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Scenario

4. Future pathways toward sustainable development

"Life can only be understood backwards; but it must be lived forwards." (Søren Kierkegaard)

"Two different worlds are owned by man: one that created us, the other which in every age we make as best as we can." (Zobolotsky (1958), from Na zakate, p. 299.)

This chapter compares semi-quantitative narratives of what would happen, if we continued as we did in the past, with alternative pathways towards global sustainable development. The "stories" are internally coherent and deemed feasible by experts, as they are derived from large-scale global modelling of sustainable development scenarios for Rio+20 in 2012.

4.1. If we continue like in the past: a "dynamics-as-usual scenario" 2010-2050

No one knows which path the world will take in the next 40 years. But there should remain no doubt that there has been an impressively strong consensus among experts since the 1970s about the major sustainability issues and the broad direction of trends, even though the precise magnitude and dynamics of the future sustainability challenge and eco-efficiency remain unknown. In contrast, perspectives differ greatly on the suggested policy solutions arising from different world views, grounded in different values.[1]

The majority - but not all - scientists are concerned about the trend outlook for the next two generations.

The UN crowd-sourcing platform registered 202 contributions from scientists around the world who voted on each other's ideas and collectively contributed a total of 95 ideas in response to the question "*What do you think the world will be like in 2050?*" The fifteen most popular ideas submitted capture almost exclusively environmental and development concerns which are prominent on the UN agenda, such as accelerating climate change, global collapse of ocean fisheries, economic growth, inequity, poverty and hunger (Table 1). In contrast, among the least popular ideas submitted were suggestions of peak material consumption, peak farmland, declining per capita energy use, large-scale efforts to reduce the human ecological footprint, and a "paradigm shift paradigm shift toward more holistic and sustainable values well under way".

Table 1. Top-15 crowd-sourced ideas on "What do you think the world will be like in 2050?"

Idea	Score
Global collapse of ocean fisheries before 2050.	90
Accelerating climate damage	89
There will be increasing inequity, tension, and social strife.	86
Global society will create a better life for most but not all, primarily through continued economic growth.	86
Persistent poverty and hunger amid riches	86
Humanity will avoid "collapse induced by nature" and has rather embarked on a path of "managed decline".	83
Two thirds of world population under water stress	83
Urbanization reaches 70% (+2.8 billion people in urban areas, -0.6 billion in rural areas).	83
The number of people going hungry is reduced by 500 million people, still leaving 250 million with insufficient food intake.	83
Continued lack of understanding of the complex non-linear dynamics of ecosystems.	80
Food production peaks around 2040 at a level 60% above today's current levels, in terms of tonnes of food per year.	75
Gross world product keeps growing until the second half of the 21st century, but at an ever decreasing rate.	75
Temperatures and sea-levels will continue rising as will the share of renewable energy use.	75
Massive human interference with P and N cycles well beyond safe thresholds	75
GHG emissions will increase by 70%, from 48 to 83 GtCO2-equiv. Most of the GHG emissions increase will be in BRICS.	75

The following is a sketch of what the world could look like in 2050, if we continued the historical path of incremental improvements in reaction to perceived crises, instead of a shift toward a long-term perspective anticipating the troubles ahead. If not explicitly stated otherwise, the following description of the *dynamics-as-usual* (DAU) world in 2050 follows the trend scenarios prepared by OECD[2] and PBL[3] for Rio+20 in 2012.

The dynamics-as-usual world in 2050 is a "growth first"-scenario. It is one of excessive material consumption by 6 billion people in both "North" and "South" which will be at the expense of another 3 billion people living in abject poverty, suffering much of the negative consequences of the others' "overconsumption" which by its sheer scale will have transgressed the majority of "planetary boundaries"[4], eventually leading to global collapse. Such potential collapse is not included in any of the mainstream trend scenarios. Hence, the following is an optimistic view of the consequences of continuing as in the past. The dynamics-as-usual scenario describes a future world that results from a continuation of incremental progress, in line with

historical patterns and trends. It is the closest to a future "projection".[5] Table 2 provides an overview of what this scenario might mean by 2050 which is described in more detail below.

Table 2. Brief characterization of the consequences of continuing like in the past (a "dynamics-as-usual scenario" 2010-2050).

Sustainability	*Development*
Nature in 2050 Crisis responses to irreversible environmental events. Accelerated increase in GHG emissions and global warming. Unabated, continued loss of biodiversity. Massive human interference with P and N cycles well beyond safe thresholds.	**People in 2050** A more crowded, urban world. Persistent poverty and hunger amid riches. One billion people without access to basic services. Billions excluded from otherwise improved global health. Universal primary and secondary education for all. Social safety nets increase coverage in developing world, but are reduced in the developed world.
Life support in 2050 Only isolated examples of systemic changes in consumption patterns. Two thirds of world population under water stress. Global deterioration of urban air pollution, but fewer deaths from indoor air pollution. Protected land and marine areas increase. Fewer forests, more land for agriculture until 2030, then reversed trends. Unabated increase in hazardous chemicals exposure. Global collapse of ocean fisheries.	**Economy in 2050** Economic growth remains the top policy priority in most countries. A global middle class in a US$300 trillion world economy amid abject poverty. Improvements in technology and eco-efficiency at historical rates. An energy-hungry, fossil-fuelled world. A thirsty world. A world repeatedly rippled by price shocks and supply disruptions.
Community in 2050 Continued resurgence of intra- and inter-country conflict at least for the medium-term, fueling multiple, protracted crises.	**Society in 2050** Continuing past trends would suggest widening governance, continuing globalization (with possible regional ups and downs), changing values, and a greatly enhanced role of women.

4.1.1. People in 2050 in a dynamics-as-usual scenario

The world in 2050 will be a more crowded, urban world. Population will follow the UN median projection. World population will be 9.2 billion in 2050, which is 2.2 billion higher than today, with most of the increase in South Asia, the Middle East and Africa. Urbanization will reach 70%, implying an increase of 2.8 billion people in urban areas, compared to a decrease of 0.6 billion in rural areas. According to other trend estimates, about 4 billion people will be added to in urban areas, requiring the building of 400 mega-cities in and around existing cities.[6]

The world in 2050 will be one of persistent poverty and hunger amid riches. Great progress is expected for another 2 billion people being lifted from poverty and hunger. As in recent decades, such progress will be fast enough to compensate for the growing world population, but leave roughly as many people extremely poor - almost 3 billion people living on <US$2 per day - as there are today. The number of people going hungry will likely be reduced by 500 million people, still leaving 250 million with insufficient food intake.

By mid-century, more than 240 million people, mostly in rural areas, will remain without access to improved water sources, and 1.4 billion people without access to basic sanitation. Child mortality from diarrhoea, caused by unsafe water supply and poor sanitation, will decrease, but Sub-Saharan Africa will lag behind.

Progress toward universal access to electricity and modern cooking fuels continues, but its pace differs greatly among countries. Global universal access is not achieved before the end of the 21st century. By 2050, there will be some 1.8 billion people without access to modern energy services for cooking and heating, down from 2.75 billion in 2010.

By 2050, billions will continue to be excluded from otherwise improved global health. For example, global premature mortality from malaria is expected to be halved to 0.4 million from 2010 to 2050.

Universal primary and secondary education for all will have been achieved by 2050. Great progress is expected on making not only primary, but also secondary education universal, with women most likely accounting for most of the higher-level degrees worldwide in 2050.[7]

Public investments in education, health, water and sanitation tend to increase in today's developing countries, and especially emerging economies, but are gradually reduced in today's developed countries. Social safety nets in developing countries evolve slowly towards increased coverage, but remain limited to the formal economy, whereas the coverage is gradually reduced in today's developed countries. There are no special efforts to reduce income disparities between countries or within countries.

4.1.2. Economy in 2050 in a dynamics-as-usual scenario

In line with current trends, economic growth remains the top policy priority in most countries, but an increasing number of social and environmental issues are increasingly taken seriously and are being addressed within the growth-focussed paradigm. This will also be reflected in an increasingly complex and wide ranging system of regional and global institutions.

By 2050, a global middle class will emerge amid abject poverty. Gross world product quadruples to US$300 trillion, with BRICS alone accounting for 40% of the world economy in 2050. Income convergence across countries continues rapidly, reaching ranges between emerging and developed countries similar ranges between developed countries today. Average GDP per capita is expected to triple to US$33,000 in 2050, a level similar to OECD countries today where GDP per capita is expected to double to US$69,000. GDP per capita in BRICS would quintuple to US$37,000 in 2050. However, some of the most vulnerable and poorest economies remain marginalized and in abject poverty.

The trade, intellectual property rights, and investment and financial systems, including official development flows follow the assumptions in the business-as-usual scenario. Incremental technology progress proceeds in line with historical patterns, including in terms of eco-efficiency. This is achieved with ever increasing public commitments and investments, as gaps become increasingly evident. As a result, "green" sectors are supported by governments and develop faster than other sectors, but do not receive support commensurate with the social and environmental efforts. Energy efficiency, water efficiency, and crop yields continue to improve as per past trends.

Renewable energy diffuses slowly into the global primary energy mix, with large differences among countries. Until at least the mid-21st century, fossil fuels remain the dominant energy source. Governments fully implement the present biofuels mandates for 2020-2025, but thereafter there is potentially a significant backlash, in view of ensuing land conflicts and rising food prices.

Global primary energy use increases by 80%, with a fairly stable mix of fossil fuels (85%), modern renewable sources (10%), and nuclear energy (5%). Rapid energy efficiency and intensity improvements will continue to be outstripped by energy demand. Absolute demand for biofuels will increase by at least on third by 2035, requiring additional land, including from clearing forests and pastureland conversions, which will put additional pressure on food prices leaving millions of urban dwellers hungry.

Water demand increases by 55%, mainly due to manufacturing (+400%), electricity (+140%) and domestic use (+130%). In the face of competing demands, there will be little scope for increasing irrigation.

