increase this number to almost a billion people, and climate change is projected to cause water shortage for an additional 100 million urbanites. There are strong incentives for cities to engage in active and better management of large and sometimes distant watersheds to ensure the delivery of sufficient quantities and qualities of freshwater.

To integrate in a meaningful way urban sustainability in the SDGs, it is important to develop more integrated and scalable indicators. Using indicators that make sense on a local scale and then possible to scale up on a regional and global scale opens up the possibility to engage local stakeholder, citizen groups, indigenous groups and many other knowledge holders in the monitoring and reporting on the SDGs. It is necessary that such indicators also capture to what extent urban regions provide stewardship of all the distant ecosystems on which they depend.

Source: Elmqvist *et al.* 2013.

Fig. 4. Urban centers have moved from being more directly linked to their hinterlands and resource base to a situation where food and other resources are transported across the globe resulting in complex and often masked feedback mechanisms

Illustration: J. Lokrantz/Azote.

Box 3 – The benefits of ecosystems services from the Baltic Sea and their relation to a “regional boundary” of nutrient elements

The Baltic Sea provides multiple ecosystem services, including economic activities such as the fisheries and tourism industries, as well as non-monetary benefits such as a recreational resources as well as natural heritage. Recent surveys of thousands of people showed how residents from all countries around the Baltic Sea valued these benefits (Söderqvist *et al.* 2010). Although the value people perceived varied by country, these values are notably not captured in normal calculations of countries’ economic performance.

While the Baltic Sea provides these benefits to the nine countries surrounding it, the sea is a complex integrated ecosystem, which is also affected by the economic activities and industries in these countries, which in turn affect the ecosystem services that it provides.

One specific problem that has received policy attention is nutrient enrichment of the Baltic Sea, and its undesirable ecological impacts. Phosphorus and nitrogen compounds, primarily from inefficient fertilizer use, may find their way into waterways and into the sea. The enhanced nutrient load (eutrophication) can lead to toxic and unsightly algal blooms. It may further cause oxygen depletion in deep waters affecting organisms living on the sea floor, risking the creation of “dead zones”. Eutrophication along with other impacts, such as overfishing, pollution and global climate change, alter the Baltic Sea ecosystem and with that its ecosystem services.

Baltic Sea countries have agreed on the multilateral, cross-sectorial “Baltic Sea Action Plan” to reduce pollution levels below certain boundaries in order to guarantee the health of the sea and the benefits it provides. Surveys showed that people are affected and concerned by pollution, and that they value the benefits of implementing the Action Plan in full, significantly more than the cost of making the changes to ensure the boundaries are met. The way in which the plan is actually implemented, and how responsibilities and costs are distributed between nations remains to be finally negotiated.

This regional experience provides important lessons that also apply at the global level. When environmental thresholds have been identified, the challenge is to ensure boundaries are set which ensure environmental security and protect the multiple ecosystem service benefits to humanity.

Source: BalticStern, 2013.

2.3 Ecosystem Services and Human Wellbeing: What is the evidence?

Overwhelming evidence clearly demonstrates that humans have changed ecosystems more rapidly and extensively in the last 50 years than in any other period in history (MA 2005), while simultaneously human wealth, health, education, and life span has been increasing. This situation appears to be a paradox assuming that human wellbeing indeed relies upon nature (Raudsepp-Hearne *et al.* 2010). However, various explanations for this paradox exist. Four common explanations are:

- Human well-being is actually declining because current ways to measure this are incomplete.
- Food production and continued agricultural growth trumps all other ecosystems because provisioning services are easier recognized as important for human well-being.
- Technology makes humans less dependent on ecosystem services.
- The worst is yet to come: there is a time lag after ecosystem service degradation before human well-being is affected.

The evidence supporting these hypotheses is mixed, but examining it clarifies the relationship between ecosystem services and human well-being. There is a large body of evidence demonstrating that human well-being, even of the worst off, has in fact increased during the past fifty years (MA, 2005), suggesting that the paradox is not an illusion. The second hypothesis that increases in agricultural ecosystem services have more than compensated for declines in other ecosystem services is supported. However, the support for hypotheses three and four is mixed. Great advances in technology and social organisation have increased the efficiency with which global civilization uses nature, but this increase in efficiency has not been used to decrease global reliance on ecosystems. Rather, global civilization has expanded its use of ecosystem and materials, making our society ever more dependent on a reliable supply of ecosystem services. There is limited evidence from the past of sustained decreases in human wellbeing caused by environmental decline. However, there is substantial evidence that the scale of human activity cannot increase at the rate it has done so far, and that current use of ecosystems is undercutting their ability to regulate themselves and provide regulating services to people. This is illustrated by the concept of overshooting planetary boundaries.

These findings do not show that the environment is unimportant, but rather that people are innovative and adaptive. However, the careless destruction of ecological infrastructure is leaving people worse off than they would be if we made more thoughtful investments in ecological infrastructure. We have a good understanding on how humanity alters the biosphere, but little is known on how these changes influence humanity. There is evidence that regulating ecosystem services (e.g. carbon uptake, water purification and climate regulation) that maintain stable environments for people are decreasing locally, while we are also pushing the entire earth system across its planetary boundaries. This suggests that there should be more investment in maintaining and enhancing these regulating services.

We need further transdisciplinary research that better answers questions of how human wellbeing and the environment are intertwined both locally and globally to improve global governance. However, we have enough understanding that we can start to act now.

As human civilization pushes beyond planetary boundaries it destabilizes the natural capital that enables the reliable production of ecosystem services. As the global economy grows, its demand for ecosystem services increases. However this squeeze between the destabilization of the planet and the need for more, suggests that civilization needs to govern the global economy to ensure that it supports rather than undercuts the biosphere, in order to ensure that the biosphere can continue to support the economy (e.g. Folke *et al.* 2011).

2.4 The planetary boundaries: humanity's safe operating space

The success of human development in the future relies on continued progress and willingness to protect the ability of the Earth to provide the ecosystem services that sustain humanity. The concept of planetary boundaries has recently been introduced to define a "safe operating space for humanity" in the Anthropocene (Rockström *et al.* 2009a, b). The planetary boundary framework seeks to define critical Earth system processes that regulate the stability of the biosphere and the Earth system as a whole, and establish the "Holocene-like" boundaries that provide a high likelihood of avoiding the transgression of thresholds resulting in deleterious or catastrophic changes. In other words, it seeks to define the planetary conditions under which human societies can continue to develop and prosper. What the planetary boundary concept

shows is that specific types of human activities can reduce or risk reductions in the ability of the planet to provide the ecosystem services that support humanity.

Rockström *et al.* (2009a, b) identified nine planetary boundaries: climate change, biodiversity loss, changes in the nitrogen and phosphorus cycles, freshwater use, land system change, ocean acidification, stratospheric ozone depletion, chemical pollution and atmospheric aerosol loading (Tables 1 and 2).

Research and debate continues in this new area of global change science (outlined more fully below). However, the scientific message is clear: the Earth system is a complex and dynamic system with hard-wired biophysical processes and interactions that need to be respected in order to maintain a stable environment for world development. The profound changes being observed in the Earth system today therefore need to be taken seriously by the world community.

2.4.1 Human-caused environmental changes have global impacts

Table 1 summarizes the large and growing body of evidence of human disturbance of Earth system processes, and the increasing social impacts of these global changes. It can be tempting to consider the planetary boundary processes in isolation from one another. However, the Earth system is a tightly coupled system where all parts – land, oceans, atmosphere, and life – interact.

Climate change gives many clear examples of this interconnection. Climate change affects land cover and biodiversity, the global biogeochemical cycles, ocean acidification and freshwater flows, and air quality and atmospheric aerosol dynamics. The interacting processes regulate the state of the planet.

For example, when CO₂ concentrations rise in the atmosphere due to human emissions from burning of fossil fuels, land and ocean ecosystems respond by drawing down a substantial portion (approximately 50%) of the CO₂ through multiple chemical and biophysical processes. This biosphere response dampens or buffers the global energy disturbance that the higher emissions of greenhouse gases cause. Moreover, as we increase our stress on the Earth system through rising emissions (which have grown from ~4 to ~9 billion tonnes of carbon per year over the past 50 years), the biosphere carbon sink has increased from ~2 to ~4.5 billion tonnes (Beer *et al.* 2010). This is Earth resilience at play – but it also means that without the responsive land and marine ecosys-

tems, sustained by suitable atmospheric and water system conditions, a much larger amount of CO₂ would remain in the atmosphere and climate impacts would be more severe. However, these interactions also have ecosystem consequences. A quarter of the CO₂ emitted by humans is dissolved in the oceans, which is leading to increasing ocean acidification (Sabine *et al.* 2004). Moreover, if land systems are degraded (such as through deforestation), the risk is that carbon stores, sequestered during periods of stable environmental conditions, may abruptly be released, causing a feedback and accelerating climate change.

Similarly, human activities do not act on single planetary boundaries but rather impact on multiple processes at once. For instance, land-use change is a key driving force behind reductions in biodiversity, changes in the properties and distribution of atmospheric aerosol, and the prevalence of chemical pollution, and it profoundly influences the biogeochemical cycles of carbon, nitrogen and phosphorus (Rockström *et al.* 2009b). Land-use change is also closely linked to altered freshwater flows, and both are closely interlinked with climate change.

These systemic interconnections have implications for global sustainability policy. For example, efforts to reduce human impacts on the climate change boundary by shifting from fossil fuels to renewable bio-fuels to reduce atmospheric concentrations of greenhouse gases can potentially put pressure on other boundary processes, for example by contributing to biodiversity loss.

The planetary boundaries concept acknowledges the inherent uncertainty that will always be associated with large-scale changes in such a complex system as our own planet. The risk of triggering abrupt and irreversible changes is extremely difficult to assess, due to the complex interactions between the living and non-living parts of the Earth system (i.e., between different planetary boundary processes). In the planetary boundary approach, the choice was made to place the “safe” boundary position for each environmental process at the lower (safest) end of the scientific uncertainty range. Taking climate change as an example, scientific evidence indicates that atmospheric concentrations of CO₂ in the range of 350–550 parts per million (ppm) have a high risk of abrupt and deleterious changes that could push the Earth system outside of the present stable Holocene state. The proposed safe boundary is set at an equilibrium CO₂ concentration of 350 ppm, which is at the lower end of the assessed uncertainty range. Transgressing a boundary thus does not mean that humanity immediately faces the imminent risk of a catastrophic tipping point. Rather, it means that the world (or its major ecosystems) has entered a danger zone where large-scale, permanent and socially very

costly changes are likely to occur. For climate change, we are already in the danger zone (at 400 ppm CO₂). The world is seeing the first clear signs of large scale tipping points, e.g., with the accelerated melting of ice in the Arctic and major shifts in marine ecosystems (IPCC AR5 2013).

Table 1. Social impacts of the Planetary Boundaries issues

Global problems	Assessments and evidence sources
<p><i>Climate</i> Many social impacts – health, environmental hazards and risks, food and water security</p>	<p>IPCC Assessment Reports 1990, 1995, 2001, 2007, 2013/14 (WGII due 2014). IPCC WG I and II (2012) <i>Managing the risks of extreme events and disasters</i>. Cambridge University Press. UN HDR (2007/8) <i>Fighting climate change: Human solidarity in a divided world</i>. http://hdr.undp.org/en/reports/global/hdr2007-8</p>
<p><i>Ocean acidification</i> Impacts on food security, commercial fisheries, coastal environments</p>	<p>Gattuso J.-P. & Hansson L. (Eds.), <i>Ocean acidification</i>, pp. 122–153. Oxford University Press. European Project on Ocean Acidification: www.epoca-project.eu/index.php/what-do-we-do/science/publications.html</p>
<p><i>Destruction of ecosystems and biodiversity</i> Loss of ecosystem services – e.g., impacts on food security, water quality, environmental hazards, fuel/fibre resources, many regulating and cultural services</p>	<p>Millennium Ecosystem Assessment (2005) <i>Biodiversity and human wellbeing: current states and trends</i>. Island Press. IPBES Sub-Global Assessments repository, http://ipbes.unepwcmc-004.vm.brightbox.net Cardinale, B. (2012). Impacts of biodiversity loss. <i>Science</i> 336 552–553. Reich, P.B. <i>et al.</i> (2012) Impacts of biodiversity loss escalate through time as redundancy fades. <i>Science</i> 336 589–592. CBD (2010) <i>Global Biodiversity Outlook 3</i>. www.cbd.int/gbo3/?pub=6667&section=6673 TEEB (2010) <i>Ecological and economic foundations. The Economics of Ecosystems and Biodiversity</i>. Island Press.</p> <p>FAO reports: 2010 – The state of the world’s plant genetic resources. www.fao.org/docrep/013/i1500e/i1500e00.htm 2010 – The Global Forest Resources Assessment. www.fao.org/forestry/fra/en/ 2012 –The State of Food and Agriculture (SOFA). www.fao.org/publications/sofa/en 2012 –The State of the World Fisheries and Aquaculture (SOFIA). www.fao.org/fishery/sofia/en UNEP (2012) <i>Global Environment Outlook 5: Environment for the future we want</i>. UN Environment Programme, Nairobi, Kenya.</p>
<p><i>Disturbance of life’s nutrient cycles</i> Imbalance in global N and P cycles causes major environmental, health and economic problems. Projected increases in population and per capita consumption of energy and animal products will exacerbate nutrient losses, air and water pollution levels, and land and ecosystem degradation.</p>	<p>Sutton M.A. <i>et al.</i> (2013). <i>Our Nutrient World: The challenge to produce more food and energy with less pollution</i>. CEH Edinburgh, for GPNM/INI. Available from www.unep.org GESAMP (1990). <i>The State of the Marine Environment</i>. GESAMP Reports and Studies No 39, IMCO/ FAW/ UNESCO/ WMO/ IAEA/ UN/ UNEP.</p>

