Prototype
Global Sustainable Development Report

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UN staff contributors: Richard Alexander Roehrl, David O'Connor, Wei Liu, David Le Blanc, Chantal line Carpentier, Irena Zubcevic, Maria Martinho, Nathalie Risse, Kebebush Welkema, Riina Jussila, Marion Barthelemy, Sami Areikat, Matthias Bruckner, Federica Pietracci, Florence Poppe, and Ola Goransson (UN DESA); Hitomi Rankine, Masakazu Ichimura, and Kilaparti Ramakrishna (ESCAP); Daniele Violetti and Fernando Castellanos Silveira (UNFCCC); Rafael Tuts (UN-Habitat); Amber Barth (ILO); Michael Herrman (UNFPA); Jesper Loldrup (IMO); Volli Carucci (WFP); Fatoumata Keita-Ouane, Jacqueline McGlade, and Jason Jabbour (UNEP); David Shropshire, Tom Alfstad, and Ferenc Toth (IAEA); Ulf-Gerrit Narloch, Michael Chaitkin and Oliver Knight (World Bank); Melchiade Bukur, Elysabeth David, Massimo Candelori, and Sergio Zelaya (UNCCD), Michael Kunz and Annukka Lipponen (ECE); Iulia Nechifor, Matthias Eck, Ana Persic, Salvatore Arico, Julian Barbière, Giovanni Boccardi, Siegfried Demuth, Qunli Han, Nazar Hassan, Blanca Elena Jiménez-Cisneros, Alexander Leicht, Philippe Pypaert, Hans Thulstrup, Jorge Luis Valdes, and Sarantuyaa Zandaryaa(UNESCO); Didier Babin and David Coates (CBD); Raul Cabral (OHRLLS); Devin Bartley, Jonathan Reeves, and Pasquale Steduto (FAO); Robert Hamwey and Bonapas Onguglo (UNCTAD); Roula Majdalani and Riccardo Mesiano (ESCWA); Joselius Samaniego, Marcia Tavares, Diane Quarless, and Charmaine Gomes (ECLAC); Marina Plutakhina, Edward Clarence-Smith, and Adegboyega Ajani (UNIDO); Hughes Rierson (WFP); Magali Outters (Stockholm Convention on Persistent Organic Pollutants).

Academic and NGO contributors: Bob Kates (University of Maine, USA), Kelly Sims Gallagher (Tufts University, USA), Juergen Friedrich HAKE (Systemforschung und Technologische Entwicklung IEK-STE, Germany), Manuel Flores Montes (The South Centre),

Huepe Minoletti (Universidad Diego Portales, Chile), Michael Zhao (IISD, China), Michele Biasutti (University of Padua, Italy), Ana-Maria Boromisa (Institute for Development and International Relations, Croatia), Magdalena A. K. Muir (Columbia University), Wenhan Xie (Chinese Academy of Surveying & Mapping), Fanghong Ye (Chinese Academy of Surveying & Mapping), Chen Shaofeng (Chinese Academy of Sciences, China), Chen Ying (Chinese Academy of Social Sciences, China), Cui Dapeng (Chinese Society for Sustainable Development (CSSD), China), Song Zheng (CSSD, China), Jiang Yi (CSSD, China), Gan Shijun (CSSD, China),Lucien Chabason (Institut du développement durable et des relations internationals, France), Maria Cortes-Puch (Sustainable Development Solutions Network (SDSN), Spain), Emilio D'Alessio (Associazione Agende 21 Locali Italiane, Italy), Alessandro Galli (Global Footprint Network, Switzerland), He Jianqing (China National Engineering Research Centre for Human Settlements (CNERCHS), China Architecture Design & Research Group (CAG), China), Huang Maoxing (School of Economics in Fujian Normal University, China), Liu Hua (UN Association of China), Liu Xuemin (Beijing Normal University), Liu Yi (Chinese Academy of Science), Pan Jiahua (Chinese Academy of Social Sciences), Qi Ye (Climate Policy Institute at Tsinghua, China), Markus Hametner (Vienna University of Economics and Business, Austria), Hachim Kennou (Mediterranean Water Institute, France), Albin Keuc (Gaja Sustainable Development Association, Slovenia), Raymond Saner (Basel University, Switzerland), Nenad Smodlaka (Institute 'Rudjer Bošković', Croatia), Natalija Koprivanac (University of Zagreb, Croatia), Tarik Kupusović (Hydro Engineering Institute, Bosnia and Herzegovina), Tuncay Neyisci (Akdeniz University, Turkey), Lidija Pavić Rogošić (ODRAZ, Croatia), Gayane Poghosyan (National Academy of Sciences of Armenia), Željka Škaričić (Regional Activity Center for the Priority Actions Programme, Croatia), Thomais Vlachogianni (Mediterranean Information Office for Environment, Culture and Sustainable Development, Greece), Keigo Akimoto (Research Institute of Innovative Technology for the Earth, Japan), Bert De Vries (Utrecht University, the Netherlands), Bassel Daher (Qatar Energy and Environment Research Institute, Qatar), Holger Hoff (Potsdam Institute for Climate Impact Research, Germany), Sarah Cornell (Stockholm Resilience Centre, Sweden), Charlie Heaps (Stockholm Environment Institute, USA), Holger Rogner (International Institute for Applied Systems Analysis, Austria), Måns Nilsson (Stockholm Environment Institute, Sweden), Magnus Andersson (Lund University, Sweden), Ola Hall (Lund University, Sweden), Souknilanh Keola (Institute of Developing Economies -IDE-JETRO, Japan), Anders Ahlström (Lund University, Sweden), David Wiberg (IIASA, Austria), Keywan Riahi (IIASA, Austria), David McCullum (IIASA, Austria), Robertus Dellink (OECD and Wageningen University, France), Siwa Msangi IFPRI, USA), Slobodan P. Simonović (The University of Western Ontario, Canada), Oliver Knight (World Bank), Mark Howells (KTH, Sweden), Manuel Weirich (KTH, Sweden), Constantinos Taliotis (KTH, Sweden), Sebastian Hermann (KTH, Sweden), Rebecca Segerstroem (KTH, Sweden), Deepak Sharma (University of Technology, Australia), Wu Jingshen (Hong Kong University of Science and Technology, China), Nancy Chen (University of California Santa Cruz, USA), Hans Herren (Millennium Institute, USA), Mayumi Sakoh (Millennium Institute, USA), Myanna Lahsen (Brazilian Institute for Space Research, Brazil), Christian Flachsland (Mercator Institute, Germany), Bob Brinkmann (Hofstra University, USA), Gisbert Glaser (ICSU), Heide Hackmann (ISSC), Sainan Zhang (Arizona State University, USA), Jesse Ausubel (Rockefeller University, USA), Detlef van Vuuren (PBL, the Netherlands), Matthew Salganik (Princeton University, USA), Anastassia Makarieva (Russian Academy of Sciences), Mori Shunsuke (Tokyo Science University, Japan), Jill Jaeger (SERI, Austria), Bob van der Zwaan (ECN, the Netherlands), Peter Haas (University of Massachusetts Amherst, USA), Alex Evans (New York University, USA), Emanuela Colombo (Politecnico di Milano, Italy), Klas Sandell (Karlstad University, Sweden), Johan Oehman (Örebro University, Sweden), Giovanni Bidoglio (EU-JRC), Ida Kubiszewski (Australian National University, Australia); Guao Risheng, Peng Sizhen, Liu Rongxia, Sun Xinzhang, Wand Wentao, Wandg Zhiqiang, Yao Na, Zhang Jiutian, Zhang Qiaoxian, Zhou Hailin, and Song Min (ACCA21, China); Yu Hongyuan (Shanghai Institutes for International Studies, China), Wang Chunfeng (APFNet and Climate Change Office SFA, China), Wei Yiming (Beijing Institute of Technology, China), Xie Gaodi (Institute of Geographical Science and Natural Resources Research (IGSNRR), China), Xie Zheng (Public Health college, BKU, China), Xue Lan (Tsinghua University, China), Yu Jie (TNC China program, China), Zhang Haibin (Peking University, China), Zhu Dajian (Tongji University, China), Zhang Xiliang (TsingHua, China), Zhang Shiqiu (Peking University, China); David Sonnenfeld, Annisa Dian Pratiwi, Chao Jiang, Cherry Ignacio, Lina Camargo, Nargis Artyushevskaya, Rakhshinda Bano, and Whitney Forman-Cook (SUNY-ESF, USA); Bettina Bluemling, Carmen Chan, Giulia Bongiorno, Jasmijn Appels, Katja Kuivanen, Niké Buijze, Rogier "Justin" Reemer, and Stan Willems, Cor Langeveld, Rolf Groeneveld, Jan van Tatenhove, Ekko van Ierland, Sijmen Schoustra, Gosse Schraa, Marc Verdegem, Theun Vellinga, Aart van der Linden, Arnold van Huis, Gerrie van de Ven, Xueqin Zhu, João Nunes Vieira da Silva, Erik de Bakker, Willem van Berkel, Peter Oosterveer, Maurice Franssen, Hans-Peter Weikard, Oene Oenema, and Ma Lin (Wageningen University, the Netherlands); Rakhyun E. Kim (McGill University, Canada); Appy Sluijs (Utrecht University, Netherlands), Scott Doney (Ocean and Climate Change Institute, Woods Hole Oceanographic Institution, USA); Henk Westhoek and Durk Nijdam (PBL, The Netherlands); Leo den Hartog (Nutreco & Co., The Netherlands), Roslynn Brain (Utah State University, USA), Danielle Nierenberg (Food Tank, USA), Athanasios Krystallis (Aarhus University, Denmark), Pete Smith (University of Aberdeen,

England), Teresa Pereira Heath (Nottingham University Business School, England), Elin Röös (Swedish University of Agricultural Sciences, Sweden), Filippo Corsini (Scuola Superiore Sant'Anna, Italy), Sunil Herat (Griffith University, Australia), Kees van Leeuwen (Utrecht University, The Netherlands), Brett Robinson (Lincoln University, New Zealand), Josh Maiyo (VU University Amsterdam, the Netherlands), Oane Visser (ISS), Hyosun Bae, Zoraida Velasco, Geoff Carr, William Daley, Margaret McKenzie, Zdenka Myslikova, Rajiv Nair, E. Peyton, and Nicholas Zimmermann (Tufts University, USA), Adeline Tay, Kuhuk Bhushan, Liliana Davila, Nisma Elias, Rini Aich, Shaxuan Lizzie Shan, Shweta Bhogale (Yale University, USA).

Contributing government officials in their expert capacity: Wang Weizhong (China), Liu Yanhua (China), Cai Zhiping (China), William Colglazier (USA), Henrique Dolabella (Brazil), Andre Simas Magalhães (Brazil), Atwa Hussein Ahmed Atwa (Egypt), Nancy Butijer (Croatia), Vesna Batistić (Croatia), Dalija Budiša (Croatia), Marijana Mance Kowalsky (Croatia), Adarsh Swaika (India), Sergey Kononuchenko (Russian Federation), Thomas Hansteen (Norway), Emil Gjeset (Norway), Zheng Han (USA), Maitha Alkaabi (UAE), Mei Zhang (UAE), Indoomatee Ramma (Mauritius), Diana Achimescu (Romania), Charalambos Hajipakkos (Cyprus), Jelena Knežević (Montenegro), Marina Marković (Montenegro), Asaf Tzachor (Israel), Franck Lauwers (Malta), Ornela Shoshi (Albania), Gladys Ghartey (Ghana), Laima Jurevičienė (Lithuania), Jorge Laguna-Celis (Mexico), Song Lei (China), Xia Cheng (China), Yu Hai (China), Yang Liu (China), Zhang Shujun (China).

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List of Abbreviations and Acronyms

10YFP	10-Year Framework of Programmes
ADB	African Development Bank
AH model	Asian Highway model
AHTEG	Ad Hoc Technical Expert Group
ALPS	Alternative Pathways towards Sustainable Development and Climate Stabilization
ANS	Adjusted Net Savings
AoA	Assessment of Assessments on Oceans
APCC	Austrian Panel on Climate Change
AREED	African Rural Energy Enterprise Development
BAU	Business-As-Usual
BEA	Bureau of Economic Analysis
BRICS	Brazil Russia India China South Africa
CBD	Convention on Biological Diversity
CDIAC	Carbon Dioxide Information Analysis Center
CDP	Committee for Development Policy
CIS	Commonwealth of Independent States
CLEWD	Climate-Land-Energy-Water-Development nexus
CLEWs	Global resource scenarios of the climate-land-energy and water
CML	Census of Marine Life
CNERCHS	China National Engineering Research Centre for Human Settlements
COP	Conference of Parties
CONF	Conference
CSD	Commission on Sustainable Development
CSSD	Chinese Society for Sustainable Development
CTI	Climate Technology Initiative
DAC	Development Assistance Committee
DALY	Disability-Adjusted Life Year
DAU	Dynamics-As-Usual
DESA	Department of Economic and Social Affairs
DMSP	Defense Meteorological Satellite Program
DSD	Division for Sustainable Development
EBSAs	Ecologically or Biologically Significant Marine Areas
EC	European Commission
ECA	Economic Commission for Africa
ECE	Economic Commission for Europe
ECESA	Executive Committee for Economic and Social Affairs
ECN	Energy Research Centre of the Netherlands
ECOSOC	Economic and Social Council
ECLAC	Economic Commission for Latin America and the Caribbean
EFA	Education For All
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ESCAP	Economic and Social Commission for Asia and the Pacific
ESCWA	Economic and Social Commission for Western Asia
ESSP	Earth System Science Partnership
EU	European Union
Eurostat	Statistical Office of the European Communities
EVI	Enhanced Vegetation Index
E-Waste	Electronic Waste
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FEEM	Fondazione Eni Enrico Mattei
GA	General Assembly
GBIF	Global Biodiversity Information Facility
GBO	Global Biodiversity Outlook
GC	Governing Council

GDP	Gross Domestic Product
GEA	Global Energy Assessment
GEO	Global Environmental Outlook
GHG	Green House Gasses
GIS	Geographic Information System
GMBA	Global Mountain Biodiversity Assessment
GNI	Gross National Income
GNP	Gross National Product
GNS	Gross National Savings
GPI	Genuine Progress Indicator
GPPP	Global Public-Private Partnership
GSDR	Global Sustainable Development Report
GSG	Global Scenario Group
GSP	High-level Panel on Global Sustainability
HANPP	Human Appropriation of Net Primary Production
HDI	Human Development Index
HLPF	High-Level Political Forum
HSE	Health Security
IAASTD	International Assessment of Agricultural Science and Technology for Development
IAEA	International Atomic Energy Agency
ICAO	International Civil Aviation Organization
ICSU	International Council for Science
IDE	Institute of Developing Economies
IEA	International Energy Agency
IEAE	International Atomic Energy Agency
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IGSA	Intergovernmental Scientific Assessments
IIASA	International Institute for Applied Systems Analysis
IISD	International Institute for Sustainable Development
ILO	International Labour Organization
IMF	International Monetary Fund
IMO	International Maritime Organization
IOM	International Organization for Migration
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPSO	International Programme on the State of the Ocean
ISA	International Seabed Authority
ISEW	Index of Sustainable Economic Welfare
ISS	International Institute of Social Studies
ISSC	International Social Science Council
ITC	International Trade Centre
ITU	International Telecommunication Union
JETRO	Japan External Trade Organization
JPOI	Johannesburg Plan of Implementation
KTH	Kungliga Tekniska Högskolan
LCFS	Low Carbon Fuel Standard
LDCs	Least Developed Countries
LLDCs	Landlocked Developing Countries
MDG	Millennium Development Goal
MEA	Millennium Ecosystem Assessment
MEW	Measure of Economic Welfare
MIGA	Multilateral Investment Guarantee Agency
MMR	Maternal Mortality Rate
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	Normalize Difference Vegetation Index
NSC	National Safety Council

NCSA	National Center for Statistical Analysis
NCTR	National Center for Transit Research
NGOs	Non-Governmental Organizations
NHTS	National Household Transportation Survey
NIPA	National Income and Product Account
NNS	Net National Saving
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OHCHR	Office of the United Nations High Commissioner for Human Rights
OHRLLS	Office of the High-Representative for the Least Developed Countries, Land-locked Developing and Small Island Developing States
OSEMOSYS	Open Source Energy Modelling System
OWG	Open Working Group
PBL	Planbureau voor de Leefomgeving
PCE	Personal Consumption Expenditures
PFAN	Private Financing Advisory Network
PNAS	Proceedings of the National Academy of Sciences
PPA	Power Purchase Agreement
PPCP	Public-Private Community Partnership
PPP	Purchasing Power Parity
PPPs	Public-Private Partnerships
PRIO	Peace Research Institute Oslo
PSPP	Public Social Private Partnership
PSRs	Principal Science Reviewers
PV	Ratio of Present Value
R&D	Research & Development
REDD	Reduced Emissions from Deforestation and forest Degradation
RES	Resolution
RITE	Research Institute of Innovative Technology for the Earth
RSN-4	Report of the Fourth Meeting of the Regional Fishery Body Secretariats Network
SAB	Scientific Advisory Board
SBSTA	Subsidiary Body for Scientific and Technological Advice
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice
SCBD	Secretariat of the Convention on Biological Diversity
SCENES	Water Scenarios for Europe and for Neighbouring States
SCI	Sustainable Cities International
SCP	Sustainable Consumption and Production
SD	Sustainable Development
SD21	Sustainable Development in the 21st century
SDA	Shared Development Agenda
SDG	Sustainable Development Goal
SDM	Security Distributing and Marketing
SDSN	Sustainable Development Solutions Network
SEA	Strategic Environmental Assessment
SE4ALL	Sustainable Energy for All
SEEA	Statistical Commission's System of Environmental-Economic Accounting
SEI	Stockholm Environment Institute
SG	Secretary General
SIDSs	Small Island Developing States
SMEs	Small and Medium Enterprises
SNAs	System of National Accounts
SPM	Summary for Policy Makers
SRC	Scientific Research Collaborations
SRES	Special Report on Emissions Scenarios
SSA	Sub-Saharan Africa

STA	Scientific Technocratic Assessments
SUNY-ESF	State University of New York – College of Environmental Science and Forestry
TFSD	Task Force for Measuring Sustainable Development
UCDP	Uppsala Conflict Data Program
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNCCD	United Nations Convention to Combat Desertification
UNCDF	United Nations Capital Development Fund
UNCITRAL	United Nations Commission on International Trade Law
UNCTAD	United Nations Conference on Trade and Development
UNDG	United Nations Development Group
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
UNFIP	United Nations Fund for International Partnerships
UNFPA	United Nations Population Fund
UNGA	United Nations General Assembly
UN-HABITAT	United Nations Human Settlements Programme
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
UNICRI	United Nations Interregional Crime and Justice Research Institute
UNIDO	United Nations Industrial Development Organization
UN/IO	United Nations Information Organization
UNISDR	United Nations International Strategy for Disaster Reduction
UNMAS	United Nations Mine Action Service
UNOPS	United Nations Office for Project Services
UNRISD	United Nations Research Institute for Social Development
UNSC	United Nations Security Council
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UNSD	United Nations Statistics Division
UNTT	United Nations System Task Team
UNWOMEN	United Nations Entity for Gender Equality and the Empowerment of Women
UNWWAP	United Nations World Water Assessment Programme
USDA	United States Department of Agriculture
USFWS	United States Department of Fish and Wildlife Service
WB	World Bank
WBCSD	World Business Council for Sustainable Development
WDI	World Development Indicators
WEC	World Energy Scenarios
WEF	World Economic Forum
WEO	World Economic Outlook
WESP	World Economic Situation and Prospects
WESS	World Economic and Social Survey
WFP	World Food Programme
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WITCH	World Induced Technical Change Hybrid
WMO	World Meteorological Organization
WSH	Water Sanitation and Health
WTO	World Trade Organization
WWF	World Wildlife Fund

Foreword

Sustainability science emerged as a new inter-disciplinary endeavour around the year 2000. In 2012 alone, more than 40,000 authors from 2,200 cities around the world published some 150,000 articles on sustainable development – six times more than ten years before. However, to-date, there exists no global sustainable development report that comprehensively looks at global progress and the future outlook in a truly integrated way, taking into account the range of perspectives in different scientific communities across the world.

The Global Sustainable Development Report (GSDR), requested by Governments at Rio+20, is the first and only comprehensive, global report on sustainable development.

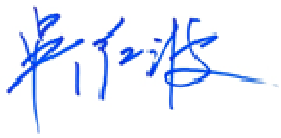
The *present prototype global sustainable development report* is the result of a collaborative effort of more than two thousand scientists and 50 staff from 20 UN entities from all world regions. The report illustrates a range of potential content and discusses potential overall directions for the Global Sustainable Development Report.

The *report* maps sustainable development assessments and related processes, and identifies key remaining challenges: to eliminate poverty and hunger; to feed, nurture, house, educate and employ the global population; to ensure peace, security and freedom; and to preserve the Earth's basic life support systems.

The *report* sketches an alternative sustainable development pathway for the future. It shows that, if we significantly adjust our current patterns of consumption and production, we can help build a more sustainable world in 2050.

The *report* also identifies a range of estimates of total, global investment needs to achieve global goals and commitments. The *report* identifies lessons learnt from national, regional and global case studies of the climate-land-energy-water-development nexus. It takes an integrated approach that looks at clusters of issues and their inter-linkages rather than specific sectors or topics.

I hope, in the future, the Global Sustainable Development Report will provide invaluable concise scientific inputs for the deliberations of the high-level political forum on sustainable development (HLPF). It could report on global progress towards the achievement of the sustainable development goals (SDGs), once they are established in 2015. It could also provide scientific evidence for linking global goals with the necessary means of achieving them. Ultimately, it will help improving the science-policy interface for sustainable development, as called for by UN member States at Rio+20.



Wu Hongbo

Under-Secretary-General for Economic and Social Affairs

1. Introduction

"The population explosion; poverty; ignorance and disease, the pollution of our surroundings, the stockpiling of nuclear weapons and biological and chemical agents of destruction are all parts of a vicious circle. Each is important and urgent but dealing with them one by one would be wasted effort." (Indira Gandhi, Stockholm Conference 1972)

1.1. Context

Bringing together great global issues at the UN: peace and security, freedom, development, environment[1]

Since the creation of the United Nations, the world's peoples have aspired to make progress on the great global issues of peace and security, freedom, development, and environment. At the end of World War II the primary focus was on peace which was sustained globally throughout the cold war, but broken locally in many places. From the 1950s, the aspiration of freedom was expressed in the struggle to end colonialism and oppression, and later to extend human rights. The success in attaining national independence was followed in the 1960s by a focus on economic development to provide the basic necessities for the poorest two-thirds of the world and higher standards of living for all. In the 1970s, global values for nature and the environment emerged, as illustrated by the UN *Conference on the Human Environment* held in Stockholm in 1972.

Peace and security, freedom, development, and environment remain prominent aspirations, and it has long been acknowledged that they are closely interlinked (Table 1). High-level panels and commissions, major documents, and global conferences have made a moral and pragmatic case for them. Insufficient development progress can threaten peace and security and vice versa. Reduced freedom can threaten peace and vice versa. Development provides the capacity to sustain nature's life support systems, but can also threaten them, in turn setting back development. The concept of *sustainable development* brought together development and environment.

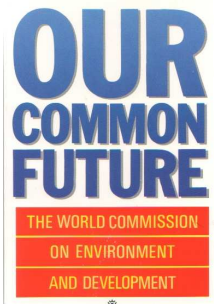
Table 1. Sustainable development – bringing together great global issues at the UN

Global issues	UN Report / World Commission	Year
Freedom and Development	Brandt report, Independent Commission on International Development Issues	1980
Peace, Freedom, Development	Palme Report, Independent Commission on Disarmament and Security Issues	1982
Peace, Environment, Development	Brundtland Report, World Commission on Environment and Development	1987

Sustainable development objectives have been widely defined along three dimensions as "economic, environmental and social" or "ecology, economy, and equity".