The world in 2050 will be one that continues to be repeatedly rippled by price shocks and supply disruptions. National energy security is expected to decrease for most countries, especially the large, Asian economies. Pressure on exploration and opening of lower quality, unconventional fossil fuel sources will contribute to repeated major energy crises that will adversely affect the poor and food security.

4.1.3. Life support in 2050 in a dynamics-as-usual scenario

There will only be isolated national examples of systematic, direct efforts to change consumption patterns by mid-century. Instead, policy makers rely primarily on price signals to impact consumer behaviour, but prices remain too low to achieve eco-efficiency changes commensurate with the challenges, in view of the successful lobbying efforts of special interest groups and strategic gaming behaviour of market actors.

In 2050, a whopping 3.9 billion people (>40% of world population) will live in river basins under severe water stress, and 6.9 billion people will experience some water stress. Groundwater continues to be exploited faster than it can be replenished (>280 km^3 per year) and is also becoming increasingly polluted. Surface water and groundwater quality is stabilized and restored in most OECD countries, whereas it deteriorates in developing countries. The number of people at risk from floods might increase by 400 million to 1.6 billion, with the value of assets at risk almost quadrupling to US$45 trillion.

Pollution loads by industry continue past trends, including for pollution from toxic chemicals. Transfer of chemical and

electronic waste to developing countries is progressively restricted to reflect stricter regulations or enforcement in some regions.

Urban air quality will continue to deteriorate globally, with concentrations in many cities far exceeding acceptable health standards. Premature deaths from exposure to particulate matter might double to 3.6 million per year, SO_2 emissions increase by 90% and NO_x emissions by 50%. This is despite continued declines in SO_2, NO_x and black carbon emissions in developed countries. Yet, there will be fewer premature deaths from indoor air pollution after 2020.

Protected land and marine areas continue to increase. No global management of fisheries is reached.

Agricultural land area is expected to increase until 2030, intensifying competition for land, and might decline thereafter, in line with declining population growth and agricultural yield improvements. Deforestation rates most likely continue to decline, especially after 2030, but most primary forests might be destroyed by 2050.

World chemicals industry sales are expected to grow by about 3% per year to 2050, leading to an unabated increase in the global burden of disease attributable to exposure to hazardous chemicals.

Continued overfishing beyond maximum sustainable yield, together with ocean warming and acidification, eutrophication, habitat degradation, and destruction of coral reefs, might lead to a global collapse of ocean fisheries based on "wild catch", with efforts to replace by aquaculture-based fisheries.

4.1.4. Nature in 2050 in a dynamics-as-usual scenario

Many of the planetary boundaries, including in terms of climate change, are expected to be breached. Irreversible environmental events and social strife are of increasing concern. Governments focus on crisis response rather than structural change.[8]

Limited effort is made on climate (continuing the increase in voluntary emissions reductions), reflecting lack of a binding multilateral agreement post Kyoto. GHG emissions are expected to increase at an accelerated rate at least until 2030, leading to an increase 48 to 83 $GtCO_{2\text{-equiv}}$ from 2010 to 2050. Most of the GHG emissions increase will be due to large emerging economies. This is despite expected decreases in LULUCF emissions from 2040 onwards. Atmospheric GHG concentrations might reach about 685 ppmv ($CO_{2\text{-equ.}}$), eventually leading to a 3-6˚C warming.

Biodiversity loss is expected to continue unabated. Biodiversity[9] is expected to decline by at least 10%, with the highest losses in Asia, Europe, and Southern Africa[10], and pressure from invasive alien species will increase. Primary forests will steadily decrease until few will be left, even if zero net forest less were to be achieved after 2020.

Human interference with P and N cycles will continue well beyond safe thresholds. Eutrophication of surface water and coastal zones is expected to increase almost everywhere until 2030. Thereafter, it might stabilize in developed countries, but continue to worsen in developing countries. Globally, the number of lakes with harmful algal blooms will increase by at least 20% until 2050. Phosphorus discharges will increase more rapidly than those of nitrogen and silicon (exacerbated by the rapid growth in the number of dams).

4.1.5. Society and community in 2050 in a dynamics-as-usual scenario

Mainstream BAU/DAU scenarios say nothing about future trends in neither community nor society. This is in contrast to some sustainable development assessments of the past. However, continuing past trends would suggest widening governance, continuing globalization (with possible regional ups and downs), changing values, and a greatly enhanced role of women. Continuing past trends suggest a continued resurgence of intra- and inter-country conflict at least for the medium-term, fueling multiple, protracted crises.

4.2. A better world we can achieve: a sustainable development scenario

The UN crowd-sourcing platform registered 287 contributions from scientists around the world who voted on each others ideas and contributed a total of 61 ideas in response to the question "*What kind of world would you like to see for yourself, your children and grandchildren in 2050?*". The fifteen most popular ideas submitted capture areas of immediate development and social concerns, such as poverty, hunger, vitamin deficiencies, social protection, universal access to basic services universal education, as well as human rights and access to justice, redress and remedy for all. In contrast, among the least popular ideas submitted were suggestions to reduce water stress, reduce air pollution and various climate change targets.

Table 3. Top-15 crowd-sourced ideas on "What kind of world would you like to see for yourself, your children and grandchildren in 2050?"

Idea	Score
Access to justice, redress and remedy for all	92
Vitamin deficiencies eliminated	90
No hunger	90
Social protection floor everywhere	89
Greatly reduced child mortality	88
Contraception available to all who want it	85
World peace and human security	85
Universal access to improved water source and basic sanitation	85
No poverty worldwide	83
Universal access to waste water treatment and solid waste management services	79
Access to decent work, socially fair and environmentally correct	78
Political, economic and social human rights for all	75
150 million hectares of degraded lands restored	73
Universal primary and secondary education	71
Universal access to modern, clean and affordable energy services	71
Life expectancy greater 80 years in all countries	71

Consistent paths to a "better world" are described in a number of sustainable development scenarios for Rio+20. The following description of a sustainable development future in 2050 is based on results from the following sustainable development scenarios:

- Global Energy Assessment Scenarios by the International Institute for Applied Systems Analysis (IIASA), Austria,[11]
- Rio+20 scenarios by PBL Netherlands Environmental Assessment Agency[12],
- Alternative pathways toward sustainable development and climate stabilization (ALPS) by RITE, Japan,[13]
- Shared Development Scenarios (SDA) for Rio+20 by the Stockholm Environment Institute (SEI), Sweden[14]
- Green growth scenarios for Rio+20 by OECD,[15]
- Great transition scenarios (2010 update) by Tellus, USA,[16]
- Exploratory WITCH scenarios by Fondazione Eni Enrico Mattei (FEEM), Italy,[17]
- Global resource scenarios of the climate-land-energy and water (CLEWs) Nexus by the Royal Institute of Technology (KTH), Sweden, and the United Nations-Department for Economic and Social Affairs (DESA)[18]
- Sustainable Development Global Simulation by National Academy of Sciences of Ukraine; Geophysical Center of Russian Academy of Science; Ukrainian Branch of World Data Center.[19]
- In addition, a number of prominent recent reviews of scenarios were considered, where appropriate, including World Wildlife Fund's Living Planet[20], UNEP's GEO-5 scenario review[21], the World Business Council for Sustainable Development's sustainable vision 2050[22], and the World Economic Forum's global risk report.[23]

While they do not refer to one single scenario, these mainstream scenarios are fairly similar in spirit and content, not least because they all bear close "family resemblance" with the IPCC SRES scenario B1.[24]

The sustainable development scenario describes a future world in which policy follows an integrated approach to economic, social and environmental goals, and major institutional change, with the overall goal of development that "*meets the needs of the present without compromising the ability of future generations to meet their own needs*". It describes a world that is clearly much more in line with the world that we all want. It is more sustainable in environmental and social dimensions and promises a decent quality of life for all people.

The sustainable development scenario reflects an integrated focus on the three pillars of sustainable development, as well as an explicit integration of (dynamic) planetary limits to ecosystems capacity. Conscious efforts are made by the international community to achieve and sustain MDGs-related goals relating to basic access to services, education, and health, and to reduce aggregate income disparities across regions in the long term. This scenario implies new economic structures, different allocation of capital and investment among public and private sectors, cooperative management of the commons at the global and national levels. In the latter half of the 21st century, sustainable development would be achieved in the sense that all regions are developed, poverty is eradicated, and the demand on natural sources and sinks does not exceed their regeneration capacity. Yet, this world in 2050 will be far from a paradise vision.

4.2.1. People in 2050 in a sustainable development scenario

In the sustainable development world, the proportion of people who suffer from hunger would be halved by 2015. It would further halved by 2030, and eradicated by 2050.[12] In

another account of such world, chronic hunger would be reduced by 50%, 75% and 94%, by 2025, 2050, and 2100, respectively.[16] Poverty as a whole could be virtually eliminated worldwide by 2050.[14]

Great progress would be made in terms of improving access to water and sanitation. In particular, the proportion of the population without sustainable access to safe drinking water and basic sanitation by could be halved by 2015, followed by another halving 2030. Eventually, universal access to improved water source and basic sanitation would be achieved by 2050.[12]

Universal access to electricity and modern cooking fuels could be achieved by 2030.[11,12] Others believe it might take until 2050.[14] This achievement, together with other pollution measures, would significantly decrease the impact of environmental factors on human health, as measured by DALY.[12]

Universal primary education is achievable by 2015.[17] Global population growth would slow, with an expected peak population to be reached in 2050. Global population could be reduced by about one billion, simply by making contraception available to all who want it and by increasing opportunities for girls and women to have education and jobs.[25]

This world would continue to become more urban like in the dynamics-as-usual world. Yet, special efforts will be made to ensure the provision of reliable and high quality public services not only in smaller urban centres but also in remote areas, which, however, is not expected to significantly alter the global trend toward urbanization and a global network of mega-cities.