Global problems	Assessments and evidence sources
Alteration of atmospheric chemistry – ozone layer, atmospheric aerosols Direct human impacts (health); indirect impacts through perturbed ecological and physical/climate functioning.	Thornton, J. (2000) Beyond risk: an ecological paradigm to prevent global chemical pollution. <i>International Journal of Occupational and Environmental Health</i> 6, 318–330.
Land use and degradation Reduced food security, reduced options for climate mitigation through biosphere management, risks of conflict, impacts on water quality and quantity.	Lambin, E.F. and H.J. Geist, eds. (2006). <i>Land-Use and Land-Cover Change. Local processes and global impacts</i> . The IGBP Series, Springer-Verlag, Berlin.
Water use Water stress, risks of conflict, ecological degradation.	Bogardi <i>et al.</i> (2012). Water Security for a Planet under Pressure. <i>Current Opinion in Environmental Sustainability</i> , 4, 1–9.
Pollution by hazardous substances Particular concern over bioaccumulative, persistent and toxic substances; substances that interfere with reproduction and healthy development. Direct human health and wellbeing effects, indirect impacts through ecological impacts.	UNEP (2013) Global Chemicals Outlook www.unep.org/pdf UNEP (2013) Costs of inaction on the sound management of chemicals. www.unep.org/hazardoussubstances/ UNEPs-Work/Mainstreaming/CostsofInactionInitiative AMAP (2009) Arctic Pollution 2009. Arctic Monitoring and Assessment Program, http://amap.no Depledge M, <i>et al.</i> (2013) Are marine environmental pollutants influencing global patterns of human disease? <i>Marine Environmental Research</i> 83, 93–95.

2.4.2 Adapting science and policy for planetary boundaries

Research on planetary boundaries

The planetary boundaries concept draws on several decades of research on physical, biogeochemical and ecological change over multiple timeframes, using modelling and observational tools (including palaeo records of past changes) to explain and predict Earth system dynamics. Rockström *et al.* (2009) was an expert deliberation to identify the “core set” of processes where human perturbation is driving the system outside of the functional range seen in the Holocene. As an academic article, it was intended primarily as a new strategic agenda for Earth system science research. Accordingly, there have been research developments in recent years.

Recently published commentaries include discussion and refinement of the boundaries for phosphorus (Carpenter and Bennett 2011), nitrogen (de Vries *et al.* 2013), freshwater use (Rockström and Karlberg 2010), an analysis of a state shift in the global biosphere (Barnosky *et al.* 2012), and an integrative boundary linking land, water and terrestrial biodiversity based on net primary productivity (Running 2012). Chemical pollution has also received further attention (Handoh and Kawai 2011, Persson *et al.* 2013). The complexity of chemical use and envi-

ronmental release and impacts means that a single quantitative boundary is not appropriate. However, the conditions under which chemical pollution poses a planetary boundary threat can be defined for improved policy application. Persson *et al.* (2013) argue for new proactive hazard identification strategies that consider issues like long-range transport and the reversibility of chemical pollution. All these studies provide evidence of systemic thresholds and biophysical regime shifts, arguing in favour of boundaries that set strong reductions in the current levels of anthropogenic perturbation.

An expanding area of research is the better characterization of the Holocene and Anthropocene, and the integration of human dimensions of global change (e.g. Steffen *et al.* 2011, Zalasiewicz *et al.* 2011, Crumley 2013). In the planetary boundaries framework, protecting human well-being is the underlying rationale for limiting the use and degradation of natural resources in order to avoid critical transitions in Earth system processes, but the human drivers and impacts are not explicitly set out. Raworth (2012) has extended the planetary boundary concept to social objectives. The “Oxfam doughnut” framework focuses explicitly on social justice principles underpinning sustainability. Others are exploring how to “downscale” the boundaries, in terms of a national-level attribution of responsibility for approaching the boundaries (Nykqvist *et al.* 2013), or alternatively applying the issues framework at a sub-global scale. To apply the planetary boundaries concept in practice, especially at sub-global scales, it becomes necessary to give explicit attention to the human drivers of change and distributional issues (Raworth 2012, Steffen and Stafford-Smith 2013).

An international Planetary Boundaries research network (PB.net)¹ is being established to support the development of new dynamic modelling tools and conceptualisations of human-environment system interaction. These new tools are needed to enable us to move beyond the use of static measures to describe the state of a dynamic system. Earth system models and integrated assessment models (as used in global assessments like the IPCC reports) were developed to address just some of the planetary boundaries issues, and so can only give a very partial picture of the impacts of interacting processes. The enduring problem that research is carried out in disciplinary “silos” means that many of these

¹ PB.net currently consists of research groups in Sweden, Denmark, Germany, the Netherlands, and Australia. The network will have its first international workshops in Spring 2014.

interactions are still poorly characterized. The current priority is to address the interactions of direct importance to humanity, notably in the climate-energy-food-water nexus (for instance, in the UN Global Sustainable Development Report 2013).²

2.4.3 Governance implications of the planetary boundaries

An important area of research and analysis addresses the governance implications of the planetary boundaries (Biermann 2012, Galaz *et al.* 2012, Whiteman *et al.* 2012). These highlight the need for adaptive governance and co-management, and polycentricity and “scale-matching” for the complex issues arising as humanity both alters Earth system functioning and develops a more predictive understanding of global changes.

Table 2 and section 3.3 below summarize the policy coverage of the planetary boundary issues. The current suite of international environmental agreements broadly cover the planetary boundary issues – but there are significant gaps in terms of the issue focus and geographical scale of the objectives. In general terms, policies have been developed at national and international levels to address direct and immediate impacts of environmental problems. For example, water, chemical pollution and nutrient cycles (nitrogen and phosphorus) are essentially treated as local to regional concerns, even though there is growing scientific evidence that these issues have effects on larger and longer-term scales than that. For chemicals and nutrient flows, knowledge is still fragmented, and global management is made more difficult by the rapid shifts in global patterns of production, consumption and environmental release. These emerging issues require improved science/policy dialogue.

Furthermore, the current suite of policies have not been developed to handle the potentially cascading social effects, nor the emergent risks associated with the complex interactions of biophysical processes. In this context, the consequences of implementation gaps and missed targets are likely to be much more serious than a single-issue perspective would indicate. There is sometimes a presumption that global problems demand global agreements, but IEAs can not be assumed to be a sensitively responsive mechanism for governance of globally important pro-

² UN Global Sustainable Development Report 2013 <http://sustainabledevelopment.un.org/index.php?menu=1621>

cesses. It can take a prohibitively long time to obtain the international consensus to set and review their objectives. As Galaz *et al.* (2012) argue, future pathways for the management of Earth system processes may require new attention to overarching principles and the strategic management of multi-level institutional interactions.

The policy interest in the concept has also triggered considerable debate about the role of scientific expertise in governance of global change issues (e.g., Nordhaus *et al.* 2012). These debates highlight the fact that scientific assessment, including the kinds of quantitative assessment that underlie the planetary boundaries, is only one part of societal risks and impacts assessments.

Table 2. The Planetary Boundaries (Rockström *et al.* 2009) and their current policy context

Planetary boundary	Current state*	Policy goals and targets?	Policy context	Scientific policy forums	Current (global) governance	Comment
Climate change < 350 ppm CO ₂ in atmosphere < +1 W m ⁻² radiative forcing	~396 ppm +1.87 W m ⁻²	2 °C warming is consistent with 350 ppm CO ₂	++	IPCC, UNFCCC SBSTA	UNFCCC, Kyoto Protocol; Vienna Convention, Montreal Protocol; UNECE CLRTAP	While the UNFCCC has a compatible level of ambition (2°C goal), the Kyoto Protocol and current pledges for a future agreement have failed to meet this level. The Kyoto Protocol will likely be successfully implemented in itself, but will not lead to achievement of the UNFCCC objective.
Ocean acidification CO ₃₂ -saturation state 2.75 (>80% of pre-industrial levels)	2.90	No explicit goal. Climate 2 °C goal will also keep ocean acidification within the boundary.	–	IPCC. OCB, EPOCA.	Minimal attention to date under UNFCCC.	No specific IEA in place, but the key policy measure would be mitigation by limiting anthropogenic CO ₂ emissions, hence the issue is indirectly addressed by the UNFCCC.
Stratospheric ozone depletion 276 DU (< 5% reduction in [O ₃] from pre-industrial level of 290 DU)	283 DU	Policy goals framed in terms of phasing out of ozone depleters (ie, the anthropogenic drivers of change, not the environmental effect)	+++	UNEP Ozone Secretariat APs	Vienna Convention, Montreal Protocol	Relevant and quantified targets have been set through the 1987 Montreal Protocol and they have high coverage and higher level of ambition than the PB. The targets are legally binding and there is a clear compliance mechanism. The Protocol has been successfully implemented, with the exception of undesired climate effects of substitute substances and illegal trade.
Biodiversity loss < 10 extinctions per million species per year	>100 E/MSY	Prevention of extinction of known threatened species (CBD Aichi Target 12)	++	IPBES, CBD SBSTTA	CBD; Ramsar; Bonn; Bern; CITES (more: www.cbd.int/ecolex/)	The Aichi Targets under UNCBD directly or indirectly address (aspects of) the PB by specifying targets for extinction rates and habitat loss. The level of ambition is moderate to very high, but success in implementing previous similar targets has been limited and there is a lack of hard commitments stipulating how the targets will be achieved.
Biogeochemical flows: nitrogen and phosphorus Synthetic nitrogen fixation < 35 Mt N yr ⁻¹ Phosphorus inflow to oceans <10 Mt yr ⁻¹ (<10 times background weathering rate)	121 Mt N yr ⁻¹ ~9 Mt P yr ⁻¹	No agreed global goal. Diverse national and regional targets air and water pollution reduction. GPNM proposed goal of improving full-chain use efficiency of N and P fertilizers by 20% from current levels.	(+)	International Nitrogen Initiative; Global Phosphorus Research Initiative; UNEP-Global Partnership on Nutrient Management; WHO; FAO; WMO, IPCC; Regional seas (e.g., Arctic Council).	UNFCCC, CBD (eg, Aichi Target 8); [UNECE] CLRTAP, Water Convention; Regionally – HELCOM (Baltic nations, EU), OSPAR Convention (North Sea, NE Atlantic)	No IEA with global coverage exists, but there are various regional agreements to reduce nutrient inputs to regional seas. The legal status and the extent to which these agreements include quantified targets vary. It is likely that the combined level of ambition, where expressed quantitatively, is significantly lower than the PBs.

Planetary boundary	Current state*	Policy goals and targets?	Policy context	Scientific policy forums	Current (global) governance	Comment
Global freshwater use < 4,000 km ³ yr ⁻¹ consumptive use of runoff resources	2,600 km ³ yr ⁻¹	No explicit global goal.	(+)	Global Water Forum. Also World Water Council; priority themes in FAO, WHO.	Since 2009, Climate and Water is a theme in UNFCCC process. Millennium Development Goal 7 addresses people's access to water and sanitation.	As of 2013, no IEA with potential global coverage exists. It is unclear to what extent existing bilateral and multilateral agreements on transboundary waters include targets on water extraction, as opposed to pollution reduction. Extrac- tion from national waters is not regulated through any IEA.
Land use change < 15% of ice-free land as cropland	11.7%	CBD Aichi Target 11 sets conservation targets by area. UNFCCC has provisions for measuring and monitoring LULUCF. Unclear how these relate to PB.	+	Global Land Project (within Future Earth)	CBD	The Aichi Targets under UNCBD indirectly address (parts of) the PB by specifying targets for protected areas and reduc- tion of habitat loss. Their level of ambition in relation to the PB is unclear and it appears there is no strong compliance mechanism.
Chemical pollution	No boundary defined	No global goal. Pollution controls are generally local, oriented towards human health and ecotoxicology, and retrospective so not precau- tionary for planetary conse- quences (as the ozone/CFC experience demonstrated).	n/a	WHO- Intergovernmental Forum on Chemical Safety, SETAC, SCI.	Several IEAs, including Stock- holm Convention, CLRTAP, etc.	PB tbd, no comparison possible. Note that several relevant IEAs exist (e.g., on hazardous waste, POPs and heavy metals), but they do not yet cover all chemical substances of potential global/planetary concern.
Atmospheric aerosol loading	No boundary defined	No global goal. Meeting existing local air quality targets set with human and ecosystem health objectives is likely also to prevent planetary regime shifts.	n/a	GEIA, UNECE-EMEP, GAP Forum	UNECE CLRTAP; UNFCCC.	PB tbd, no comparison possible. Note that WHO has issued a global particulates guideline and there are several regional IEAs on particulates concentration and emissions, but they are primarily based on health concerns rather than environment and climate concerns.