The origins of the concept of sustainable development

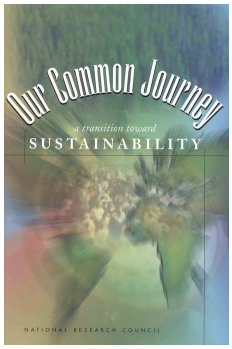
The concept of sustainable development has a very long history in science. For example, already in 1713 Hans Carl von Carlowitz referred to "sustainable yield" (*nachhaltiger Ertrag*) in the context of sustainable forestry management.[2] Especially since the late 1960s, there has been a large amount of scientific literature on sustainable development issues. Natural and social scientists highlighted a series of sustainable development issues and recommended integrated policy action in many areas, e.g., on development, poverty, hunger, employment, equity between generations and countries, gender equality, environmental pollution, resource scarcity, and on the means to achieve policy objectives in these areas, such as technology, finance, capacity building and trade.



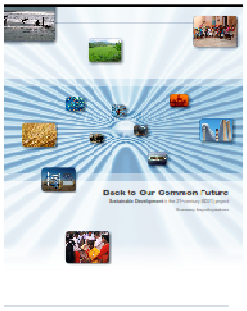
The Brundtland report[3] of 1987, entitled *Our Common Future*, defined the concept of *sustainable development* as "*…development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". The report built on earlier scientific perspectives on the interdependence of society and environment pioneered by the International Union for Conservation of Nature (IUCN). The report also illustrated the fact that conflicts can arise from pre-emption of development options or from environmental degradation, and that conflict is also a major cause of unsustainable development. The concept of sustainable development was subsequently adopted by Governments at the *Earth Summit* of 1992 in Rio de Janeiro, together with a set of *Rio Principles*[4] and a global action plan, *Agenda 21*,[5] which included many goals and targets. Some of these goals became part of the Millennium Development Goals a decade later.

Reconnecting science and policy towards a global sustainable development report

It is important to note that the policy framework itself emerged with little science.[6] There were only two scientists on the World Commission on Environment and Development (WCED)[7] and little science was present in Rio in 1992.[8] Ten years later at the Johannesburg World Summit on Sustainable Development, there was some scientific presence. In contrast, scientists were among the most prominent groups at the side events of the UN Conference on Sustainable Development ("Rio+20") in Rio in 2012.



The increasing presence of science at UN meetings on sustainable development is also due to the efforts of academies of science and individual scientists to reconnect science and technology with the policy on sustainable development. For example, the US National Academy of Sciences created a Board on Sustainable Development in 1995 which sought to make the concept of sustainable development manageable and measurable by focusing on a minimal sustainability transition over two generations until 2050. It chose three normative goals that had emerged at the top of the agenda of global conferences: meeting the human needs of the 9 billion (expected by 2050), while preserving the life support systems of the planet, and reducing hunger and poverty. The results were published in a report, entitled *Our Common Journey*[9] in 1999. It was the first comprehensive global sustainable development report, albeit with a developed country perspective as a starting point. The report argued for action on what we already know and for creating a *sustainability science* for what we needed to know.



The UN Division for Sustainable Development[10] in collaboration with 178 scientists produced a series of reports - the so-called *SD21 study* - in preparation for Rio+20 in 2012. The study was prepared under a project entitled *Sustainable Development in the 21st Century* and was financed by the European Union. It documented the range of perspectives among scientists on sustainable development issues, with a view to identifying common ground, especially in the areas of energy, land-use, agriculture, food security, cities, and on sustainable development scenarios.[11] The study also included a review of implementation of Agenda 21 and of the Rio principles.

Despite these and other efforts, *to-date there exists no* comprehensive, authoritative *global sustainable development report* that would bring together the range of existing assessments, review global progress and future pathways in a truly integrated way, taking into account the range of perspectives of scientific communities across the world. This is despite the policy prominence and the existence of many topical assessments (see chapter 2).

Rio+20's call for a Global Sustainable Development Report

In 2012, the *Secretary General's High-level Panel on Global Sustainability* in its final report in preparation for Rio+20 detailed the importance of basing sustainable development policy-making on the best and most up-to-date evidence and in this regard also recommended a *Global Sustainable Development Outlook* which would bring together assessments across sectors in an integrated manner.[12]

The recommendation was considered by Rio+20.[13] In its outcome document, Rio+20 decided to establish a universal, intergovernmental high-level political forum on sustainable development (HLPF) which would, as one of its functions, "*strengthen the science-policy interface through review of documentation bringing together dispersed information and assessments, including in the form of a global sustainable development report, building on existing assessments*" (§85k).[14]

In response, the UN Secretary-General tasked the Division for Sustainable Development (DSD) of the Department of Economic and Social Affairs (DESA) to undertake "*in-depth analysis and evaluation of trends and scientific analysis in the implementation of sustainable development, including lessons learned, best practices and new challenges, and cross-sectoral analysis of sustainable development issues*". Further details were provided in the revised programme budget adopted by the General Assembly at the end of 2012.[15]

1.2. "Prototype" UN report

Prototype report to support deliberations on the scope and methodology for the GSDR

Since 2013, the Division for Sustainable Development of the United Nations Department of Economic and Social Affairs has worked on the present "*prototype report*" that could illustrate a range of potential content, alternative approaches and various ways of participation, in order to support member States' deliberations on the scope and methodology of future editions of the Global Sustainable Development Report. An Executive Summary of the prototype report was presented by the UN Undersecretary General for Economic and Social Affairs at the inaugural session of the high-level political forum on sustainable development on 24 Sept. 2013.[16] Following further review and consultations, a full prototype report will be presented at the meeting of the high-level political forum under the auspices of the Economic and Social Council in July 2014.

Substantive starting point: assessments at the global, regional and national levels

The prototype report has made use of existing scientific research and in-depth studies from a wide range of sources, including the large number of scientific contributions for Rio+20. It considered hundreds of assessments, including 57 international assessments, 69 national sustainable development reports, 125 flagship publications of the UN system, 23 outlook reports prepared by intergovernmental organizations and more than 1,000 academic articles and think-pieces. In particular, it has considered the following: international scientific, topical assessments (e.g., IPCC, IPBES, GEA, GEO, IAASTD); Sustainable Development in the 21st Century (SD21) project studies; Sustainable Development Solutions Network (SDSN); Sustainable Development issue briefs, official submissions and other inputs for Rio+20; the Future Earth Initiative; science-policy briefs on sustainable development by Academies of Science and others; institutional reports; and Government-sponsored research on sustainable development.

1.3. Participation and consultations

The present report is the result of a collaborative effort of scientists, experts, UN staff and selected government officials. Hundreds of contributors and reviewers from 46 countries have supported the Report, including 57 UN staff from 21 entities, 35 government officials, 2 major groups, 161 named academics and scientists, inputs from 178 experts that had participated in a DSD project in preparation for Rio+20[11], and an international team of young scientists and research students from several universities.

UN system effort

The Division for Sustainable Development (DSD) of the United Nations Department of Economic and Social Affairs (DESA) led the preparations of the Global Sustainable Development Report. It reached out to scientific communities and to colleagues in the UN system to provide focused inputs to the report. As of 1 May 2014, 21 UN entities had joined the effort (Box 1).

Box 1. UN entities that have supported the production of a prototype global sustainable development report

As of 1 May 2014, the following 21 UN entities had joined the effort:

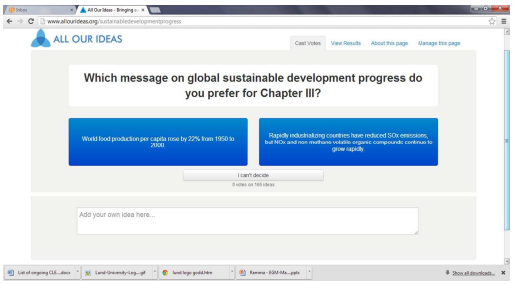
- Convention on Biological Diversity (CBD),
- UN Department of Economic and Social Affairs (DESA),
- UN Economic Commission for Latin America and the Caribbean (ECLAC),
- UN Economic and Social Commission for Asia and the Pacific (ESCAP),
- United Nations Economic and Social Commission for Western Asia (ESCWA),
- UN Economic Commission for Europe (ECE),
- Food and Agriculture Organization (FAO),
- International Labour Organization (ILO),
- International Maritime Organization (IMO),
- International Atomic Energy Agency (IAEA),
- Office of the High-Representative for the Least Developed Countries, Land-locked Developing and Small Island Developing States (OHRLLS)
- United Nations Convention to Combat Desertification (UNCCD),
- United Nations Environment Programme (UNEP),
- United Nations Educational, Scientific and Cultural Organization (UNESCO),
- United Nations Conference on Trade and Development (UNCTAD),
- United Nations Industrial Development Organization (UNIDO)
- United Nations Framework Convention on Climate Change (UNFCCC),
- United Nations Population Fund (UNFPA),
- UN Human Settlements Programme (UN-Habitat),
- World Food Programme (WFP), and
- World Bank (WB).

The International Monetary Fund (IMF) participated as an observer.

Participating scientists and "crowd-sourcing"

In view of the limited time available for the preparation of the present report, DESA first approached scientists in the aforementioned initiatives, scientists suggested by UN

partners, and major scientific groups, notably the International Council for Science and the International Social Science Council.



A multi-lingual crowd-sourcing platform developed by Princeton University was used to collect even wider views from thousands of scientists across the world.[17] A special effort was made to reach the younger generation of scientists. Inputs were made in English, Spanish and Chinese. In the future, a much wider range of languages might be used. Key messages and findings of the Report are crowd-sourced rather than being decided by UN staff or selected scientists. Social and natural scientists were encouraged to make their voices heard on the UN Website until the end of 2013.[18]

It is anticipated that a longer period will be available for the preparation of future editions of the Report. Governments might consider various models for the selection and engagement of scientists.

Expert group meetings and consultations

Box 2. Expert group meetings in support of a global sustainable development report

In addition to informal consultative meetings and briefings, the following expert group meetings have been organized in support of a global sustainable development report:

- High-level Expert Group Meeting for the Global Sustainable Development Report - Engaging National Assessments (Beijing, China, 12-13 Dec. 2013)
- Expert Group meeting for the Global Sustainable Development Report - Future directions and formalization of network of scientific contributors (Dubrovnik, Croatia, 21-22 Oct. 2013)
- Expert Group Meeting on the science-policy interface (New York, USA, 5 Sept. 2013)
- Expert Group Meeting on the evolution of assessments for sustainable development (New York, USA, 3-4 Sept. 2013)
- Expert Group Meeting for the Global Sustainable Development Report – Case studies of the Climate-Land-Energy-Water-Development Nexus (Stockholm, Sweden, 29-30 May 2013)
- Expert Group Meeting on innovative ways of measuring sustainable development progress (Lund, Sweden, 26-27 May 2013)
- DESA-ICSU-ISSC meeting on Sustainable Development Goals (New York, USA, 201-21 March 2013)
- OSEMOSYS scenario modellers meeting (New York, USA, 29 March 2013)

In 2013, a series of expert group meetings and consultation meetings were organized to support the preparation of draft chapters and to explore informal networks of scientific contributors for future reports (Box 2). The meetings differed greatly in terms of content, focus, and meeting participants. One of these meetings resulted in the "*Dubrovnik Declaration*" which provided a "*regional perspective on science-policy interface for a sustainable future*".[19]

1.4. Objective and scope

Objective

The report is a UN publication that brings together findings of scientific assessments, as input for policy deliberations at the High-level political forum (HLPF) and beyond. It is designed as a "prototype" version of a future *Global Sustainable Development Report* which is expected to support the work of the high-level political forum. The prototype report aims to support the deliberations of Governments in 2014 on the scope and methodology of the future report, in line with the General Assembly resolution A/RES/67/290 on "*Format and organizational aspects of the high-level political forum on sustainable development*" of July 2013. It is intended as a technical, analytical, and descriptive contribution to the global debate on sustainable development that digests, synthesizes and draws out policy implications of relevant scientific and social scientific research.

The present report aims to bring together science and policy-making. It is neither conceived as a scientific report nor as a political document. Instead, it is a report drafted by UN staff to facilitate dialogue between these two communities.[20]

Target group

The target group of the report comprises government officials, policy makers and other decision-makers at all levels.

Scope

The Report looks three generations into the past (1950-2013) and two generations into the future (until 2050). The

challenge is to learn from our trial and error approaches in the past, in order to achieve a global sustainability transition by 2050, which aims to eliminate poverty and hunger; enable livelihoods; feed, nurture, house, and educate more than nine billion people; secure peace, security and freedom; and preserve the Earth's basic life support systems. The report focuses on *global* sustainable development, in terms of issues, impacts, institutions and technology. Aspects at the regional, national and local levels are covered where appropriate.[21]

While the general Brundtland definition of sustainable development[3] (quoted above) is widely accepted, more specific definitions derived from an operational translation of the principle of inter-generational equity differ greatly from each other, especially in terms of vastly different scopes. These definitions are grounded in different worldviews that ultimately arise from different sets of values. The different choices of values lead to different emphases on what is to be sustained and what is to be developed, as well as on different relevant time scales (Table 2). Most sustainable development definitions are based on elements of nature, life support, people, and economy, whereas not much work takes into account the community and society dimensions. The economic, social and environmental dimensions of sustainable development are apparent in Table 2.

Table 2. Literature review of sustainable development definitions

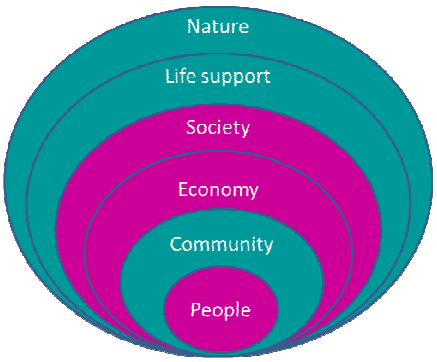
	Sustainability			***Development***	
Values	**What is to be sustained?**	**How long?**	**Linked by**	**What is to be developed?**	**By when?**
Freedom **Equality** **Solidarity** **Tolerance** **Respect for nature** **Shared respon-sibility** **etc.**	**Nature** **Earth** (e.g., no anthropogenic climate change or interference with the phosphorus and nitrogen cycles). **Biodiversity** (e.g., no human interference, biological invasions). **Ecosystems** (e.g., in the oceans).	Centuries, forever years, decades centuries, forever	**Only** **Mostly** **But** **And** **Or**	**People** **Health, life expectancy**, child survival. Elimination of **poverty** and **hunger**. **Education** and skills. **Access** to good food, housing, modern energy, clean air, water, sanitation, health care, etc. **Income and employment opportunities**. **Equity**, equal opportunity, **social mobility** **Human security** (e.g., economic, food, health, environmental, personal, community and political security). **Human rights** (e.g., right to life and to a fair trial; freedom from torture and slavery; freedom of speech, thought, conscience and religion; freedom of movement). Well-being and **happiness.**	Now, several years, decades. Now. Now.
	Life support **Ecosystem services** (e.g., forests, grasslands, ocean fisheries, coastal zones). **Resources** (e.g., water, material consumption, croplands). **Environment** (e.g., air pollution, chemicals, tropospheric ozone, agriculture).	Several years, decades		**Economy** **Wealth.** **Productive sectors.** **Consumption**. Economic **growth**, income convergence. **Trade**, production and distribution systems. **Economic resilience**; national energy, water and food security. **Infrastructure**, buildings, urbanization. **Scientific, technological and innovative capacities**.	Now, one or more years. Decades
	Community **Peace** **Cultures** (e.g., cultural heritage, traditions, traditional knowledge). **Groups** **Places**	Several years, decades		**Society** Effective **institutions.** **Social capital**, resilient societies. Legitimate **States.** Productive **regions** providing opportunities. Stable and happy **families.** **Intergenerational equity.**	Several years. Decades

Note: Adapted from NRC (1999)[9], Kates et al. (2005)[22], and UN (2012)[11]. The listed issues are indicative of areas typically covered in SD definitions.

The framework of Table 2 is used throughout this publication, including for reporting on past progress and future scenarios. It helps linking to related ongoing debates. For example, the debate on the *Millennium Development Goals* focuses primarily on issues in the "People" cluster. The green economy debate aims to combine developing the "Economy" with preserving the environmental "life support mechanisms". The discussion on *Sustainable Development Goals* has focused on developing both "People" and "Economy", while sustaining the Earth's "Life support" mechanisms. The planetary boundaries proponents suggest global goals on the Earth's "Life support" mechanisms. Proponents of "strong sustainability" emphasis the "Nature" cluster, as they are convinced that Nature cannot be substituted or sold. Debates on the issue clusters "Community" and "Society" have typically been carried out in isolation from the other sectors, even though linkages had already been emphasized in the Brundtland report.

The six areas of issues to be sustained or developed have different scopes. In fact, groups of people form communities, which in turn make up a national economy, which can be one aspect of a society, which in turn is part of and depends on nature's life support system, which is but one element of nature as a whole (Figure 1).[23]

Figure 1. From people to nature



Note: purple = to develop; green= to sustain

Source: DESA.

The above framework is an elaboration of the idea of "*interdependent and mutually reinforcing pillars of sustainable development - economic development, social development and environmental protection*", as recognized by UN Member States since the Johannesburg Declaration on Sustainable Development of Sept. 2002[24] (Table 3). It provides more detail, including on the level of balance between development and sustainability in every pillar. It also allows for other issues that have been suggested as "fourth pillars", such as institutions, governance or culture. For example, the UNESCO Universal Declaration on Cultural Diversity, adopted in 2001, stated that "*...cultural diversity is as necessary for humankind as biodiversity is for nature*".[25] Some economists have advocated that the three pillars of sustainable development should comprise interlinkages, intergenerational equity, and dynamic efficiency[26] - a perspective that is also captured by the framework.

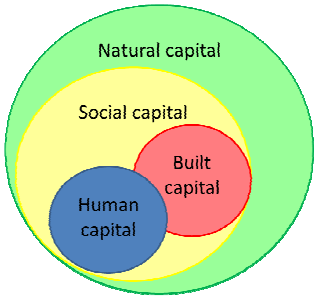
Table 3. Coverage of three pillars of sustainable development

		Social	Economic	Environmental
What is to be developed?	People	+++	++	+
	Economy	++	+++	+
	Society	+++	+	+
What is to be sustained?	Nature	+	+	+++
	Life support	+	++	++
	Community	+++	+	+

Note: The plus signs indicate the level to which each pillar is captured. +++: strong focus; ++: focus; +: related but not a focus.

Another variation of the same conceptual framework uses the capital approach. Human and built capital (the economy) is embedded in society and ultimately in nature.

Figure 2. Three dimensions of sustainable development in the capital approach



Source: adapted from Costanza et al. (2014)[27].

1.5. Outline

The present report maps sustainable development assessments and related processes and highlights emerging issues identified by scientists (chapter 2); assesses sustainable development progress (chapter 3); tells the "stories" of future pathways toward sustainable development based on the literature and discusses investment and technology needs (chapter 4); assesses various approaches to measuring sustainable development progress (chapter 5); identifies lessons learnt from national, regional and global case studies of the climate-land-energy-water-development nexus (chapter 6); presents illustrative science digests for decision-makers (chapter 7) and suggests a number of issues for consideration (chapter 8).

The report takes an integrated approach that looks at clusters of issues and their inter-linkages rather than specific sectors or topics. Background materials are available at: http://sustainabledevelopment.un.org/globalsdreport/

2. Assessments for sustainable development

"An expert is a person who has made all the mistakes that can be made in a very narrow field." (Niels Bohr)

"Pollution is not a technical problem. The fault lies… in the sense of values of the contemporary world which ignores the rights of others and is oblivious of the longer perspective." (Indira Gandhi, 1972)

This chapter maps the *landscape of assessments* rather than their findings. It might help as an entry point for decision-makers who are interested in the scientific basis of their decisions. [28]

2.1. Introduction

What is an assessment?

Assessments differ from academic reviews. Assessments are typically prepared for decision-makers and address broad and complex topics, by drawing on large and representative groups of experts. Assessments are problem-driven and usually synthesize scientific findings on complex issues, reducing complexities. They inevitably make judgments, but generally aim to separate descriptive and normative elements of the assessment. In order to support decision-making, uncertainty statements are essential and often controversial (Table 4).[29] Participating experts in this report expressed preferences for different variations of assessment models and emphasized the practical difficulties in clearly separating political and scientific considerations in these assessments.

Table 4. Comparing reviews with assessments

	Review	***Assessment***
Audience	Scientists	Decision-makers
Carried out by	One or a few	Large and varied group based on relevant geographic and disciplinary representation
Topic	Simple, narrow	Broad and complex
Identifies gaps in	Research: curiosity-driven	Knowledge for implementation of outcomes: problem-driven
Uncertainty statements	Not required	Essential
Judgement	Hidden; a more objective analysis	Required and clearly flagged
Synthesis	Not required, but sometimes important	Essential to reduce complexity
Coverage	Exhaustive, historical	Sufficient to deal with main range of uncertainty associated with the identified issues

Source: Watson and Gitay (2004), cited in IAASTD (2009), Global Report[30], p.5.

It should also be noted that choosing sustainable development goals necessarily involves a normative judgement as to the relative importance of issues. Therefore, broad sustainable development assessments can never live up to the scientific standards of the natural sciences.

In fact, it has been suggested that no assessment can live up to the scientific standards of the natural sciences. Efforts to mobilize science and technology for sustainable development are more likely to be effective, if they manage boundaries and enhance salience, credibility and legitimacy. However, there are trade-offs between these three characteristics – you cannot optimize credibility, e.g. through scientific standards, without compromising relevance and legitimacy.[31]

Scientific assessments have also been characterised as contributions of science to the overall process of social learning, by which science informs multiple stakeholders with the aim to respond to their needs and aspirations. IN turn, multi-stakeholder dialogues can guide the way science is designed and help target its efforts towards societal outcomes. *"[I]f assessments were perceived as continuous learning processes, they could be organized as processes of perpetual improvement and reflective change of the assessment as an institution itself and, consequently, they might become more powerful institutions in the process of solving environmental problems*".[32]

Which assessments are "assessed"?

For the purpose of this report, assessments qualify as *sustainable development assessments*, if their underlying sustainable development definition captures at least one item to be sustained, one item to be developed, and at least two of the economic, social and environmental dimensions (Table 2). Most of the identified assessments are broader and include all three dimensions, yet fully comprehensive assessments are exceedingly rare.

There are thousands of sustainable development assessments. In view of the limited time and resources, the present report considered the following subset:

- 57 international assessments suggested through the crowd-sourcing Website;
- 125 flagship publications of the UN system;
- 23 outlook reports prepared by intergovernmental organizations.
- 69 national sustainable development reports that had been submitted to Rio+20;

2.2. International assessments

2.2.1. International scientific assessments

The UN crowd-sourcing platform registered 319 contributions from scientists around the world who voted on each other's ideas and contributed a total of 57 assessments that they would like to bring to the attention of decision-makers. On top of the list came prominent intergovernmental assessments and UN publications (Table 5). A number of high-profile assessments such as the IPCC were suggested but did not make it to the top of the list, possibly because scientists felt that decision makers were already sufficiently familiar with them.

Table 5. Top 15 assessments scientists worldwide would like to bring to the attention of decision-makers.

Assessment	Led by
Assessment of assessments on oceans	UN
PNAS Sustainability Science	US Academy of Sciences
Scientific Synthesis of the Impacts of Ocean Acidification on Marine Biodiversity	CBD
Global Energy Assessment	IIASA
Census of Marine Life	Alfred P Sloan Foundation
SD21 project for Rio+20	UN, EU
TRENDS report	UN
Global Biodiversity Outlook	CBD
Intergovernmental Panel on Biodiversity and Ecosystem Services	IPBES
Reports on the achievement of the Millennium Development Goals	UN
Grand Challenges	ICSU
Global assessments listed on the website of IPBES	IPBES
Global Forest Resources Assessment	FAO
State of the World's Plant Genetic Resources for Food and Agriculture	FAO
World Water Futures until 2050	UNWWAP
Work of IPSO on Oceans	IPSO

Source: UN crowdsourcing platform results as of 2 September 2013, http://www.allourideas.org/assessments
Note: The above list is user generated and no judgement has been made as to constitutes an assessment (see Table 4).