4.2.2. The economy in 2050 in a sustainable development scenario

In the sustainable world, economic growth would no-longer be the primary goal, nor one of the most important goals. Yet, as a result of pursuing other SDGs, global income convergence is expected, including through catch-up development of African countries by mid-century.[17] As a result, GDP per capita might be more than US$10,000 (in PPP terms) in all regions by 2050.[14]

By the end of the 21st century, differences in GDP per capita between countries worldwide would be similar to the prevailing such differences between OECD countries today. This leads to much lower differences in incomes across countries, as well as conscious efforts to limit intra-country income differences, and thus significantly lower conflict potential.

Despite this much higher incomes in all world regions, the world would manage to optimize energy efficiencies and conservation, so that it could do with primary energy use of less than 70GJ per capita by 2050.[17]

Absolute water use will increase from 3,560 km^3 in 2000 to 4,140 km^3 in 2050. This is at least 25% lower than in the trend scenario due to accelerated increases in water efficiency and conservation.[15]

The sustainable development world would also benefit from higher energy security, due to limited energy trade, increased diversity and resilience of energy supply by 2050, much of which as a co-benefit of environmental policies.[11]

Possibly, in this scenario the 500 million richest people, regardless in which developing or developed country they live, would take a leading role in changing their consumption pattern and contribute resources to eradicate poverty. The high willingness to pay for technology performance by these "rich" leads to accelerated technology change toward cleaner clusters that are thereafter gradually adopted by lower income groups.

4.2.3. Life support in 2050 in a sustainable development scenario

Despite all the water measures taken in the sustainable development world, it is expected that there might be an additional 2 billion people living under severe water stress compared to the year 2000, reaching 3.7 billion people living under water stress in 2050.[15] More optimistic scenarios outline pathways toward a future in which the number of people living under severe water stress could be limited to less than 2 billion until 2050.[16] In all these cases, it would mean a significant reduction of the number of people living in water scarce areas compared to the trend scenario.[12] However, overall flooding risks, as well as surface or groundwater quality are expected to continue to worsen, even in this "better world we can achieve".

Great improvements could be achieved in terms of reducing air pollution. In particular, it should be possible to keep PM2.5 concentrations below 35 $\mu g\ m^3$ by 2030[12], and to reduce NO_x, SO_2 and black carbon emissions by 25% compared to the baseline by 2050.[16] Reduced air pollution could reduce the number of premature deaths globally by 50% by 2030.[11]

Similarly, in this world deforestation and land degradation will be slowed and later even reversed deforestation.[16]

In this world, increased efforts will be made to minimize chemicals pollution to the environment and related health hazards. However, even with such efforts, chemicals will most likely continue to pose serious and even increasing threats to human health and the environment in the future. This is in part due to chemicals and materials needed for the production of "green technologies" needed to address the series of global commons issues.

Overfishing will be slowed and fish stocks later restored towards mid-century.[16]

4.2.4. Nature in 2050 in a sustainable development scenario

Coordinated efforts are made to curb greenhouse gas emissions in order to achieve scientifically recommended targets (e.g. 350 ppm), through the whole range of possible policies, technologies and regulations. Global average temperature change could be limited to 2°C above pre-industrial levels with a likelihood of at least 50% (or 60%) from 2050 to 2100.[11,12,15,16] This could be achieved by stabilizing atmospheric GHG concentrations below 450 ppmv $CO2_{-eq}$. from 2010 to 2100[12], even though lower targets of 350ppmv appear possible as well by 2100[16], all of which would however, require unprecedented measures and global collaboration.

In this "better future we can achieve", the extinction of known threatened species will be prevented and the situation improved of those in most decline by 2020. In quantitative terms, the world will achieve halving the rate of biodiversity loss by 2020 and stabilizing biodiversity at that level (depending on region) by 2050. The rate of loss of natural habitats would be halved and degradation and fragmentation reduced by 2020. Ultimately, at least 17% of terrestrial and inland water areas and 10% of coastal and marine areas would be conserved by 2020, in line with the CBD Aichi protected area targets.[12, 15]

Great efforts will be made to limit the continued rise of human interference with the global phosphorus and nitrogen cycles, however, only with limited success, through removal in wastewater treatment and reduction in its use, but without harming the ability of the agricultural system to meet the hunger target. [12,15]

4.2.5. Community and society in 2050 in a sustainable development scenario

Developments in community and society will be essential to achieve such comprehensive transformation to a sustainable development world. However, as scenario analysts do not offer a clear vision of what changes this would precisely entail, we do not offer any further details in this area either.

Table 4 provides an overview of the goals and targets contained in the sustainable development scenarios for Rio+20, the outcome of which in 2050 has just been described.

Table 4.Goals and targets in sustainable development scenarios for Rio+20

Vision		Theme	Types of goals, targets, and outcomes	IIASA-GEA	PBL	SEI	OECD	RITE-ALPS	FEEM	GSG
To develop	People	Poverty	Eradicate hunger by 2050		X					X
			Eliminate poverty by 2050			X				
		Access	Universal access to improved water source and basic sanitation by 2050		X		X			
			Universal access to electricity and modern cooking fuels by 2030 {or 2050}	X	X	{X}				
		Health & education	Decreased impact of environmental factors on DALY		X					
			Universal primary education by 2015						X	
	Economy	Income	GDP per capita > US$10,000 PPP in all regions by 2050			X				
			Income convergence; catch-up of Africa by 2050						X	
		Resources	Primary energy use less than 70GJ per capita by 2050						X	
			Primary energy use per capita is only 13% higher in 2050 than in 2010, and 48% higher in 2100.					X		
			Use of renewables increase by 3.1 times from 2010 to 2050.					X		
			Water demand increases from 3,560 km^3 in 2000 to only 4,140 km^3 in 2050				X			
		Security	Limit energy trade, increase diversity and resilience of energy supply by 2050	X						
			Population weighted average of energy security index increases only by 2.3.					X		
To sustain	Life support	Resources	Limit the increase in the number of people under severe water stress to an additional +2 bln {or +1.4 bln) from 2000, reaching 3.7 bln {or 3.1bln} in 2050.				X	{X}		
			People under severe water stress <2 bln until 2050 {or 2.9 billion in 2100}					{X}		X
			Reduce number of people living in water scarce areas vs. trend scenario		X					
			Reduce the area for energy crop production to almost zero by 2020. From 2010 to 2050, limit increase in cropland area for food production to +15%, and reduce the irrigated area for food production by 5%.					X		
			Cumulative fossil fuel use limited to <520 Gtoe from 2010 to 2050					X		
			Slow and later reverse deforestation and land degradation							X
			Slow overfishing and later restore fish stocks							X
		Air pollution	Keep PM2.5 concentration below 35 µg m^3 by 2030		X					
			Reduce NO_x, SO_2 and black carbon emission by 25% vs. baseline by 2050 Reduce				X			
			SO_2 by 42% and black carbon by 21% by 2050 vs. 2010					X		
			Reduce premature deaths due to air pollution by 50% by 2030	X						
	Nature	Climate change	Limit global average temperature change to 2°C [or 2.8°C] above pre-industrial levels with a likelihood of >50% {or 60%} by 2100.	X	X	{X}	X	[X]		X
			Atmospheric GHG concentration stabilization below 450 ppm [or 350ppmv] {or 550ppmv} CO_2-eq. by 2100.		X				{X}	[X]
			Limit ocean acidification to keep aragonite stable, with pH=8.0 in 2150					X		
		Biodiversity	By 2020: Prevent extinction of known threatened species and improve situation of those in most decline; halve the rate of biodiversity loss; halve the rate of loss of natural habitats and reduce degradation and fragmentation by 2020; conserve at least 17% of terrestrial and inland water. By 2050: stabilize biodiversity at the 2020/2030 level.		X					
			CBD Aichi protected area targets of 17% of terrestrial and inland water areas and 10% of coastal and marine areas by 2020.		X		X			
		Phosphorus and nitrogen cycles	Phosphorus removal in wastewater treatment increases from 0.7 Mt in 2000, 1.7 Mt in 2030, to 3.3 Mt in 2050				X			
			Reduce N/P use where possible, but without harming the ability of the agricultural system to meet the hunger target		X					

Sources: IIASA-GEA (Riahi et al., 2012)[11]; PBL (van Vuuren et al., 2012)[12]; SEI (Nilsson et al., 2012)[14] ; OECD (2012)[15]; RITE-ALPS (Akimoto et al., 2012)[13] ; FEEM (2011)[17]; GSG (Raskin et al., 2010)[16].

4.3. The most likely world in 2050? A prediction for the world in 2052

Jorgen Randers, one of the authors of the "Limits to Growth" report in 1972, presented a new report to the Club of Rome in 2012. In the book, entitled "*2052*" he reflects on his forty years of "*worrying about the future*", based on which he prepared a "*forecast*" for 2052. Indeed, it is a forecast and not as a scenario, as he believes that humanity will continue not take the necessary actions to get on a desirable SD path that could have prevented overshoot. It is against this background that he predicts a future world in "*managed decline*".[26]

While the study considers a wide range of constraints, such as finite reserves of fossil fuels, finite availability of arable land, finite amounts of wild fish, and finite space for biodiversity reserves, it foresees the emerging climate crises as the most pressing global constraint over the next forty years. GHG emissions are already two times higher than what is absorbed by oceans and forests. The study notes that the world is already in "overshoot", heading towards the climate crises. Increasing atmospheric GHG concentrations and rising temperatures will worsen humanity's living conditions increasingly. Actions are not expected to be sufficient to limit global warming to below plus 2°C. However, there are signs that humanity will avoid "*collapse induced by nature*" and has rather embarked on a path of "*managed decline*".

The study predicts most variables to follow historical trends until around 2030, after which a number of "*variables start to stagnate and decline*". Temperatures and sea-levels will continue rising as will the share of renewable energy use.