2.5 A safe and just space for humanity within boundaries

The Millennium Ecosystem Assessment (MA 2005) applied the concept of ecosystem services specifically to “human wellbeing and poverty alleviation,” highlighting how ecosystem services can contribute to multiple dimensions of wellbeing including security, basic material for a good life, health, good social relations and freedom of choice and action. The impact of ecosystem services on human wellbeing can appear most tangible and obvious at the local level, but they also operate at all intermediate scales right up to the global. The planetary boundaries aim to identify the conditions under which regulating ecosystem services can be maintained at the planetary scale. These are the Earth system processes that maintain conditions for prosperous development, dubbed “Earth system services” by Steffen *et al.* (2011).

The changing patterns of human demand for ecosystem services also have impacts on the biosphere across all scales, often eroding natural capital. For example, one of the main human activities is agriculture, and the human transformation of wild ecosystems to agro-ecosystems has enhanced the supply of many ecosystem services, such as food production. However, it has done this at the expense of other services, such as climate regulation and water purification (MA, 2005). As currently practiced, agriculture is a major contributor towards the overshoot of many of the planetary boundaries (Foley *et al.* 2011).

Ultimately the survival of humanity depends upon the biosphere, and the continued functioning of the global economy relies upon the reliable supply of the ecosystem services that a stable planet provides. Meanwhile the well-being of individuals is intimately linked to their ability to access ecosystem services, as well as the many products and services produced by economies. Thus destabilizing the Earth system by crossing planetary boundaries can have consequences for human wellbeing by reducing the supply of ecosystem services, and also by impairing the functioning of the global economy increasing the costs of maintaining essential services needed to achieve a good life. This economic dimension requires explicit attention.

Economic valuations of ecosystem services seek to capture their aggregate societal value. In reality different individuals and groups benefit from different ecosystem services to different extents, so that changes in ecosystem services create winners and losers. The poor are typically

more sensitive to impacts on ecosystem services, due to their greater reliance on natural resource-based livelihoods, and their vulnerability to natural hazards. This also applies globally, as poorer nations have suffered more costs and reaped fewer rewards from environmental changes (Srinivasan *et al.* 2008).

The contributions that ecosystem services make to wellbeing also depend on the perspectives and circumstances of the beneficiaries. Thus, from a poverty alleviation perspective, ecosystem services should be appraised in terms of how poor people's lives are actually improved (Daw *et al.* 2011). For example, the wellbeing impact of food or flood protection depends on how hungry someone is or how exposed their wealth is to flooding. This also has implications for the way in which the ecosystem services concept is deployed in economic policy. The financial income from a payment for ecosystem services could have a greater wellbeing impact on poor individuals than the same income might have for a wealthier individual.

Thus the challenge of sustainable development is not just about the simple existence of natural capital or remaining within planetary boundaries. For the biosphere to support wellbeing, access to the benefits from ecosystem services needs to be equitably shared. Some have attempted to illustrate this challenge by depicting the sustainability challenge as aiming to meet a "floor" of basic social requirements for poverty alleviation within the biophysical constraints of the planetary boundaries (Raworth, 2012). This approach has been depicted as a framework shaped like a doughnut which creates a "safe and just space" between the two, in which humanity can thrive (Figure 5).

Fig. 5. Planetary and social boundaries: a safe and just space for humanity

Source: Raworth, 2012.

3. International policy and the move towards global sustainability

There are many international environmental agreements that contribute to the global sustainable development agenda. Most prominent are the three Rio Conventions adopted at the 1992 Earth Summit in Rio de Janeiro, in response to the most pressing issues of environmental *unsustainability*. These are the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD) and the Convention to Combat Desertification (CCD).

With the planetary boundary framework, a scientific rationale for linking and reinforcing these agreements is brought into the picture, providing an Earth system “dashboard” for assessing their effectiveness in terms of safeguarding global sustainability. By setting contemporary environmental changes into the context of the natural processes seen through the geological history of the planet, the planetary boundaries concept has direct relevance to the widely-used Brundtland definition of sustainable development: “meeting the needs of the present without compromising the ability of future generations to meet their own needs.” It also provides an important foundation for efforts to “Protect the integrity of the global environmental and development system,” as emphasized in the preamble of the 1992 Rio Principles.

Much needs to be learned from the experiences of earlier global collective efforts towards sustainability. Prominent in these experiences, and closely linked to the SDG process, is the development and implementation of the Millennium Development Goals (MDGs). In the following section, we discuss the MDGs, exploring the lessons and opportunities for the SDGs.

3.1 The Millennium Development Goals

In year 2000, the UN adopted the Millennium Development Goals to address the problems associated with poverty, in a 15-year timeframe. The eight MDGs address different issues including extreme poverty and hunger, universal education, gender equality, child health, maternal health, HIV/AIDS, environmental sustainability and global partnership to address national disparities in development. Each goal has targets that are to be achieved by 2015. Good progress has been made in many areas. The targets for poverty, slums and water supply have already been reached. But projections indicate that in 2015 close to one billion people will be living on an income of less than \$1.25 per day. Hence, abject poverty remains a global challenge, hampering people's capacity to meet their basic needs for nutrition, sanitation, empowerment and health. And since 2000, many other global issues have become prominent sustainability concerns deserving global attention. The MDG process gives important insights for this process.

3.1.1 *Clear overarching objectives mobilize global cooperative action*

The outcome document from the UN Rio+20 conference states that SDGs should be

“action-oriented, concise and easy to communicate, limited in number, aspirational, global in nature and universally applicable to all countries while taking into account different national realities, capacities and levels of development and respecting national policies and priorities.”

Many of these characteristics are shared with the MDGs. Importantly, the MDGs provide easily understood, quantitative targets; with time-bound objectives that promote awareness, political accountability, improved metrics, social feedback, and public pressure for human development goals (Sachs 2012).

3.1.2 *SDGs are an opportunity to better integrate environment and human development issues*

The MDGs have been criticized for focusing too narrowly on social development, while not providing for social-ecological interactions, innovation and adaptation (Waage *et al.* 2010). Goals 2 to 6, and to a large extent Goal 1, focus almost entirely on the social dimensions of devel-

opment, not fully reflecting how deeply linked they are with environmental and economic factors (UN Task Team 2012; see also fig 8).

MDG7 set environmental sustainability targets addressing natural resource depletion, biodiversity destruction, inadequate access to water and sanitation, and the worst problems of slum environments. While these are serious problems in many parts of the world, a very large proportion of environmental unsustainability is left untouched. Also, the MDG process frames these environmental issues in one “stand-alone” goal. This means that many interdependent social and ecological issues have not been prioritised, where they could have offered “win-wins”. For example, healthy and productive ecosystems play a vital role in addressing hunger and nutrition. Better integration of environment and development within goals would also ensure scrutiny of the potentially damaging environmental consequences of activities towards other goals (e.g., ODA funding).

Environmental policies have been primarily oriented towards “problem fixing,” often focused on technical and economic responses. Earth’s degraded ecosystems and landscapes are subject to more policy protection than ever before, but the damage of the past has not been fully reversed. Current efforts are not enough in key areas of climate (and its twin problem, ocean acidification; IPCC AR5 2013), destruction of ecosystems and biodiversity (MA 2005, GB03 2010, GEO5 2012), and the release of polluting substances into land, water and atmosphere (UNEP 2012). Development policies need to go further to recognize the connections between (narrowly defined) economically productive actions and effects on the environment. They also need to recognize that people are part of the world’s ecosystems, affecting the functioning of the whole Earth at multiple, linked scales.

Social dimensions of unsustainability have so far been most clearly reflected in the global concern about reducing poverty. This may help explain the tendency for the primacy of economic development in “triple bottom line” formulations of sustainability. At Rio+20 and in debates since then, there have been calls for more effort addressing issues of governance and social justice. Here too, a focus on social-ecological interactions can enrich understanding. Good governance and environmental justice are tightly linked, because people obtain many benefits and services from well-functioning ecosystems. These values need to be recognized and taken into account in decision-making (TEEB 2010), even if they do not necessarily need to be translated into monetary terms and embedded in market mechanisms.

3.1.3 *SDGs can focus on greater equity while recognizing Earth's fundamental limits*

Taking current population projections and present levels of anthropogenic environmental impact into account, global society faces an enormous challenge in order to “live within global environmental limits.” Since equity for human development is an underpinning concept of sustainability (affirmed in Agenda 21 and the Rio Principles), it needs to be more prominent in the SDGs than it has been in the MDGs. The MDGs focused on meeting the most basic needs of the world’s poorest people. Fulfilling these needs marks a baseline condition for global equity. However, equity also implies that burdens and rewards of development should not be spread too divergently. The SDGs present an opportunity to strengthen this dimension of equity, in accordance with the intentions agreed in Rio 1992, and reaffirmed in Rio+20.

Several concepts have been proposed that provide a framework for recognizing both environmental limits and the principle of equity. These include environmental space (Siebert 1982, Buhrs 2009, Kitzes *et al.* 2008), and Cap-and-Trade of ecological footprints (Ohl *et al.* 2008). The latter two extend the ecological footprint concept (Wackernagel and Rees 1996) to include a broader range of demands within an equity framework.

For many reasons, footprinting approaches may not be directly useful for the design of global sustainability policy (Ayres 2000, Van den Bergh and Verbruggen 1999, Wiedmann *et al.* 2006). The footprint approach cannot easily include non-renewable resources, nor does it address key social aspects of sustainability such as access to education and healthcare. It is also insufficient when it comes to assessing how viable or vulnerable the natural ecosystems providing goods and services are (Deutsch *et al.* 2000). Moreover, history suggests that elites push the burden of compliance onto marginalised groups. So while footprinting approaches can provide important aggregate frameworks for equity in terms of material interactions between humans and nature, the “how” of global sharing is as important as the “what.”

3.1.4 A fairer process for developing and implementing goals

An important component of an equitable and sustainable development is that policy should be defined and implemented with fairness, impartiality, and justice.

The MDGs recognized that inequality of opportunities between men and women (MDG3 and 5) and among the world's nations (MDG8) presents major barriers to sustainable development. Continuing in this spirit, human rights and fundamental freedoms need to be respected and observed in the process of developing and implementing the SDGs. At the level of individual people, addressing the enduring problems of disparity and discrimination on the basis of gender will need to continue beyond 2015. Attention is also turning to other marginalized and underprivileged groups.

At the level of nations, progress towards MDG8 (global partnership) has been much too weak. The UN's 2012 Gap Task Force report is explicit about the extent of rhetoric: poor nations still face unsustainable debt obligations; miniscule aid commitments have not been met; and "the Task Force has had difficulty identifying areas of significant new progress towards the MDGs." The need for delivery on MDG8 commitments has been described as at "emergency proportions" (UN General Assembly 2010) – the vulnerability of the poorest is rigidly institutionalized. It is in this context futile to pursue efforts to improve the health and education of poor individuals while their nations (and thus their post-2015 prospects) are still being crippled by inequitable institutional relations.

The UN General Assembly (e.g., UNGA 2010) has sought to learn lessons from the MDG process. This learning requires scrutiny of the institutional processes, documentation and monitoring of the whole process from design to implementation (and ultimately, goal achievement), and engagement with the stakeholders in the process. There is strong consensus that more participation is needed in public decision-making processes, especially in the case of complex issues characterized by divergent norms and values and high uncertainty. Participation matters for several reasons:

- It strengthens legitimacy, as part of a transparent and democratic process – Agenda 21 (Sors 2001, also <http://habitat.igc.org/agenda21/app.htm>), Aarhus convention (Lee and Abbott 2003).
- It deepens the available knowledge in the context of contested and complex issues – precautionary approaches require engaging with the full diversity of knowledge, creativity and perspectives (Stirling and Gee 2002, Stirling 2009).
- Ethical and normative dimensions, because people are the source of values in society, and because participation builds inclusion and fairness.

3.1.5 *Urgent, universal, unambiguous goals*

A key to the relative success of the MDGs is that they are clear and simply-stated goals that address a well-recognized global problem – extreme poverty. The SDGs would do well to structure themselves that way too. They should not be about defining a new, multi-dimensional long-term shared sustainability *vision* for the global community, because aiming for global consensus at that scale is more likely to fail.

The SDGs should be about dealing with *today's* most pressing and unacceptable problems, as soon as possible. Since the SDGs were first suggested, the number of proposed goal areas has ebbed and flowed, often looking like a shopping list. A challenge for the SDGs (and partly shared by the MDGs) is that the complex architecture of the world presses against simple, “modular” goals. Whatever the set of desirable target areas for the SDGs might be, the real power of the concept comes from linking them together under a single shared overarching statement. The MDG shows how this works: the MDG targets cover a very wide range of issues, but they are all oriented towards the unifying objective of poverty alleviation.

Another challenge arising from real-world complexity is that interactions among social groups, and between society and nature, are fluid, transformative and often unpredictable. Policies for sustainability need to be adaptive and adaptable. This also argues for a fixed-term and probably near-term focus for the SDGs (the MDGs were time-limited, over a 15 year period). There have been discussions about extending the frame of the SDGs to 20+ years into the future, on the basis that fundamental institutional and infrastructural transformations are needed and these take time. The problem with this argument is that the short-termism that characterizes the world's decision-making processes is not going to disappear (because it is part of human behaviour and psychology; it is an essential part of adaptive governance; it reflects cultural uni-

versals of power in politics, and for many more reasons). Long-term objectives often simply slip down the agenda unless specific time-bound steps are set in place – and it is precisely those steps where concerted international action should be focused.