Widening scopes and multiple goals of international assessments since 2000

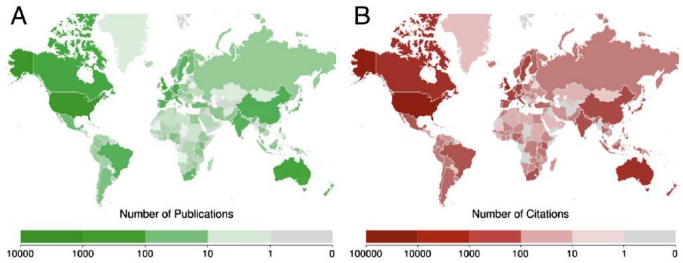
Sustainable development assessments conducted in the 1970s and 1980s considered a wide range of issues, even when the assessments had a sectoral focus to begin with.[33] Later sustainable development assessments typically followed increasingly narrow scopes and explored single objectives or goals, such as identifying optimal technology systems for reducing greenhouse gas emissions. Examples include the periodic assessments by the Intergovernmental Panel on Climate Change (IPCC), as well as the assessments on ozone depletion in support of the Montreal Protocol.

Since the 2000s, assessments have started to widen again their scopes and to consider "co-benefits" and multiple goals. Notable examples are the Millennium Ecosystem Assessment (2005), the International Assessment of Agricultural Knowledge, Science and Technology for Development (2008), and the Global Energy Assessment (2012).

Emergence of sustainability science by 2000

Sustainability science emerged as a new inter-disciplinary, unified scientific endeavour around the year 2000. It is a field defined by the problems it addresses rather than by the disciplines it employs, similar to health science.[34] The number of authors who published articles with "sustainable development" or "sustainability" in the title doubled about every eight years since the early 1970s. In 2010, about 37,000 scientists authored such articles in biology, engineering and social science journals. They worked in universities or are practitioners in government, NGOs or the private sector in 174 countries.[35] Google scholar registered 150,000 academic articles published in 2012 alone that indicate "sustainable development" as their ultimate objective - six times more than ten years ago (Figure 4). The geographic distribution of sustainability science is unusually wide, when compared to typical specialized fields of the natural sciences, which indicates the quality and quantity of sustainability science contributions from developing countries (Figure 3).[35]

Figure 3. Geographic distribution of sustainability science publications.



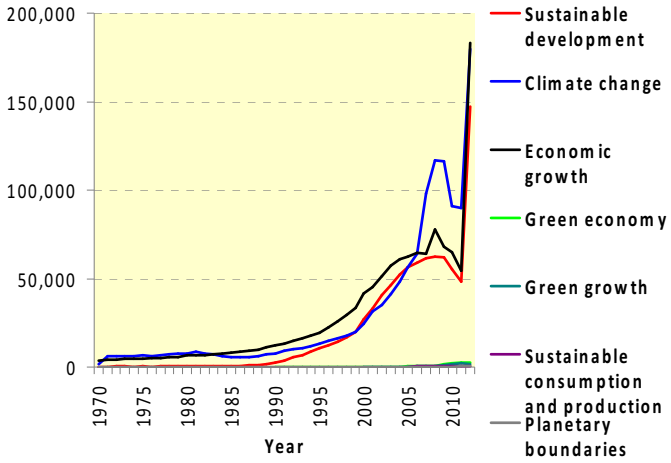
Notes: (A) National counts of number of publications. (B) National counts for number of citations received. *Source:* Bettencourt and Kaur (2011).[35] Copyright © by Bettencourt et al..

Thousands of sustainable development assessments

Thousands of scientific assessments have been performed – some of them on a regular basis – on various temporal and geographic scales. Most of them focused on specific systems and sectors that are of special importance for sustainable development. For example, there are 1,023 assessments in the database for the Assessment of assessments on oceans[36] and 215 assessments at multiple scales in the database for the Intergovernmental Science-

Policy Platform on Biodiversity and Ecosystem Services (IPBES)[37]. These lists are growing and have to be updated on a regular basis. Comprehensive databases could not be identified that capture sustainable development assessments in other relevant areas.[38] There is evidence for a large number of climate change-related assessments.

Figure 4. Number of articles (contained in Google Scholar) indicating selected ultimate objectives.



Source: authors' calculations based on Google Scholar data.

Assessments differ greatly in terms of scope, scale, organization, process, participation, resources and perceived policy relevance

57 international assessments were suggested through the crowd-sourcing Website and considered here. While the full list of assessments is available on the UN Website[39], here we present selected international assessments, especially those that have served as models for new initiatives. They illustrate very different approaches in terms of scope (one or multiple goals), scale (local to global, present to centuries), organization (by universities, NGOs, governments or the UN), process, participation (a few to 3000 scientists), resources (US$0.05 million ad hoc project to US$650 million ten-year programme), and policy relevance (linked to a political process or not). It should be noted that all of these assessments have been perceived by some to be to a varying extent political, even when conducted by scientists.

The *Intergovernmental Panel on Climate Change (IPCC)* – created in 1988 – has produced some of the most well-known assessments. The global assessments take a very long-term perspective and focus on a single objective – to prevent dangerous anthropogenic interference with the climate system. They are UN-sponsored and engage more than 2,000 scientists from 154 countries who are collaboratively working on assessments for up to six years at a time. The assessments are comprehensive reviews of the academic literature and have become very detailed, exceeding 1,500 pages in each working group. The assessments directly support the UNFCCC process. Most importantly, the *Summary for Policy Makers* is adopted/negotiated by Governments in the IPCC plenary. Governments are also nominating participating scientists. The operational budget is about US$ 8 million per year and in-kind contributions are estimated at several times that amount. Hence, the total cost of the current six-year assessment cycle was probably around US$168 million.[40]

The *International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD)* is another example of an intergovernmental scientific assessment. In contrast to the IPCC, the IAASTD was a one-time assessment and included local and traditional knowledge in the assessment alongside peer-reviewed academic material. It had a multi-stakeholder bureau and put emphasis on a consultative process involving 900 participants in 110 countries. IAASTD looked at the period of 1940 to 2050 and explored three overarching goals: (a) reducing hunger and poverty; (b) improving nutrition, health and rural livelihoods; and (c) facilitating social and environmental sustainability. It was a three-year initiative, co-sponsored by six UN system entities and had an operational "baseline" budget of US$10.7 million.

The *Millennium Ecosystem Assessment (MA)* was a scientific appraisal - at multiple scales - of the condition and trends in the world's ecosystems and the services they provide, as well as the scientific basis for action. It was governed by a board comprising UN entities, civil society, and the private sector. The assessment was drafted by a team of 1,360 experts from 95 countries, and it was reviewed by 44 governments, 9 scientific organizations, and 600 individuals. The budget of the five-year assessment amounted to US$24 million plus in-kind contributions. There was no formal link of MEA to a political process, but the impact of its capacity building activities is often noted.

The *Assessment of Assessments on Oceans (AoA)* is an ongoing eight-year initiative with an operational budget of about US$5 million per year. In contrast to many of the other assessments that aim to assess existing academic literature and/or other knowledge, the AoA carries out a "critical analysis of the assessments in order to evaluate their scientific credibility, policy relevance, legitimacy and usefulness". It aims to assess more than 1,000 relevant marine and coastal environmental assessments at global, regional and national levels. Ecological, social and economic

aspects are considered. The AoA is tasked to support a working group of the UN General Assembly.

The planned assessments of the *Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES)* are expected to focus on an assessment of hundreds of existing assessments.

The *Global Energy Assessment (GEA)* has followed an approach similar to the IPCC's for collaborative drafting of the extensive report.[41] It explores four goals: (a) stabilizing global mean temperature rise to 2°C above pre-industrial levels by 2050; (b) energy security by diversification and resilience of energy supply (e.g., dependence on oil imports); (c) eliminating household and ambient air pollution; and (d) universal access to modern energy services by 2030. It also focuses on the global and regional levels and takes a long-term perspective (1850-2050). The assessment was initiated by the International Institute for Applied Systems Analysis (IIASA)- an international research and policy think-tank of academies of science (and similar entities) of 20 countries. In contrast to the IPCC, the more than 300 authors and 200 academic reviewers were selected exclusively by their peers. The Global Energy Assessment informally and de facto supports the UN Secretary General's ad hoc initiative on "*Sustainable energy for all*".

The *UN reports on the achievement of the Millennium Development Goals (MDGs)* have regularly monitored progress towards the achievement of the 8 MDG goals, in order to support directly the MDG process. They are UN publications that are prepared by UN staff with inputs from the entire UN system, together with other experts and scientists. They assess progress using official data at the national, regional, and global levels for the period of 1990 to 2015.

The *Committee for Development Policy (CDP)* is a group of 24 development economists appointed for a period of three years by the UN Secretary General. It provides advice on emerging cross-sectoral development issues and on international cooperation for development. In particular, the Committee members meet once or twice a year to assess potential graduation from or inclusion in the list of Least Developed Countries. Reports are typically drafted by UN staff upon instruction by the committee members. The Committee has recently also been requested to produce assessments on climate change, as well as on Small Island Developing States. The Committee is subsidiary to the UN Economic and Social Council (ECOSOC) to which it makes its recommendations.

Sustainable Development in the 21st Century was a two-year global assessment project carried out by the UN Department for Economic and Social Affairs and co-financed by the European Union in preparation for Rio+20.[11] The project was the only assessment contribution that formed part of the official budget for Rio+20. It assessed progress since 1950 and explored a global sustainability transition to 2050. It also included a review of implementation of Agenda 21 and the Rio Principles. The project studies were drafted by lead authors under the supervision of UN staff, in collaboration with 178 academics, practitioners, scientists, policy analysts and economists. The project studies were technical in nature, but linked to diverse political messages. Differences and commonalities in the views of scientists were identified and clearly described in the reports, with a view to finding common ground in support of intergovernmental negotiations under UN auspices.

The *Census of Marine Life* was an international scientific assessment at multiple scales which was carried out as a ten-year research programme and engaged 2,700 scientists – even more than the IPCC. It was organized as a purely scientific process with no formal link to a political or governmental process. The assessment was initiated by the Alfred P Sloan Foundation and had a total price tag of US$650 million.

The number of assessments and the resources devoted seem proportional to the associated economic stakes

The number of assessments and the resources devoted [to different sectors and themes] seems to be proportional to the associated economic stakes. This has made climate change assessments the most proliferating area over the past 20 years.[42] In contrast, there is no standard international assessment on sustainable agriculture, and food security and nutrition. The example of the IPCC highlights that even within one assessment there can be significant differences between chapters devoted to different sectors.

What typologies of assessments make most sense?

Three broad groups of assessments can be distinguished: intergovernmental scientific assessments (IGSA); scientific-technocratic assessments (STA); and scientific research collaborations (SRC). They can be further categorized along the following elements (Table 6):

- What is the scope? Broad sustainability or thematic/sectoral?

- What is the overall approach? "Top-down" like the IPCC or "bottom-up" like the Stanford Energy Modelling Forum;
- Who nominates/selects participants? For example, is it pro bono participation based on nomination, or consultants hired by an organization? Is participation representative?
- Who finances the assessment and its participants?
- Is there a formal or informal link to a political process?
- Is it a primarily descriptive assessment? Is it policy relevant? Is it policy prescriptive?
- Who drafts the text and who approves it?
- Is it a regular or an ad hoc assessment?
- What kind of knowledge is assessed?
- What is the content focus of the assessment? Does it focus on the diagnosis of problems or identification of solutions? Does it look at the past or the future?[43]

Table 6. Simple typology of international SD assessments

Type	Refer to as	Examples	Description	Link to political process	Participants nominated/ selected by	Drafted by	Text approved by	Frequency	Normative or descriptive	Type of knowledge assessed
Intergovernmental scientific assessments (IGSA)	IPCC model	IPCC, IPBES	Regular IGSA	Formal	Governments	Scientists	Govern-ments, peers	Regular	Primarily descriptive	Academic, peer-reviewed
	IAASTD model	IAASTD	Ad hoc stakeholder IGSA	Formal	Multi-stakeholder Bureau	Scientists	Govern-ments	Ad hoc	Primarily descriptive	Academic and traditional/local knowledge of stakeholders
	GEO model	GEO	Regular UN science publication with formal link	Formal	Governments, stakeholders	Scientists guided by UN	Peers	Regular	Descriptive and normative	Academic, peer-reviewed, UN
	AH model	Asian Highway expert group	Intergovernmental UN expert group	Formal	Governments	UN staff guided by experts	UN	Regular	Descriptive	Governments, UN, academic, private sector
Scientific, technocratic assessments (STA)	CDP model	UN Committee for Development Policy	Standing UN expert groups with formal reporting to governments	Formal	UN Secretary General	UN staff guided by Com-mittee members	Committee	Regular	Normative	Academic, peer-reviewed, UN
	GSP model	High-level Panel on Global Sustainability;	Ad hoc initiatives of the Secretary General	Formal, weak	UN Secretary General	UN staff guided by Panel	Panel	Ad hoc	Normative	UN, governments, academic, NGOs, stakeholders
	UN flagship model	GBO, WESS,	UN flagship publications, drawing on UN expert groups, and linked to UN process	Formal, weak	UN	UN staff jointly with experts	UN	Ad hoc or regular	Descriptive and normative	Academic, NGOs, UN , government, stakeholders
	Pre-Summit stocktaking	UN SD21 study	Stocktaking made in preparation for high-level international conferences	Formal, weak	UN	Lead authors, sometimes with UN staff	UN	Ad hoc	Descriptive	Academic, practitioners' views
Scientific research collabo-rations (SRC)	GEA model	Global Energy Assessment	Collaborative scientific collation of scientific knowledge	Informal	Peers	Scientists	Authors, Peers	Ad hoc	Descriptive and normative	Academic, peer-reviewed
	MEA model	Millennium Ecosystem Assessment	Identification of scientific basis and knowledge gaps for action.	Non-governmental	Selected by science panel, endorsed by board	Scientists	Peers	Ad hoc	Descriptive and normative	Academic, peer-reviewed, stakeholders
	CML model	Census of Marine Life; Future Earth	Collaborative scientific research programme	Non-governmental	Peers	Scientists	Authors, Peers	Ad hoc	Descriptive	Academic, own research

Note: Increasing role of governments from top to bottom.

Strengths and weaknesses of various assessment models depend on the objective and particular context

The IPCC model of intergovernmental scientific assessments has been very influential in shaping more recent assessments that aimed to strengthen the science-policy interface. In fact, IPCC-style assessments have been instituted also at the national level, for example, in Austria (APCC) and Hungary. The IPCC model has been the most successful institutional model of formalizing the science-policy interface. It has put key problems identified by science high on policy makers' agendas and has also enabled science to inform solutions. It is not clear if any other model has the potential to mobilize the scientific community to the same extent. At the same time, the IPCC model of assessment has received a large amount of criticism, including from scientists some of whom were long-time leading authors of the IPCC. Some contributors to the present prototype report noted deficits of the IPCC model in terms of comprehensiveness, objectivity and transparency. For example, it was suggested that the line-by-line government approval requirement of the summary for policy makers had politicised and constrained the work of scientists on the main report. Changes in the summary that had to be carried over into the main report had "watered-down" the latter. On the other hand, it was pointed out that the government approval would guarantee a functioning science-policy interface in the first place. Furthermore, a fundamental inconsistency was noted between the need of decision-makers for certain and "unequivocal" statements on the one hand and the need for continuous questioning as fundamental drivers of scientific progress on the other hand.[44] Most importantly, it was suggested that the IPCC model poses a number of constraints to the voice of developing countries. In particular, it was pointed out that developed country academics and analysts still make up to 80 per cent of the IPCC assessments teams and that "*97 per cent of the references in IPCC reports are from Western journals*". Academics from developing countries have fewer resources and are time poor. They do not publish as regularly in international journals, but in local journals or books that are unknown internationally, also because of language barriers and because of the way the academic peer review system functions. Yet, most contributing scientists recommended the IPCC model as one of the most useful ways to improve the science-policy interface by, improving the dialogue among scientists, and between scientists and policy makers.

The UN flagship publication model has been praised for its relatively low cost and wider stakeholder participation, as well as the fact that a wider range of knowledge can be tapped, and that resultant publications are directly linked to a UN process which guarantees consideration by decision makers. It was also pointed out that the flagship publications of some UN entities typically provide a wide range of views. Diversity of views can provide a wider range of options to decision-makers. Hence existing overlaps between UN assessment publications do have their benefits. Yet, a loose coordination between assessments and especially the various outlook publications of the UN system could benefit decision-makers in making their choices. An assessment of these assessments in the form of the Global Sustainable Development Report could also illustrate the benefits as well as limitations of integrated approaches. Illustrative examples are provided in the full report.

Assessments organized by scientists and their peers benefit from much greater flexibility than assessments driven by international organizations or governments. On the other hand, UN- and government-driven assessments are more likely to be used in decision making processes. Also, most international scientific assessments have been weak on the social aspects, including on multistakeholder contributions.

It has also been pointed out that most of the prominent assessments ignore important agreed commitments, such as those contained in Agenda 21 and the Rio Principles, as well as those in conventions (e.g., UNFCCC and CBD). This is apparent in the heavy reliance in their analysis on regional groupings, ignoring the groupings that have been intergovernmentally agreed (e.g., LDCs, Annex I in the UNFCCC, etc.).[45]

Assessments generally enable tackling broad and complex issues to support finding solutions to address the identified problems and challenges. Each assessment necessarily needs to weigh its ambition against the costs of multi-stakeholder engagement.

Social scientists have criticized the prevailing approach of environmental assessments to focus on technical knowledge. "*Approaching the world's environmental challenges as a question of technical knowledge, to be filtered through existing institutional government arrangements, is very much part of the problem*" (Park et al., 2008).[46] Societies tend towards maintaining the status quo[47] and a key question for social scientists is how dominant institutions can change.[48]

The need for connecting traditional knowledge and scientific knowledge has been particularly emphasized in biodiversity conservation, but is evident also with respect to other sustainable development issues. Indigenous and local communities have cultivated and used biological diversity in a sustainable way for thousands of years, and their skills and techniques provide valuable information to the global community and a useful model for biodiversity policies.[49] Advances have been made in the recognition of indigenous community conservation areas which replace the earlier conservation paradigm of protecting wilderness and excluding local people often making them victims of conservation.[50]

Economic considerations are central to most policy analysis and instruments, but linkages with environmental, social and political aspects are still weak. While efforts have been made to improve how "physical" sciences inform sustainable development policy analysis, no commensurate effort has been made in economics. Deficiencies of mainstream economic approaches to sustainable development have become apparent, yet most assessments continue to rely on these approaches. Sustainability is mostly seen as a matter of including externalities in the long run and formally considering resources as finite. Cost-benefit analysis is widely used to inform sustainable development policy. Approaches are basically individualistic, non-complex, non-evolutionary and equilibrium oriented, in contrast to the key systems analyzed. As a result, recommendations can be potentially misleading. Alternative approaches are needed to analyze possible patterns of evolution (rather than "net-benefits"), dynamic possibilities, and abrupt discontinuities or "extreme events", including the complex relations of environmental impacts with social aspects.

Global assessments may be less relevant for countries with special needs than subregional or national assessments. This is because global assessments might not necessarily reflect the unique situation of small island developing countries, least developed, land-locked developing countries. Vulnerability factors that are most relevant for these countries do not always show up as "crucial" in global assessments. Similarly, smaller developed and developing countries do not necessarily see their particular challenges and action priorities reflected in the global sustainable development debate and related assessments. Hence, there may be a need to build global assessments on national ones. Such view was emphasized in some of the UN expert group meetings that were organized in support of this report, and it is evident in the *Dubrovnik Declaration* on a "regional perspective on science-policy interface for a sustainable future" (see Annex 1).

2.2.2. UN flagship publications and outlook reports

The Executive Committee of Economic and Social Affairs Plus (ECESA Plus) is the UN inter-agency coordination mechanism on sustainable development and the follow-up to Rio+20.[51] ECESA Plus alone brings together 53 UN entities working on sustainable development, including Funds, Programmes, Regional Commissions, Convention Secretariats, Specialized Agencies, International Financial Institutions, the World Trade Organization and IOM. All these entities typically have their own flagship reports in which they report on major trends and suggest policy issues for consideration. Together with similar reports by non-UN intergovernmental organizations, there are hundreds of international flagship reports, all of which suggest policies in their own areas of expertise and within their institutional mandates.

Policy coherence among UN flagship publications

In preparation of the present report, 125 flagship publications of the UN system, and 23 outlook reports prepared by intergovernmental organizations were analysed in terms of scope, the report's approach, diagnosis of trends and challenges, and policy recommendations. They are listed in Annex 2.

The wide range of policy recommendations contained in the UN publications is illustrative of the many different views and perspectives on key policy issues related to sustainable development. Hence, the fact that the messages of various publications are not consistent with each other is not a bad thing. However, they would be much more useful for policy makers, if the various options and their implications across sectors and themes, and information on alternative integrated solutions were accessible in an actionable format. The Global Sustainable Development Report might help in this respect. Table 7 illustrates the dilemma with an example of messages on food, biofuels and land.

At present, it appears that almost all outlook publications are being developed in isolation from each other and are supported by separate sectoral or issue-based communities. The resulting incoherence of assumptions means that these outlooks essentially describe slices of very different future worlds. And important inter-linkages are not always taken adequately into account. In fact, some cases that are described may even be physically or socio-economically impossible. For example, recent energy outlooks typically project massive global increases in

biofuel use, and, while they will be within scientifically sound "potentials", they will typically not account for the changed patterns of water use and their implications, nor for the interactions with innovation systems and economic growth. While these omissions are not always a problem, they can be in some cases. Sectoral and issue-based outlooks are important and valuable exercises, but their credibility and usefulness could be greatly enhanced by systematic interaction between the various communities. A global sustainable development report could bring together outlooks in a coherent way and highlight issues where interactions should be taken into account. A UN home for global scenario models from various scientific communities might be very useful in this context.

Table 7. Example of messages of UN systems publications on food, biofuels and land compared with integrated solutions.

	Which status and trends are highlighted in UN system publications?	Which overall objectives are suggested in UN system publications	Expected impacts on other sectors by 2030, from literature	Solutions proposed in UN system publications	Alternative, integrated solutions
Food production	Still about 1 billion people suffering from hunger by 2050. World population of ten billion by 2050. 40 to 50% of food does not come to the plate.	Produce more food: +70% food by 2050 (FAO)	Increase in arable land as in the past: +15-30%? Increase in water use: +100%. Additional nitrogen and phosphorous loadings (beyond safe global limits?).	Sustainable intensification (FAO). Zero food waste (UNSG).	Change diets. Reduce waste in food chain. Act on access to food. Integrated land planning. Reconsider first generation biofuels. Reforestation. Investments in land regeneration.
Biofuels	Current mandates by many countries imply large supply increases. Carbon balance of biofuels ranges greatly and is uncertain. Competition with food and water. Land "grabbing" and social issues.	Produce more biofuels to reduce greenhouse gas emissions.	Increase in arable land as in the past: +3-10%. Increase in water use: +50-70%? Loss of biodiversity due to mono-cropping. Likely loss of forests. Reduced biotic regulatory function leading to much higher greenhouse gas emissions.	Sustainability criteria for biofuels. Second generation biofuels in the future.	
Land degradation	Continued loss of arable land during past decades.	Loss of 0.1% per year to 2020-2030, then zero net loss target (proposed by many before Rio+20)	If historical land degradation is continued +5-10%? Degraded water supply. Degraded ecosystem services.	Investments in land regeneration. Climate change adaptation.	

Established UN publications containing environmental assessments

By far the largest number of UN publications with scientific assessments are on environmental issues. In fact, UNEP and convention Secretariats do have established processes for these publications.