While global CO_2 emissions might peak around 2030, they will fall back to 2010 levels by 2050, due to economic decline and continued incremental progress in emissions mitigation. While global CO_2 emissions will fall linearly from 2050 to zero in 2100, global temperature will continue increasing through the second half of the 21st century.

Global population might peak by 2040 and slowly decline thereafter. Global primary energy use is forecast to peak in the year 2042, staying almost flat between 2030 and 2050. Per capita energy use will decline gradually after 2035, due to energy efficiency investments.

Global consumption (i.e., the annual expenditure, private and public, on goods and services) will peak around 2050. Gross world product keeps growing until the second half of the 21st century, but at an ever decreasing rate. GDP per person continues increasing, as does annual production of goods and services. Investment shares in GDP start rising, in view of needed investments to tackle depletion, pollution, climate change, and biodiversity loss. Production of consumer goods and services per person peaks around 2050 and declines thereafter.

Food production peaks around 2040 at a level 60% above today's current levels, in terms of tonnes of food per year. Climate change starts to reduce the amount of land suitable for agriculture and to slow the rise in land yields, overwhelming the fertilizing effect of more CO2 in the atmosphere. Per capita food availability stagnates at 30% above today's level, which means that many people will still go hungry.

The ecological cost of growth will be seen in the continuing fall in the amount of unused biological capacity. By 2050 half of all land that had been unused by humans in 2010 will have been grabbed for human use, e.g., for buildings, infrastructure, forestry, and agriculture.

The study's author characterizes the future depicted in his forecast as one of collective failure as the most likely future outcome: "*I would not say the future I've just described is anyone's goal. It is not where I, nor the contributors to the book, or likely you as a reader, would want to go…. we won't go there as a result of consciously bad intent. Rather, we will go there in a forty-year-long marathon during which global society will try to create a better life for everyone—mainly through continued economic growth. The effort will succeed in some places, but not everywhere. Billions will be better off in 2052 than in 2012, and some will reach Western lifestyles. The poorest two billion will be stuck near where they are today…. There will be increasing inequity, tension, and social strife... the world of 2052 will not be an optimal starting point for the ensuing forty years.*" (Randers, 2012, p.229)[26]

4.4. Note on global scenarios at the science-policy interface

4.4.1. Scope and ambition

The sustainable development scenarios for Rio+20 illustrate what would be needed to achieve a better future for everyone. They were designed to inspire decision-making. Hence, they are important for a functioning science-policy interface.

The scenarios illustrate futures that most people would consider more desirable than trend scenarios. They describe a world that is more sustainable in important

environmental and social dimensions and that promises a decent quality of life for everyone. Table 4 lists all the explicit sustainable development goals and targets used in the prominent sustainable development scenarios prepared for Rio+20. While these scenarios differ in various aspects, they are nevertheless fairly similar in spirit and content.

Yet, the level of ambition of the sustainable development goals is limited both in terms of their scope and their target levels. The sustainable development worlds appear far from paradise visions for 2050. In fact, they are not free from contradictions, and confront decision-makers with a number of unresolved trade-offs. They highlight the enormity of the global sustainable development challenge, and indicate that - no matter what - at some point in the future we will be forced to make more drastic behavioural changes. It is the strength of these mainstream scenarios to highlight this important fact, based firmly on assumptions about the future that are considered plausible and reasonable today. Essentially, they show what could be achieved would we overcome - at a global level - all the socio-economic and political constraints, exploring the utmost at pushing back technological limits.

The sustainable development goals and targets compiled in Table 4 are similar to major international development and sustainability goals that are either agreed or are under consideration. They are also grounded in (subsets of) existing mainstream scientific sets. However, for a number of reasons they leave out elements of wider sustainable development perspectives that typically include community or societal aspects, such as peace or social capital.

4.4.2. Trade-offs and synergies

All the sustainable development scenarios for Rio+20 include unresolved trade-offs and untapped synergies. Many sustainable development scenarios are *unsustainable* in at least one or more respects. Furthermore, none of the mainstream scenarios for Rio+20 explores a path towards sustainable development path in 2050 that achieves the full set of sustainable development goals suggested by science.[27]

One key problem is the existence of important trade-offs across time, sectors, and issues. For example, proposed solutions suggested by energy policy makers may be inconsistent or even contradictory with trade policy, monetary goals, or ecological objectives. Even sustainable development goals agreed at the global level may turn out to be inconsistent when defined by sectoral or issue-focused experts and policy makers.[28]

The scenario studies for Rio+20 illustrate synergies and opportunities that could be reaped with integrated policy strategies geared to the simultaneous achievement of multiple sustainable development goals. Synergies are especially large for simultaneously addressing climate change mitigation, energy security, and air pollution. However, in some countries CO_2 emission reduction measures can also lead to reduced energy security. Furthermore, the objective of universal energy access is much cheaper to attain and pretty much independent from the others. Synergies are also large between ensuring food security and restoring agricultural ecosystems; between conservation of ecosystem services and security of supply; between climate policy and R&D; and between education, R&D, environmental improvements and economic growth.

The scenario studies for Rio+20 also illustrate trade-offs between pursing objectives that need to resolved. For example, all the mainstream sustainable development scenarios for Rio+20 see increases in biofuel production and deployment of modern renewables, and consequently lead to significantly increased water and land use, increased water stress for the majority of the world population, as well as unsustainable anthropogenic interference with phosphorous and nitrogen flows. These trade-offs are unresolved. Yet, these scenarios were designed to be sustainable development scenarios. They satisfy the sustainable development goals chosen by modellers, yet would fail a wider range of scientifically accepted goals.

Among the sustainable development scenarios for Rio+20 considered here, the PBL scenarios go the furthest in trying to resolve the broadest range of sustainable development goals.[12] However, even in that case, some trade-offs remain unresolved. For example, in these scenarios climate mitigation and water-use efficiency will significantly reduce the demand for water, but the total number of people living in severely water-stressed river basins will only marginally decrease. Similarly, in all their Rio+20 scenarios, global nitrogen fertilizer use continues to increase by at least another 50% until 2050. The same applies to phosphorus fertilizer use. "*Nitrogen and phosphorus fertilizer use will inevitably have to increase to sustain the increasing food production. The increase is particularly strong in developing countries.*"[12] It should be noted that the planetary boundaries for nitrogen[29] and phosphorus[30] were already being exceeded in 2010. And there would still

be more than 400,000 children dying from hunger, unsafe water, and traditional energy use in the PBL's GlobT scenario by 2050.[12]

Most of sectoral scenario studies (e.g., those on food, water, forests, or development), as well as national integrated studies, are carried out in isolation from integrated, cross-sectoral global scenario studies.[31] Hence, while these national and sectoral studies show ways of overcoming some of the local and sectoral trade-offs, they all but disregard feedbacks and constraints across sectors or world regions. At the same time, it should be noted that the global integrated studies also underestimate binding constraints to overcoming trade-offs, since they aggregate over local constraints, basically assuming free availability of resources over large geographic areas. In other words, it is highly likely that sustainable development scenarios in general tend to underestimate the challenge of what would need to be done to move humanity onto a truly sustainable development path. The lesson is an expressed need for greater caution and humility at what can be done.

In summary, all sustainable development scenarios for Rio+20 illustrate important trade-offs and synergies, the magnitude of which varies greatly depending on assumptions. No sustainable development strategy was proposed and quantified in any of these scenarios that does not show unresolved trade-offs leading to un-sustainability in several areas. There is a need for scenarios that follow a plausible, robust sustainable development strategy to achieve a really comprehensive list of sustainable development goals.

4.4.3. Scenario agreement on overall policy conclusions and on specific solutions

Among the scenarios reviewed here, there is a high level of agreement on overall scenario conclusions, but little agreement on specific policy suggestions.

Despite a variety of modelling approaches and sustainable development goals, the SD scenarios for Rio+20 agree to a high extent in terms of their overall conclusions:

- There are numerous, feasible pathways to SD.
- There is no agreement on "must have" lists, but scenarios show the benefit of reigning in overall material and energy use, increased end-use efficiency, and reduced poverty.
- Making progress in one dimension can lead to both synergies and trade-offs.
- Complex trade-offs related to the global commons need to be tackled globally.
- There is no single solution or policy for sustainable development. Bottom-up measures and policies need to be tailored to each issue, country, and sector.
- Politicians' SD goals have become increasingly ambitious, while their attainment has become increasingly difficult.
- Education, RD&D and population goals are essential with very large synergies to the development and environmental dimensions.
- A broad pursuit of SD is far superior in performance over pursuing single-issue objectives in isolation[32] (e.g., promote economic growth first and introduce cap-and-trade later).

Great differences remain in terms of specific policy recommendations that are drawn ex-post from the scenario results, reflecting the range of analysts' worldviews and organizations' interests. This is despite the fact that these scenario development teams showed large overlaps in terms of participation of few prominent modellers and models.[33]

In view of most scenarios' focus on technology solutions, it is important to note that prevailing solutions proposed by key decision-makers have fallen far short of the technically feasible factor of 4 (to 5) increase in global eco-efficiency as shown in the scenarios - and increase which would allow doubling global wealth, while halving resource and energy use.

4.4.4. Progress in global scenario modelling since the 1970s

Today's global models are generally much more user-friendly, can tap into better data, and be run on higher performing computers than in the past. In particular, models have become geographically more disaggregated and draw on extensive technology and environmental data, including in spatial form. However, these additional details have come at a price in terms of models focusing increasingly on single or few issues and objectives. Similarly, scenario time-horizons have become shorter.

The primary concerns that global models address have moved from fundamental questions to specific, single issues. Most recently, global econometric models have re-emerged to quantify economic policies in the sustainable development context, especially for energy and climate change.

By some accounts, the single most important progress in global modelling has been in modelling of technology change. However, this focus has had the impact of conveying the message that technology is the single most important or even the only lever of change for achieving sustainable development. Some models have also explicitly included political variables.