3.2 SDGs and developments in UN

To achieve sustainable development, it was suggested by the governments of Colombia, Guatemala and Peru that specific sustainable development goals should be established. This proposal was discussed during the UN Rio+20 conference, where a decision to establish SDGs was made. Initially Colombia, together with a group of other countries, identified a suite of priority issues that constituted the basis for first discussions.

Nations and international organisations are now working to define what such goals should be. The UN plays an important role in these developments. A priority is to identify a post-2015 agenda, as 2015 is the year the MDG objectives are to be achieved. Three of the SDG-linked initiatives are the Open Working Group on Sustainable Development Goals (OWG),³ the High Level Panel of Eminent Persons on the post-2015 agenda (HLP), and the Sustainable Development Solutions Network (SDSN).

The OWG is a 30-member group of the UN General Assembly that was established in January 2013. Its objective is to prepare a proposal on SDGs. They will report to the General Assembly in 2014. The HLP was initiated by Secretary-General Ban Ki-moon in July 2012 to advise on the global development framework post 2015. The report “A new global partnership: eradicate poverty and transform economies through sustainable development” was submitted to the Secretary-General in May 2013. It presents a universal agenda to eradicate extreme poverty by 2030 and underlines the importance of putting sustainable development at the core of the agenda for the future. To achieve this a new global partnership is needed. Twelve goals have been proposed that cover various issues including: poverty, gender equality, education, health, food security, water and sanitation, energy, jobs, natural resources, governance, peace and a global enabling environment. The report has received a positive response but some critique has also been expressed. For example it does not mention the Convention on Biological Diversity and

³ See <http://sustainabledevelopment.un.org/index.php?menu=1549>

the Aichi targets in relation to Goal 9 that aims at managing natural resource assets sustainably. A report by Rockström *et al.* (2013). “Sustainable Development and Planetary Boundaries,” was submitted to the HLP. It states that

“Rather than knowingly crossing the planetary boundaries, the world can agree and cooperate on living within the playing field they imply, by adopting improved technologies, stabilizing the world’s population, and protecting threatened species and ecosystems. Such a strategy would leave all regions of the world better off than on the business-as-usual path. Placing the world on such a ‘Sustainable Development Trajectory’...must be a central objective of the post-2015 framework.”

Another key initiative is the SDSN, that aims to be a facilitator in support of sustainable development problem solving by involving technical and scientific expertise from various disciplines including not only academia but also civil society and the private sector. There are twelve thematic groups within SDSN that aim at identifying common solutions and finding best practices within different fields. SDSN published the report “An action agenda for sustainable development” in which they suggest a list of ten SDGs. One of them, goal number 2, is directly related to planetary boundaries: “Achieve development within planetary boundaries.” It states that “All countries have a right to development that respects planetary boundaries, ensures sustainable production and consumption patterns, and helps to stabilize the global population by mid century.” Three specific targets are brought forward within goal number 2:

“(1) Each country reaches at least the next income level as defined by the World Bank; (2) Countries report on their contribution to planetary boundaries and incorporate them together with other environmental and social indicators into expanded GDP measures and national accounts; (3) Rapid voluntary reduction of fertility through the realization of sexual and reproductive health rights in countries with total fertility rates above three children per woman and a continuation of voluntary fertility reductions in countries where total fertility rates are above replacement level.”

The SDGs outlined by SDSN bear a similarity to those listed in the UN General Assembly report to the Secretary-General, “A life of dignity for all: accelerating progress towards the Millennium Development Goals and advancing the United Nations development agenda beyond 2015.”

In March 2013, a month before the SDSN’s proposed goals and targets, Griggs *et al.* (2012) published a set of six Sustainable Development Goals (see also Appendix 4). These two sets of SDGs have been formulated based on the latest science, while also considering IEAs and the MDGs (see Fig-

ure 6). The six SDGs suggested by Griggs and co-workers consider both MDGs and global sustainability objectives. The targets set within each SDG directly address social, economic and environmental dimensions. These goals, and the targets beneath, may be operationalized through a policy framework across levels from international to local (see Figure 6 and 7).

One example of an already existing international environmental agreement that is important in the process of establishing SDGs is the Strategic Plan for Biodiversity 2011–2020, adopted at the tenth meeting of the Conference of the Parties to the Convention on Biological Diversity. The Strategic Plan for Biodiversity contains a number of elements, for instance the twenty Aichi Biodiversity Targets, which are readily available for integration into the SDGs. The incorporation of these goals, targets and indicators into the SDGs has multiple benefits, not only ensuring policy coherence and building on existing implementation processes, but also reflecting the political will of the 193 Parties to the Convention on Biological Diversity. At the latest Trondheim Conference on Biodiversity the SDGs were discussed. In an information document⁴ to the conference the proposed SDGs were divided into four different types of goals based on their linkages to biodiversity (Figure 7). These four types have then been matched with relevant targets and other elements of a strategic plan (Appendix 6).

⁴ Biodiversity and Sustainable Development – the relevance of the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets for the post-2015 development agenda and the Sustainable Development Goals. Key Messages, The seventh Trondheim Conference on Biodiversity, Trondheim, Norway, 27–31 May 2013 Document TC7/INF2

Fig. 7. Potential types of goals based on the linkages of social objectives to biodiversity and ecosystem services

Source: Biodiversity and Sustainable Development – the relevance of the Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets for the post-2015 development agenda and the Sustainable Development Goals. Key Messages, The seventh Trondheim Conference on Biodiversity, Trondheim, Norway, 27–31 May 2013 Document TC7/INF2.

Fig. 6. Six sustainable development goals (SDGs) for integrated delivery of Millennium Development Goals and planetary “must-haves” (or Global Sustainability Objectives). (From Griggs et al. 2013. Sustainable Development Goals for people and planet. Nature 495, 305–307)

Illustration: J. Lokrantz/Azote.

3.3 International Environmental Agreements

For the development of the post-2015 agenda and the SDG process, it is necessary to examine how existing international environmental agreements (IEAs) and/or policy targets can be used and to what extent they address global sustainability goals as well as how they relate to critical Earth system processes as outlined in the planetary boundaries framework.

The biophysical processes underpinning planetary boundaries have partly been addressed in some IEAs (see Table 1) but even where they are considered, that does not mean that targets have been identified. Progress may also be restrained by the implementation gap, such as in the situation with climate change. A success story is the Montreal Protocol and its effect on limiting emissions of ozone-depleting substances (The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer). When going through existing IEAs and institutions it becomes clear that they can be utilized more effectively in order to calibrate policy targets in relation to the scientific evidence on PBs and global environmental thresholds. To the extent that policy-makers wish to use this evidence to develop new policies, implementation deficits need to be addressed properly and the level of ambition of existing targets need to increase.

The policy context of the planetary boundaries has been examined further in a research report by Stockholm Environment Institute and Stockholm Resilience Centre for the Swedish EPA in which a methodology for measuring national performance on PBs is developed (Nykvist *et al.* 2013). Another relevant assessment on global environmental goals has recently been concluded by UNEP (UNEP 2012), summarized in Appendix 2. The results from mapping out IEAs relevant to the planetary boundaries can be considered to be consistent with the “Environment Scorecard” coming out of UNEP’s report, where comparison is made with environmental goals themselves and not with planetary boundaries (see Appendix 2). An important message from these two reports is that a range of environmental goals and targets already exist, but that there are significant implementation deficits.

A more detailed comparison of planetary boundaries and targets agreed under IEAs needs to consider several aspects; how relevant the target is to the planetary boundaries, its coverage, its level of ambition, whether the target is legally binding, whether a strong compliance mechanism exists, and whether the target has so far been successfully achieved.

Overall, the planetary boundaries framework does not introduce new issues on the policy agenda as such but rather suggests specific values for boundaries, based on scientific research. However, with the planetary boundaries concept a number of new institutional issues need to be addressed. Notably, IEAs are not equipped to manage compounded and complex effects (e.g. the cocktail effect from different chemical pollutants) or tipping points. Part of the problem is that it requires a significant time span to review and revise targets (e.g. for emission levels or resource extraction rates). Another part of the problem is the uncertainty of how policy targets under different IEAs or institutions relate to each other, which has been characterised as the “institutional interplay” (Oberthür and Stokke 2011).

To avoid “problem shifting,” i.e. reducing pressure on one planetary boundary by increasing pressure on another (e.g. by expanding feedstock for biofuels to mitigate climate change which leads to increased pressure on local freshwater resources in cultivation areas), one approach that could be examined further is whether the boundaries could be used as a set of criteria when undertaking environmental impact assessment of major policies and societal investments (Nilsson and Persson 2012). Environmental impact assessment is one of the most established tools in the environmental governance toolbox and has increasingly been used at “higher” and more strategic levels in policy-making. In the same way, global impacts could be considered by using planetary boundaries as benchmarks. In this way, they could be used both in impact assessment of local or national policies and investments and in policies and investments that have a clear transboundary dimension. The main challenge would be to agree which institution could be given the authority to demand and propose changes in light of such impact assessments, as it would likely involve a compromise with the subsidiarity principle.

Among the seven quantified planetary boundaries and their control variables, we found that six are addressed directly in IEAs, while ocean acidification is only addressed in the Strategic Plan of the CBD.⁵ This may not come as a surprise given that ocean acidification is a relatively new scientific finding. In addition, the problem relates to climate as reduction in anthropogenic CO₂ emissions is needed to reduce the problem; this is already addressed by the UNFCCC (see also Kim, 2012). Nevertheless,

⁵ Mentioned in UN CBD Aichi Target No. 10.

IEAs for specific environmental issues have generally been created for different reasons than for the same issue being included in the planetary boundaries framework. For example, particulates (as atmospheric aerosols) have been addressed for their human health effects rather than environmental and climate effects, and phosphorus emissions for their local eutrophication effect rather than for the global consequences it may have.⁶ However, the specific issues raised in the planetary boundaries framework are not new as such as most of the planetary boundaries have been addressed to some extent in several IEAs in force to date. What is new is the attempt to find boundaries and identify thresholds for various environmental and natural resource variables of global relevance and to put it in a framework that is useful for policy and management.

Table 1 primarily shows to what extent PBs have been *addressed*. As mentioned above the planetary boundary for stratospheric ozone depletion was successfully dealt with. UNEP's Global Environmental Goals project highlights other successfully achieved goals, such as lead in gasoline and the supply of safe drinking water (UNEP 2012; see Appendix 2). Common to all these issues is that they have direct and clear human health effects, as opposed to more environmentally mediated effects on human well-being. This suggests that if impacts on humans can be clearly communicated it is given higher priority.

In order to connect potentially harmful anthropogenic interference with Earth system processes with visible and measurable effects on human beings, the notion of "Earth system services" could be used. Drawing on terminology for ecosystem services, Steffen and colleagues (2011) identify examples of provisioning, regulating and supporting Earth system services, in an effort to concretise how societies and economies are dependent on seemingly abstract and large-scale environmental processes.

Another reason why existing goals have not yet been adequately effective, according to the UNEP's Global Environmental Goals project, is that many are simply not specific enough; the few goals that are specific and measurable appear to have a much better record of success than the ones that are more aspirational (see Appendix 2).

When considering how well matched the proposed planetary boundaries are by existing policy responses, it should be emphasised that IEAs may not always be a sufficient approach. As explored by Galaz and col-

⁶ Oceanic anoxic events occur when oceans become completely depleted of oxygen below the surface levels. No such events have happened for millions of years, but geological records show they have happened many times in the past and they have been associated with mass extinctions.

leagues (2012), a focus on formal international agreements alone gives a too simplistic perspective on the features of global environmental governance. They suggest that insights from planetary boundaries research highlight the need to consider flexible multilevel forms of state and non-state collaborations and partnerships; the importance of legitimate and inclusive international and regional scientific assessments; the important role played by international organizations; and the need for international policies that support social-ecological innovation (Olsson and Galaz 2012, Westley *et al.* 2012). Surely international agreements and national enforcement matter, but these should not be decoupled from local and regional adaptive forms of ecosystem stewardship as these have been proven to be critical in dealing with key features of global change.

As an example of activities of a non-state actor, the planetary boundaries concept has been included in the work of the World Business Council for Sustainable Development (WBCSD). To connect resilience and the planetary boundaries concept with their business strategy, they embarked on a collaborative project with Stockholm Resilience Centre and other science inputs worldwide.

Overall, planetary boundaries may be viewed as an issue for multi-level governance.

To sum up, comparing planetary boundaries and the current suite of IEAs suggests that there are four important avenues for future engagement in IEAs relevant for the development of SDGs:

- *Reduce implementation deficits in relation to existing targets and commitments* – Typical for climate change, biodiversity loss and land use. The latter also suffer from a lack of more direct targets addressing the problem that the planetary boundary is trying to capture.
- *Highlight the global scale and implications of problems currently addressed regionally* – Freshwater and biogeochemical cycles are dealt with through regional approaches, failing to consider the global picture.
- *Extend the rationale for acting from effects on human health and well-being to effects on ecological and Earth system resilience* – Concerning aerosols, for example, there has been progress when the problem directly results in measurable risks to human health but less so when it relates to (more uncertain) risks to the environment. Momentum for “environmental” policy initiatives could be strengthened if there is a stronger and clearer connection to human well-being, since the latter is commonly perceived as more urgent.