UNEP's Global Environment Outlook (GEO) has been produced every five years.[52] GEO-5, the latest in the series, released in June 2012, provides an assessment of the state and trends of the global environment in relation to internationally agreed goals; evaluates the gaps and barriers in their implementation; and provides policy options that have the potential to speed-up realization of these goals. Through an integrated environmental assessment approach, a series of GEO reports have analyzed environmental state and trends at the global and regional scales, described plausible outlooks for various time frames and formulated policy options. Each GEO report builds on the assessment findings of its predecessor and also draws from lessons learned on process. The elaborate multi-year assessment process which is detailed in Annex 3 aims to bridge environmental science and policy.[53]

Under the Convention on Biological Diversity (CBD) there are established assessment processes. The Global Biodiversity Outlook (GBO)[54] provides a global overview of the status and trends of biodiversity and highlights key implications for sustainable development and human well-being. The GBO-3 was a key source of information in the development of the Strategic Plan for Biodiversity 2011-2020 and its Aichi Biodiversity Targets. In addition, focused assessments have been prepared under the Convention. The most important thirteen of them are detailed in Annex 3 which provides information on the characteristics of the assessment processes and their outcomes, on the use of scenarios and other tools, on the policy impact of the assessment, and the capacity needs identified and addressed. The systematic assessment framework under CBD may hold lessons for a systematic assessment of assessments on sustainable development.

2.3. National assessments

2.3.1. National sustainable development reports and related processes

For the present report, an inventory of national sustainable development reports not older than 10 to 15 years was created and the reports and associated national processes were assessed against the following criteria:

- scientific or thematic topic(s) addressed by the assessment
- assessment tools and indicators
- geographical scope of the assessment
- time period covered by the assessment
- total number of editions completed
- methodology employed to prepare this assessment
- funding arrangements
- peer review arrangements
- innovative or noteworthy approaches

Approaches, methodologies and outcomes vary greatly between countries which does not allow for direct cross-country comparisons. The vast majority of the Rio+20 reports submitted were funded by the United Nations (UN) and undertaken in developing countries. Developed countries that have established national sustainable development report processes mostly did not submit their reports to the UN in preparation for Rio+20. Many countries have produced additional thematic reports with no link to the Rio process on themes such as water, greenhouse gases, and social equity.

The following sources were considered in this report:

- 69 national sustainable development reports prepared for Rio+20 in 2012.[55]
- 6 other recent national sustainable development reports for China, Turkey, Vietnam, India, Thailand, and South Africa.[56]
- National reports, strategies, indicator profiles, statements, and voluntary initiatives, prepared for sessions of the UN Commission on Sustainable Development (CSD) by 193 member States.[57]
- SIDSNet documents on Small Island Developing States.[58]
- National assessment reports prepared by many governments for the World Summit on Sustainable Development in 2002.[59]
- 148 national progress reports on the Millennium Development Goals.[60]
- Website of the Global Network of National Councils for Sustainable Development which lists 53 national sustainable development offices.[61]
- Selection of national government websites.

Table 8 summarizes the availability of national sustainable development assessment reports. They exist for roughly half of all developed countries, but only four such reports had been submitted to Rio+20 in 2012. The overwhelming majority of the national reports submitted to Rio+20 were from developing countries in Africa and Latin America and the Caribbean. The country coverage of MDG progress reports has been three times better than for CSD progress reports and twice better than for Rio+20 reports. These data are indicative of the relative low importance to date attached to sustainable development by UN entities and member States.

Table 8. Summary of national sustainable development documents, by region.

Regions	Number of States with reports submitted to the UN (Per cent of all UN member States)					Total number of States
	CSD Indicator Profiles[1]	CSD National Strategy Profiles[1]	CSD National Reports[1]	MDG Progress Reports[2]	Rio+20 National Assessment Reports[3]	
Developed	25 (50%)	28 (56%)	29 (58%)	21 (42%)	4 (8%)	**50**
Northern Africa	1 (20%)	1 (20%)	1 (20%)	5 (100%)	2 (40%)	**5**
Sub-Saharan Africa	7 (15%)	6 (13%)	8 (17%)	43 (92%)	34 (72%)	**47**
South-Eastern Asia	1 (9%)	1 (9%)	1 (9%)	9 (82%)	4 (36%)	**11**
Eastern Asia	2 (50%)	2 (50%)	3 (75%)	4 (100%)	0 (0%)	**4**
Southern Asia	0 (0%)	0 (0%)	1 (13%)	8 (100%)	4 (50%)	**8**
Western Asia	1 (8%)	2 (15%)	2 (15%)	10 (77%)	3 (23%)	**13**
Caucasus and Central Asia	0 (0%)	0 (0%)	1 (13%)	8 (100%)	3 (38%)	**8**
Oceania	2 (15%)	2 (15%)	2 (15%)	11 (85%)	1 (8%)	**13**
Latin America and the Caribbean	4 (12%)	5 (15%)	8 (24%)	29 (85%)	14 (41%)	**34**
Totals	**43 (22%)**	**47 (24%)**	**56 (29%)**	**148 (77%)**	**69 (36%)**	**193**

1. This accounting only includes reports posted on United Nations websites for CSD12 through CSD19.
2. This accounting includes UN Member States, not associate members of the regional commissions.
3. Note that this accounting includes only national assessment reports submitted to Rio+20

Figure 5. UN member States that submitted national sustainable development reports in preparation for Rio+20

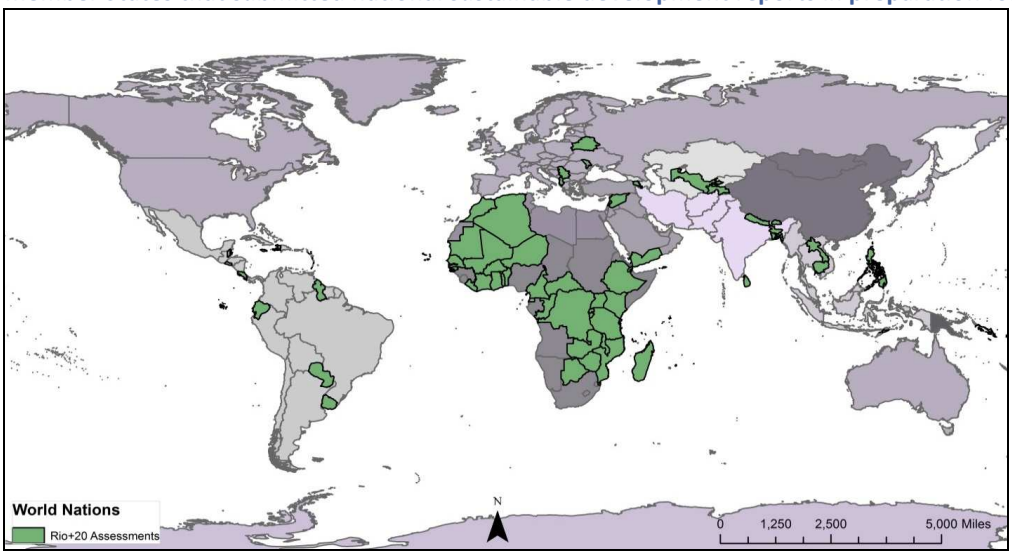


Table 9. List of topics, cross-sectoral issues, and themes maintained by the UN Division for Sustainable Development

• Africa • Atmosphere • Biodiversity and ecosystems • Biotechnology • Capacity-building • Chemicals and waste • Climate change • Demographics • Desertification, land degradation and drought • Disaster risk reduction • Education • Employment, decent work for all and social protection • Energy • Finance • Food security and nutrition and sustainable agriculture	• Forests • Gender equality and women's empowerment • Green economy in the context of sustainable development and poverty eradication • Health and population • Indicators • Industry • Information for decision-making and participation • Institutional arrangements • Institutional framework for sustainable development • Integrated decision-making • International cooperation for an enabling environment • International legal instruments and mechanisms	• Mining • Mountains • National sustainable development strategies • Oceans and seas • Poverty eradication • Rural development • Science • Small Island Developing States • Sustainable cities and human settlements • Sustainable consumption and production • Sustainable tourism • Sustainable transport • Technical cooperation • Technology • Trade • Water and Sanitation

Source: UN Sustainable Development Platform http://sustainabledevelopment.un.org/topics.html

The UN Division for Sustainable Development maintains 43 topics that were contained in Agenda 21, the Rio+20 outcome document or had been chosen for the CSD implementation cycles (Table 9). Some 405 thematic topic national assessment reports had been submitted to the CSD for implementation cycles 2004 through 2011 (CSD12 through CSD19). The coverage illustrates big differences in terms of national priorities under the sustainable development agenda. The top three topics on which reports were submitted include chemicals and waste; desertification, land degradation, and drought; and sustainable consumption and production. Topics in the mid-range were mining, rural development, sustainable transport, water and sanitation, sustainable cities and human settlements; and atmosphere. Climate change had the fewest reports by countries.

There is a set of 134 CSD agreed sustainable development indicators. They are internationally comparable, also as a composite index. Some of these indicators have been used in national reports, but the overall set has not been generally used to measure progress. The list of 57 MDG indicators was not originally designed to measure sustainable development. However, they are typically being used in national assessment reports of developing countries.

2.3.2. National/subnational environmental assessments

Integrated environmental assessments have become increasingly common at national and subnational levels, and the practice of project-level assessment (e.g., environmental impact assessment EIA) has become almost universal and even mandatory in most countries and sectors.[62] In fact, a complex hierarchy of environmental assessments has emerged (see also chapter 4). In contrast to international sustainable development assessments, in their early days these national and subnational assessments focussed narrowly on environmental issues but have widened their scope ever since. Yet, most national assessments of resources, such as of land, energy and water, continue to be carried out in isolation by separate and disconnected institutional entities.[63]

Amongst the approaches and instruments used to carry out national assessments, attention has increasingly been given during the past 40 years to Strategic Environmental Assessment (SEA).[64] Lessons learnt from SEA are summarized next.

Strategic environmental assessment (SEA)

SEA has been used worldwide at national and sub-national levels. SEA definitions and practises are context specific and vary widely. They typically refer to a range of qualitative and quantitative, analytical and participatory approaches to support public policy makers in systematically taking into account environmental considerations and inter-linkages with economic and social considerations.[65]

In the early days of SEA, it only captured the environmental impacts of already formulated policies, plans and programmes. Today, it serves as an entry point for broader, integrated or sustainability assessments.[66] In fact, a continuum of SEA approaches exists with various degrees of integration - from environmental integration to cross-sectoral and cross-disciplinary integrated assessments. SEAs take an "up-stream", long-term approach, exploring the potential environmental risks and opportunities of policies, plans and programmes and their interactions with social and economic issues long before individual projects are designed. SEAs set the context for "downstream" decisions and projects which have a more narrow focus[67]. Coordination of assessments across the hierarchy (called "tiering") is being implemented the Netherlands and being considered in other countries.

SEA has been applied to transport, mining, forestry, land use planning, agriculture, energy, waste and water management, natural resources and tourism, climate change and more broader encompassing strategies such as national development plans, Poverty Reduction Strategies (Box 3), and trade negotiations and agreements.

In 2005, the Paris Declaration on Aid Effectiveness called upon donors and partners to "*develop and apply common approaches for strategic environmental assessment at the sector and national levels*". International, legally binding instruments on SEA have been adopted in the last few years, including the European Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment which applies to the EU Member States and the Kyiv Protocol (on Strategic Environmental Assessment) to the Espoo Conventions which is open to all UN member States.[68]

On the order of several thousand SEAs were carried each year by the end of the 2000s at national and local levels In the European Union.[69] Legal and administrative provisions requiring SEA also exist in Australia; New Zealand; Canada; USA; and Hong Kong, China. An increasing number of developing countries are applying SEA. Ghana, South Africa, China, Viet Nam, the Dominican Republic and Guatemala having introduced SEA provisions in their legislation and/or policies. A survey carried out in 2010 indicated that at least 120 SEAs and related activities were underway in developing countries.[70]

Box 3. SEA and Poverty Reduction Strategy Papers (PRSPs)

Poverty Reduction Strategy Papers (PRSPs) were introduced in 1999 by the World Bank and the IMF as an instrument to help fulfilling the need for countries to strategically examine current and planned macroeconomic structural policies and programmes to specifically identify opportunities to promote long-term growth, reduce poverty and achieve the MDGs.

SEA has been applied to PRSPs in Ghana, Tanzania, Benin and Rwanda. They followed different approaches and helped to[71]:

- more systematically integrate environmental considerations those strategies;
- link these considerations with national socio-economic issues;
- balance competing concerns relating to natural resources and economic conditions;
- provide a framework for integrating sustainable development considerations in sectoral and districts plans and programs;
- improve governance and raise awareness of environmental issues in macro policy and planning advocacy representatives
- build capacity for the integration of the environment in the strategies;
- improve cooperation and collaboration between key stakeholders (planners, Ministry of Environment, Ministry of Finance);
- define national targets and priorities to achieve the Millennium Development Goals (MDGs).

Integration of environment issues can help to enhance the overall social and economic goals of a policy, plan and programme.[72] Benefits of using SEAs include the identification of cost effective alternatives or options (e.g. various corridors or transport modes in the case of a transportation policy); introduction of interventions such as environmental technology which reduce pollution and increase competitiveness; avoidance or mitigation of environmental risks and liabilities such as habitat loss; support for wider socio-economic goals such as energy or food security; integration of measures to manage climate change risks; and increased stakeholder involvement in decision making. Box 4 lists lessons-learnt from a review of SEA applications which may also be relevant for other sustainable development assessments.

Box 4. Lessons learnt from SEA

Reviews of SEA applications worldwide have identified the following key lessons learnt:

- Integrate SEA as part of the policy, plan or programme development process (and not consider it as a parallel process) at an early stage of this process to inform decisions;
- Understand the strengths and weaknesses of the institutional framework in which the policy, plan or programme is set to ensure that the SEA has impact;
- Ensure adequate Government ownership of the process;
- prioritize recommendations and prepare a plan that clearly outlines how and when SEA recommendations can be implemented;
- Improve availability and quality of data (several SEAs identify a lack of data as a constraint and cause of uncertainty);
- Promote transparency and establish consultation mechanisms with key stakeholders (including the public) at different steps of the process;
- "Demystify" SEA to decision-makers and staff of organizations where it is applied through trainings and other capacity building initiatives;
- Estimate, as part of the SEA process, human and financial resources necessary for implementing its recommendations, and plan for a follow up mechanism to ensure implementation;
- Systematically highlight trade-offs and synergies between environmental, social and economic components of the policy, plan or programme on which SEA is applied and present conclusions in a language that captures the attention of decision-makers.

Finally, it should be noted that there are different views as to the usefulness and cost-effectiveness of the thousands of environmental assessments of different types that are being carried out every year in all parts of the world. With international support, developing countries have adopted these assessment approaches at a much earlier development stage than developed countries historically. Good practises and successful examples that exist in developing countries are typically showcased, yet there is also much evidence for the overall unsustainability of many countries' development trajectories (see chapter 3). Hence, a sustainable development report might want to also assess the overall effectiveness of the present hierarchy of assessments.

Environmental Performance Reviews

The Environmental Performance Review (EPR) is an assessment of the progress a country has made in reconciling its environmental and economic objectives and in meeting its international environmental commitments. The EPR programme aims to assist countries to improve their management of the environment by making concrete recommendations; promote the exchange of information; help integrate environmental policies into sector-specific economic policies; promote greater accountability; and strengthen international cooperation.

The EPRs are evidence- and fact-based, relying on national and international data. The performance approach of EPRs has given priority to identifying national objectives (i.e. goals, and targets); international commitments of the reviewed country; and use of statistics and indicators to measure the achievement of targets. The EPR programme emphasizesthe use of economic analysis: The polluter pays principle, the user pays principle, economic efficiency, integration of environmental and financial-fiscal policies, as well as integration of environmental and sector policies (e.g. energy, transport, agriculture) are constant features of EPRs reports. An EPR is undertaken at the request of a country and supported by OECD and UNECE.

The OECD Environmental Performance Reviews provide independent assessments of OECD countries' progress in achieving domestic and international environmental policy commitments. They aim to promote peer learning, enhance countries' accountability to each other and improve governments' environmental performance - individually and collectively. The analyses are supported by a range of economic and environmental data. Targeted recommendations are designed to reinforce national environmental policy initiatives. The EPRs identify good practices and make recommendations to improve the reviewed country's environmental policies and programmes. Since 1992, over 60 EPRs have been conducted in OECD member countries. Most OECD member countries have been reviewed twice. Some OECD non-member countries have also been reviewed, including China. The second cycle of EPRs (2001-2009) consisted of three substantive blocks of issues: (a) environmental

management (air, water, nature/biodiversity and waste management); (b) sustainable development (integration); and (c) international commitments and co-operation on environmental matters. The 3rd cycle which started in 2009 aims to enhance policy advice and implementation by focusing on a few selected issues in each country review, while maintaining basic comprehensive coverage and accountability for the major environmental challenges; and speed up the review cycle by increasing the number of country reviews carried out per year, reducing the period between reviews of individual countries from between eight and nine down to five-to-six years.

UNECE undertakes Environmental Performance Reviews in countries that are not OECD members. First-cycle EPRs established baseline conditions regarding trends, policy commitments, institutional arrangements and capabilities for carrying out national evaluations. From 1994, the first cycle of reviews was performed in 20 countries of the UNECE region.[73] Second-cycle EPRs assess progress and help stimulate greater accountability. Emphasis is placed on implementation and financing of the environment policy, integration of environmental concerns into economic sectors, and promotion of sustainable development. Since 2000, UNECE has carried out 18 second EPRs. The third-cycle EPRs will include environmental governance and financing in a green economy context, countries' cooperation with the international community and environmental mainstreaming in priority sectors. Since 2012, UNECE has cooperated with other UN Regional Commissions to carry out EPRs in other parts of the world.[74]

Trade Sustainability Impact Assessments

Trade Sustainability Impact Assessments are a policy tool for the prior assessment of the economic, social and environmental implications of a trade negotiation. They are carried out during the negotiation phase, and help integrate sustainability into trade policy. These assessments were first developed in 1999 for the WTO-DDA negotiations. Since then they have been applied to all the EU's major multilateral, regional or bilateral trade negotiations.

Trade Sustainability Impact Assessments are independent studies conducted by external consultants. Studies involve comprehensive consultation of stakeholders to ensure a high degree of transparency and to take account of the knowledge and concerns of relevant interest groups both in the EU and in the partner country/region.

These assessments help to integrate sustainability into trade policy by analyzing the issues covered by a trade negotiation from a sustainable development perspective; informing negotiators of the possible social, environmental and economic consequences of a trade agreement; providing guidelines for the design of possible flanking (complementary) measures, the scope of which can extend beyond trade policy (e.g. internal policy, capacity building, international regulation), and which are intended to maximize the positive impacts and reduce any negative impacts of the trade negotiations in question. The assessments study the likely impacts of trade liberalization in areas such as income, employment, capital investment, equity and poverty, health and education, gender inequality, environmental quality of air, water and land, biological diversity and other natural resource stocks.

Since 2002, the European Union had launched several TSIAs for bilateral negotiations (Chili 2002, Ukraine 2007, Korea and China 2008, India and Libya 2009, Canada and Georgia 2011, Armenia, Morocco and Tunisia 2013, Jordan, Egypt and USA are under implementation) and those undertaken with regional groups (Arab States members of the Gulf Cooperation Council 2004, African Caribbean Pacific 2007, Mercosur Association, Asean countries, Central America Association, Andean community association 2009). Also, the Euro-Mediterranean Free trade Area was subject to TSIA. TSIA in support of negotiations on a multilateral Trade in Services Agreement had been launched since 2013 by the European Union.

2.4. Designing assessment processes to link knowledge with action

A synthesis of research from the World Academy of Sciences (TWAS) and from the Sustainability Science Program of the US Academy of Sciences found many different barriers to effective mobilization of knowledge to support action for sustainable development, including mutual incomprehension between scientists and decision makers of all types (from farmers to ministers), fragmentation of the knowledge system, and lack of flexibility in a world of uncertainty and surprises.[75] Proponents of sustainable development assessments suggest designing these assessments in a way to overcome these barriers.

Many suggestions have been made to improve assessments and ultimately the science advice to Governments. New Zealand's chief science advisor recently suggested ten principles for organizing science advice that appears to capture many of the suggestions on the topic (Box 5). He

further suggests a complementary role of science advisors, advisory groups and academies of science. A one-on–one trusted relationship between a science advisor and a policy maker may be most geared to addressing rapid crises and disasters, whereas an advisory group and academies may be the better solution for tackling complex and chronic issues, such as many of sustainable development issues. Devising a process for preparation of future editions of a global sustainable development report may want to be based on these principles.

Box 5. Ten principles for organizing science advice, suggested by New Zealand's chief science advisor

1. *Maintain the trust of many:* the public, the media, policy-makers, politicians and the science community.
2. *Protect the independence of advice*: from both political interference and premature filtering in the policy process.
3. *Report to the top:* scientific advice to be available directly and uncensored to the head of department or government.
4. *Distinguish science for policy from policy for science*: Science advising must be clearly separated from the role of administering the system of public funding for science, to avoid a potential conflict of interest and the perception of science advice as self-interested lobbying.
5. *Expect to inform policy, not make it:* Science advice is about presenting a rigorous account of what we do and do not know. Science is only one of several stakeholder inputs to policy. Other considerations include fiscal considerations and public opinion. It is the policy makers' job to choose between options with different trade-offs.
6. *Give science privilege as an input into policy*: Despite being only one of several types of knowledge inputs into policy, scientific knowledge should be given a privileged space, due to its lower value intensity compared to traditional and local knowledge and beliefs.
7. *Recognize the limits of science:* Science advisors must not overstate what is or can be known. Instead, it is essential that they are clear about the limits of what science can say and achieve. Uncertainties should be made explicit to decision-makers. "There is a dangerous temptation to use science to justify value-based beliefs and a lack of literacy about what science is (a process)".
8. *Act as a broker not an advocate*: Trust can be earned and maintained only if the science adviser or advisory committee acts as a knowledge broker, rather than as an advocate. The Japanese Council of Science published a "Code of Conduct for Scientists" that provides a good basis for this.[76]
9. *Engage the scientific community.* The science adviser must reach out to scientists for the specific expertise, encourage them to make their knowledge accessible and understandable, and sensitize them to realizing when they cross the threshold to advocacy.
10. *Engage the policy community*: This engagement is important to change attitudes and ultimately enhance both demand for and supply of evidence for public policy.

Source: adapted from Gluckman (2014).[77]

2.5. Emerging issues identified by science

The UN crowd-sourcing platform registered 1,115 contributions from scientists around the world who voted on each other's ideas and contributed a total 96 issues they would like decision-makers to consider for action. Table 10 lists the top-15 most popular issues identified.

The World Economic Forum, in preparation for its Global Risks Report 2014, carried out a survey among "stakeholder" on "global risks", i.e. global issues that should be taken into account by decision-makers due to their potentially large impact and high probability of occurrence. In contrast to the survey among scientists conducted for this report, in the WEF survey respondents had to choose from 31 given risks (Table 11).

Table 10. Top-15 sustainable development issues scientists worldwide would like decision-makers to consider for action

Emerging issues identified by scientists	Score
Regional conflicts due to global competition for natural resources (oil and minerals)	92
The climate-land-energy-water-development nexus	91
Political instability and social unrest from increased income and wealth inequalities	89
Child labour	87
Nonexistent or decreasing environmental justice in developing and developed countries.	84
Youth unemployment	84
Persistence of poverty in poor and even in rich countries	83
Anthropogenic reductions in net primary productivity[78]	81
Weak family structures	79
The poor and the weak everywhere are the losers of increasingly market-based solutions	79
Large-scale increases in genetic mutations in humans due to accumulation of toxic chemicals in our environment and in food chains	79
Human appropriation of net primary production	79
Asteroid threat to human civilization	78
Violence in schools	77
Ethnic violence	76

Source: Results of crowdsourcing issues from scientists, conducted by the UN for the present report.

Some of the issues were identified as highly important by both scientists and the WEF stakeholders, such as water and food, income disparity, unemployment, and socio-political instability. However, WEF stakeholders also highlighted issues that are currently high on the global political agenda, in particular fiscal crises, systemic financial risks, climate change and global governance. Scientists on the other hand, also highlighted other issues such as regional conflicts over resources, persistence of poverty, child labour, human appropriation of net primary

productivity, environmental justice, human genetic mutations due to exposure to toxics, weak family structure, asteroid threats, school violence and ethnic violence. In other words, open crowdsourcing among scientists might be one way to support agenda-setting for the high-level political forum for sustainable development.