Very large-scale collaborations have emerged with tens or even hundreds of collaborators in some global modelling projects. At the same time, the limited consensus among modellers is apparent. There is limited agreement on SD scenarios development and especially on the nature and level of scientific-technical, political, social, economic and financial "limits".

The predictive performance of baseline scenarios has remained low. They have tended to be more pessimistic than actual trends that unfolded in reality. In particular, the performance of most global scenarios that were explicitly designed as "predictions" or "most likely cases" has been low.

In the past 20 years, a donor-driven global scenario model "industry" has arisen with many players and disjoint communities. Extra-budgetary donors have had a strong influence on the topics addressed and the overall policy messages.

Expenditures have focused on model applications and adaptations for government and business clients. A decreasing share has been invested in "basic research", model methodologies and the development of completely new models.

In short, progress has been made in key areas, but weaknesses and limitations have become apparent in some areas as well.

4.4.5. Lessons-learned

There is no agreement on the role of science in policy making. Hence, not everyone thinks scenario analysis is a useful activity. Yet, scenario models reflect specific worldviews that have greatly shaped the worldviews of decision-makers. Hence, policy recommendations made by analysts need to make special efforts to make underlying assumptions clear to decision-makers.

Scenarios have been powerful tools at the science-policy interface. But most often than not, model results are "cherry-picked" by decision-makers. Scenario analysts need to anticipate such cherry-picking and offer their recommendations with this fact in mind.

It is easier to agree on goals/targets than on policies, actions or indicators. There is no consensus on limits, but almost everyone agrees that technology is important.

To-date, no scenario exists that would consider the full range of SD goals suggested by science or by politics. And the broader the set, the more unresolved trade-offs and synergies remain. This is a serious challenge and will require significant resources to resolve.

For the past forty years, global models have been looking for applications, rather than vice versa. The results are fragmented modellers communities focusing on applications. More resources for model development tailored to broad, new problems is needed.

There are obvious problems with an increasingly complex hierarchy of assessments, which is perceived as burdensome by some parts of government. In order to make scenario modelling relevant and sustainable at the same time, this problem must be acknowledged and many lower level (project) assessments might replaced by fewer higher-level, strategic assessments.

Results require a long time. This is especially true in the case of policy impacts of scenario work. Hence, scenario analysts should be patient and focus on the long-term, rather than quick-wins through government contracts guiding their work.

4.5. Investment and technology needs and market potentials

Each of the sustainable development scenarios for Rio+20 that have the basis of the description of a feasible sustainable development world in 2050 provides information in financing and technology needs to achieve the chosen goals. However, since their scope and model assumptions vary significantly, their results also range widely. In view of the trade-offs and synergies discussed above, it is not possible to simply add up the various costs of achieving each one of the goals.

Therefore, assessing financing and technology needs for sustainable development continues to present considerable conceptual and practical challenges. In order to quantify "needs", normative goals and targets have to be agreed upon. Different goals and targets give rise to different needs. Costs and investment requirements can be defined only with respect to a counterfactual situation or baseline.

A clear understanding of the baseline is essential to interpret the needs estimates. Different sustainability goals are associated with different time frames, and this has implications in terms of sequencing of investment and financing needs.

The transition to sustainable development involves concerted action in a range of sectors. There are many interdependencies, synergies and trade-offs across sectors, which affects investment requirements and financing needs. There may be co-benefits or cross-sector impacts. Thus, estimates of investment requirements or "needs" are best to be derived from integrated models with a clear set of global goals.

For sustainability purposes, the quality of investment (what technologies and services are invested in, for example, for energy infrastructure or agriculture) is as important as the amounts of investment. Yet, the extent to which the qualitative dimension is captured by existing models and studies is highly variable.

Within each of the clusters or sectors examined globally, the range of published estimates is wide, reflecting differences in data, scope, methodologies, baselines, and other factors including sheer uncertainty. Investment requirements for the energy transition respecting agreed climate targets are large, of the order of trillions US$ per year. Overall, the order of magnitude of the investment requirements for "climate-compatible" and "sustainable development" scenarios (which include goals and target related to climate) are of the order of several trillions per year.

Investment requirements for MDGs and other related goals (e.g. universal access to electricity) are one order of magnitude lower than those related to climate change mitigation. The opportunity cost of achieving those goals would seem to be low, regardless of what other goals are adopted. The order of magnitude of estimated investment requirements for the management of global commons (biodiversity, oceans, forests) is several tenths to hundreds of billion dollars per year.

Taking into account the above-mentioned caveats, analyses of investment requirements and financing needs for sustainable development in the coming decades conclude that financial needs are significant, of the order of the several trillions per year.[34]

Figure 1 presents orders of magnitude for investment requirements in various sectors, obtained from the literature. The most comprehensive assessments indicate trade-offs and synergies among areas and clusters. However, there is no agreement among models on the implications of those trade-offs and synergies for investment requirements and financing needs.

In particular, the identified ranges of estimates of total, global investment needs were as follows:

- *Energy:* US$30 to 80 billion per year for universal access to modern energy services; US$250 to 400 billion per year for energy efficiency; and US$200 to 700 per year for renewable energy depending on assumptions for energy demand and ambitions for emissions mitigation;
- *Climate change:* US$300 to 1,200 billion per year for climate change mitigation and US$50 to 400 billion per year for climate change adaptation, with estimates depending on the level of ambition.
- *Sustainable transport:* US$2.5 to $3 trillion per year to 2050.
- *Biodiversity:* US$154 to 436 billion per year for achieving the 20 Aichi Targets.

The identified ranges of estimates of total investment needs in developing countries were as follows:

- *Poverty eradication:* US$20 to 200 billion per year to achieve the MDGs;
- *Food security:* USS$ 50 to 83 billion (without capital replacement) per year to increase agricultural yields and feed everyone without expansion of agricultural land;
- *Water and sanitation:* US$18 to 80 billion per year depending on ambition (e.g. MDG 7 versus universal coverage) and geographic scope
- *Forests:* US$40 to 160 billion per year;
- *Oceans:* US$30 to 40 billion per year;
- *Infrastructure investment in developing countries:* need to more than double from a current level of US$0.8-0.9 trillion per year.
- *Education:* US$9 to 26 billion per year for achieving 'education for all' in developing countries by 2015.
- *Least developed countries:* Financing gap estimated at US$50 to 75 billion per year.
- *Africa (infrastructure only):* Financing gaps of US$31 billion per year for infrastructure (mainly power), US$25 billion a year for universal access to modern energy services by 2030, and US$18 billion per year for climate change adaptation.

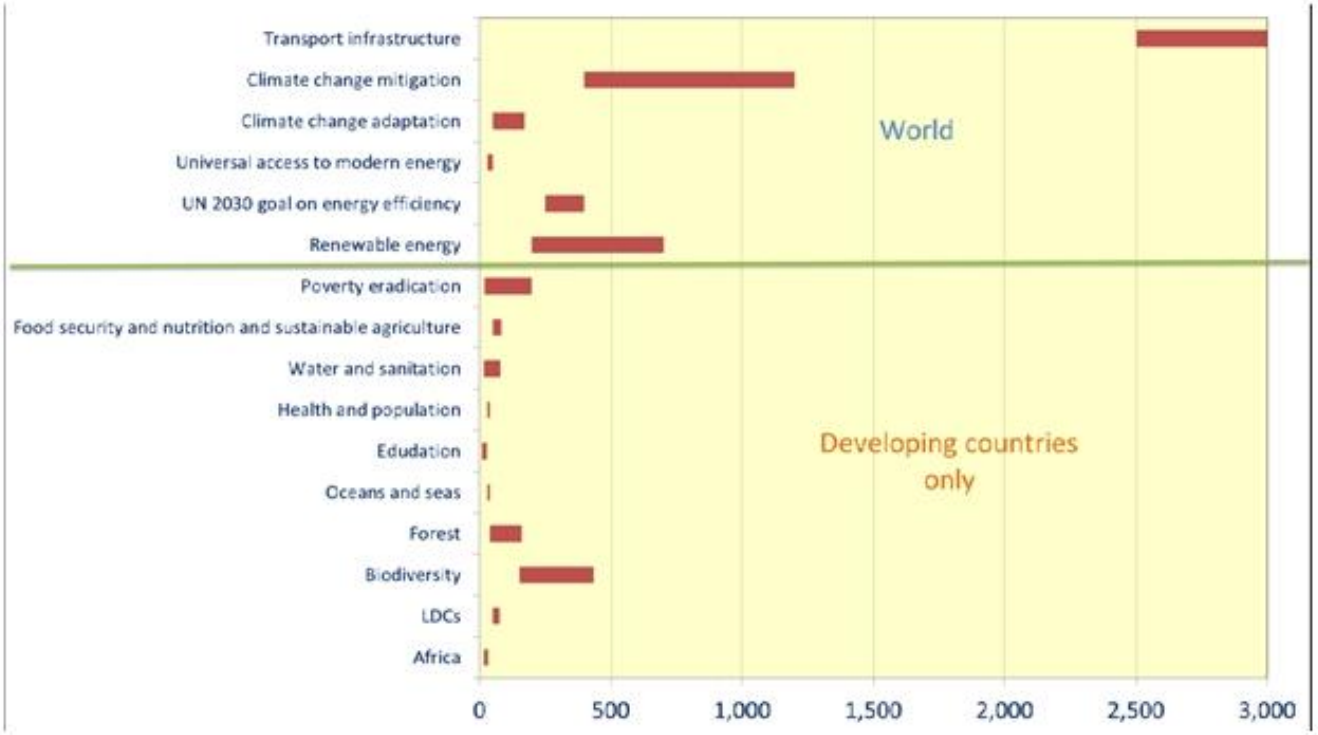
(Note: these figures are *not* additive!)

Table 44 in Annex 4 provides a range of selected sources of estimates of total, global investment needs.