- *Pursue other tools for international cooperation other than formal IEAs* –A range of voluntary initiatives exist and capacity-building efforts targeted at developing countries could be an effective way of reducing implementation deficits.

3.4 Synergising legal systems for the emerging new development agenda

The emerging Sustainable Development Goals can also benefit from linking International Environmental Agreements to progressive interpretations of International Human Rights Law, in particular to the associated environmental cross-cutting dimensions (Darcy *et al.* 2009). Human rights are inalienable rights and imply State obligations of “doing” and “not doing” towards individuals and collectives. While in the 1970s, civil and political rights (e.g. freedom of speech and freedom of assembly) were sometimes seen in clash with economic, social and cultural rights (Nicholson and Chong 2011). Since the 1990, there is an increasing recognition that civil and political rights are indivisible and interdependent to economic, social and cultural rights (Howard 1983) and that both set of rights include State’s obligations of action and inaction. Moreover, many State’s Constitutions – the legal instrument with highest hierarchy and legitimacy in many countries – also enshrine these rights as well as environment-specific rights; national legal systems are especially important for providing coercive enforcement mechanisms for these rights as international mechanisms have significant limitations (Nicholson and Chong 2011).

Hence, the progressive recognition of crosscutting environmental dimensions of human rights can contribute to the theoretical framing including equity dimensions as well as providing legal basis and legitimacy for the SDG. For example, proposals of SDGs, linked to the biodiversity planetary boundary include “thriving lives and livelihoods” and “healthy and productive ecosystems.” Article 11 under the International Covenant of Economic, Social and Cultural Rights, referring to the State’s obligation to improving living conditions can contribute to provide legal basis for these proposed goals and planetary boundary. This Article 11 has been interpreted to include State obligations to reduce pollution (Churchill 1998) and ensuring that the corporate sector fulfills its associated responsibilities. Hence, this Article could also contribute to provide legal basis to other proposed SDGs such as “clean energy” as well as to action towards respecting other planetary boundaries.

Sustainability depends on global and local action where not only States but also other non-State actors take action and recognise their own responsibilities towards a sustainable future. Hence, synergies with voluntary standards (e.g. Plan Vivo) as well as local norms (e.g. Community Protocols) can contribute to secure people's rights and healthy ecosystems.

In sum, the legal framework for the new development agenda can build on synergies between Multilateral Environmental Agreements and Human Rights Law (see table 3.) as well as on legal landscapes at distinct scales. Grounding the emerging Sustainable Development Goals in crosscutting environmental dimensions of human rights can contribute to provide legal basis and legitimacy to action towards fostering spaces where humanity as well as other living beings and ecosystems can thrive.

Table 3. The legal framework for the new development agenda can build on synergies between Multilateral Environmental Agreements and Human Rights Law

International treaties ⁷ (binding)		Declarations, principles and guidelines agreed between States (non-binding)
Environment	<p>Convention on Biological Diversity, 1992/1993.</p> <p>Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization 2010.</p> <p>Cartagena Protocol on Biosafety 2000/2003.</p> <p>The Nagoya – Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety 2010.</p> <p>United Nations Framework Convention on Climate Change 1992/.</p> <p>United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, 1994/1996.</p> <p>Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 1971/1975.</p> <p>Convention on the International Trade in Endangered Species of Wild Flora and Fauna 1973/1975.⁸</p> <p>Convention on the Conservation of Migratory Species of Wild Flora and Fauna, 1973/1975.⁹</p> <p>Convention on Access to Information, Public Participation in Decision-Making, and Access to Justice in Environmental Matters, 1998/2001.</p> <p>The International Treaty on Plant Genetic Resources for Food and Agriculture, 2001/2004.</p>	<p>Stockholm Declaration of the United Nations Conference on the Human Environment, 1972.</p> <p>Rio Declaration on Environment and Development, 1992.</p> <p>Agenda 21, 1992.</p> <p>Forest Principles, United Nations Conference on Environment and Development Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests, 1992.</p> <p>Akw on Voluntary guidelines for the conduct of cultural, environmental and social impact assessments regarding developments proposed to take place on, or which are likely to impact on, sacred sites and on lands and waters traditionally occupied or used by indigenous and local communities (CBD 2004).</p> <p>Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity (CBD 2004).</p> <p>Interlaken Declaration on Animal Genetic Resources.</p> <p>Karihiwaia:ri Code of Ethical Conduct to Ensure Respect for the Cultural and Intellectual Heritage of Indigenous and Local Communities (CBD 2010).</p> <p>The Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization (CBD 2002).</p>
Human Rights	<p>International Covenant on Civil and Political Rights, 1966/1976.</p> <p>International Covenant on Economic, Social and Cultural Rights, 1966/1976.</p> <p>International Convention on the Elimination of All Forms of Racial Discrimination, 1965/1969.</p> <p>Convention on the Rights of the Child, 1989/1990.</p> <p>Convention on the Elimination of All Forms of Discrimination Against Women.</p> <p>Indigenous and Tribal Peoples Convention No. 169, 1989/1990 (depository: ILO).</p>	<p>Universal Declaration of Human Rights, 1948.</p> <p>Declaración sobre el Derecho y Desarrollo en lo Social, 1969.</p> <p>United Nations Declaration on the Right to Development, 1986.</p> <p>Draft Declaration of Principles on Human Rights and the Environment 1994.</p> <p>Declaration on the Responsibilities of the Present Generations Towards Future Generations 1997.</p> <p>Declaration on the Rights of Persons Belonging to National or Ethnic, Religious and Linguistic Minorities.</p> <p>United Nations Declaration of the Rights of Indigenous Peoples 2007.</p> <p>The Universal Declaration on Cultural Diversity UNESCO 2001.</p> <p>The Universal Declaration on Bioethics and Human Rights UNESCO 2005.</p>

Source: Ituarte-Lima, C., Schultz, M., Hahn, T. and Cornell, S. (2012) "Safeguards in scaling-up biodiversity financing and possible guiding principles", Stockholm Resilience Centre, Information document for the CBD-Conference of the Parties 11, (UNEP/CBD/COP/11/INF/7). <http://www.cbd.int/doc/meetings/cop/cop-11/information/cop-11-inf-07-en.pdf>

⁷ The first year mentioned is when the international treaty was adopted and second when it entered into force.

⁸ Amended 1979.

⁹ Amended 1979.

4. Formulating Sustainable Development Goals in the Anthropocene

4.1 An integrated framework for SDGs

As previously described a number of different initiatives, networks and organisations around the world are currently working to provide guidance and recommendations on the post-2015 development agenda. The UN has launched a number of initiatives (see section 3.2) and the Overseas Development Institute provides an online and continuously updated collection of all the publicly available proposals for future SDGs.¹⁰

The scope of the current report is not to go through all these in detail but rather to describe and review how the post-2015 agenda and formulation of SDGs can incorporate the scientific insights provided by Earth system and Resilience science. From this work three overarching insights emerge:

SDGs must address the new challenge of meeting the twin universal challenge of poverty alleviation and human wellbeing on the one hand, and global environmental sustainability on the other. Global sustainability being an overarching precondition for human prosperity.

Scientific insights number 1

SDGs must go beyond the disciplinary division (pillars) of social, economic and environmental goals, and avoid becoming a collection of single issue-based objectives. Any accepted set of SDGs need to acknowledge that ecological and social systems are inseparably linked and must facilitate a deeper analysis of the multiple interconnections, trade-offs and synergies between goals and targets. SDGs should be designed to enhance the awareness of, and focus on, the role of natural

¹⁰ <http://tracker.post2015.org>

capital and ecosystem services within (not alongside) economic development and poverty reduction.

In Griggs *et al.* (2013), it is argued that the twin priorities for the formulation of SDGs must be the protection of Earth's life-support system and poverty reduction. In other words, it is not sufficient to simply extend the MDGs, as some are suggesting, because humans are already transforming the planet's atmosphere, oceans, waterways, forests, ice sheets and biodiversity in ways that could undermine development gains. In this context, the classic model of sustainable development, of three integrated pillars – economic, social and environmental – is regarded as flawed. Instead, it is suggested that sustainable development should be redefined as “development that meets the needs of the present while safeguarding Earth's life-support system, on which the welfare of current and future generations depends” (ibid.). Taking this new definition of sustainable development, and using existing international agreements, six provisional SDGs are proposed (see Figure 6, A Unified Framework):

1. Thriving lives and livelihoods.
2. Food security.
3. Water security.
4. Clean energy.
5. Healthy and productive ecosystems.
6. Governance for sustainable societies.

Reducing poverty and hunger, improving health and well-being and creating sustainable production and consumption patterns remain driving principles. The proposed goal of improving lives and livelihoods, for example, would promote sustainable access to food, water and energy while protecting biodiversity and ecosystem services. The targets beneath each goal include updates and expanded targets under the MDGs, including ending poverty and hunger, combating HIV/aids, and improving maternal and child health. But also a set of planetary “must haves”: climate stability, reducing biodiversity loss, protection of ecosystem services, a healthy water cycle and oceans, sustainable nitrogen and phosphorus use, clean air and sustainable material use (see Fig 8. and Appendix 4 for a detailed list of the goals and targets).

Fig. 8. An infographic describing this report's "unified framework for global sustainability" and how it relates to the evolution of insights on the interactions between development and the environment from the 1970s to the present

Illustration: J. Lokrantz/Azote.

The “infographic” in Figure 8 summarises how an integrated approach is part of an evolution of thinking and continuous scientific explorations and insights on the complex interactions between human development and the environment and the main components of such an approach.

1. It starts with the seminal “Limits to growth” report in 1972, which was a reaction to the conventional economic view that “Land” (nature and natural resources) was something passive and unimportant to the production of wealth (compared to the much more important “Labour” and “Capital”).
2. The timeline continues with the Venn diagram of sustainable development, a concept which gained attention in 1987 and became mainstreamed during the first Rio conference in 1992. In reality the global sustainable development agenda has mostly focused too much on economic development and marginalised both the social and environmental aspects (see “Mickey Mouse sustainability” model in the upper left corner). Likewise, the MDGs (plotted inside the circles of the Venn diagram) have also been criticized for focusing too narrowly on some aspects of development, while not providing for social-ecological interactions, innovation and adaptation. Actually, goals 2 to 6 and to a large extent goal 1, focus almost entirely on the social dimension of development, not fully reflecting how deeply linked they are with environmental and economic factors.
3. In 2005 and 2008 the MA (Millennium Ecosystem Assessment) and TEEB (The Economics of Ecosystems and Biodiversity) reports respectively, emphasised the importance of ecosystem services for human development and this was followed in 2009 by the planetary boundaries approach reiterating (in a new way) the biophysical limits to economic development.
4. This framework was later adapted by the “Oxfam doughnut” which added a “floor” of basic social requirements for poverty alleviation within the constraints of the planetary boundaries. From 2015 we show a possible unified framework for Sustainable Development Goals, combining the sustainable development, ecosystem services and planetary boundaries concepts in the adoption of a “development within Earth limit” approach (see e.g. Griggs *et al.* 2013). This unified framework even redefines sustainable development as “development that meets the needs of the present while safeguarding Earth’s life-support system, on which the welfare of current and future generations depends.”

5. The pie chart in the upper right corner shows one example of how a SDG for sustainable food security could be framed based on this unified framework. It is an example of how the post-2015 agenda and formulation of SDGs can incorporate the scientific insights provided by Earth system and Resilience science, meeting the twin universal challenge of poverty alleviation and human wellbeing on the one hand, and global sustainability on the other.

The United Nations Sustainable Development Solutions Network (SDSN) has proposed a list of ten transformations needed in the “A Framework for Sustainable Development” document:¹¹

1. Ending Extreme Poverty and Promoting Sustainable Growth.
2. Promoting Healthy Lives and Sustainable Fertility.
3. Promoting Quality Education, Job Skills, and Decent Work.
4. Promoting Gender Equality, Personal Security, and Wellbeing.
5. Averting Dangerous Climate Change and Industrial Pollution.
6. Ensuring Food Security and Sustainable Food Supplies.
7. Protecting Biodiversity and Ecosystem Services.
8. Building Smart, Healthy and Resilient Cities.
9. Fulfilling the Promise of Technologies for Sustainable Development.
10. Ensuring Good Governance and Accountability.

While there is substantial overlap with the set of SDGs suggested by Griggs *et al.* 2013, the SDSN develops the traditional three pillars of sustainable development – economic, social, and environmental – by adding good governance and personal security as a fourth dimension “to highlight several enabling conditions for sustainable development, including transparency, effective institutions, the rule of law, participation and personal security, accountability, and adequate financing for public goods.” They also conclude that well-crafted post-2015 goals should “promote integrated thinking and put to rest the futile debates that pit one dimension of sustainable development against another.” See Appendix 5 for detailed list of the goals and targets.

¹¹ <http://unsdsn.org/files/2012/12/121220-Draft-Framework-of-Sustainable-Development.pdf>

The SDGs must be made operational through a bottom-up approach with scalable indicators.