Table 11. Top-10 global risks identified by a stakeholder survey of the World Economic Forum.

"Global risk" identified by WEF stakeholders	No.
Fiscal crises in key economies	1
Structurally high unemployment/underemployment	2
Water crises	3
Severe income disparity	4
Failure of climate change mitigation and adaptation	5
Greater incidence of extreme weather events (e.g., floods, storms, fires)	6
Global governance failure	7
Food crises	8
Failure of a major financial mechanism/institution	9
Profound political and social instability	10

Source: Global Risks Perception Survey 2013-2014, as reported in WEF's Global Risks Report 2014.[79]
Note: From a list of 31 risks, survey respondents were asked to identify the five they are most concerned about.

In preparation for the current report, a number of young researchers provided briefs on the issues that they would like to bring to the attention of policy makers at the global level (Table 12). Interestingly, most of the issues identified do not only pose a challenge, but are also promising solutions. Future editions of the global sustainable development report may thus provide a means of inputs by young scientists who arguably will be most decisive in the world's endeavour to address its most pressing global challenges in the coming decades.

Table 12. Issues identified by young researchers

Issues identified by young researchers
Ocean acidification
Microbial marine life and application of bioreactors
Use of biocatalysts (enzymes) in chemical industry for more sustainable production
Producer responsibility for e-waste
Protein substitutes for feed and food in the livestock sector
Phosphorus security, agricultural inputs, reserves and recycling
Rapid increase of large-scale land investments

Source: Report produced by young researchers in preparation of the current report.[80]

It should be noted that for some sustainable development issues there are established processes to identify emerging issues based on scientific knowledge. For example, the Convention on Biological Diversity has such process that is based on a set of globally agreed criteria for the identification of new and emerging biodiversity issues.[81] Recently identified and/or assessed issues under this process include synthetic biology, geo-engineering[82], marine debris[83], biofuels[84], ocean acidification[85], ocean fertilization[86], and underwater noise[87].

Similarly, UNEP established a foresight process with inputs from 400 scientists, in order to rank emerging global environmental issues. The UNEP process suggested "21 issues for the 21st century" to its Governing Council Meeting in 2012.[88] The UNEP-identified issues are rather broad environmental areas rather than specific issues identified through crowdsourcing in support of the present report. This illustrates the impact of process design on the types of identified issues. Crowdsourcing allows the submission of ideas by all participants, whereas traditional approaches start with a list of issues identified by a smaller group of experts.

Table 13. Top-10 emerging, environmental issues identified by UNEP

Issues	No.
Aligning governance to the challenges of global sustainability	1
Transforming human capabilities for the 21st century: meeting global environmental challenges and moving towards a green economy	2
New challenges for ensuring food safety and food security for 9 billion people	3
Broken bridges: reconnecting science and policy	4
Social tipping points? Catalyzing rapid and transformative changes in human behaviour towards the environment	5
New insights on water-land interactions: shift in the management paradigm?	6
Beyond conservation: integrating biodiversity across the environmental and economic agendas	7
Accelerating the implementation of environmentally-friendly renewable energy systems	8
New challenges for climate change mitigation and adaptation: managing the unintended	9
Greater risk than necessary? The need for a new approach for minimizing risks of novel technologies and chemicals	10

Source: UNEP (2012). 21 issues for the 21st century.[88]
Note: Ranking based on scoring by the UNEP Foresight Panel and after considering the polling results of more than 400 scientists.

UNEP and DESA organized a similar expert-based foresight process to identify the top emerging issues for Small Island Developing States[89], the results of which differed significantly from UNEP's general foresight process. Hence, there may be a need for systematic channels of input from countries in special situations, and from smaller economies and sub-regions that are not so well represented in the global level debate.

3. Review of progress

"Freedom is not worth having if it does not include the freedom to make mistakes." (Mahatma Gandhi)

This chapter provides a brief summary of global sustainable development progress from 1950 to 2013. Such review relates closely to a core function of the high-level political forum and thus might provide the basis for future editions of the Report which could focus on the most recent trends and progress. Due to space limitations, the list of trends can only be illustrative.

The UN crowd-sourcing platform registered 110 contributions from scientists around the world who voted on each other's ideas and contributed a total 166 ideas/messages in response to the question "*Which message on sustainable development progress do you prefer for Chapter III?*" The most popular ideas submitted have been included in the text below. They included statements on increased human security; on persistent gaps in life expectancy, poverty and health; on increasing income inequality, affluence, consumption, population, urbanization, and literacy; as well as on the human ecological impact on freshwater, forests and coastal areas. In contrast, among the least popular ideas submitted were statements on climate change, biodiversity, land use, air pollution, terrorism and globalization – all issues that are high on the international political agenda. In other words, the majority of – but not all – scientists decided to highlight many of the core development and sustainability issues already outlined in the Brundtland report in 1987. [90]

3.1. Sustainable development trends and progress

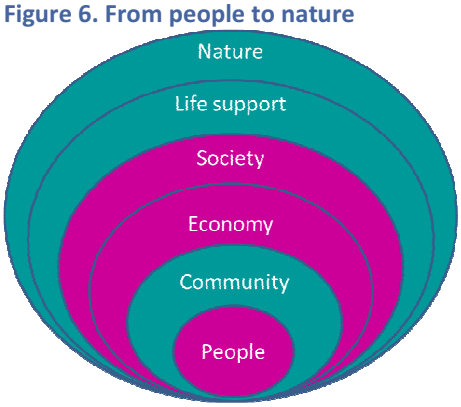
This section describes sustainable development trends since 1950. It does not assess progress against existing goals or commitments which is the subject of section 3.3. It builds on a wide range of assessments, in particular:

- Statistical Tables for the UN Millennium Development Goals Report 2013[91] and the UNDATA database.[92]
- Work by Bob Kates[93] and colleagues (Kates and Parris, 2003[94]; and Kates, 2010[95]) which drew on *Our Common Journey* (NRC, 1999).

Historical progress towards sustainable development has been mixed since 1950. There has been progress in some areas, but worsening trends in others. In fact, there is evidence that impressive progress in some areas has come at the expense of worsening trends in other areas.

The world has managed to feed, nurture, house, educate and employ on the order of an additional 800 million people every decade from 1970 to 2000, and even 1.1 billion people in the 2000s. In the past 12 years alone, we have built cities for 770 million people (equivalent to 93 New York cities), more than in any decade before. These are enormous achievements. Today's world GDP is more than ten times larger than in 1950 and average per capita GDP is four times as large.[96] Yet, we have not managed to employ our much greater wealth and technological capacity to eliminate poverty and hunger. 850 million people go hungry today which is about as many people as decades ago. There are two hundred million more slum dwellers today than twenty years ago. The unabated increase in the scale of material consumption has increased global environmental, social and economic pressures. There is increasing evidence that we are jeopardizing several of the Earth's basic life support systems. Countries trapped in persistent poverty have probably suffered most from these impacts. And future generations will most likely face much greater challenges to meet their own needs.

Figure 6. From people to nature



Note: purple = to develop; green= to sustain

We follow the framework of Table 2 and Figure 6. Groups of people form communities which make up the economy which is but one aspect of a society depending on nature's life support systems. Results are summarized in Table 14 and key data sources provided in Annex 4 (Table 45) together with a critical note on statistical methods and uncertainty.

Trade-offs and synergies for progress in the various areas are complex - they differ at various spatial and time scales and change over time. Aggregate, global results for 1950-2013 are summarized in Table 18 (section 3.2).

Table 14. Overview of global sustainable development trends

Sustainability	*Development*
Nature Anthropogenic interference with one-half of the terrestrial ecosystems and one-quarter of the freshwater supply. Biodiversity continues to decrease at rates 100 to 1,000 times their pre-human levels. Global CO_2 emissions from fossil-fuel burning, cement manufacture, and gas flaring have increased at an accelerated rate. They increased from 24.8 $GtCO_2$ in 2000 to 35.1 $GtCO_2$ in 2012 - the largest increase in any decade in human history. 41 per cent of the oceans showed high human-induced impacts on marine ecosystems in 2012.	**People** World population reached 7 billion people, 80 million added each year. Life expectancy extended by 22 years with persistent gaps between regions and a widening gap between men and women and since 1950. Better global health and shifting disease, but more years in injury and illness. The 2000s were the first decade since 1980 when both the absolute numbers and the proportion of people in absolute poverty declined. However, the number of relative poor in the developing world has continued to increase ever since 1980. 850 million people suffer from hunger which is slightly more than in 1990 but 150 million less than in 1970. Universal primary education achieved in most parts of the world. The literacy rate of 15- to 24-year-olds in developing countries reached 88 per cent in 2011. In stark contrast to twenty years earlier, today women dominate tertiary education in most parts of the world. 740 million people lack access to safe drinking water (i.e. 500 million fewer than in 1990) and 2.4 billion people lack access to basic sanitation (650 million more than in 1990). Water pollution continues to claim the lives of millions. Great improvements in modern energy access since 1990, but in 2010 there were still 1.27 billion people without access to electricity and 2.59 billion without access to clean cooking fuels. Increased aging including in many developing countries. 810 million people are now older than 60 years. In 2010: 215 million international migrants (59 million more than in 1990) and 740 million internal migrants. 383 million employed people getting by on less than US$1.25 per day – half the number of 1990, but no reduction in LDCs, LLDCs and SIDS. Intergenerational social mobility earning, wage and educational mobility varied widely across countries Mixed progress on human security and human rights. Overall well-being of people – as measured by HDI - has substantially improved since 1950.
Life support Human settlements now cover 7% of the world's ice-free land cover and their croplands another 21%. The protected terrestrial and marine areas have been greatly expanded in developed and developing countries. Loss of half of the world's forests historically to domestication. Tropical forests declined at around 12-14 million hectares per year in both the 1990s and 2000s, and a similar amount was degraded. In contrast, temperate and boreal forests were reforesting since the 1980s. Global arable land and permanent crops expanded by 160 million ha since 1961, due to expansion in developing economies, but the world likely reached peak farmland by 2010. Humanity claims about 24 per cent of the global terrestrial net primary production, more than ever before. Local and regional freshwater shortages, and water stress was widespread in one-third of the world. The proportion of overexploited fish stocks tripled from 10% in 1970 to 30% in 2012. Many concentrations of local air pollutants have decreased, but the health burden of local air pollution remains large, especially in megacities of developing countries. Ozone layer on a long-term path to stabilization by 2020/2030. Degraded coastal zones where half the world population lives.	**Economy** Affluence has increased amidst persistent poverty. The world economy doubled since 1990 to US$69 trillion in 2012. The Genuine progress index per capita has slightly decreased since 1978. Consumption remains grossly inadequate for the poorest. Greater material consumption and less per unit of value, but progress in technology access and performance has fallen far short of the requirements for sustainability. From 1988 to 2008, all gains in real income have been reaped by the super-rich in all countries and the rising middle-class in developing countries. Growing income inequality in many parts of the world. Trade has grown at more than twice the rate of economic growth since 1950. Total assistance to developing countries more than doubled since 2000 to US$126 billion in 2012. The proportion of net ODA to donors' gross national income regained their 1990 levels of 0.32% in 2010, up from 0.22% in 2002. Estimates for 2012 are 0.29%. Energy almost tripled between 1970 and 2010 – reaching 493EJ. Renewable energy share increased from 5.4% in 1970 to 7.0% in 2000 and 8.2% in 2010. Growing but slowing water withdrawals.
Community More State-based armed conflicts than in the cold war. Greatly reduced number of deaths from non-State armed conflicts, including terrorism. Diversity of cultural heritage, traditions, and traditional knowledge and 90% of indigenous languages threatened, but also indications of some revivals.	**Society** Extraordinary changes in developed and developing countries alike, in terms of values, attitudes, and actual behaviour, in particular the attitudinal and behavioral shifts in sex and reproduction, the role of women, the environment, and human rights. Fewer stable families in most developed and developing countries than in past decades. In developed countries, crude marriage rate halved since 1970 and divorce rate increased. The average duration of marriages has stayed constant at 10-15 years. Widening governance and globalization. Power has shifted from the nation State upward to the global level and downward to the local level, and at all levels from the public to the private. Crisis of multilateralism. In most countries where a high level of societal consensus existed on intergenerational equity, it has been lost or come under pressure.

Note: red colour coding indicates trends that scientists have expressed concerns about, green indicates what is typically considered a trend toward sustainable development, and black indicates a neutral or mixed trend.

3.1.1. People (1950-2013)

Population

Today's world population growth is only half of what it was at its peak in the early 1960s. However, world population reached 7.1 billion people in 2012, with about 80 million people being added each year in net terms (Table 15). While an increasing population has contributed to economic opportunities and growth, it remains a serious challenge to feed, nurture, house, educate and employ an additional 80 million people – about the population of Germany - each year. While the lives of billions people have improved since 1950, billions continue to be depraved of even the most basic services. In fact, the absolute numbers of people in poverty have not drastically changed for decades despite enormous development progress.

Today, about 1.25 billion people live in developed countries and 5.83 billion in developing countries. There are 0.88 billion people in the least developed countries (LDCs) - four times as many as in 1950.[97] Since most population growth occurred in poor countries but materials consumption is concentrated in higher income countries, the additional global pollution pressure due to increased population has remained low since the 1990s, in contrast to the earlier decades.

Table 15. Global number of people, in billions, 1950-2012

	1950	1970	1990	2000	2012
In absolute poverty: living on less than US$(PPP)1.25 per day			1.95	1.78	1.17
Employed but living on less than US$1.25 per day			0.83	0.69	0.38
Living on less than US$2.15 per day			3.1	3.3	2.7
Below relative poverty line in developing world			2.5	2.7	2.8
Hungry		1.0	0.8	0.8	0.85
Without safe drinking water			1.25		0.74
Without access to sanitation			1.80		2.44
Without access to electricity		1.8	2.0	1.65	1.27
Migrants			0.16		0.21
Above 60 years of age	0.2	0.25	0.5	0.6	0.81
Internet users	0	~0	0.003	0.36	2.4
Urban residents	0.75	1.35	2.28	2.86	3.63
Slum dwellers			0.67	0.78	0.87
Population of least developed countries	0.20	0.31	0.51	0.66	0.88
World population	2.5	3.7	5.3	6.1	7.1

Life expectancy and aging

Life expectancy at birth is one of the most objective, broadest measures of progress. Life expectancy at birth has been extended by 22 years since 1950, reaching 69 years in 2011, which was primarily due to reductions in infant and child mortality.[98] Yet, there continue to be persistent gaps between regions and a widening gap between men and women.[99] A child born in Africa still has 25 years less life expectancy than one in Europe - a difference that has not changed in more than a century. The world's maternal mortality rate and the under-5 mortality rate have both been roughly halved between 1990 and 2010, but the average rates are still about ten times as large in the developing world as in the developed world.

One consequence of longer life expectancy has been aging. The world population is aging, including in many developing countries. The population older than 60 years reached 810 million which was equivalent to 11 per cent of the world's population in 2012. Aging has changed consumption patterns and has increasingly constrained the long-run economic growth potential. In developed counties, aging has increasingly stressed public pension systems and intergenerational equity consensus, whereas in developing countries it has tended to exacerbate old age poverty. Aging has also contributed to shifting global health patterns.

Health

Global health has improved, due to immunization, improved water, sanitation, and nutrition. But with increased life expectancy, the global burden of disease has shifted from infectious diseases to chronic diseases.[100] Men and women spend more years living with injury and illness.[101] A number of infectious diseases re-emerged around the turn of the century, due to increased global trade, mobility and antimicrobial resistance. Today's HIV prevalence (0.8 per cent of the population ages 15-49) is three times the level of twenty years ago.[104] More than half of all people with advanced HIV infection in developing countries do have access to antiretroviral drugs. Most deaths from malaria are concentrated in LDCs and in Sub-Saharan Africa, where only 37 per cent of children under 5 with fever are treated with appropriate anti-malarial drugs. The number of new cases of tuberculosis has decreased since 2002, and 87 per cent of patients were successfully treated in 2010. Better health has not only increased life

expectancy, but has enabled long-term investments in education and skills, and has reduced poverty and positively impacted the economy. It should be noted that health issues are often a key reason for poverty in developing and developed countries.

Poverty

Poverty is a matter of great concern not only for ethical reasons, but since it has the potential to jeopardize progress on all other sustainable development issues. Poor people struggle to meet their immediate, most basic survival needs, allowing no room for longer-term considerations.

Today there are more relatively-poor people than in 1980 in what is a less absolutely-poor world. The 2000s were the first decade since 1980 when both the absolute numbers and the proportion of people in absolute poverty declined.

The number of absolute poor had not changed much between 1980[102] and 2000, but it decreased thereafter. Today, there are 1.17 billion people in absolute poverty that are getting by on less than US$(PPP)1.25 per day, down from 1.78 billion in 2000 (Table 15). However, this progress has been uneven across regions and countries. Most of the total reduction is due to poverty reduction in China and other parts of Asia. Yet, even Africa which had seen a doubling of its poverty headcount from 1980 to 2005, achieved absolute reductions by 2008. One third of the absolute poor lived in least developed countries (LDCs). Hence, the majority of absolute poor live in developing countries that are not LDCs.

Even as the number of absolute poor has declined, the number of people living on between US$1.25 and US$2.15 a day has doubled to 1.16 billion since 1980. Furthermore, the number of relative poor in the developing world has *increased* since 1980, and it continued to increase from 2.5 billion in 1990 to 2.8 billion in 2012 (Table 15).[103] An increasing number of these relative poor live in the slums of cities in developing countries. It is debatable whether moving from living on one dollar a day in a rural area to living on two dollars a day in a city's slum can be considered progress at all.

The *proportion* of population living on less than US$1.25 per day (i.e. absolute poverty) in developing countries has been more than halved from 47 per cent in 1990 to 22 per cent in 2010.[104] The respective reduction in the LDCs was from 64 to 46 per cent, whereas the share stayed roughly constant in the Small Island Developing States at 29 per cent.

The world's *number of working poor* - i.e. employed people getting by on less than US$(PPP)1.25 per day - more than halved since 1990 to reach 384 million in 2012 (Table 15). However, in Least Developed Countries, Land-locked developing countries and Small Island Developing States the number of working poor has not changed much at all in the past twenty years. It was 138 million, 47 million and 3 million, respectively.

In short, the world has made little progress in reducing the absolute number of poor. At any time for the past quarter century, about 3 billion people have struggled to survive on a daily basis. In a world without extreme poverty, their ideas and innovations could have contributed to build better lives, improve technology performance and economic prosperity.

Hunger

Not all, but many of the poor suffer from hunger, i.e. they have less than the minimum level of dietary energy consumption. Today, 850 million people – 260 million of which in Least Developed Countries (LDCs) - suffer from hunger which is *more* than in 1990 but *less* than in 1970 (Table 15). This means that 1 in 3 people in LDCs and 1 in 7 people in developing countries still go hungry today. Yet, world food production per capita has risen significantly since 1950. The absolute number of people suffering from hunger decreased by more than 200 million from 1970 to 1990, reaching 800 million in 1990. No more absolute reductions have been achieved since. Beginning in 2006, as food production declined from adverse weather, fuel costs increased, and a growing share of corn production went to biofuels, food prices surged and the numbers of hungry started to rise again.

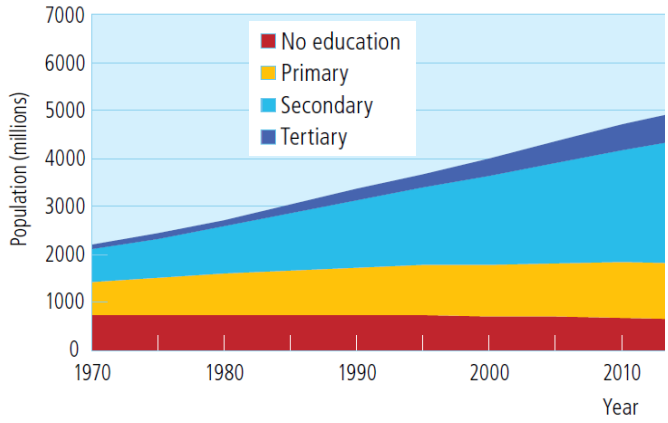
On the other hand, the *proportion* of children going hungry has been significantly reduced, especially since 1990. The global prevalence of underweight children under five years of age decreased from 25 per cent in 1990 to 16 per cent in 2011. In fact, it decreased in all developing regions.[105] Yet, large pockets of hunger persist. It should be noted that today there are more boys than girls that are undernourished and underweight, especially in Africa and Latin America.[104]

Education and literacy

Continued and sustained improvements in literacy have been achieved, with adult illiteracy having been cut in half since 1970. The literacy rate of 15- to 24-year-olds in developing countries was as high as 88 per cent in 2005-2011 (the most recent estimate) - eight percentage points more than twenty years earlier. Literacy rates in Eastern Asia, Latin America, South-Eastern Asia, Western Asia and the Caucasus and Central Asia have reached levels similar to developed countries. However, progress elsewhere has been uneven. While the Least Developed Countries and South Asia achieved the greatest improvements in literacy, progress in literacy in Sub-Saharan Africa has remained slow.[104]

There are reasons for optimism for the future. Net enrolment ratios in primary education in developing countries have greatly increased from 80 in 1990 to 91 in 2011. Universal primary education has been achieved in most parts of the developing world, with the notable exceptions of the Least Developed Countries and some parts of Sub-Saharan Africa and South Asia. It should be noted, however, that this finding is based on net enrolment rates and not the percentage of the cohort of children who have completed primary school (note a global dropout rate of 25 per cent). In the past twenty years, great progress has also been achieved in secondary and tertiary education (Figure 7).[106]

Figure 7. World population aged 15 years and above by level of educational attainment in 1970–2010



Source: Lutz (2009).[107] *© 2009 Royal Statistical Society.*

In stark contrast to twenty years ago – today women dominate tertiary education in most parts of the world, in developed and developing countries alike. In 2011, there were more women than men in tertiary education - 44 per cent more in Small Island Developing States, 29 per cent more in developed countries, 27 per cent more in Latin America, 8 per cent more in Eastern Asia, 7 per cent more in Northern Africa, 6 per cent more in South-Eastern Asia. The notable exceptions are Least Developed Countries where there are almost twice as many men as women enrolled in tertiary education, compared to three times as many men as women twenty years ago.

Education of women has been one of the most important factors leading to falling fertility rates, which has greatly reduced population growth and contributed to aging societies in many countries. The shift has been especially drastic in a number of Asian developing countries.

Rapid expansion of secondary and tertiary education in developing countries (Figure 7) has been one of the most important factors driving global economic growth since 1990. It has changed the global economic landscape.

Access to basic services

Lack of knowledge, skills and resources have limited progress in terms of access to basic services, especially in the poorest countries. In contrast, some of the larger and rapidly growing, developing economies have been able to pool resources and skills to make impressive progress in providing access to basic services.

Significant progress has been made in developing countries in terms of access to safe drinking water. In 2011, 87 per cent of the population used an improved water source, up from 70 per cent in 1990. About 740 million people still lack access to safe drinking water, which is 500 million fewer than twenty years ago.[104] 57 per cent of the population of developing countries used an improved sanitation facility in 2011, up from only 36 per cent in 1990. This was not big enough progress to compensate for the growing population. Today, 2.4 billion people lack access to basic sanitation, which is 650 million *more* than twenty years ago (Table 15).[104] Taking into account population growth, 2.3 billion people were provided with access to safe drinking water and 1.1 billion with basic sanitation – an enormous achievement. Water pollution remains a major problem in rapidly growing urban areas in Africa, Asia, and Latin America, and infectious water-borne diseases continue to claim lives of millions, especially children.

Great improvements have been achieved in terms of modern energy access since 1990. The number of people without access to electricity increased from 1.8 billion in 1970 to 2 billion in 1990, after which it decreased to 1.65

billion in 2000 and to 1.27 billion people (24% of the developing world population) in 2010. Taking into account population growth, this means that from 1990 to 2010, more than 2.5 billion people were provided with access to electricity – an enormous achievement (Table 15). Furthermore, in 2010, 2.59 billion people (49% of the developing world) relied on the traditional use of biomass for cooking, which causes harmful indoor air pollution. These people lived primarily in rural areas of developing Asia and Sub-Saharan Africa.