Again, it is very important to note that it does not make sense to add-up the estimates of investment needs presented in Figure 1. The investment needs are *not* additive, since action in one area would have important and non-trivial synergies and trade-offs in the other areas. Also, the investment needs are total investment needs - both public and private. They are *not* estimates of public investment needs.

Upon request of the Intergovernmental Committee of Experts on Sustainable Development Financing, DESA provided information from a survey of quantitative financing needs estimates for all 27 thematic areas and cross-sectoral issues identified in section III of the Rio+20 outcome document. Further details are provided in a background paper of the UNTT Working Group for the Committee.[35] Reliable, global estimates could not be identified for the areas of sustainable tourism; sustainable cities and human settlements; promoting full and productive employment, decent work for all and social protection; Small Island Developing States; Landlocked Developing Countries; regional efforts; disaster risk reduction; desertification, land degradation and drought; mountains; chemicals and waste; sustainable consumption and production; mining; and the sustainable development goals (since they have not yet been agreed, of course).

Figure 1. Orders of magnitude of investment requirements for various sectors from the literature



Source: DESA (2013); UNTT Working Group on Sustainable Development Financing (2013)[35]; Delamonica et al. (2001)[36]; CSD-15 (2005)[37]; Hutton et al. (2007)[38]; Toubkiss (2006)[39]; WHO (2004, 2008, and 2012).[40]

In terms of what developing countries need in the area of clean environmentally sound technology facilitation, it was found out that (a) technology needs have not been mapped systematically, and that (b) views vary significantly as to whether the international programmes and mechanisms to assist in terms of capacity building or otherwise correspond to the needs (see SG's Report A/68/310, 2013)[41].

Data are limited and fragmented for assessing the magnitude and nature of the technology gap that developing countries are facing. This is particularly the case for smaller developing economies and the Least Developed Countries (LDCs). Indeed, "most empirical evidence focuses on emerging economies. There is a need for more comprehensive information about the needs of technology recipients in developing countries."

There is also a need to survey technology needs at the country level. It is generally accepted that both technology needs and capabilities differ among developing countries. Certain technologies may be better

suited for some countries than for others, given resource endowments, existing technological capabilities and other factors.

These financing and technology needs could alternatively be seen as future market potentials. Global capital markets, representing some USD 200 trillion in financial assets[42], should in principle have the size and depth to step up to the investment challenge. The public sector has a critical role in setting goals, building a regulatory environment including establishing clear price signals, and investing in public infrastructure in ways that create conditions for attractive investment risk/return profiles, and tracking progress. These conditions are not in place in many countries where a range of institutional, technical, political and financial barriers deter investment. Hence, the absence of private financing is often regarded as an indicator of deficiencies in the domestic investment policy infrastructure.

4.6. Financial approaches

As discussed, achieving sustainable development requires major structural and technological changes in key sectors such as energy, building, transportation, industry, agriculture and fisheries, and infrastructure. Sustainable development financing in all these sectors must come from domestic and external sources, and includes both public and private finance flows. These finance sources should be seen as complementary, as each has unique objectives and attributes.

Huge obstacles remain in the way of mobilising predicable external finance to meet sustainable related goals. Public policies and sources of revenues are critical both to address market failures and to raise resources for financing long-term investments in infrastructure, high risk investments such as innovation and new technologies, other global public goods, and merit goods like social protection and basic education.

In this context, there are three levels of the challenges for advancing dialogue and setting of stakeholder priorities: i) clarifying global goals and commitments, ii) assessing investment requirement and financing needs, and iii) considering financial flows and practical options for sustainable development. (Please note that assessing financing needs was briefly discussed in the last section. So, we only focus on goals and financial options here.) These three levels are embodies in two key tracks of the Rio+20 follow-up processes: the Open Working Group on Sustainable Development Goals and the Intergovernmental Committee of Experts on Sustainable Development Financing.

Ideally, both inter-governmental processes could provide clear information to address the three levels of the challenges. However, there is a need for a more integrated approach, in particular linking of practical solutions with goals and financing needs.

As a practical solution, we suggest a simplified framework/structure which stakeholders may want to use to report on information that they are tracking in their sectors of interest. The result would be short assessments for the sectors mixing qualitative and quantitative elements. The framework aims to provide the decision-makers with elements for answering the following questions at the sector/area level:

- *What are the global goals and targets in the sector?*
- *What are the financing needs for the goals and targets?*
- *How to mobilize international public finance and private finance at scale needed?*
- *What are the different instruments and financing options in the sector on both a profit and non-profit basis, and including non-financial incentives such as improving regulatory frameworks and the provision of goods and services?*
- *How to ensure most efficient, effective use of scarce financial resources to achieve sustainable development objectives?*

We use a matrix to organize the information under this framework/ structure.

The matrix here (Table 5) aims to map out, in a summarized form, the relevant information of the three levels of the challenges. It provides an overview of existing global goals and commitments, overall patterns of financial flows, and the practical financial options and approaches. It begins by connecting the three levels in relation to the primary focus here on scaling up and mobilising additional resources from a variety of sources and the effective use of financing in order to promote sustainable development. The linkages between the three levels of the challenges are essential to achieving major structural and technological changes: no one of the three sets of issues can achieve results without the other two.

The first three columns of Table 5 present the global goals and targets based on the thematic areas identified by the Open Working Group (OWG) on Sustainable Development

Goals (SDGs). They include poverty eradication, education, health, biodiversity, forest, oceans, climate etc., which capture the broad span of views. Through defining the global sustainable development goals and targets will conceivably forge a more integrated approach to sustainable development. It will connect social, environmental and economic goals; and address varying conditions and levels of progress through a flexible lens to more accurately measure progress.

The main purposes of the finance approach section of Table 5 are to present an overall pattern of financial flows in each of the areas, and to highlight a number of practical options/ mechanisms of finance that could be used to fill the existing gap in public resources and unlock private finance. The key stakeholders include Government, non-traditional partners, ODA and official climate finance, and innovative sources of finance. We describe financial options and approaches by utilising the following characterisation:

1) Financial approach: the financial facilities or mechanisms, such as public private partnership led by public or private sector, including philanthropic and organizations (NGO), through which public and private funds flow;

2) Business model: the core aspects of a business describes the rationale of how an organization creates, delivers, and captures value, in economic, social, environmental contexts;

3) Financing instruments: the types of financial products or policy tools via which finance is delivered.

These characterisations in Table 5 are intended to bring some clarity and illustrate to the complex institutional roles and mechanisms that operate on the ground in international finance. A clear and comprehensive map of the options could be a tool for policy makers to recognize the opportunities for private finance and ensure that instruments and public sources are used strategically to steer and leverage them. As noted, some common forms of public contributions include global funds, grants and guarantees for blended loans from development finance institutions, structured grants (for viability-gap funding, project preparation, and through specific forms of contracts—such as pilots in advanced market commitments and development impact bonds), risk-based instruments (first-loss funding, guarantees and political risk insurance), concessional loan and finance, and equity participation.

For the private sector, the expanding role of NGOs, the philanthropic foundations, and the public and individual charity is also noted.

To mobilize additional finance, public-private partnership can make an important contribution. Public private partnerships (PPP) here includes a broad range of public private engagements, and will be important in the delivery of the sustainable development objectives, including the development of ongoing sectoral capacity to deliver those goals at the national and local scale.

A traditional model of PPP involves a contract between the public sector and a private enterprise, in which the enterprise provides a public service or project and assumes financial, technical or operational risks. Another model is the public-private community partnership (PPCP), where government and private enterprises work together for social welfare, eliminating the focus on profit. Public social private partnership (PSPP) includes government, private enterprises, and social enterprises and social economic organizations, with the partnership implementing social aims. Global public-private partnership (GPPP) is a governance mechanism to foster cooperation between the public and private sectors facilitated by an international intergovernmental organisation like the United Nations. Specialized sectoral partnerships are also illustrated and have potential in achieving specific goals and targets. For example, a health services PPP can be a long-term contract where government engages private enterprises to innovate and deliver health services over a contract term. The private enterprise is paid for its services and assumes financial, technical and operational risks while benefitting from shared cost savings.

For the purpose of financing the sustainable development objectives, we have considered the following four categories in the finance approach section:

1) public finance from governments and international organizations;

2) blended public and private finance;

3) private financing in support of international and national programmes; and

4) non-financial contributions in all these categories, such as improvement of regulatory

frameworks, in kind contributions including the provision of expert and technical advice and services, tangible and intangible goods, and data and data analytics.

We differentiate when public and private finance is offered on a profit and non-profit basis. We also recognize cross cutting issues across the sustainable development areas, such as climate adaptation and mitigation; the energy water and food security nexus; and maternal and child health; and education and economic development.

Importantly, mapping out existing financial options in the above-mentioned framework is for an illustration purpose during an interim period. Once the post-2015 development agenda and the SDGs are agreed, future editions of the global sustainable development report may thus provide a means of inputs by financial specialists of SDG sectors. It will carry out a full review and presentation of workable financial options for different sources, which could revive efforts to scale up financing for sustainable development, and help mainstream the financing the post-2015 sustainable development agenda.