Scientific insights number 2

Measuring progress on the SDGs will require agreed sets of indicators for use at national, regional and international levels and in developed and developing countries. Although environmental indicators have been developed since the 1960s (OECD 1998), they have in the past been treated separately from social and economic indicators. While significant advances toward developing indicators for multidimensional policy targets have been made, much work remains to be done (e.g. Attaran 2005, McArthur *et al.* 2005, Walpole *et al.* 2009, Reyers *et al.* 2013). Principally, two major obstacles are impeding further progress: (1) inadequate data with which to measure changes in the biosphere, human well-being, poverty, and other components relevant to policy targets (Scholes *et al.* 2008, Reyers *et al.* 2013), and (2) the difficulty in actually measuring the policy target of interest, often on account of poorly understood, unquantified, and complex concepts (e.g. ecosystem services, poverty, and well-being). In the rush to address the first obstacle, data inadequacy issues, the second obstacle has been largely overlooked. This has resulted in a plethora of measures and indicators (based on existing data) that frequently fall short of their intended purpose (Mace and Baillie 2007, Reyers *et al.* 2013).

The Millennium Ecosystem Assessment (MA 2005) developed a framework that allowed for the use of a wide range of indicators (Pereira *et al.* 2005), although these still lacked integration and were not scalable. Indicators were originally designed to span national to global scales (Butchart *et al.* 2010, GBO3 2010) but it has been repeatedly emphasized that there is a need for a set of scalable indicators, which could be used for upscaling of observations from local to global scales as well as downscaling (SCBD 2011). A global observation network with the aim of providing the data and indicators needed by the scientific community, international conventions and IPBES, is now being developed under the auspices of the Group on Earth Observations Biodiversity Observation Network (Scholes *et al.* 2012, Pereira *et al.* 2013).

The task of developing more integrated and scalable indicators will be crucial for SDGs, since it is important to base information on the results of localized interactions. Using indicators that make sense on a local scale and then possible to scale up on a regional and global scale opens up the possibility to engage local stakeholder, citizen groups, indigenous groups and many other knowledge holders in the monitoring, reporting and de-

velopment of the SDGs. One example which aims to do this is the IPBES decision to base assessments on the enriched picture provided by multiple knowledge holders and recognition of multiple sources of evidence for understanding drivers of change and responses in social-ecological systems, the Multiple Evidence Base approach MEB (Box 4).

MEB implies that different knowledge systems are viewed as generating equally valid evidence for interpreting change, trajectories, and causal relationships in ecosystem assessments. A peer-review process for a MEB approach takes into account that different criteria of validation should be applied to data and information originating from different knowledge systems (Duraiappah *et al.* 2012). Placing insights from knowledge systems side by side will enable an enriched understanding of the social-ecological system or the issues at hand, such as understanding effects of climate change in the Arctic, rangeland dynamics, or the role of sacred sites for human well-being (Berkes, 2007, Moller *et al.* 2004). A MEB approach can serve as a learning platform for generating insights and triangulation across knowledge systems, as well as a basis for further co-production of knowledge (see Figure 9 in Box 4).

Box 4. The Multiple Evidence Base (MEB)

Within IPBES, the member states have demanded that the platform “should recognize and respect the contribution of indigenous and local knowledge to the conservation and sustainable use of biodiversity and ecosystems”, as a means of contributing to the platform's four objectives; perform assessments, generate knowledge, identify policy relevant tools, and capacity building. In response to these demands, and similar demands from other assessments and processes, a Multiple Evidence Base (MEB) approach has been developed (Tengö *et al.* 2013) for diverse knowledge systems to contribute on their own terms to an enriched picture based on qualitative and quantitative knowledge and understanding. To secure the legitimacy, credibility, and salience the approach is developed as a dialogue process in partnership between researchers, representatives of indigenous peoples and local communities (and their networks and organizations), practitioners, and governmental, international and intergovernmental institutions (Tengö *et al.* 2013).

Fig. 9. Outlining the Multiple Evidence Base Process, where diverse knowledge systems are viewed as generating different manifestations of valid and useful forms of knowledge, and complementarities and innovations to be gained from cross-fertilization

Illustration: J. Lokrantz/Azote.

The SDGs must consider economic targets and indicators.

Scientific insights number 3

Many argue that we will never achieve sustainable development unless we change the current economic paradigm, which is a fundamental cause of the current crises (e.g. Costanza *et al.* 2012). Hence, it is important to consider GDP and other current measures of national income

accounting in the context of sustainable development goals. Such measures are “notorious for overweighting market transactions, understating resource depletion, omitting pollution damage, and failing to measure real changes in well-being” (ibid.). In the words of Dasgupta and Duraipappah (2012) “we are mis-measuring our lives by using per capita GDP as a yardstick for progress.” A number of alternative measures have been proposed (and to some extent applied) to integrate environmental social aspects in measures of well-being on the national level, e.g. inclusive wealth, genuine savings, Index of Sustainable Economic Welfare (ISEW) and the Genuine Progress Indicator (GPI). However, as noted by Stiglitz *et al.* (2009) there is a risk of integrating too many aspects in aggregated measures, implying that urgently needed measures centred on people’s well-being and sustainability must be plural. There is no single measure that can summarize the full complexity of human well-being in different socio-economic and geographic contexts. What ever system we choose it should not just measure average levels of well-being within a given community, and how they change over time, but also document the diversity of peoples’ experiences and the linkages across various dimensions of people’s life (ibid.).

In summary, the unified framework for the post-2015 agenda and formulation of SDGs that is suggested in this report implies another addition to the evolution of the economic model, beyond the “Green Economy Model” and complementing the “Ecological Economics Model” described by Costanza *et al.* (2012). Such incorporation of the scientific insights provided by Earth system and resilience science could be called a “Biosphere Economics Model” (see table 4).

Table 4. Basic characteristics of the current economic model, the “green economy” model, the “ecological economics” model and the “biosphere economics” model (adapted from Costanza *et al.* 2012)

	Current Economic Model	Green Economy Model	Ecological Economics Model	Biosphere Economics Model
Primary policy goal	<i>More:</i> Conventional economic growth measured by GDP. Assumption is that growth will ultimately allow the solution of all other problems. More is always better.	<i>More but with lower impact:</i> GDP growth “decoupled” from carbon and from other material and energy impacts	<i>Better:</i> Focus must shift from merely growth to “development” in the real sense of improvement in sustainable human wellbeing. More is not always better.	<i>More resilient:</i> Integrating the role of the biosphere and global resilience in macro-economic models to safeguard well-being in an increasingly turbulent world.
Primary measure of progress	GDP	Still GDP, but recognizing impacts on natural capital	Index of Sustainable Economic Welfare (ISEW)/Genuine Progress Indicator (GPI) (or other improved measures of real welfare)	Plural welfare measures centred on sustainability, no single measure can capture the full complexity of human well-being and its relation to the biosphere.

5. Conclusions and recommendations

Based on this overview of the state of the art, our conclusions and recommendations are:

- *First:* We recommend the adoption of a “development within Earth limits” approach in the further process of designing SDGs. We argue that the twin priorities for the formulation of SDGs must be the protection of the biosphere – society’s non-negotiable “life-support systems” – and the reduction of poverty as an essential part of a fair and just global society.
- *Second:* We believe it is important to build the further development on integrating what we already have, respecting the fact that any SDG development needs to build on the MDGs, learning from experiences of the MDGs, ensuring that their advances towards poverty eradication are achieved.

Together, these recommendations require a deeper analysis of the multiple interconnections, trade-offs and synergies between SDGs. Measuring progress in reaching the targets for the SDGs must require an agreed set of scalable indicators that should be inclusive of different knowledge systems, building data and knowledge from local to national, regional and international levels. The environmental targets should be based on the latest research on the dynamics of the Earth system, and benefit from learning and early warning and monitoring activities emerging in multiple knowledge systems.

- *Third:* There are many existing global environmental agreements (such as the Aichi-Biodiversity Targets, see also Table 1) that link closely to planetary boundaries. These form the foundations of a robust policy framework for both the formulation of the SDGs and their implementation. Better integration across the social and environmental dimensions can provide the needed impetus towards closing the current implementation gap.

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7. Svensk sammanfattning

Hur ska FN jobba vidare med hållbar utveckling efter att millenniemålen gått ut 2015? Vad kan den tvärvetenskapliga forskningen om ekosystemtjänster, resiliens och planetens hållbara gränser bidra med i denna process? Detta diskussionsunderlag från Stockholm Resilience Centre vid Stockholms Universitet (som togs fram under perioden mars-oktober 2013) undersöker sambanden mellan mänskligt välbefinnande och biosfären, och beskriver hur och varför dessa länkar bör påverka utformningen av de nya hållbarhetsmålen. Rapporten är finansierad av Nordiska ministerrådet och utgör en uppföljning av ett tidigare diskussionsunderlag, som presenterades för de nordiska miljöministrarna under deras möte i Jukkasjärvi den 7 februari 2013.

Att utarbeta globala hållbarhetsmål – Sustainable Development Goals (SDGs) – var ett av de viktigaste besluten som togs under Rio+20, FNs konferens om hållbar utveckling som hölls i Brasilien i juni 2012. Denna process utgör ett gyllene tillfälle för det internationella samfundet att ta itu med både sociala behov och miljömässiga utmaningar på en och samma gång. Erfarenheterna av arbetet med millenniemålen visar att samordnade ansträngningar för att hantera globala problem kan ge positiva resultat, öka medvetenheten och utkräva globalt politiskt ansvar. Millenniemålen har på så sätt varit framgångsrika när det gäller att uppmärksamma en rad frågor kopplade till extrem fattigdom, men de har inte varit lika lyckosamma när det gäller att koppla de globala miljö- och klimatutmaningarna till fattigdomsbekämpning och människors välbefinnande.

Denna uppföljningsrapport analyserar både vad vi kan lära oss av arbetet med millenniemålen, och hur befintliga internationella överenskommelser bör återspeglas i utvecklingen av en ny global utvecklingsagenda efter år 2015. Rapporten syftar också till att bidra till utarbetandet av de faktiska hållbarhetsmålen, inklusive processorienterade mål och skalbara indikatorer, som lämpar sig för att mäta mänsklig utveckling och global hållbarhet i en alltmer föränderlig omvärld.

Utifrån rapportens genomgång av den senaste forskningen om kopplade sociala och ekologiska system dras tre övergripande slutsatser om utformningen av de nya globala hållbarhetsmålen:

- *De måste bygga på ett synsätt som betonar "utveckling inom planetens hållbara gränser"*

Vi hävdar att de två huvudprioriteringarna i formuleringen av de nya målen måste vara skyddet av biosfären (samhällets icke förhandlingsbara "livsuppehållande system") och minskning av fattigdomen som en avgörande del av ett rättvist globalt samhälle.

- *De måste bygga vidare på erfarenheterna från arbetet med millenniemålen så att deras framsteg mot att utrota bland annat fattigdom och hunger verkligen uppnås*

Tillsammans kräver dessa rekommendationer att de nya hållbarhetsmålen måste gå ett steg längre än den klassiska uppdelningen i sociala, ekonomiska och miljömässiga mål, och undvika att bli en samling enfrågemål. Målen måste istället bygga på insikten att ekologiska och sociala system är oskiljaktigt sammanlänkade och underlätta en djupare analys av alla de kopplingar, avvägningar och synergier som finns mellan olika mål och indikatorer.

Genom att utveckla indikatorer som fungerar på lokal nivå och sedan skala upp dem på regional och global nivå ges möjligheten att engagera lokala intressenter, medborgargrupper, urbefolkningar och många andra kunskapsbärare i övervakning, rapportering och utveckling av hållbarhetsmålen.

Målen och indikatorerna bör baseras på den senaste forskningen om dynamiken i jordens klimat- och ekosystem, och dra nytta av lärande och kunskap om tillståndet i miljön och tidiga varningssignaler som växer fram i flera olika kunskapssystem (alltifrån forskningsbaserad kunskap till praktiska erfarenheter bland resursnyttjare och lokalbefolkningar).

- *De bör även integrera de många befintliga globala miljööverenskommelser som redan är nära kopplade till planetens hållbara gränser*

Överenskommelser som t ex Aichimålen för biologisk mångfald bildar grunden för ett robust ramverk för både utformningen av de nya hållbarhetsmålen och deras genomförande. Genom bättre integration mellan de sociala och miljömässiga dimensionerna kan de nya hållbarhetsmålen ge den nödvändiga drivkraften för att överkomma det nuvarande genomförandegapet mellan många föreslagna åtgärder och satta mål.