Progress in terms of access to basic services – where it was achieved – has improved health, promoted education, reduced poverty and environmental pollution, yet increased economic growth. For example, the provision of access to electricity to more than 2.5 billion people has greatly reduced local and indoor pollution, while only marginally increasing global environmental pressures. The environmental trade-offs have been negligible for providing 2.3 billion people with access to safe drinking water and 1.1 billion with basic sanitation.

Migration

International migration has been punctuated by cyclical periods of economic growth and immigration liberalization, as well as by periods of forced emigration from war, (resource) conflict, and political change. Although the share of international migrants has remained at about 3 per cent since 1990, their absolute numbers have increased. In 1990, an estimated 156 million people worldwide were living in a country other than that of their birth. By 2010, there were 215 million international migrants and 740 million internal migrants. Immigration restrictions have become increasingly strict in many countries.

Migration has often been a result of poverty, conflict and lacking opportunities. It also has had important long-run economic impacts, in terms of a perceived brain-drain and remittances. Remittances have become a very important source of international financing for some developing countries, especially Small Island Developing Countries. In cases without immigration/migration restrictions (including intra-national), migration has been circular, meaning migrants typically return to their place of origin, bringing with them financial resources and skills.

Intergenerational social mobility

Intergenerational social mobility, in terms of earning, wage and educational mobility, varies widely across developed countries, but tends to be lower in unequal societies.[108] There is evidence that intergenerational wage mobility is lower in many developing countries than in most developed countries. Access to education has been identified as an important determinant of intergenerational wage persistence in OECD countries.[109] [110]

There are only few studies that attempted to identify the global trend in intergenerational social mobility. One such study used surnames to track the rich and poor through many generations in England, the United States, Sweden, India, Japan, Korea, China, and Chile. In all these societies from medieval England to modern-day Sweden, the intergenerational correlation (for generalized social status) was between 0.7 and 0.9, which implies very low social mobility - it takes 10 to 15 generations for social mobility to erase most of the initial differences in general social status.[111] According to this study *"social mobility seems to be a constant, independent of inequality…. 50 to 70 per cent of the variation in general social status within any generation is predictable at conception*".[111] Neither free public education, modern economic growth, nor redistributive taxation appears to have changed this constant.[111]

Human security and human rights

The world has seen mixed progress on human security and human rights. Data on human security and human rights are sparse and subject to controversies. Significant progress has been made in many parts of the world in terms of the economic and social dimensions. Such progress has not been matched by progress in personal and political security.[112] The long-run trend to democratization continued.[113] There is no general consensus on the direction and magnitude of the inter-linkages between human security and human rights with other sustainable development issues.

Overall well-being

Since 1950, the overall well-being of people as measured by the Human Development Index has substantially improved. The long-run trend to greater well-being continued in the most recent decade, but was set-back from 2008 by the global economic crisis and high commodity prices. But the HDI is not really a good measure of well-being. However, some question whether overall well-being has *substantially* improved since 1950, and in this context refer to objective measures of well-being and surveys of subjective well-being (see, e.g., UNEP's GEO-4 report).

3.1.2. Economy (1950-2013)

World GDP

Affluence has increased amidst persistent poverty. World GDP (i.e. the sum of national GDP) increased from US$5 trillion in 1950 to US$17 trillion in 1970, US$36 trillion in 1990, US$49 trillion in 2000 and 67 trillion US$ in 2010. From 2000 to 2011, world average GDP per capita increased from 8,000 to 9,700 US$. World economic output grew by 3.9 and 3.1 per cent in 2011 and 2012, respectively.[114] Since there is no national economy that has achieved absolute decoupling between economic growth and material consumption and pollution, continued world GDP growth at or above the previous century's average of 3 per cent per year, has meant ever increasing (even though shifting) environmental and resource pressures. The global military expenditure reached US$ 1.75 trillion in 2013 which was about the same proportion of world GDP as in 2004.

Per capita gross domestic product (purchasing power parity) has more than tripled since 1960. All regions of the world except Africa, where growth had stopped in the 1990s, showed such growth. Africa also joined the catch-up growth in the 2000s. However, differences between regions persist. Furthermore, ever increasing incomes have only partially been used for long-term investments in education, infrastructure and health.

Table 16. Global macroeconomic data

World	1950	1970	1990	2000	2010
GDP (in trillion US$)		17	36	49	67
GDP (in trillion (1990) int'l dollars)	5	14	27	37	52
GDP per capita (1,000 int'l 1990 dollars)	2.1	3.7	5.1	6.1	7.8
Total assistance to developping countries (billion US$)			53	54	128
World-adjusted[115] Genuine Progress Index (1,000 US$(2005))	2.0	3.5	4.0	3.9	3.9

Source: authors adapted from UNSD, OECD DAC, and Kubiszewski et al. (2013).

Genuine progress indicator

The genuine progress indicator (GPI) is a measure of economic welfare. It adjusts average incomes for elements that are added up in the GDP but that hardly anyone would consider elements that increase economic welfare. For example, more accidents, diseases, traffic jams, and exploited natural resources all increase GDP, but arguably do not increase economic welfare (see chapter 5 for more details). The world's average per capita genuine progress index also doubled from 1950 to 1978, but has actually decreased slightly since 1978.[116] In other words, in contrast to previous decades, economic growth since 1978 has no-longer increased economic welfare per person at an aggregate, global level. Of course, many people are economically much better off today than decades ago, but many others have borne the negative side effects of growth, both in developed and developing countries. Furthermore, the components of GPI illustrate the inter-linkages between the present economic growth model and environmental and social issues.

Trade and global economic landscape

Trade has grown at more than twice the rate of economic growth since 1950, and current trade in money and capital is 100 times greater than trade in goods and services. The increased integration of world markets has brought with it a disintegration of the production process through "offshore-outsourcing". A number of developing countries (referred to by some as "emerging economies") have benefitted greatly from these trends, whereas others have been further marginalized. The "emerging economies" have achieved rapid and sustained catch-up growth, especially since the 1980, which has shifted global production and distribution patterns. They account for rising shares of global GDP, manufacturing, and trade. As a result, the share of advanced economies in global economic activity declined from 80 per cent in the 1960s to 57 per cent in 2008-2009, whereas the share of "emerging economies" rose from 17 to 39 per cent.[117] The relative contribution of advanced economies to global economic growth over time, declined from 70% in 1973-1985 to 57% in 1986-2007, and to 6% in 2008-2009, while the contribution of emerging economies rose from 26% to 39% and 86%, respectively. Consequently, "South-South"-cooperation among "emerging economies" has become decisive in global economic management.

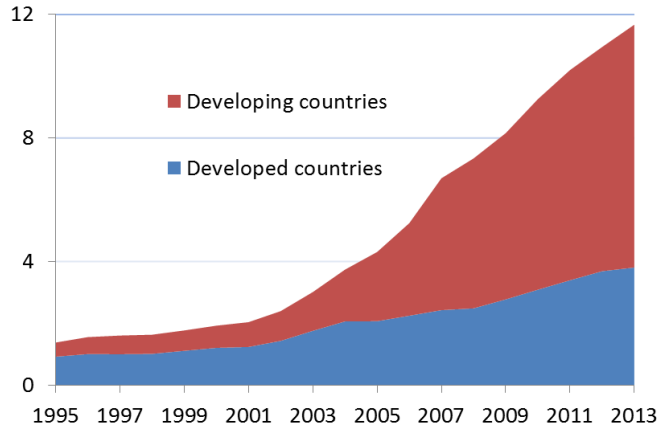
Money supply, financialization and reserves

The growth rate of global money supply has accelerated, and the money supply of the world's major economies has tripled since 2000, i.e. it has increased much faster than GDP.[118] Over the last twelve years, the nine largest currency blocs in the world have increased their total money supply by more than 200 per cent (using current exchange rates). To achieve short term economic goals, most central banks monetized that debt, injecting large sums of money into their economies. The super-

exponential growth of money supply has raised concerns about long-term economic and financial sustainability.

The shares of the financial sector in the national economies of major developed and developing countries has significantly increased since the late 1980s. Liberalization and a greater role of the private sector has been a major factor in this process. As a consequence, funds have been looking for financial returns on investment (ROI) typically on the order of 10 to 15 per cent or more which is much larger than ROIs of 2 to 5 per cent for many long-term investments (e.g., infrastructure) that are essential for a sustainable future. Before the 1980s, ROIs of 5 per cent were completely acceptable to financiers. In short, financialization has essentially "redirected" the economic engine to short-term and/or unsustainable investments. Policy interventions by Governments, such as green taxes, subsidies, feed-in tariffs and risk guarantees, have increasingly aimed to make the long-term, sustainable investments more attractive in line with their social returns. However, there are many examples where this approach has fallen short of expectations, due to strategic gaming, unintended consequences and other reasons.

Figure 8. Global forex reserves in trillion US$, 1995-2013



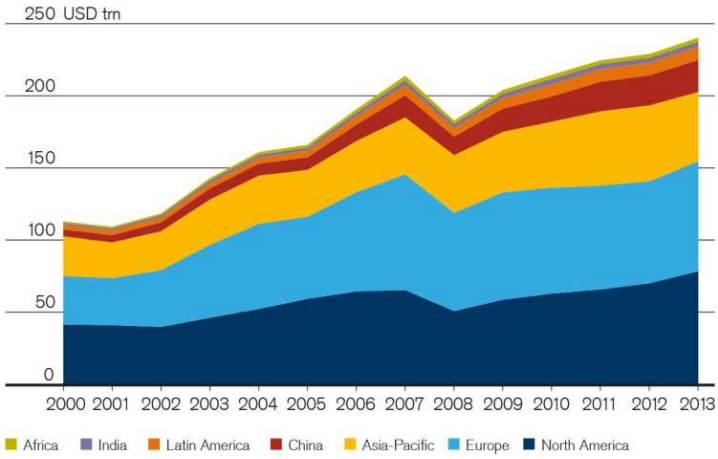
Source: IMF.[119]

The accumulation of forex reserves has increased at an accelerated rate, especially in some developing countries (Figure 8) – the export-intensive "emerging economies" and natural resource-exporting countries. Large reserves have been accumulated as insurance precipitated by a perceived global economic and financial instability. While the global trading system seemed to work just fine with less than US$2 trillion in global forex reserves in 2000, they reached US$11.7 trillion in 2013. Global forex reserves have increased much faster than world trade since 2000 - at about 14 per cent per year compared to 4 per cent per year. In contrast, in the 1990s global forex reserves increased at roughly the same rates as overall world trade. In other words, on the order of US$10 trillion could be invested in projects with in long-term sustainable development impacts, if we achieved a more balanced and stable global economic system.

Global household wealth and its distribution

Despite the setback caused by the global financial crises in 2008, global household wealth more than doubled from US$113 trillion in 2000 to US$241 trillion in mid-2013 (Figure 9). This is equivalent to a 68 per cent increase in wealth per adult, from US$30,700 for the 3.7 billion adults in 2000 to US$51,600 for the 4.7 billion adults in 2013. Today, global household wealth is about four times the size of world GDP, compared to only two times in 2000. Thus, the world today is in a much better financial position to address the big development and sustainability challenges. This is despite the lingering impacts of the global financial crisis of 2007-2008.

Figure 9. Global household wealth, 2000-2013

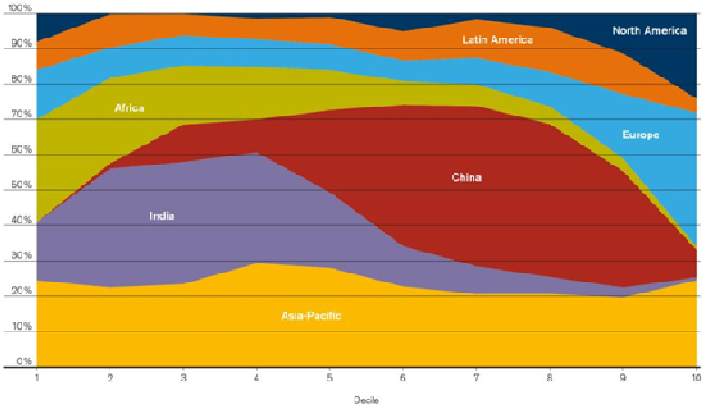


Source: Credit Suisse Global Wealth Databook 2013.[120] Reprinted with permission from Credit Suisse Research Institute.

Global household wealth is unequally distributed: *"To be among the wealthiest half of the world, an adult needs only USD 4,000 in assets, once debts have been subtracted. However, a person needs at least USD 75,000 to belong to the top 10% of global wealth holders and USD 753,000 to be a member of the top 1%. The bottom half of the global population together possess less than 1% of global wealth. In sharp contrast, the richest 10% own 86% of the world's wealth, with the top 1% alone accounting for 46% of global assets."*[120] There are about 31 million US$ millionaires and 1,151 billionaires in the world. Figure 10 shows the regional

distribution of global household wealth. The ten per cent adults with the lowest net wealth live in all world regions.

Figure 10. Regional distribution of global household wealth



Source: Credit Suisse Global Wealth Databook 2013.[120] Reprinted with permission from Credit Suisse Research Institute.

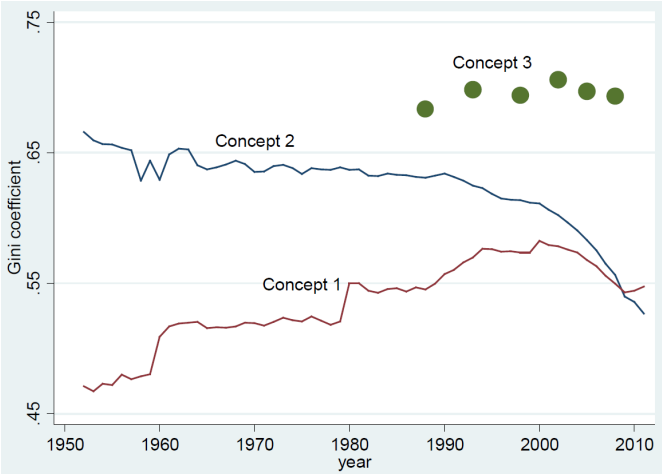
Income inequality

While income and wealth are related, there are major differences in terms of this relationship among regions.

Income inequality between countries calculated from GDP per capita or mean incomes without population-weighting) has increased since 1950 until the early 2000s after which it declined. However, when adjusted for the countries' different population sizes, income inequality between countries has continuously *decreased* since 1950. These measures, however, do not account for inequality within countries. Another measure of global income inequality is global inequality between individuals, not countries - where each person, regardless of his country, enters in the calculation with his actual income. By this measure, global inequality has not changed significantly since the late 1980s (Figure 11).[121]

From 1988 to 2008, all gains in real income have been reaped by the rising middle-class in developing and newly industrialized countries, as well as the "super-rich" in all countries. In contrast, incomes of the poorest in developing countries and of very low and high middle-income groups in developed countries have stagnated or decreased (Figure 12). For the poorest people and least developed countries, consumption remains grossly inadequate, with unmet needs for energy and materials for food production, housing, consumer goods, transportation, and health.

Figure 11. International and global income inequality



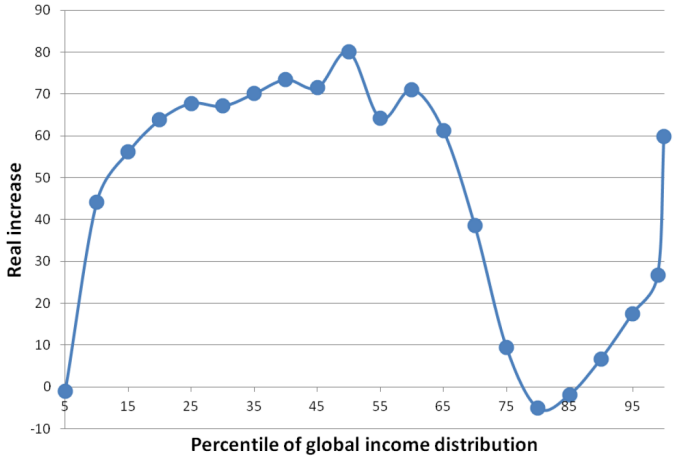
Concept 1: Inequality between countries, calculated from GDP per capita or mean incomes without population-weighting.

Concept 2: Same as concept 1, but weighted by population.

Concept 3: Global inequality between individuals, not countries - each person, regardless of his country, enters in the calculation with his actual income.

Source: Milanovic (2012).[121] Reprinted with permission from the World Bank. Copyright © by the World Bank.

Figure 12. Changes in real income between 1988 and 2008 at various percentiles of the global income distribution.



Note: real income calculated in 2005 international dollars.

Source: Milanovic (2012).[121] Reprinted with permission from the World Bank. Copyright © by the World Bank.

Since 1950, public social protection programmes (e.g. health care and social security) grew in centrally planned countries and all industrialized market-oriented countries. Since the 1980s, however, many of these programmes have shrunk or even disappeared. In developing countries, public

social protection programmes – where they existed - also shrank,. Since 2000, income inequality increased significantly in most countries, except in Latin America where growth in social protection programmes had marked effects. One explanation that has been put forward for the increasing within-country inequality is "globalization" driven by international trade and investment.

Aid flows

In many developing countries, aid flows have been essential for achieving development goals (e.g., public energy and water goals), for disaster relief, and for providing regional and global public goods.

Annual total assistance (ODA, and non-ODA debt forgiveness) to developing countries reached US$125.6 billion in 2013 – more than twice the level in 1990 and 2000. About one third of this amount went to LDCs. The proportion of net ODA (OECD/DAC) to donors' gross national income regained their 1990 levels of 0.32% in 2010. Estimates for 2013 are 0.29%.[122]

A majority of extremely poor people today live in middle-income countries that have growing resources at their disposal, but may still lack the domestic capacity fully to alleviate poverty and address inequality. Moreover, a growing share of poor people are concentrated in fragile and regions affected by conflict, where institutions that would enable public and private investments are weak.

Technology

Paradoxically, humanity has not made full use of its greatly expanded wealth and technological capabilities to effectively solve global sustainable development challenges. At the end of 2011, an estimated 2.3 billion people were Internet users, the majority of whom were in developing countries. Information-sharing and knowledge generation has grown at an accelerated pace. Over the past 20 years, the number of people in the emerging global innovation community has more than doubled. It is estimated that US$1.2 trillion was spent on research and development, globally, in 2009, with the contribution of middle- and low-income countries more than doubling over the previous 15 years. While the participation of the poorest and smaller economies remains negligible at the global level, several technology-intensive developing economies have become world leaders not only in the manufacturing and trade of technologies, but also increasingly in research and innovation. Communication and interconnection in this increasingly urbanized cluster have reached levels that would have been unimaginable just a few decades ago. All of this should, in principle, have put humanity in a much better position to find solutions to sustainable development challenges. Yet, persistent poverty means that opportunities to mobilize the ingenuity of more than 4 billion poor people are being wasted.

Technology has greatly shaped society and the environment. While technology progress has addressed many problems, it has also added new problems.[123] All technologies consume resources, use land and pollute air, water and the atmosphere. An urbanizing world must innovate at an ever faster rate, with the general pace of life inevitably quickening, just in order to sustain continuous growth and avoid a planet of slums, social strife and environmental destruction.[124] Governments have called for concerted actions to accelerate change towards cleaner technology. Actual progress in technology performance at the global level has fallen far short of such ambitions.[125, 126]

Materials consumption

The global growth in material consumption exceeded the growth in population, but was less than the growth in income or value of product. However, for the poorest people and least developed countries, consumption remains grossly inadequate, with unmet needs for energy and materials for food production, housing, consumer goods, transportation, and health.

The global metabolic rate has almost doubled since 1950 to more than 9 tonnes of biomass, construction materials, fossil fuels, ores and industrial minerals per capita per year. Its fastest increase in the past 100 years was experienced in the 2000s, primarily due to increased construction.[127] National metabolic rates continue to vary greatly between countries, even up to a factor of 10 between countries at similar GDP per capita levels.[128]

Primary energy use doubled from 1970 to 2000. Energy use further increased from 384EJ in 2000 to 493EJ in 2010. At the same time, the renewable energy share increased from 5.4% in 1970 to 7.0% in 2000 and 8.2% in 2010.

Global withdrawals of water to satisfy demands grew rapidly in the 20th century. Between 1900 and 1995, water withdrawals increased by over six times, more than double the rate of population growth. However, per capita withdrawals peaked in the mid-1980s. Since then, they have declined and absolute water withdrawals have slowed

worldwide. In industrialized countries, greater efficiency of use has led to lower per capita consumption (e.g., -22% in the US from 1980 to 1995). Agriculture, primarily irrigation, accounts for 70% of current freshwater withdrawals. About 50 countries are already experiencing moderate to severe water stress all year round, while many others have water stresses during part of the year. Local and regional imbalances between water availability and growing demand are a growing concern globally.

3.1.3. Society (1950-2013))

The past sixty years have seen extraordinary changes in developed and developing countries alike, in terms of values, attitudes, and actual behaviour, in particular the attitudinal and behavioural shifts, the role of women, the environment, and human rights.

Women

In addition to the gains in educational attainment described above, women have made inroads in the work place over the past twenty years. The share of women in wage employment in the non-agricultural sector increased from 35% in 1990 to 40% in 2011. In 2012, close to half (48%) of the world's women were employed, compared to 73% of men. 48% of women and 75% of men were employed in developing countries. 49% of women and 62% of men were employed in developed countries. The largest proportion of women employed were in the Least Developed Countries (61%), East Asia (64%), and Sub-Saharan Africa (58%).

The proportion of seats held by women in national parliaments almost doubled since 1990 to 21% in 2013. This share is similar in developed countries, developing countries, and the least developed countries - 24% and 20%, and 21%, respectively.

The adolescent birth rate, i.e. the number of live births per 1,000 women aged 15-19, has decreased in almost all parts of the world since 1990. By 2010, the world average was 49 per 1,000 women aged 15-19. By far the lowest adolescent birth rate was found in Eastern Asia.

Household size

Average household size has decreased in developed and developing countries alike in recent decades, due to aging, higher incomes and fewer stable families. Had the household size stayed at the level of 1985, there would have been 155 million fewer households in the 76 biodiversity hotspot countries in 2000, and another 230 million additional households by today.[129] In particular, the number of single-person households and single-parent households has increased, with important social, economic and environmental consequences. The environmental impact of household size is very significant, in some cases even more so than the absolute population size.[129]

Larger households are much more resource efficient due to scale economies. For example, two-person households in the UK use 31 per cent less electricity and 35 per cent less natural gas per person than single-person households, whereas four-person households use 55 per cent and 61 per cent less, respectively (Table 17).[130] In other words, the continued reduction in household size has counteracted the gains from technologies' increasing efficiencies, especially since the 1970s.

Table 17. Households size versus electricity and natural gas use

Household size	Per capita electricity use		Per capita natural gas use	
	Netherlands	UK	Netherlands	UK
1	100	100	100	100
2	75	69	77	65
3	60	55	64	47
4	54	45	58	39
5	47	38	52	35

Note: One-person household = 100.

Source: Fawcett et al. (2000)[130]

Families

Across the world, there are fewer stable families than in the past decades. Countries with the highest divorce rates include developed and developing countries alike. In almost all developed countries, the crude marriage rate has declined since the 1970s – it was halved on average.[131] Crude divorce rates have increased in almost all countries. However, the average duration of a marriage has not significantly changed in the past forty years and ranges between 10 and 15 years. Divorce rates are higher in cities than in rural areas, in developed and developing countries alike.

Societal views on intergenerational equity

In most countries where a high level of societal consensus existed on intergenerational equity, it has been lost or come under pressure. National pension systems – where they exist – have typically been under constant reform

discussion. This is closely related to aging and broader societal changes.

Institutions

At a global level, new institutions of governance have emerged, transnational corporations and financial institutions grow and consolidate, and networks of nongovernmental institutions collaborate and expand. At the subnational level, government has devolved, privatization is more common than in the past, and civil society in many places has been strengthened. Power has shifted from the nation State upward to the global level and downward to the local level, and at all levels from the public to the private. A "crisis of multilateralism" has been diagnosed, indicating that expectations for global governance have grown much faster than actual institutional developments.