Table 5: Financial approaches for Sustainable Development - An Illustration

Themes identified by UN member States[43]	Existing goals or commitments	Existing targets	Overall pattern of financial flows	Financial Approach (e.g. PPP)	Business Models	Financing instruments
1. Poverty eradication (MDGs)	Eradicate poverty	Reduce extreme poverty by half by **2015**	Mainly ODAs for LDCs; charity and remittance are also account for significant portion.	Global funds on a profit and non-profit basis: Development bank loan guarantees, and non-financial benefit. Private gifts and funding through philanthropic foundations and large scale and micro charitable contributions on a non-profit basis.	1. Homestrings[44] dispora approach through institutional and individual investors funding Homestrings' approved projects on a for profit basis in Africa, including focus on energy, water and infrastructure 2. Bottom-of-the-pyramid venture capital investors and funds	Mobilize financing from international capital markets by issuing long-term bonds repaid by donor countries. Development impact bond, viability-gap funding: financial contribution to make investment commercially viable. Micro-finance of businesses and individuals in developing countries and economies on market or favourable finance terms.
2. Food security and sustainable agriculture (MDGs and beyond)	World free of hunger	Reduce hunger by half by **2015**	Public sector investment which can co-exist with private sector investment, and both profit and non-profit approaches Increasing recognition of, and financial flows, to integration of water, energy and food security. Separately, there are private and public initiatives to fund the development of agriculture strains and technologies that are disease and drought resistant, higher in protein and nutrients, or which support adaptation to climate change.	Global, regional and national funds: Payment for ecosystem services, biodiversity and conservation holdbacks and preservation. For example, various national publically funded initiatives to promote sustainable agriculture and food security. National initiatives such as Qatar National Food Security Program, and Global Dry Lands Alliance[45]. Qatar Pilot Plant[46] for greenhouses using seawater in desert. Depending on the economics of the specific projects, these may be done on a profit or cost recovery basis, or as pilot initiative to develop and implement sustainable technologies. Another example on a non-profit basis is when farmers are paid to not farm on marginal lands, or to alternate crops to enrich soils. Financing from both public and private sources. Another example is encouraging local sustainable harvesting of wild foods, in the context of sustainable forestry and fisheries, and biodiversity conservation, which conveys non-profit ecosystem goods and services.	Certified agricultural products whose production respects social, environmental specifications. Agricultural producers; Certification organizations issue certificates. consumers paying a 5-10% price premium on certified goods: e.g. coffee, cocoa, banana, marine fisheries, and various organic products	Mobilize financing from international capital markets by issuing long-term bonds repaid by donor countries. E.g development impact bond. certified agricultural, forestry, and fishery products; First loss funding/ Subordinated debt; Co-payments: payment made on delivery of an pre-determined outcome
3. Water and sanitation (MDGs)	Ensure access to safe drinking water and stop unsustainable exploitation of water resources	Reduce proportion of people without sustainable access to safe drinking water and basic sanitation by half by **2015**.	Mostly from public investment, which may co-exist with private sector investment. Some exclusively privately initiatives and funded approaches on both a profit and non-profit basis. It is also useful to consider whether it is the initial provision of water and	Payment for ecosystem services; Valuing ecosystem services, for example New York watershed and Philadelphia Clean Water Act obligations; financing for project preparation for preparation of robust feasibility studies. For example, linking water, food and energy, encourage lower or sustainable water uses with energy, or using renewable energy for irrigating food crops or to desalinate/ sanitize water for multiple purposes (PEC Fund that assists with	Governments, water basin agencies, industrial businesses, private companies and foundations; national and international NGOs, multi-lateral organizations as customers to pay, private landowners and land stewards, for streams, rivers and lakes meeting water quality standards, biodiversity conservation, protection of specific wildlife habitats.	Government-, private or civil society mediated or Payment for Ecosystem Services (Watershed and Biodiversity) Allow trading and sale of water licences with conservation or upstream holdback

Themes identified by UN member States[43]	Existing goals or commitments	Existing targets	Overall pattern of financial flows	Financial Approach (e.g. PPP)	Business Models	Financing instruments
			sanitation services, or improving existing infrastructure and services	renewable energy desalination projects for Pacific SIDS).		
4. Health (MDGs)	Reduce child mortality; im-prove maternal health; combat HIV/AIDs etc.	Reduce by two thirds, between 1990 and **2015**, the under-five mortality rate.	Mostly rely on domestic public finance, or large philanthropic foundations (i.e., Gates Foundation[47])	1. Global Funds International Finance Facility for Immunization Private investment in the development and distribution of medicine, vaccines and technologies. One longstanding example is the private funding for the distribution of malaria nets in collaboration with developing nations. Further examples are: 1. (IFFIm) to finance GAVI Alliance; 2. UNITAID 3. 3. Civil society and philanthropic focus and investments in reducing malaria, polio, HIV etc.	Domestic budget or philanthropic approach using trust funds or charitable donations. Private finance for research and development of medicine and vaccines for developing countries, where products may either be distributed at no charge or subsidized rate, or available for production with waiver of IP or licensing fees. Provision of medical services on an organizational and individual basis, i.e., Doctors without Borders/ Medicines sans frontiers).	1. Vaccine Bonds 2. Social Impact Bond 3. Debt2Health 4. Advance Market Commitments (AMCs): an ex-ante commitment for public purchase of supply; Co-payments: payment made on delivery of an pre-determined outcome
5. Education (MDGs)	Universal primary schooling	By **2015**, children everywhere (boys and girls alike) will be able to complete a full course of primary schooling	Mostly rely on domestic public finance, though area of international finance as well For example, Nordic public funding programmes with emphasis on linking education and gender equity. Private finance has focused on specific issues such as technology access and development.	Public fund: Global Partnership for Education, Nine innovative financial mechanisms summarized by UNESCO, such as debt-for-education swaps: a debt conversion scheme is a mechanism whereby a creditor country cancels another country's debt against its commitment to use the funds in pre-agreed development programs	National payments/tax credits/ financial incentives for parents whose children in public schools or higher education (Brazil leading model for payments, but many countries have tax and financial incentives) Private finance for development and distribution of low cost computers, and internet access in developing countries. Microsoft's Skype in the Classroom which provides free access to basic education.	Concessional finance: public provision for interest -rate subsidy or long-term tenor on finance; Project preparation: financial contribution for preparation of robust feasibility studies. Development impact bond: e.g. Goldman Sachs Social Impact Bond for Early Childhood Education[48]
6. Employment (MDGs, JPOI)	Full and productive employment and decent work for all.	**By 2015**, achieve full and productive employment and decent work for all. **By 2020**, increase decent employment for the urban poor.	Mostly rely on private investment within national framework. Consumer certification/ preference and boycotts are an example of private sector non-profit approaches.	WTO and support of open international market in services. Implementation of ILO international labour standards[49] Financing for anti-human trafficking initiatives.	Integrated Reporting; Consumer boycotts; Fair Trade products[50], including product certification process and purchasing guide. International private employment contract, obtained through internet.	Development impact bond: e.g. Goldman Sachs Social Impact Bond for Massachusetts[51]
7. Oceans (Ch. 17 of Agenda 21; JPOI; Aichi Targets 6, 10 and 11; Target 7.B of MDG)	Protection of the oceans and all kinds of seas	By **2015**, the multiple anthropogenic pressures on coral reefs are minimized, so as	Important role of public resources in management of protected areas.	1. Payment for ecosystem services 2. Marine Stewardship Council sustainable fisheries certification[52] 3. Iceland's fisheries management system[53] Total Allowable Catch system, sophisticated	QualityCoast applies sustainable destination tourism criteria and indicators and issue awards for coasts and islands. Municipal governments collaborate with local tourism businesses, and pay for	Eko Asset Management - fisheries bonds; Co-payments: payment made on delivery of an pre-determined outcome

Themes identified by UN member States[43]	Existing goals or commitments	Existing targets	Overall pattern of financial flows	Financial Approach (e.g. PPP)	Business Models	Financing instruments
		to maintain their integrity and functioning.		tracking, and market aspects (rent/sell quotas)	award.[54]	
8. Biodiversity (Aichi Targets; Target 7.B of MDGs)	20 Aichi Goals of halting global biodiversity loss	Achieving, by **2010**, a significant reduction in the rate of biodiversity loss.	Important role of public resources in management of biodiversity, environmental impact assessment, integrated management, and conservation and protected areas. National and regional (such as Arctic and European) flows of public finance to meet national and regional biodiversity targets.	1. Global funds: Payment for ecosystem services 2. Biobanking: Biodiversity Banking and Offsets Scheme;[55] 3. Yasuni-type Mechanism	1. Payments for Ecosystem Services 2. Certification Of Products And Production Sites 3. Payments for non-use of areas of biodiversity importance, or through restricting to compatible uses. 4. Promotion of touristic, and limited hunting, fishing gathering uses of areas of conservation. 5. Carbon sequestration payments for natural areas, particularly forest and coasts (as natural areas have most carbon). For entire circum-Arctic, through the Arctic Council[56], there is a pattern of financial support for conservation and use of natural ecosystems and species by indigenous peoples and local residents, which may include special or protected markets. Public and private actors including Governments; Water basin agencies; Industrial businesses; Private companies and foundations; National and international NGOs, Multi-lateral organizations pay private landowners and land stewards for acres of restored or conservation land managed/ wetlands, biodiversity conservation	International, national and private payment for ecosystem services (IPES) A global mechanism for raising and distributing funds from beneficiaries of ecosystem services to those who conserve them; Co-payments: payment made on delivery of an pre-determined outcome Payments to indigenous peoples and organizations to support harvesting and co-management of ecosystems (ie. Sami in Scandinavia for fishing and herding, Cree/Arctic Athabascan in North America, Inuit throughout circumpolar Arctic)
9. Forest (Aichi Targets on forest; Four shared global objectives on forests at UNFF in 2006.)	Forest component of Aichi targets: reducing deforestation	25% reduction in annual global deforestation and degradation rates by **2015,** compared with the 2000-05 average	Important role of public resources in management of protected areas. Co-exist with private sector investment	Global funds: Reduced emissions from deforestation and forest degradation (REDD) scheme REDD/REDD+ A specific IPES aimed at reducing greenhouse gas emissions from deforestation and forest degradation (REDD) in developing countries	Regulated industry; donor countries; Multi-national Corporations; NGOs, Multi-lateral Organization, Project developers pay acres of restored or conservation managed forest from Forest nations; Local communities and landowners. Forest Stewardship Council; Scientific Certification Systems; Program for the Endorsement of Forest Certification; the certifying bodies themselves, etc. issue the certificate on acres of sustainable managed forest to private producers of wood.	Forest-Backed Bonds[57]; Forest Carbon Financing (Compliance, Voluntary, and REDD) Co-payments: payment made on delivery of an pre-determined outcome Certified forest products