8. Appendix

8.1 Appendix 1

List of ecosystem services, as defined in the Millennium Ecosystem Assessment (adapted from World Resources Institute, 2008)

Service	Subcategory	Definition	Examples
Provisioning services: The goods or products obtained from ecosystems such as food, timber and fiber.			
Food	Crops	Cultivated plants or agricultural produce that are harvested by people for human or animal consumption as food	Grains Vegetables Fruit
	Livestock	Animals raised for domestic or commercial consumption or use	Chicken Pigs Cattle
	Capture fisheries	Wild fish captured through trawling and other nonfarming methods	Cod Crabs Tuna
	Aquaculture	Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of freshwater or saltwater confinement for purposes of harvesting	Shrimp Oysters Salmon
	Wild foods	Edible plant and animal species gathered or captured in the wild	Fruit and nuts Fungi Bushmeat
Fiber	Timber and other wood fiber	Products made from trees harvested from natural forest ecosystems, plantations, or nonforested lands	Industrial roundwood Wood pulp Paper
	Other fibers (e.g., cotton, hemp, silk)	Nonwood and nonfuel fibers extracted from the natural environment for a variety of uses	Textiles (clothing, linen, accessories) Cordage (twine, rope)
Biomass fuel (wood fuel)		Biological material derived from living or recently living organisms – both plant and animal – that serves as a source of energy	Fuelwood and charcoal Grain for ethanol production Dung
Freshwater		Inland bodies of water, groundwater, rainwater, and surface waters for household, industrial, and agricultural uses	Freshwater for drinking, cleaning, cooling, industrial processes, electricity generation, or mode of transportation

Service	Subcategory	Definition	Examples
Genetic resources		Genes and genetic information used for animal breeding, plant improvement, and biotechnology	Genes used to increase crop resistance
	Biochemicals, natural medicines, and pharmaceuticals	Medicines, biocides, food additives, and other biological materials derived from ecosystems for commercial or domestic use	Echinacea, ginseng, garlic Paclitaxel as basis for cancer drugs Tree extracts used for pest control
Regulating services including supporting services: Regulating services are the benefits obtained from an ecosystem's control of natural processes such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards. Regulating services normally include also Supporting services, i.e. the natural processes such as nutrient cycling and primary production that maintain the other services.			
Air quality regulation			
		Influence ecosystems have on air quality by emitting chemicals to the atmosphere (i.e., serving as a "source") or extracting chemicals from the atmosphere (i.e., serving as a "sink").	Lakes serve as a sink for industrial emissions of sulphur compounds Vegetation fires emit particulates, ground-level ozone, and volatile organic compounds
Climate regulation	Global	Influence ecosystems have on global climate by emitting greenhouse gases or aerosols to the atmosphere or by absorbing greenhouse gases or aerosols from the atmosphere	Forests capture and store carbon dioxide Cattle and rice paddies emit methane
	Regional and local	Influence ecosystems have on local or regional temperature, precipitation, and other climatic factors	Forests can impact regional rainfall levels Lakes regulate humidity levels and influence frequency of frosts, important for agriculture
	Carbon sequestration	The extraction of carbon dioxide from the atmosphere serving as a sink	Expanding areas of boreal forests, increases the sink Deforestation in the tropics, decreases the sink Ocean carbon sequestration
Water regulation			
		Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge, particularly in terms of the water storage potential of the ecosystem or landscape	Permeable soil facilitates aquifer recharge River floodplains and wetlands retain water – which can decrease flooding during runoff peaks – reducing the need for engineered flood control infrastructure
Erosion regulation			
		Role vegetative cover plays in soil retention	Vegetation such as grass and trees prevents soil loss due to wind and rain and siltation of waterways Forests on slopes hold soil in place, thereby preventing landslides
Water purification and waste treatment			
		Role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water; assimilation and detoxification of compounds through soil and subsoil processes	Wetlands remove harmful pollutants from water by trapping metals and organic materials Soil microbes degrade organic waste, rendering it less harmful

Service	Subcategory	Definition	Examples
Disease regulation		Influence that ecosystems have on the incidence and abundance of human pathogens	Some intact forests reduce the occurrence of standing water—a breeding area for mosquitoes—which lowers the prevalence of malaria
Pest regulation		Influence ecosystems have on the prevalence of crop and livestock pests and diseases	Predators from nearby forests – such as bats, toads, and snakes – consume crop pests
Pollination		Role ecosystems play in transferring pollen from male to female flower parts	Bees from nearby forests pollinate crops
Natural hazard regulation		Capacity for ecosystems to reduce the damage caused by natural disasters such as hurricanes and to maintain natural fire frequency and intensity	Mangrove forests and coral reefs protect coastlines from storm surges Biological decomposition processes reduce potential fuel for wildfires
Nutrient cycling		Role ecosystems play in the flow and recycling of nutrients (e.g., nitrogen, sulphur, phosphorus, carbon) through processes such as decomposition and/or absorption	Decomposition of organic matter contributes to soil fertility
Cultural services: The nonmaterial benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment.			
Recreation and ecotourism		Recreational pleasure people derive from natural or cultivated ecosystems	Hiking, camping, and bird watching Going on safari
Spiritual, religious and ethical values		Spiritual, religious, aesthetic, intrinsic, “existence”, or other values people attach to ecosystems, landscapes, or species	Spiritual fulfillment derived from sacred lands and rivers Belief that all species are worth protecting regardless of their utility to people – “biodiversity for biodiversity’s sake”
Aesthetic values		The beauty and aesthetic values of nature in all its appearances.	Beauty of nature, from a molecule to a flower to a forest

8.2 Appendix 2

The UNEP report *Measuring Progress: Environmental Goals and Gaps*,¹² outlines findings from a UNEP study that has catalogued and analyzed existing “Global Environmental Goals” contained in international agreements and conventions. It asks the fundamental question as to why the aims and goals of these policy instruments have often fallen far short of their original ambition and intentions. One possible reason is that many of the goals are simply not specific enough; the few goals that are specific and measurable appear to have a much better record of success.

Area	Global Environment Goal	IEA	Progress
Atmosphere	<i>Climate:</i> ...deep cuts in global greenhouse gas emissions are required according to science ... with a view to reducing global greenhouse gas emissions so as to hold the increase in global average temperature below 2°C above pre-industrial levels.	The Cancun Agreements, Decision 1/CP.16 of the Conference of the Parties of the UN Framework Convention on Climate Change	Little or no progress
	<i>Stratospheric ozone:</i> Determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it, with the ultimate objective of their elimination.	Montreal Protocol on Substances that Deplete the Ozone Layer, Preamble	Significant progress
	<i>Lead in gasoline:</i> Reduce respiratory diseases and other health impacts resulting from air pollution, with particular attention to women and children, by... supporting the phasing out of lead in gasoline	Johannesburg Plan of Implementation, para. 56(b)	Significant progress
	<i>Outdoor air pollution:</i> Enhance cooperation at the international, regional and national levels to reduce air pollution, including transboundary air pollution [and] acid deposition.	Johannesburg Plan of Implementation, para. 39	Some progress
	<i>Indoor air pollution:</i> [Assist] developing countries in providing affordable energy to rural communities, particularly to reduce dependence on traditional fuel sources for cooking and heating, which affect the health of women and children	Johannesburg Plan of Implementation, para. 56(d)	Little or no progress
Biodiversity	<i>Extinction risk of species:</i> Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss	Millennium Development Goal 7, Target B	Little or no progress

¹² UNEP (2012) *Measuring Progress: Environmental Goals and Gaps*, Nairobi, UNEP. http://www.unep.org/geo/pdfs/geo5/Measuring_progress.pdf

Area	Global Environment Goal	IEA	Progress
Chemicals and wastes	<p><i>Natural Habitats:</i> By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced</p> <p><i>Invasive alien species:</i> By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment</p> <p><i>Access and benefit sharing:</i> By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.</p> <p><i>Protected areas:</i> By 2020, at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.</p> <p><i>Sustainably managed production areas:</i> By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity</p> <p><i>Species harvested for food and medicine:</i> By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity</p> <p><i>Fish stocks:</i> To achieve sustainable fisheries... maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015</p>	<p>Aichi Biodiversity Target 5</p> <p>Aichi Biodiversity Target 9</p> <p>Aichi Biodiversity Target 16</p> <p>Aichi Biodiversity Target 11</p> <p>Aichi Biodiversity Target 7</p> <p>Aichi Biodiversity target 13</p> <p>Johannesburg Plan of Implementation, para. 31 (a)</p> <p>Johannesburg Plan of Implementation, para. 23</p> <p>Johannesburg Plan of Implementation, para. 23(g)</p>	<p>Little or no progress</p> <p>Some progress on policy responses, little or no progress on trends in invasive alien species</p> <p>Some progress</p> <p>Some progress</p> <p>Little or no progress</p> <p>Little or no progress</p> <p>Further deterioration</p> <p>Some progress, insufficient data to assess globally</p> <p>Some progress</p>

Area	Global Environment Goal	IEA	Progress
Land	<i>Persistent organic pollutants:</i> Each Party shall... prohibit and/or take the legal and administrative measures necessary to eliminate its production and use of the chemicals listed in Annex A [selected persistent organic pollutants] subject to the provisions of that Annex.	Stockholm Convention on Persistent Organic Pollutants, article 3.1(a)(i)	Some progress
	<i>Sound waste management:</i> Determined to protect, by strict control, human health and the environment against the adverse effects which may result from the generation and management of hazardous wastes and other wastes.	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, Preamble	Some progress, insufficient data to assess globally
	Radio active waste: The objectives of this Convention are (i) to achieve and maintain a high level of safety worldwide in spent fuel and radioactive waste management... (ii) to ensure... effective defenses against potential hazards... (iii) to prevent accidents with radiological consequences.	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Article 1	Some progress
	<i>Access to food:</i> Halve, between 1990 and 2015, the proportion of people who suffer from hunger	Millennium Development Goal 1, Target C	Some progress on reducing hunger/little or no progress on ensuring sustainable food supply
	<i>Desertification and drought:</i> ...combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa.	United Nations Convention to Combat Desertification (UNCCD), Article 2(1)	Little or no progress
	Deforestation: Reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation	General Assembly resolution 62/98 of 31 January 2008, section IV, Global Objective 1	Some progress
	<i>Wetlands:</i> The Contracting Parties shall formulate and implement their planning so as to promote the conservation of the wetlands included in the List, and as far as possible the wise use of wetlands in their territory	Ramsar Convention on Wetlands, article 3(1)	Further deterioration
	<i>Ecosystem services:</i> To improve recognition of the social, economic and ecological values of trees, forests and forest lands, including the consequences of the damage caused by the lack of forests; to promote methodologies with a view to incorporating social, economic and ecological values of trees, forests and forest lands into the national economic accounting systems....	Agenda 21, Chapter 11, paragraph 21(a)	Little or no progress
	<i>Drinking water:</i> Halve, by 2015, the proportion of people without sustainable access to safe drinking water	Millennium Development Goal 7, Target C	Significant progress, more progress in urban than in rural areas
Water			

Area	Global Environment Goal	IEA	Progress
Policies and programmes	<p><i>Sanitation:</i> Halve, by 2015, the proportion of people without sustainable access to... basic sanitation</p> <p><i>Ground water depletion:</i> To stop the unsustainable exploitation of water resources by developing water management strategies at the regional, national and local levels, which promote both equitable access and adequate supplies</p> <p><i>Water use efficiency:</i> Improve the efficient use of water resources and promote their allocation among competing uses in a way that gives priority to the satisfaction of basic human needs.</p> <p><i>Freshwater pollution:</i> Intensify water pollution prevention to reduce health hazards and protect ecosystems by introducing technologies for affordable sanitation and industrial and domestic wastewater treatment, by mitigating the effects of groundwater contamination and by establishing, at the national level, monitoring systems and effective legal frameworks</p> <p><i>Marine pollution:</i> States shall take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control.</p> <p><i>Corals:</i> States should identify marine ecosystems exhibiting high levels of biodiversity and productivity and other critical habitat areas and should provide necessary limitations on use in these areas, through, inter alia, designation of protected areas. Priority should be accorded, as appropriate to: (a) coral reef ecosystems...</p> <p><i>Extreme events:</i> Support efforts to prevent and mitigate the impacts of natural disasters...</p>	<p>Millennium Development Goal 7, Target C</p> <p>Millennium Declaration, General Assembly resolution 55/2 of 18 September 2000, para. 23</p> <p>Johannesburg Plan of Implementation, para. 26(c)</p> <p>Johannesburg Plan of Implementation, para. 25(d)</p> <p>United Nations Convention on the Law of the Sea, article 196, para. 1</p> <p>Agenda 21, Chapter 17, para. 85 Johannesburg Plan of Implementation, para. 134</p> <p>Johannesburg Declaration on Sustainable Development, para. 5</p> <p>Millennium Development Goal 7, Target A</p>	<p>Some progress</p> <p>Little or no progress on groundwater pollution and monitoring, further deterioration on groundwater supply</p> <p>Some progress</p> <p>Insufficient data to assess</p> <p>Little or no progress</p> <p>Further deterioration</p> <p>Some progress in disaster response and risk reduction, further deterioration in disaster impacts</p> <p>Some progress</p> <p>Insufficient data to assess</p>

8.3 Appendix 3

Comparison between proposed planetary boundary areas with how UNEP chooses to bundle existing Global Environmental Goals, GEGs.¹³

Proposed planetary boundary areas	UNEP bundles of GEGs
Athmospheric aerosol loading	Air pollution and air quality
Biodiversity loss	Biodiversity
Chemical pollution	Chemicals and wastes
Climate change	Climate change
	Energy
	Forests
Global freshwater use	Freshwater
Ocean acidification	Oceans and seas
Land system change	Soil, land use, land degradation and desertification
	Environmental governance
Perturbed biochemical flows (N2 & P)	
Stratospheric ozone depletion	

¹³ UNEP (2012) Compilation of Internationally Agreed Environmental Goals and Objectives, Nairobi, UNEP.