3.1.4. Nature (1950-2013)

Human overall impact on nature

Human economic activities have reached a level where they significantly impact and alter nature at the global level. For example, human modification, management, or appropriation of nature reached about one-half of the terrestrial ecosystems and one-quarter of the freshwater supply.

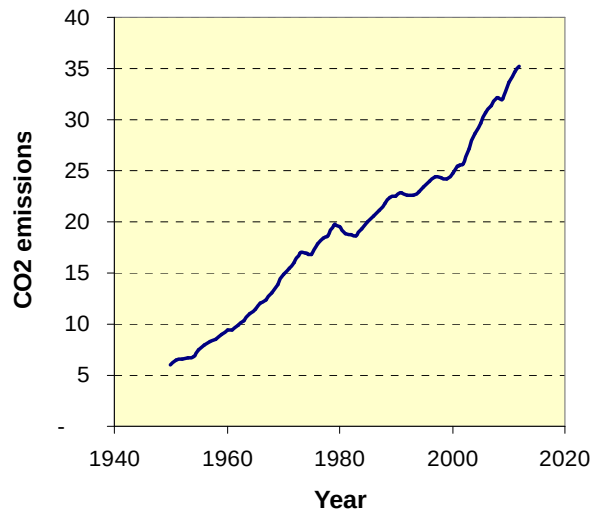
Biodiversity

Biodiversity continues to decrease at rates 100 to 1,000 times their pre-human levels. 11% of bird species, 18% of mammals, 8% of plant species, and 5% of fish species are threatened. In some areas as many as 20% of freshwater species are threatened, endangered, or extinct. Exotic species have increased diversity in some places and decreased it elsewhere as immigrant species replace local ones ("biological invasions").

CO_2 emissions

Global CO_2 emissions from fossil-fuel burning, cement manufacture, and gas flaring have increased at an accelerated rate since 2000 - from 24.8 $GtCO_2$ in 2000 to 35.1 $GtCO_2$ in 2012. (Figure 13).[132] Despite the global economic crisis, this was the largest increase in any decade since 1750. The tropospheric CO_2 concentration has now reached 393 ppmv in 2012, 113 ppmv more than at the beginning of the industrial revolution. The 2000s have been the warmest decade on record since measurements began in 1861.

Figure 13. Global CO_2 emissions from fossil-fuel burning, cement manufacture, and gas flaring



Oceans

41 per cent of the oceans showed high human-induced impacts on marine ecosystems in 2012, with the highest impacts in coastal regions. The ocean currently absorbs approximately 26 per cent of carbon dioxide emitted into the atmosphere resulting in ocean acidification at a rate that may not have been seen for the last 30 million years. Ocean acidification is known to have significant impacts on ocean areas, including reduced ability of many key marine organisms, including calcareous phytoplankton, the base of much of the marine food chain, to build their shells and skeletal structures. Otherwise the chemical composition of the open oceans has not yet been greatly affected by human activities (with the exception of lead). Oceans have warmed leading to sea level rise of 10 to 20 cm over the last century. There is no clear evidence yet that warming had significantly altered the system of ocean currents.

3.1.5. Life support (1950-2013)

Human impact on nature has increasingly reached a scale that it alters and impacts a series of life support functions provided by nature which ultimately are essential for human survival. This includes land use and the appropriation of net primary productivity, freshwater use, overfishing, and local and regional air pollution.

Land use

The world's land cover of the ice free earth is divided into dense settlements (1%), villages (6%), croplands (21%),

rangelands (30%), forests (19%), and wildlands (23%).[133] The protected terrestrial and marine areas have been greatly expanded in developed and developing countries alike - from 8.9 to 14.6% of total surface area and from 4.6 to 9.7% of territorial waters between 1990 and 2012.

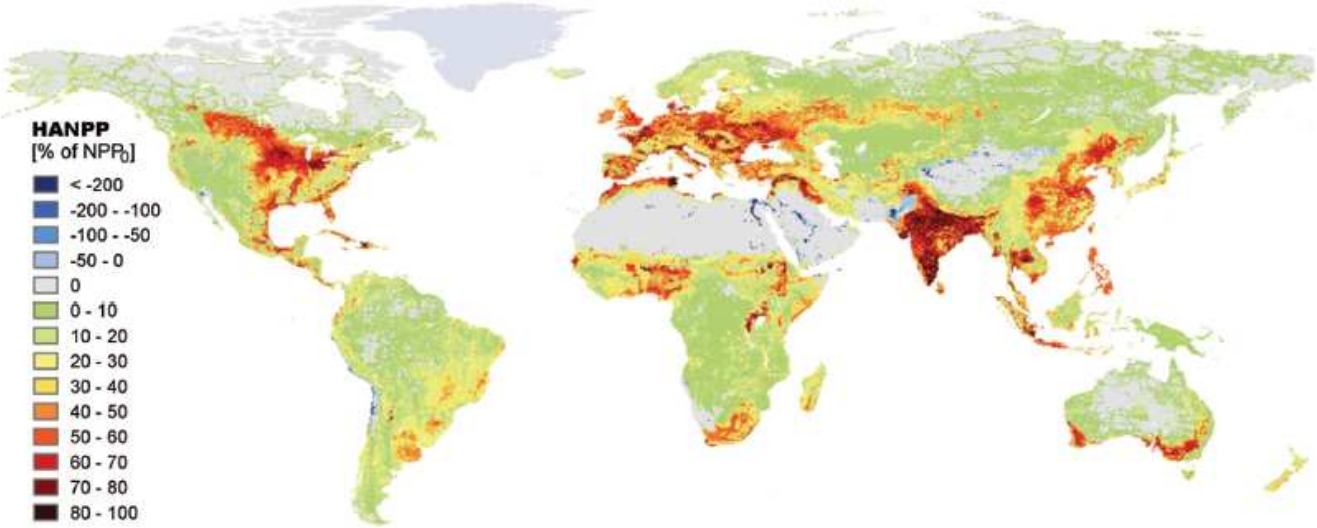
Despite the loss of half of the world's forests historically to domestication, they currently occupy 20 per cent of the world's ice-free land are, with over one-half located in the tropics. Tropical forests declined at around 12 to 14 million hectares per year in both the 1990s and 2000s, and a similar amount was degraded due to commercial logging, agriculture, cattle ranching, dam building and mining.[134] Altogether 57 per cent of tropical forests have been lost. In contrast, temperate and boreal forests were reforesting since the 1980s, with the exception of Siberia. After 1990, growing stock expanded in many forested countries[135], and during 1990–2010 the density of forests grew in all world regions, albeit unevenly.[136]

Grasslands have been extensively modified worldwide and increasingly degraded in terms of standing biomass. There has been a sustained expansion of croplands in developing economies, especially the tropics, arid and semiarid lands, and high mountains. Arable land per person has been cut from 0.42 ha to 0.20 ha while food production rose 160% from 1950 to 2010. Fortunately for the sparing of cropland, meat consumption is increasing only half as fast as affluence. Global arable land and permanent crops increased from 1,371 million ha in 1961 to 1,533 million ha in 2009. According to one account, peak farmland may have been reached by 2010.[137]

Human appropriation of net primary production

Human appropriation of net primary production (HANPP) is a prominent measure of human domination of the biosphere. HANPP measures human alterations of photosynthetic production in ecosystems and the harvest of products of photosynthesis. It reduces the amount of energy available to other species, influences biodiversity, water flows, carbon flows between vegetation and atmosphere, energy flows within food webs, and ecosystem services. Humanity claims about 15.6 Pg C/year or 24 per cent of potential net primary productivity, of which 53% was contributed by harvest, 40 per cent by land-use-induced productivity changes, and 7 per cent by human-induced fires.[138] According to the latest estimates, HANPP has doubled from 13 per cent of net primary production of potential vegetation in 1910 to 25 per cent in 2005.[139] The long-term impact of such a level of anthropogenic interference on the ecosystem of is controversial and greater technological progress than otherwise anticipated may be required, in order to feed a growing population. With current technologies. intensified production on prime croplands in most countries depends on high inputs of water, fertilizer, pesticides, and improved seeds, with limits to yield increases becoming apparent.

Figure 14. Human appropriation of net primary productivity excluding human fires.



Source: Haberl et al. (2007).[138] Copyright © by the National Academy of Sciences.

Water

Local and regional freshwater shortages, and water stress was widespread in one-third of the world, where withdrawals exceeded 20 per cent of available supply. In many developing countries, the quality of available water continues to decline because of pollution and salinization.

Fisheries and coastal areas

Commercial ocean fisheries were significantly more stressed in 2012 than in previous decades. Despite strong international consensus to preserve maximum sustainable yields, the proportion of overexploited fish stocks tripled from 10% in 1970, to 27% in 2000, and 30% in 2012. Even where elaborate institutional frameworks exist, overfishing has continued to happen, as in the case of the Bluefin tuna in the Eastern Atlantic and in the Mediterranean.

Half the world's population live within 200 kilometres of a coastline, a number that has grown over time. Much of their waste, garbage, and waterborne pollutants, as well as ship-borne waste, oil spills, and distant agricultural runoff, end up offshore and have degraded coastal zones.

Coastal habitats have come under pressure, with approximately 20 per cent of the world's coral reefs lost and another 20 per cent degraded. Mangroves have been reduced to 30 to 50 per cent of their historical cover, impacting biodiversity, habitat for inshore fisheries, and carbon sequestration potential. 29 per cent of seagrass habitats are estimated to have disappeared since the late eighteen hundreds. Over 80 per cent of the world's 232 marine eco-regions reported the presence of invasive species which is the second most significant cause of biodiversity loss on a global scale.

Air pollution

Most concentrations of local air pollutants (e.g., nitrogen dioxide, ozone, sulfur dioxide, carbon monoxide, and lead) have decreased in developed countries, many also in developing countries. Global SO_x emissions peaked in 1989 and have declined since. However, the health burden of local air pollution remains large, especially in megacities of developing countries.

The global release of chlorofluorocarbon gases peaked in the late 1980s, and the ozone layer is on a long-term path to stabilization by 2020/2030.

3.1.6. Community (1950-2013)

Conflicts

The number of State-based armed conflicts increased from fewer than 20 in the 1950s to over 50 in 1991. Thereafter, it decreased to fewer than 30 in 2005 – a level not seen since the 1970s. Since 2005, however, the number has again increased.[140] There have been more State-based armed conflicts in recent years than during the cold war. There is also evidence for a very long-term trend toward more frequent and ever more intense conflicts.[141]

The number of reported battle-deaths from non-State armed conflicts has decreased by more than half since 1992, in contrast to the perception created by international media. Even more striking, today's number of deaths from one-sided violence (such as terrorism) is one hundredth of its peak in 1994.[140]

Culture

There is ample indicative evidence that the impact of the above trends on cultural heritage, traditions, and traditional knowledge and indigenous languages have been very significant. For example, indigenous cultures today are threatened with extinction in many parts of the world. There are between 6,000 and 7,000 oral languages in the world today, and most of them are spoken by only very few people. At the current rate, as many as 90 percent of the world's languages might disappear in this century. Yet, there are also indications that some indigenous languages and cultures are revitalizing. [142]

3.2. Reflection on synergies and trade-offs

As illustrated above, historical progress towards sustainable development has been mixed since 1950. There is evidence that impressive progress in some areas has come at the expense of worsening trends in other areas. However, these trade-offs have been rather complex and have sometimes differed greatly at various spatial and time scales. They have also changed over time depending on the overall environment. For example, success in reducing poverty has in some cases led to a reduction in biodiversity, whereas in others it has been key to its conservation. Similarly, no country has achieved absolute decoupling between economic growth and material consumption. Yet, it is also clear that economic growth can hold the key for increased knowledge, technology and financial resources all of which are essential in finding solutions to higher efficiencies and an eventual absolute decoupling.

Table 18 summarizes - in a stylized way - the actual direction of trade-offs and synergies as they actually played out in aggregate at the global level from 1950 to 2013. It is important to note that there are no global trends that did not also have some negative impacts on sustainable development (indicated in red) in some other areas. Hence, there is really no silver bullet and trade-offs need to be accepted in line with values and preferences of the people concerned. It also holds an important lesson for the implementation of the envisaged future sustainable development goals.

The inter-linkages in Table 18 are based on one expert judgement. It refers to a particular context – the global level and the past since 1950. On many of these items, there is no general consensus. For example, poverty can cause biodiversity loss, but has not always or generally been the case. And there are examples where improvements in biodiversity have reduced poverty, but this is not always the case.

Indeed, the history of SD progress highlights the complexity of global interlinked systems and the limits to what governments can do to change long-run trends ("slow variables"). There are even instances of well-intended government policies that had unintended consequences in the aggregate. Therefore, pragmatic, flexible approaches are needed as is better support from the scientific community, including from global modellers.

Table 18. Inter-linkages between trends and sustainable development issues at the global level, 1950-2013

Trends in…. [list below]	..have not impacted ("o"), supported ("+") or negatively impacted ("-") sustainable development progress in these areas [list on the right]	To develop																									To sustain									
		People											Economy									Society					Community		Life Support					Nature			
		World population	Life expectancy	Global health	Poverty and hunger	Education	Access to basic services	Aging	Migration	Intergenerational social mobility	Human rights and human security	Overall well-being	World GDP	Economic welfare	Trade and economic integration	Money supply, reserves, financialization	Global household wealth	Income inequality	Aid flows	Technology	Materials consumption	Attitudes and life styles	Household size	families	Societal views on intergenerational equity	Institutions	Peace and conflict	Culture and languages	Land use	Human appropriation of net primary production	Water	Fisheries and coastal areas	Local and regional air pollution	Overall human impact on nature	Biodiversity	Greenhouse gas emissions	Oceans
People	Growing world population		o	+	-	-	-	+	+	o	o	o	+	o	+	o	+	o	o	+	-	o	+	+	+	+	o	+	-	-	-	-	-	-	o	o	o
	Extended life expectancy	+		-	+	+	+	-	o	+	o	+	+	+	o	+	+	+	o	+	-	-	-	+	-	+	o	+	-	-	-	-	-	-	o	o	o
	Better global health	-	+		+	+	+	-	o	+	o	+	+	+	o	+	+	+	-	o	o	+	o	o	+	o	o	+	o	o	o	o	o	o	o	o	o
	More relatively poor in an absolutely less poor world	-	+	+		+	+	o	+	o	+	o	o	+	o	o	o	+	-	o	o	o	o	o	o	o	+	o	+	+	+	o	o	+	o	o	o
	More hungry people	-	-	-		-	-	+	+	-	-	-	-	-	o	o	o	-	+	o	+	-	o	-	-	-	-	o	o	o	o	o	-	o	o	o	o
	Almost reached universal primary education	+	+	+	+		o	o	O	+	+	+	+	+	o	o	o	+	-	o	o	+	-	o	o	+	o	+	o	o	o	o	o	o	o	o	o
	Billions lack access to basic services	+	-	-	-	-		+	-	o	-	-	o	-	o	o	o	-	+	-	+	-	o	o	o	-	-	o	-	-	o	-	-	+	-	+	-
	Aging societies	+	o	-	-	o	o		-	-	o	o	-	o	o	-	+	-	o	-	o	-	-	o	-	o	o	+	o	o	o	o	o	o	o	o	o
	Increased int'l migration	o	o	-	+	+	+	o		+	o	o	+	+	+	+	+	-	-	+	o	+	-	-	-	-	o	-	+	o	o	o	o	o	o	o	o
	No significant change in intergenerational social mobility	o	o	o	-	-	o	o	o		o	o	o	o	o	o	+	-	o	o	o	o	o	o	+	o	o	o	o	o	o	o	o	o	o	o	o
	Mixed progress on human rights and human security	o	o	+	+	+	+	o	-	o		+	o	o	o	o	o	o	o	o	o	+	o	o	o	-	-	-	o	o	o	o	o	o	o	o	o
	Overall well-being improved	-	+	+	o	o	o	o	+	o	o		o	+	o	o	o	o	-	o	o	o	o	+	+	+	+	+	o	o	o	o	o	o	o	o	o
Economy	Global economic growth	+	+	+	+	+	+	+	+	o	o	o		o	+	-	+	o	-	+	+	-	-	-	-	o	-	-	-	-	-	-	-	o	-	-	-
	Increased affluence amidst persistent poverty	-	o	-	o	o	o	+	-	-	o	o		+	+	-	+	-	o	+	+	-	-	o	o	o	-	-	-	-	-	-	-	o	-	-	-
	Stagnating global economic welfare	o	o	-	-	o	o	o	-	-	o	-	o		-	o	-	-	+	o	-	o	-	-	-	-	-	-	-	-	-	-	-	o	-	-	-
	Increased trade and economic integration	o	o	o	+	+	o	o	+	o	o	o	+	o		-	+	+	-	+	-	+	-	o	o	+	+	-	-	-	-	-	-	-	-	-	-
	Increasing money supply, int'l reserves and financialization	o	o	o	o	o	o	o	o	o	o	o	+	o	+		+	-	-	+	-	o	o	o	-	-	o	o	o	o	o	o	o	o	o	o	o
	Increasing wealth	+	+	+	+	+	+	-	+	o	o	+	+	+	+	-		o	-	+	-	-	-	+	o	o	+	o	-	-	-	-	+	-	-	-	-
	No change in global inequality between individuals	o	o	o	o	o	o	o	-	-	o	o	o	o	o	o	o		o	o	+	o	o	o	o	o	-	-	o	o	o	o	o	o	o	o	o
	Increasing aid flows	-	+	+	+	+	+	-	+	o	o	o	o	o	+	-	o	+		+	-	+	-	-	o	o	o	-	-	-	-	-	+	-	-	-	-
	Increased R&D and technology performance	o	+	+	o	+	o	-	o	o	o	+	+	+	+	-	+	-	-		+	-	o	o	o	+	o	+	+	+	+	+	+	+	+	+	+
	Billions of poor people excluded from global innovation process	o	-	-	-	-	-	o	-	-	o	o	-	-	-	o	-	-	+			o	o	o	o	-	-	o	-	-	o	o	-	o	o	o	o
	Accelerated increase in global metabolic rate	o	o	o	o	o	o	o	-	o	o	o	+	-	+	-	-	o	o	+		o	o	o	-	o	-	o	-	-	-	o	o	-	-	-	-
	Increased energy and water demands	o	+	o	-	o	-	o	-	o	o	+	+	o	+	-	o	o	o	+		-	o	o	-	o	-	o	-	-	-	o	o	-	-	-	o

Trends in…. [list below]	..have not impacted ("o"), supported ("+") or negatively impacted ("-") sustainable development progress in these areas [list on the right]	To develop																									To sustain									
		People											Economy									Society					Comm unity		Life Support					Nature			
		World population	Life expectancy	Global health	Poverty and hunger	Education	Access to basic services	Aging	Migration	Intergenerational social mobility	Human rights and human security	Overall well-being	World GDP	Economic welfare	Trade and economic integration	Money supply, reserves, financiialization	Global household wealth	Income inequality	Aid flows	Technology	Materials consumption	Attitudes and life styles	Household size	families	Societal views on intergenerational equity	Institutions	Peace and conflict	Culture and languages	Land use	Human appropriation of net primary production	Water	Fisheries and coastal areas	Local and regional air pollution	Overall human impact on nature	Biodiversity	Greenhouse gas emissions	Oceans
Society	Extraordinary changes in values, attitudes, and life styles.	+	o	-	o	+	o	-	-	o	o	o	+	-	+	-	+	-	+	o	-		-	-	-	-	o	-	-	-	o	-	+	-	-	-	-
Society	Smaller households	+	o	-	-	o	o	-	o	o	o	o	+	-	+	-	-	-	o	o	-	-		-	-	-	o	-	-	-	o	o	-	-	-	-	-
Society	Fewer stable families	+	o	o	-	-	o	-	-	-	o	-	+	-	o	-	-	-	o	-	-	-	-		-	-	o	-	-	-	o	o	o	-	o	-	o
Society	Weakened pension system and lost consensus on intergenerational equity	+	-	-	-	-	o	-	-	o	o	-	o	-	o	+	o	-	o	o	o	-	-	-		-	o	-	o	o	o	o	o	o	o	o	o
Society	Crisis of multilateralism	o	o	-	-	-	-	o	o	o	-	-	o	-	-	-	o	o	-	-	o	o	o	o	o		-	+	o	o	o	o	o	o	o	o	o
Com-munity	More State-based armed conflicts	+	-	-	-	-	-	o	-	+	-	-	-	-	-	-	-	o	+	-	+	o	o	-	-	-		-	o	o	o	o	o	o	o	-	o
Com-munity	Declining cultural diversity, traditions and indigenous languages	+	o	o	-	o	o	o	-	o	-	-	o	-	o	o	o	o	o	-	o	-	-	-	-	-	-		o	o	o	o	o	o	o	o	o
Life Support	Protected terrestrial and marine areas increased	o	o	o	o	o	o	o	-	o	o	+	o	+	o	o	o	o	+	o	o	-	o	o	o	o	o	-		+	+	+	+	+	+	+	+
Life Support	Extension of croplands	o	o	o	+	o	o	o	+	o	o	o	+	o	+	o	+	o	o	o	-	o	o	+	+	o	o	o		-	-	-	o	-	-	-	-
Life Support	Loss of tropical forests, but increased temperate and boreal forest area	o	o	o	-	o	-	o	-	o	o	o	+	-	+	o	+	-	o	o	o	o	o	o	o	o	-	-		-	-	o	o	-	-	-	o
Life Support	Increased human appropriation of net primary productivity	o	o	o	-	o	o	o	o	o	o	o	o	-	o	o	o	o	o	o	-	o	o	o	o	o	-	-	-		-	o	o	-	-	-	-
Life Support	Increased local and regional freshwater shortages and water stress	+	-	-	-	-	-	+	-	o	o	-	-	-	o	o	o	-	+	o	+	o	o	-	o	-	-	-	+	+		o	o	o	-	+	o
Life Support	Stressed ocean fisheries and coastal degradation	o	o	o	-	o	o	o	-	o	o	o	-	-	-	+	o	-	o	o	o	-	o	o	o	o	-	-	-	-	o		o	-	-	o	-
Life Support	Concentrations of many local and regional air pollutants gave decreased	-	+	+	+	o	o	o	o	o	o	+	+	+	o	o	o	o	-	o	o	o	o	o	o	o	o	o	+	+	o	o		+	+	+	+
Nature	Increased overall human impact on nature	o	o	o	-	o	-	o	-	o	o	o	o	-	o	o	o	-	+	+	+	o	o	o	o	o	-	-	-	-	-	-	-		-	-	-
Nature	Decreasing biodiversity	o	o	o	-	o	o	o	-	o	o	o	o	-	o	o	o	o	+	o	-	o	o	o	o	o	o	-	-	-	-	-	o	-		o	o
Nature	Accelerated increase in greenhouse gas emissions	o	o	-	-	o	o	o	-	o	o	o	o	-	o	o	o	-	+	+	o	o	o	o	o	o	-	o	-	-	-	-	+	-	-		-
Nature	Increased human-induced impacts on marine ecosystems	o	o	o	-	p	p	p	-	o	o	-	o	o	-	o	o	-	+	o	o	o	o	o	o	o	o	o	-	-	o	-	o	-	-	o	

Note: The table illustrates the overall impact that global trends listed on the right had on the sustainable development progress in the areas listed on the top. "o" indicates that the trends have had no or no clearly identifiable impact on sustainable development, "+" (green colour) indicates a trend that supported sustainable development, and "-" (red colour) indicates a negative impact on sustainable development in the listed area over past decades. The table refers to the particular global context 1950-2013 and cannot be generalized. Inter-linkages at the national level or for different times may be different.

Source: Authors based on expert judgement.

3.3. Progress in terms of commitments on sustainable development

Next we summarize progress on the implementation of sustainable development commitments.

3.3.1. Progress of implementation of Agenda 21 and the Rio Principles

A comprehensive review of the implementation of Agenda 21 and the Rio Principles was undertaken by DESA in the context of the SD21 project for Rio+20. This section draws on that report.

Implementation of Agenda 21

Success on Agenda 21 has been highly variable. Despite being a comprehensive plan to deliver sustainable development, implementation has not always been systemic. However, there are good examples of where Agenda 21 has achieved positive and lasting outcomes.