Themes identified by UN member States[43]	Existing goals or commitments	Existing targets	Overall pattern of financial flows	Financial Approach (e.g. PPP)	Business Models	Financing instruments
10. Sustainable consumption and production (SCP) (Ch.4 Agenda 21; and Ch. 3 of JPOI)	Changing unsustainable patterns of consumption and production	International plan of action is in place, but no time-bound target.	Important role of public resources in management of protected areas, and global commons. Co-exist with private sector investment	Payment for ecosystem services	Integrated Reporting; Benefit Corporation designation;[58] Quality Coast develops and applies sustainable destination tourism criteria and indicators and issue awards. Municipalities pay.	N.a.
11. Means of implementation (MDGs, Rio+20; Copenhagen Accord)	Develop a global partnership for development.	Meet the 0.7% ODA/GNI target now; $100 billion per year for climate change by **2020**	Important role of public resources in management of protected areas, and global commons. Co-exist with private sector investment	Payment for ecosystem services	Integrated Reporting	Blended DFI loans: Public grant funds or guarantees are provided to a national, regional or multilateral DFI that combines them with own funds raised on capital markets to create a loan.
12. Sustained and inclusive economic growth (Rio+20)	Achieve SD promoting sustainable, inclusive and equitable economic growth.	Sustained real economic growth in all countries.	Important role of private resources.	See options for addressing poverty, basic infrastructure, energy, water and food. In particular, payment for ecosystem services	Integrated Reporting; Community-level financing for community infrastructure	Political risk insurance: protection against select (rare but costly) policy-oriented risks
13. Needs of countries in special situations, and middle-income countries (Istanbul Programme of Action)	Address the special needs of Africa, LDCs, LLDCs and SIDSs.	Range of targets	Domestic resources and development assistance. Public and private partnership and also wholly private financing, particularly for infrastructure, energy and water.	See options for addressing poverty, basic infrastructure, energy, water and food.	See models for addressing poverty, basic infrastructure, energy, water and food.	First loss funding/ Subordinated debt; Co-payments: payment made on delivery of an pre-determined outcome; Development impact bond
14. Human rights, the right to development and global governance (Rio+20)	Respect, protect and promote human rights and fundamental freedom for all	Range of targets	Critical role of public finance but also may be private finance typically on a non-profit basis for targeted issues such as gender, indigenous peoples, or historically targeted or disadvantaged minorities (i.e., Roma in Europe).	Implementation of ILO international labour standards, Anti-human-trafficking initiatives. Initiatives to support subsistence activities and economic development for indigenous peoples (particularly in circum-Arctic)	Integrated Reporting; Payments to indigenous peoples and communities, and support of their participation in co-management, particularly for Arctic.	Government or private sector payments to indigenous peoples. Private, including consumer support, of indigenous economies.
15. Equality (MDGs)	Promote gender equality and empower women	Equal girl's enrolment in primary school; women's share of paid employment etc. by **2015**	Mostly from public finance but also private finance and philanthropic initiatives, such as Girls' education and maternal health initiatives.	N.a.	Integrated Reporting Public funding including gender equity components.	N.a.
16. Energy (Rio+20	Make sustainable	(Informal) sustainable energy	Critical role of public sector investment	1. Green energy power purchasing agreements; 2. African Rural Energy Enterprise Development	1. Homestrings: dispora funding in Africa, and focus on energy and	Emissions trading regimes and credits Feed-in Tariffs

Themes identified by UN member States[43]	Existing goals or commitments	Existing targets	Overall pattern of financial flows	Financial Approach (e.g. PPP)	Business Models	Financing instruments
Outcome Document)	energy for all a reality	for all targets	Co-existing or wholly independent private sector investment; Reference to UN Sustainable Energy for All initiative, and public private partnerships. In particular, important role of municipalities in city-wide programmes for renewable energy, energy efficiency and urban renewal (i.e., SCI Energy Lab[59]); or development of sustainable business clusters, expertise and platform (i.e., Durban)	(AREED)[60] model on the business development and seed capital components of the project; 4. CTI PFAN, business plan/incubator approach including regional networks covering Latin America, Asia, Africa and CIS 5. California Low Carbon Fuel Standard[61] with low carbon requirement and LCFS credits	infrastructure; 2. End user financing;[62] 3. Community financing and tax incentives for renewable energy, micro-grids and energy storage 4. Sovereign wealth funds with criteria on clean energy investments 5. Regulatory requirements combined with market based components, i.e., Renewable Energy Portfolio Standards, Feed-in Tariffs, Green Energy PPAs	Green Energy PPA; First loss funding/ Subordinated debt; Political risk insurance; Blended DFI loans; Equity investment: partial (mainly minority) public ownership to reduce private sector risks and facilitate access to debt finance; Viability-gap funding; project preparation
17. Sustainable cities, transport. (MDGs and beyond)	Comprehensive global goals and targets on sustainable cities and transport are not available. t	The vulnerability and resilience of cities and municipalities is being recognized, as well as their global role in leading on education, employment, environment, health and innovation. Some targets are available at local and city levels.	Mostly private sector is outside public or social housing component. Important role of municipalities in city-wide programmes for renewable energy, energy efficiency, urban renewal, and overall sustainability. (SCI Energy Lab) Low carbon cities (Scandinavia) where financially support appropriate businesses and activities.	Voluntary Solidarity Contribution' project for UNITAID; Valuing ecosystem services, for example New York watershed and Philadelphia Clean Water Act obligations Private investment in public infrastructure with toll based cost recovery; Provide viability-gap funding; Project development, including financing for project preparation.	Integrated Reporting; Community-level financing for community infrastructure Urban planning requirement and decisions with business incentivized sustainability components. Low carbon public and local government transport, with conversion/ substitution of natural gas, LNG and H2.	Subsidies and credits for conversion to or use of natural gas, LNG and H2; First loss funding/ Subordinated debt; Political risk insurance; Blended DFI loans; Equity investment: partial (mainly minority) public ownership to reduce private sector risks and facilitate access to debt finance
18. Climate Change and Disaster Risk Reduction (Copenhagen Accord)	Hold global mean temperature increase below 2°C.	By **2050** or longer term based on scientific evidence	$100 B annual international commitment to adaptation finance for developing countries, but growing recognition that much of this money will come from private sector. 75% from private flows and mostly domestic finance.	Global funds: Global carbon cap and auction systems Emission trading schemes; Public Finance Mechanisms to Mobilise Investment in Climate Change Mitigation;[63] Matching Relief Fund, or Matching Challenge Fund[64] or other Adaptation Finance/Funding	Integrated Reporting; Allocating a proportion of funds raised from a cap and auction scheme for CO2 emissions among wealthy nations. World Bank administered trust funds and programmes from public and private donors to support disaster risk reduction.)	First loss funding/ Subordinated debt; Political risk insurance; Blended DFI loans; Co-payments (e.g. feed-in tariffs): Payment made on delivery of an pre-determined outcome; Equity investment: partial (mainly minority) public ownership to reduce private sector risks and facilitate access to debt finance
19. Conflict prevention, post-conflict peace-building	Maintain international peace and security - UN Charter	Maintain international peace and security	Mostly domestic public finance Private financing for targeted issues such as child or female soldiers or camp followers.	Re-direct military expenditures to sustainable development. Through circum-Arctic and Arctic Council, deploy military and military resources to search and rescues and emergency response.	UN leads programmes on post-conflict peace-building. Private funding for rehabilitation and societal re-integration of child and female soldiers or camp followers post conflict.	Political risk insurance: protection against select (rare but costly) policy-oriented risks

Source: Authors' elaboration. The 19 areas are adapted from the Open Working Group the Sustainable Development Goal process (2013) and various publications mentioned above.

[1] "If we continue like in the past" describes a *dynamics-as-usual scenario* which takes into account expected future improvements in technology, institutions, policy, and behaviour. Hence, *dynamics-as-usual* can be significantly different from *business as usual* which does not anticipate these future improvements.

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[Note: The present text also draws on text included in earlier draft versions of the report].

[4] Many of the global limits are not fixed but a function of scientific and technological capacity.

[5] It provides a less conservative and more dynamic benchmark than BAU for comparison with the other scenario families. [6] Satterthwaite, D. (2007). The urban challenge revisited. Environment 49 (9): 3-18. http://www.environmentmagazine.org/Archives/Back%20Issues/November%202007/Satterthwaite-full.html

[7] Source: DESA (2012).

[8] More extreme scenario variants might also be explored where governments react massively in the face of environmental disaster or social conflicts. For example, a collapse of the global thermohaline circulation might trigger large-scale geo-engineering, migration flows, and military conflicts.

[9] measured as terrestrial mean species abundance.

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[32] Schrattenholzer et al. (2005) illustrate this for the IPCC and WEC scenarios. They show that - except for the A1T-550 scenario of IPCC-TAR (a highly techno-optimistic scenario the feasibility of which is far from ensured) - all other stabilization/mitigation scenarios are unsustainable in at least one of four dimensions.

[33] There is also a close family resemblance between the sustainable development scenarios for Rio+20. Indeed, authors explicitly refer back along the scenario family lines. Scenarios of the IPCC-SRES B1 family (2000) closely resemble WEC-C (1997). The GEA mix scenario (IIASA and PBL) resembles IPCC-SRES B1, as does PBL's earlier SD scenario for the Club of Rome (2009). SEI scenarios for Rio+20 were explicitly designed to follow the GEA scenario. The OECD green growth scenarios were to a significant extent developed by PBL colleagues, resembling PBL's parallel work for Rio+20. WBCSD vision draws on the WEC scenarios. RITE-ALPS scenarios are based on IPCC-SRES and TAR work. FEEM scenarios are somewhat more stylized, but were also influenced by the SRES work.

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