8.4 Appendix 4

Six Sustainable Development Goals proposed by researchers in a commentary article in Nature.¹⁴

Goal	Target
Goal 1: Thriving lives and livelihoods. End poverty and improve well-being through access to education, employment and information, better health and housing, and reduced inequality while moving towards sustainable consumption and production.	This extends many targets of the Millennium Development Goals (MDGs) on poverty, health and urban environments and applies them to developed nations. It should include targets on clean air that build on World Health Organization guidelines for pollutants such as black carbon ⁶ ; reductions in emissions of stratospheric ozone-depleting substances in line with projections from the Montreal Protocol; critical loads for man-made chemical compounds and toxic materials; and sustainable practices for extraction, use and recycling of scarce minerals and metals and other natural resources.
Goal 2: Sustainable food security. End hunger and achieve long-term food security – including better nutrition – through sustainable systems of production, distribution and consumption.	The MDG hunger target should be extended and targets added to limit nitrogen and phosphorus use in agriculture ^{3,7,8} . Nutrient-use efficiency should improve by 20% by 2020; no more than 35 million tonnes of nitrogen per year should be extracted from the atmosphere; phosphorus flow to the oceans should not exceed 10 million tonnes a year; and phosphorus runoff to lakes and rivers should halve by 2030.
Goal 3: Sustainable water security. Achieve universal access to clean water and basic sanitation, and ensure efficient allocation through integrated water-resource management.	This would contribute to MDG health targets, restrict global water runoff to less than 4,000 cubic kilometres a year and limit volumes withdrawn from river basins to no more than 50–80% of mean annual flow ^{3,9} .
Goal 4: Universal clean energy. Improve universal, affordable access to clean energy that minimizes local pollution and health impacts and mitigates global warming.	This contributes to the UN commitment to sustainable energy for all, and addresses MDG targets on education, gender equity and health. To ensure at least a 50% probability of staying within 2°C warming ¹⁰ , sustainability targets should aim for global greenhouse-gas emissions to peak in 2015–20, drop by 3–5% a year until 2030, and fall by 50–80% by 2050.
Goal 5: Healthy and productive ecosystems. Sustain biodiversity and ecosystem services through better management, valuation, measurement, conservation and restoration.	This combines the MDG environmental targets with 2030 projections of the Aichi Targets adopted by the Convention on Biological Diversity (see www.cbd.int/sp/targets). Extinctions should not exceed ten times the natural background rate. At least 70% of species in any ecosystem and 70% of forests should be retained. Aquatic and marine ecosystems should be managed to safeguard areas crucial for biodiversity, ecosystem services and fisheries.
Goal 6: Governance for sustainable societies. Transform governance and institutions at all levels to address the other five sustainable development goals.	This would build on MDG partnerships and incorporate environmental and social targets into global trade, investment and finance ⁴ . Subsidies on fossil fuels and policies that support unsustainable agricultural and fisheries practices should be eliminated by 2020; product prices should incorporate social and environmental impacts. National monitoring, reporting and verification systems must be established for sustainable-development targets; and open access to information and decision-making processes should be secured at all levels.

¹⁴ Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., Shyamsundar, P., Steffen, W., Glaser, G. Kanie, N and Noble, I. (2013). Sustainable Development Goals for people and planet. *Nature* 495, 305–307).

8.5 Appendix 5

Sustainable Development Goals and targets proposed by the Sustainable Development Solutions Network¹⁵

Goal	Goal definition	Targets might cover
Goal 1: End Extreme Poverty	By 2030 extreme poverty in all its forms (as defined by the MDGs) should be eliminated everywhere, with fragile states receiving the special support they need.	Reduction to [zero] in incomes below \$1.25-per-day. [Suitably updated and expanded Targets of MDGs 1–7 included under the goals below]. Enhanced support for highly vulnerable states.
Goal 2: Achieve Development within Planetary Boundaries	All countries have a right to development that respects planetary boundaries and that helps to stabilize the global population by mid-century.	Each country reaches at least the next level in the World Bank country classification. Countries respect planetary boundaries in national policies and incorporate them into an expanded measure of GDP. All high-fertility countries encourage the rapid voluntary reduction of total fertility rates.
Goal 3: Achieve Gender Equality, Human Rights and the Rule of Law	All countries ensure the delivery of public services and rule of law irrespective of gender, ethnicity, national or social origin, to end discrimination and reduce inequality. Ensure freedom from all forms of violence, especially for women and children.	Gender equality in access to public services and participation in the economy and governance. Eradication of discrimination based on ethnic, national or social origin, including in the delivery of public services and the rule of law. Elimination of all forms of violence against every segment of the population, especially women and children.
Goal 4: Achieve Food Security and Rural Prosperity	Countries enable their farmers to adopt improved farming practices and technologies to raise food yields with reduced environmental impacts. Food losses will be low and all people will enjoy healthy diets. The rural sector will provide decent jobs and universal access to basic infrastructure (water, sanitation, transport, energy, and connectivity).	End hunger including stunting of young children Sustainable crop and animal production systems that achieve higher yields with lower inputs of water, energy, and soil nutrients and lower post-harvest losses, and a halt to forest and wetland conversion to agriculture. Provide universal access to basic infrastructure services in rural areas (water, sanitation, modern energy, transport, broadband).
Goal 5: Empower Inclusive, Productive and Resilient Cities	All cities become socially inclusive, economically productive, and resilient to climate change. They will improve governance and policymaking to support rapid urban transformation.	Every city mainstream climate change, disaster risk reduction, and environmental sustainability into ongoing and planned investments. Every city ensure universal access to infrastructure in water, sanitation, energy, transport, and waste management. Every city reduce urban air and water pollution to safe levels.
Goal 6: Achieve Health and Wellbeing at all Ages	Every country ensures universal access to primary health care for communicable and non-communicable diseases, and promotes healthy and sustainable behaviors by all individuals.	Reach universal access to primary healthcare that includes reproductive health services and control of communicable and non-communicable diseases. Reduce child mortality to no more than [25] per 1,000 and maternal mortality to no more than [30] per 100,000 births. Countries report indicators of subjective wellbeing and social capital.

¹⁵ SDSN (2013) An Action Agenda for Sustainable Development, a report to the UN Secretary General.

Goal	Goal definition	Targets might cover
Goal 7: Ensure Effective Learning for Every Child for Life and Livelihood	Each country ensures that all children receive early childhood education and care, and primary and secondary education, to prepare them for the challenges of modern life and for decent livelihoods.	All girls and boys receive quality primary and secondary education, achieving stage-appropriate learning levels. All girls and boys have access to early childhood care and education programs. Youth unemployment is below [10] percent.
Goal 8: Curb Human-Induced Climate Change	Each country reduces greenhouse gas emissions from energy, agriculture, and land-use change to be consistent with global efforts to curb climate change.	Decarbonize the energy system by 2050 with intermediate targets for 2020 and 2030. Reduce non-energy related emissions of greenhouse gases through improved practices in agriculture, land use, and industry. The adoption of market-based incentives and corrective pricing to accelerate the transition to low-carbon energy systems.
Goal 9: Secure Ecosystem Services and Biodiversity	Each country sustainably manages its marine and terrestrial ecosystems to ensure the continuation of robust planetary life support systems, taking into account ongoing climate change, emerging diseases, invasive species, habitat fragmentation, and other drivers of global change.	Polluters pay the full social costs of their pollution and environmental resource use. All countries adopt policies for all ecosystems, including oceans, coastal, forests, wetlands, and others, to address climate change, emerging diseases, invasive species, over-extraction, and other drivers of habitat and biodiversity loss. All countries inventory the biodiversity, ecosystem functions, and ecosystem services at biome and national scales.
Goal 10: Transform Governance for Sustainable Development	All public and private stakeholders commit to transparency, accountability and good governance. The international rules governing international finance, trade, and intellectual property are reformed and made consistent with sustainable development. The financing of poverty reduction and global public goods including climate change are strengthened and based on a graduated set of global rights and responsibilities.	Every stakeholder commits to achieving the SDGs, with governments (national and local) and major companies reporting on performance. Adequate public finance for poverty eradication, including the goal of 0.7% of targets for all high-income countries, and global public goods: international trade, investment, tax, intellectual property, and disclosure rules reformed to be consistent with the Sustainable Development Goals.

8.6 Appendix 6

Table A. Proposed SDGs divided into four types based on their linkages to biodiversity*

Type	Griggs et al. (2013)	Boltz et al. (2013)	Colombia/Guatemala proposal (DESA, 2012)
<i>Type 1: Goals that relate to constituents or determinants of human well-being that directly depend on, and impact, biodiversity and ecosystems</i>	<p>Goal 2: <i>Sustainable food security</i>. End hunger and achieve long-term food security – including better nutrition – through sustainable systems of production, distribution and consumption.</p> <p>Goal 3: <i>Sustainable water security</i>. Achieve universal access to clean water and basic sanitation, and ensure efficient allocation through integrated water resource management.</p> <p>Goal 4: <i>Universal clean energy</i>. Improve universal, affordable access to clean energy that minimizes local pollution and health impacts and mitigates global warming.</p>	<p><i>Food security for all</i>: physical and economic access to sufficient, nutritionally adequate and safe food and its effective utilization; founded upon ecologically sustainable agriculture, fisheries and rural development policies and practices.</p> <p><i>Water security for all</i>: access to safe drinking water and sanitation, secure environmental flows to sustain human and ecosystem health, and protection against water-related hazards.</p> <p><i>Health for all</i>: health equity, health security and healthy environments, ensuring access to treatment for infectious disease and family health, mitigating the emergence and incidence of disease.</p> <p><i>Sustainable energy for all</i>: universal access to energy, with increased share of renewable energy sources and improved energy efficiency.</p>	<i>Advancing Food Security Energy, including from renewable sources</i>
<i>Type 2: Goals that relate to constituents or determinants of human well-being that do not directly depend on, or impact, biodiversity and ecosystems</i>		<p><i>Opportunities for all</i>: reduced poverty and inequality, access to social services and security.</p> <p><i>Peace and justice for all</i>: personal security, political voice, transparent and equitable governance and access to fair justice.</p>	<i>Promoting Sustainable Human Settlement Development</i>
<i>Type 3: Goals that relate to the maintenance of the planet's life support system</i>	<p>Goal 5: <i>Healthy and productive ecosystems</i>. Sustain biodiversity and ecosystem services through better management, valuation, measure, conservation and restoration.</p>	<p><i>Earth system security</i>: policies and incentives for an effective global programme of ecosystem conservation, restoration and low emissions to avoid harmful or irreversible damage to ecosystems.</p>	<i>Biodiversity and Forests Oceans Water Resources</i>
<i>Type 4: Overarching goals that encompass multiple dimensions of sustainable development.</i>	<p>Goal 1: <i>Thriving lives and livelihoods</i>. End poverty and improve well-being through access to education, employment and information, better health and housing, and reduced inequality while moving towards sustainable consumption and production.</p> <p>Goal 6: <i>Governance for sustainable societies</i>. Transform governance and institutions at all levels to address the other five sustainable development goals.</p>		<i>Combating Poverty Changing Consumption Patterns</i>

* Biodiversity and Sustainable Development – the relevance of the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets for the post-2015 development agenda and the Sustainable Development Goals. Key Messages, The seventh Trondheim Conference on Biodiversity, Trondheim, Norway, 27–31 May 2013 Document TC7/INF2.

Table B. How the Strategic Plan for Biodiversity 2011–2020 and the Aichi targets can be integrated into different types of proposed SDGs*

Type	Modality for integration of biodiversity	Relevant targets and other elements of the Strategic Plan	Example indicators
Type 1: Goals that relate to constituents or determinants of human well-being that directly depend on, and impact, biodiversity and ecosystems	Targets or indicators related to biodiversity could be integrated under this type of goal	Targets 5, 6, 7, 8, 9, 13	E.g. for food: Diversity of crops and livestock in production. Fertilizer use efficiency. Pesticide use. Water use. Land use change. Catch per unit effort (fisheries).
Type 2: Goals that relate to constituents of determinants of human well-being that do not directly depend on, or impact, biodiversity and ecosystems	Information (but no specific reference in the framework)	Target 1, target 18	
Type 3: Goals that relate to the maintenance of the planet's life support system	The Goal itself could be a biodiversity goal which could be derived from the Vision of the Strategic Plan. This could be supported by more specific targets and indicators.	Vision statement Potentially all targets, but especially T5, T10, T11, T12, T13, T14, T15	Forest area. Wetland area. Protected areas. Abundance (LPI:fish stocks) Threatened species status.
Type 4: Overarching goals that encompass multiple dimensions of sustainable development.	Targets or indicators related to biodiversity could be integrated to this type of goal.	Vision statement Target 4: Reference to sustainable consumption and production (<i>Goal or Target</i>) Goal A and targets 1–4	Broad based measures of societal progress – beyond GDP (<i>Indicator</i>) in line with target 2

* Biodiversity and Sustainable Development – the relevance of the Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets for the post-2015 development agenda and the Sustainable Development Goals.Key Messages, The seventh Trondheim Conference on Biodiversity, Trondheim, Norway, 27–31 May 2013 Document TC7/INF2.

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The development of a Post-2015 agenda and Sustainable Development Goals, SDGs, provide a global window of opportunity to address both social needs and environmental challenges together. This discussion paper by the Stockholm Resilience Centre looks into the links between human wellbeing and the biosphere, and describes why and how these links should influence the formulation of the new SDGs. It explores what we can learn from the MDGs, and how existing international agreements can be reflected in the Post-2015 MDG process. The paper also seeks to contribute to the elaboration of targets, including process-oriented targets and scalable indicators suitable for a rapidly changing world.

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