Overall, based on expert ratings, progress on Agenda 21 has been limited. Of the 39 Agenda 21 Chapters, most were rated by both expert assessors as having only made limited progress to date. Three chapters (chapter 4 on Changing consumption patterns; chapter 7 on Promoting sustainable human settlement development; and chapter 9 on Protection of the Atmosphere) were rated as having made no progress or witnessed a regression. Only five chapters were rated by both assessors as having achieved good progress or better: chapters 27 and 18 on involvement of NGOs and local authorities, chapter 35 on Science for sustainable development, chapter 38 on International institutional arrangements, and chapter 39 on International legal instruments and mechanisms). Ratings varied across the two assessors for a few chapters, but overall the two sets of rating are fairly consistent.

Successes: Arguably, Agenda 21's biggest success has come through driving ambition on what sustainable outcomes are achievable on a sector by sector basis. For example, our understanding of biodiversity, of the contribution that agriculture makes to development or of the role of indigenous peoples in society, has been advanced in no small part through Agenda 21. Furthermore, Agenda 21 has engendered a much stronger notion of participation in decision-making. This affirmation of the important role of non-governmental actors has percolated all levels of government, international law and international governance.

Challenges: In retrospect, the format for Agenda 21 based on sectors may have contributed to defeating the concept of integration that is at the heart of sustainable development, which seeks to promote cross-sectoral solutions. Some areas of Agenda 21 have remained largely unsuccessful and could even be deemed failures.

Implementation of the Rio Principles

The review of the Rio Principles shows that many of the principles have been transposed into further international laws or national instruments, but have not necessarily filtered down into meaningful action in practice. Without full compliance and enforcement mechanisms there is little to ensure that States comply with the objective and aspiration of the principles. However, there are some successes in this regard, such as Principle 10 (Access to Environmental Information) as enshrined in the Aarhus Convention which covers most European Union (EU) members.

Overall, based on expert ratings, progress on the Rio Principles has been slow. Of the 27 Rio Principles, 17 were rated by both expert assessors as only having made limited progress to date.[143]

3.3.2. Progress towards achievement of current goals or commitments in 19 focus areas

Initial discussions of the UN Open Working Group (OWG) on Sustainable Development Goals (SDGs), an intergovernmental working group established by the UN General Assembly on 22 January 2013 and tasked to prepare a proposal for SDGs, considered 19 focus areas as potential areas for future SDGs. These have now been narrowed down to a fewer number of areas with a view to the OWG's finalizing its report by the end of July 2014. Global progress towards achievement of goals or commitments has been rather mixed in these initial 19 focus areas. Clearly, the level of progress depends, *inter alia,* on the level of ambition of the goal or commitment in the first place. Early achievement of a goal might reflect faster than foreseen progress or an inadequately ambitious goal. These differences are discussed in more detail in chapters 4 and 5.

Table 19. Progress towards achievement of goals or commitments in the initial 19 focus areas of the SDG OWG

Thematic areas identified by Member States	Selected international reports and assessments	Existing goals or commitments	Examples of existing targets	Current Status
1. Poverty eradication (MDGs)	UN *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports*	Eradicate poverty	Reduce extreme poverty by half by **2015**	Completed in the MDGs context, but still 1 billion people in extreme poverty
2. Food security and sustainable agriculture (MDGs and beyond)	UN *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports;* FAO *The State of World Reports; the State of Food Insecurity Reports;* UNCCD Reports	World free of hunger	Reduce hunger by half by **2015**	On-track in the MDGs context
3. Water and sanitation (MDGs)	UN *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports;* UN *World Water Development Report;*	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**.	On-track in the MDGs context
4. Health (MDGs)	UN *Millennium Development Goals Report*; World Bank-IMF *Global Monitoring Reports;* WHO *World Health Report*	Reduce child mortality; improve maternal health; combat HIV/AIDs etc.	Reduce by two thirds, between 1990 and **2015**, the under-five mortality rate.	On-track in the MDGs context
5. Education (MDGs)	UN *Millennium Development Goals Report*; World Bank-IMF *Global Monitoring Reports; UNESCO Global Monitoring Reports*	Universal primary schooling	By **2015**, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	Off-track
6. Employment (MDGs)	ILO *Global Employment Trends;* World Bank *World Development Reports*	Full and productive employment and decent work for all.	Time-bound targets for assessments are not stated	Off-track
7. Oceans (Ch. 17 of Agenda 21; JPOI; Aichi Targets 6, 10 and 11; Target 7.B of MDG)	UNGA *Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socio-economic Aspects;* UNEP *Keeping Track Reports;*	Protection of the oceans and all kinds of seas	By **2015**, the multiple anthropogenic pressures on coral reefs are minimized, to maintain their integrity and functioning.	Off-track
8. Biodiversity (Aichi Targets; MDG Target 7.B)	CBD *Global Biodiversity Outlooks*	20 Aichi Goals of halting global biodiversity loss	Achieving, by **2010**, a significant reduction in the rate of biodiversity loss.	Off-track
9. Forest (Aichi Targets on forest; Four shared global objectives on forests, agreed at UNFF Session 6)	UN Forest Forum Reports; CBD *Global Biodiversity Outlooks;* FAO *Global Forest Resources Assessments*	Forest component of Aichi targets: reducing deforestation	A 25 per cent reduction in annual global deforestation and degradation rates by **2015** relative to the 2000-05 average	Off-track
10. Sustainable consumption and production (SCP) (Ch.4 Agenda 21; and JPOI Ch. 3)	UN *Trends Reports: Towards Sustainable Consumption Production;* World Business Council for SD: *Vision 2050 Report*; UNEP: *The Marrakech Process Progress Report*	Changing unsustainable patterns of consumption and production	International Plan of Action is in place, but no time-bound target yet.	Off-track
11. Means of implementation (MDGs, Rio+20; Copenhagen Accord)	UNCTAD *Trade and Investment Reports; MDG Gap Task Force Reports*; World Bank *World Development Reports*; IPCC Reports WIPO *Annual Reports*	Develop a global partnership for development.	Meet the 0.7% ODA/GNI target now; $100 bn per year for climate change by **2020**	Off-track
12. Sustained and inclusive economic growth (Rio+20)	UN DESA *World Economic and Social Survey;* UNIDO *Industrial Development Report*	Achieve sustainable, inclusive and equitable economic growth.	On-going	Mixed progress.
13. Needs of countries in special situations, and mid-income countries (Istanbul PoA; Rio+20)	SG's Report on Implementation of the Programme of Action for the LDCs; UN-OHRLLS *Reports on LDCs, LLDCs and SIDS*; ADB: *African Development Reports*	Address special needs of Africa, LDCs, LLDCs and SIDS. Goals/commitments on mid-income countries?	On-going	Mixed progress among these groups.
14. Human rights, the right to development and global governance (Rio+20)	UNDP *Human Development Reports;* World Bank: *World Development Reports*	Respect, protect and promote human rights and fundamental freedom for all	On-going	Mixed progress.
15. Equality (MDGs)	*Human Development Reports;* UN-Women *Progress of the World's Women;* UN *Millennium Development Goals Reports*	Promote gender equality and empower women	Equal girl's enrolment in primary school; women's share of paid employment etc. by **2015**	Off-track
16. Energy (Rio+20 Outcome Document)	*Global Tracking Framework Report;* IIASA *Global Energy Assessment;* IEA *World Energy Outlooks;* IPCC WG III Reports	Make sustainable energy for all a reality	On-going	Off-track
17. Sustainable cities, transport (MDGs etc.)	UN-HABITAT: *Global Reports on Human Settlement*; IEA: *World Energy Outlook*.	Improve the lives of slum-dwellers	Achieve, by **2020**, a significant improvement in the lives of at least 100 million slum dwellers	Off-track
18. Climate Change and Disaster Risk Reduction (Copenhagen Accord)	*IPCC Assessment Reports;* UNFCCC Independent Reports; UNEP: *Emission Gap Reports;* World Bank: *Turn Down the Heat Reports;* UNISDR *Global Assessment Report*	Hold global mean temperature increase below 2°C .	By **2050** or longer term based on scientific evidence	Off-track
19. Conflict prevention, post-conflict peace-building	*Human Security Report*	Maintain international peace and security – UN Charter	Time-bound goals are not stated	Different views on how much progress has been made.

3.4. Perspectives: Making sense of the debate on sustainable development progress

Views on progress made, remaining gaps and ways forward toward sustainable development cover broad spectrum and tend to differ across and within governments, civil society groups, academia, and the public at large. The following statements are typical[144,145]:

a) Elements of a sustainable future are already visible. Corporations and NGOs are showing the way. What is needed is to quickly scale up these initiatives;
b) While we are not yet on a sustainable development path, we know what should be done, and we have the means to do it. All that is needed is political will to implement commitments in terms of finance, technology and capacity development;
c) Current environmental trends are unsustainable. Markets are the most efficient way to guide us on the right path. What is needed is full internalization of environmental externalities, and expansion of markets for ecosystem services;
d) We are on a fundamentally unsustainable path. Drastic changes in behaviour and lifestyles are necessary to achieve the necessary transition towards sustainable development;
e) Humanity has transgressed the Earth's carrying capacity decades ago. Only an immediate stop to ecosystem destruction, as well as population control and large-scale restoration of ecosystems might restore global biotic regulation and prevent total collapse of ecosystems, including the human species.

At first glance these statements look mutually contradicting. More in-depth analysis shows that none of them is necessarily wrong. Different conclusions are reached by choosing different scopes and completely different time scales. In fact, system size and time scales increase greatly from the focus on local, current actions to the comprehensive view of the Earth's biota and thousands of years. However, policy prescriptions derived from short-run and narrow approaches are often contradictory to those that would be predicated on long-run considerations.

What is immediately apparent too is that the different statements mix opinions on: (i) where we are today with respect to sustainability; (ii) what the main constraints to progress are; (iii) what means should be adopted to achieve sustainable development; and (iv) what specific policies should be used. Importantly, few perspectives articulate ends (where we want to be), as opposed to means.

Not only do views differ across all actors. One of the main barriers to productive dialogue is the fact that arguments are made at very different levels, referring to:

1. Sustainable development as an overarching goal, including the scientific basis that underpins it or its application to specific sectors or clusters;
2. The overall approach that should be followed to achieve sustainable development;
3. The nature and content of strategies that the international community and national governments select for going forward;
4. The details of the blueprints (e.g. Agenda 21) upon which action is based;
5. Progress and shortcomings in the implementation of specific actions and plans.

This can result, at best in unproductive exchange of arguments, at worst in incomprehension and mistrust. This report argues that in order to start a constructive conversation on sustainable development, views at these different levels have to be made explicit as far as possible. The range of perspectives on specific sectors and issues are described in the UN's SD21 study. [145]

4. Visions, scenarios and 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.

People across the world have a range of views or "visions" of what kind of world they would like to see for themselves, their children and children in the future. The Rio+20 Conference of 2012 (UNCSD) agreed on key elements of a common vision for sustainable development. The UN Open-Working Group on the Sustainable Development Goals (SDGs) further explores international consensus. Furthermore, there are different preferences for alternative future pathways toward achievement of the vision. Scenarios are plausible and internally consistent pictures of the future. They are useful tools – often making use of quantitative models - to systematically explore the feasibility of visions and proposed future pathways towards their achievement. They provide information on the "means of implementation" that are needed and can be useful in monitoring progress.

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 improvements in eco-efficiency remain unknown. In contrast, perspectives differ greatly on the suggested policy solutions arising from different world views, grounded in different values.[146]

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 about their vision for 2050: "*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 20). 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 toward more holistic and sustainable values well under way".

Table 20. 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 change	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[147] and PBL[148] 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"[149], 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".[150] Table 21 provides an overview of what this scenario might mean by 2050 which is described in more detail below.

Table 21. 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. This will be in addition to the roughly 4 billion people already living in urban areas, requiring the building of 400 mega-cities in and around existing cities.[151]

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 less than 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.[152]

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 among 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 to ranges among developed countries today. Average GDP per capita is expected to triple to US$33,000 in 2050, a level similar to OECD countries today whose 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 dynamics-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 challenges. 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 one 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. More biofuels also means that less water is available for food production.

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 which raises serious concerns about global food security.

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.

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.

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

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.

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.

Agricultural land area is expected to increase until 2030, putting pressure on other uses of land, and might decline thereafter, in line with declining population growth and agricultural yield improvements. Deforestation rates will most likely continue to decline, especially after 2030, but most primary forests might be destroyed by 2050.

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

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.[153]

Limited effort is made on climate (continuing the increase in voluntary emissions reductions), reflecting lack so far of a global binding multilateral agreement post Kyoto. GHG emissions are expected to increase at an accelerated rate at least until 2030, leading to an increase from 48 to 83 $GtCO_2$-equivalent 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-equivalent), eventually leading to a 3-6˚C warming.

Biodiversity loss is expected to continue unabated. Biodiversity[154] is expected to decline by at least 10%, with the highest losses in Asia, Europe, and Southern Africa[155], 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 referenced here 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 other's 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 concern, such as poverty, hunger, vitamin deficiencies, social protection, universal access to basic services and 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 22. 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,[156]
- Rio+20 scenarios by PBL Netherlands Environmental Assessment Agency[157],
- Alternative pathways toward sustainable development and climate stabilization (ALPS) by RITE, Japan,[158]
- Shared Development Agenda (SDA) Scenarios for Rio+20 by the Stockholm Environment Institute (SEI), Sweden,[159]
- Green growth scenarios for Rio+20 by OECD,[160]
- Great transition scenarios (2010 update) by Tellus, USA,[161]
- Exploratory WITCH scenarios by Fondazione Eni Enrico Mattei (FEEM), Italy,[162]
- 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)[163]
- Sustainable Development Global Simulation by National Academy of Sciences of Ukraine; Geophysical Center of Russian Academy of Science; Ukrainian Branch of World Data Center,[164]
- In addition, a number of prominent recent reviews of scenarios were considered, where appropriate, including World Wildlife Fund's Living Planet[165], UNEP's GEO-5 scenario review[166], the World Business Council for Sustainable Development's sustainable vision 2050[167], and the World Economic Forum's global risk report.[168]

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.[169]

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 occurs, 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 dimensions 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 countries and regions in the long term. This scenario implies new economic structures, different allocation of capital and investment among public and private sectors, and 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 be further halved by 2030, and eradicated by 2050.[157] In another account of such a world, chronic hunger would be reduced by 50%, 75% and 94%, by 2025, 2050, and 2100, respectively.[161] Poverty as a whole could be virtually eliminated worldwide by 2050.[159]

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 could be halved by 2015, followed by another halving by 2030. Eventually, universal access to improved water source and basic sanitation would be achieved by 2050. [157]

Universal access to electricity and modern cooking fuels could be achieved by 2030.[156,157] Others believe it might take until 2050.[159] This achievement, together with other pollution measures, would significantly decrease the impact of environmental factors on human health, as measured by DALYs.[157]

Universal primary education is achievable by 2015.[162] Global population growth would slow, with an expected peak population to be reached in 2050. Global population in that year 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.[170]

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 alter significantly 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 sustainable development objectives, global income convergence is expected, including through catch-up development of African countries by mid-century.[162] As a result, GDP per capita might be more than US$10,000 (in PPP terms) in all regions by 2050. [159]

By the end of the 21st century, the range of differences in GDP per capita among countries worldwide would be similar to the prevailing range of differences among OECD countries today. Also, conscious efforts to limit intra-country income differences could significantly lower conflict potential.

Along with much higher incomes in all 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.[162]

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.[156]

Absolute water use would 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.[160]

Possibly, in this scenario the 500 million richest people, regardless in which developed or developing country they live, would take a leading role in adopting more sustainable consumption patterns and contribute resources to eradicate poverty. The high willingness to pay for higher technology performance and quality of life by these “rich” leads to accelerated technology change toward cleaner technology 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 measures taken in the sustainable development world, there might be an additional 2 billion people living under severe water stress in 2050 compared to the year 2000, reaching 3.7 billion people.[160] More optimistic scenarios outline pathways toward a future in which the number of people living under severe water stress could be limited to fewer than 2 billion until 2050.[161] 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.[157] However, overall flooding risks, as well as surface and 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 µg/ m^3 by 2030[157], and to reduce NO_x, SO_2 and black carbon emissions by 25% compared to the baseline by 2050.[161] Reduced air pollution could reduce the number of premature deaths globally by 50% by 2030. [156]

Similarly, in this world deforestation and land degradation will be slowed and later even reversed.[161]

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 global environmental threats.

Overfishing will be slowed and fish stocks later restored towards mid-century.[161]

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.[156,157,160,161] This could be achieved by stabilizing atmospheric GHG concentrations below 450 ppmv CO_2-equivalent $_q$. from 2010 to 2100[157], while a lower target of 350ppmv appears possible as well by 2100[161], but only with unprecedented measures and global collaboration.

In this "better future we can achieve", the extinction of known threatened species will be prevented and the situation of those in steepest decline by 2020 improved. 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 .[157, 160]

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 use, without harming the ability of the agricultural system to meet the hunger target. [157,160]

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 23 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 23.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 DALYs		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				X			
			Reduce 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 steepest 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 to 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)[156]; PBL (van Vuuren et al., 2012)[157]; SEI (Nilsson et al., 2012)[159] ; OECD (2012)[160]; RITE-ALPS (Akimoto et al., 2012)[158] ; FEEM (2011)[162]; GSG (Raskin et al., 2010)[161].

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 a scenario, as he believes that humanity will continue not to take the necessary actions to get on a desirable sustainable development path that could prevent overshoot. It is against this background that he predicts a future world in "*managed decline*".[171]

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 crisis 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 crisis. 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).[171]

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 23 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 objectives used by scenarios is limited both in terms of their scope and their target levels. The resulting "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 if we would overcome - at a global level - the major socio-economic political and technological constraints.

The sustainable development goals and targets compiled in Table 23 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 in 2050 that achieves the full set of sustainable development goals suggested by science.[172]

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, macroeconomic 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.[173]

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. Synergies are also large between ensuring food security and restoring agricultural ecosystems; 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 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, contributing to 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 to achieve 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 trade-offs among the broadest range of sustainable development goals.[157] 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."*[157] It should be noted that the planetary boundaries for nitrogen[174] and phosphorus[175] were already being exceeded in 2010. And there would still be more than 400,000 children dying from hunger, unsafe water, and indoor air pollution from traditional energy use in the PBL's GlobT scenario by 2050.[157]

Most 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.[176] 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 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 a 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 truly 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 benefits 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[177] (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 prominent modellers and models.[178]

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 – an 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 sustainable development 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. It should be noted that most baseline scenarios have not been designed as future projections, yet users have typically interpreted them as projections. And the performance of those global scenarios that were explicitly designed as "predictions" or "most likely cases" have typically 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 more 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 are needed for model development tailored to broad, new problems.

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 be replaced by fewer higher-level, strategic assessments.

Results require a long lead time. This is especially true in the case of policy impacts of scenario work. Hence, scenario analysts need to be patient and focus on the long-term.

4.5. Investment and technology needs and market potentials

Each of the sustainable development scenarios for Rio+20 that have been the basis of the description of a feasible sustainable development world in 2050 provides information on 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 simply to 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 (i.e. in what technologies and services investments are made 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.

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.

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.[179]

Quantitative estimates for estimates of investments needs for the thematic areas and cross-sectoral issues identified in section III of the Rio+20 outcome document were reviewed by UNDESA in the context of the work of the Intergovernmental Committee of Experts on Sustainable Development Financing..[180] [181]I

Investment requirements for the energy transition respecting agreed climate targets are large, of the order of trillions of US dollars 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 trillion dollars 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.

Figure 15 presents orders of magnitude estimates for investment requirements in various sectors, obtained from the literature. This includes:

- *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 are as follows:

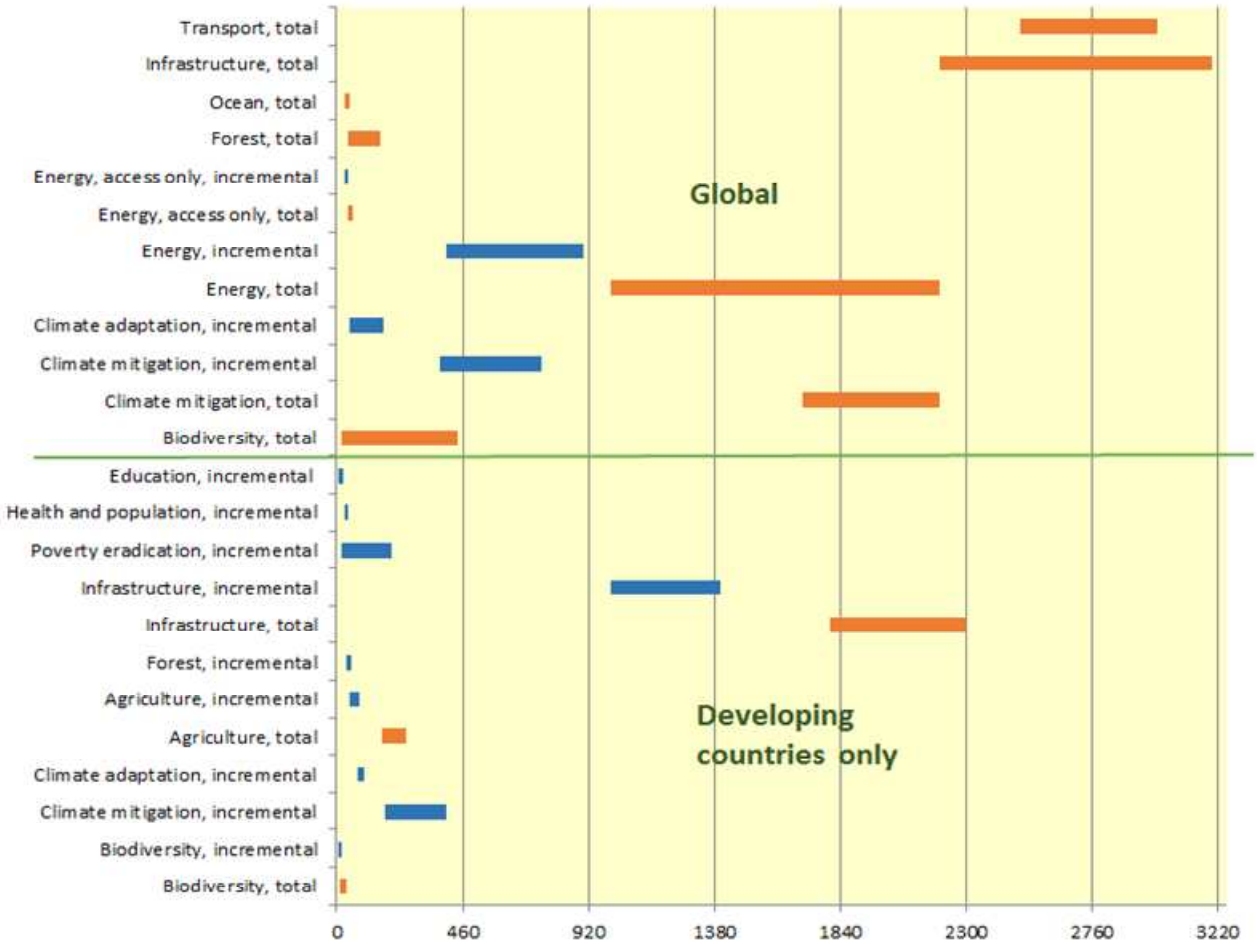
- *Poverty eradication:* US$20 to 200 billion per year to achieve the MDGs;
- *Food security:* USS$ 50 to 83 billion (without capital replacement) per year to increase agricultural yields and feed everyone without expansion of agricultural land;
- *Water and sanitation:* US$18 to 80 billion per year 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.

Table 3 in Annex 4 provides a range of selected sources of estimates of total, global investment needs.

It is worth restating that it does not make sense to add-up the estimates of investment needs presented in Figure 15, 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 alone.

In a number of sectors or areas, reliable estimates of investment needs for the future do not exist. Focusing on the 27 thematic areas and cross-sectoral issues identified in section III of the Rio+20 outcome document, 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; and mining.

Figure 15. Orders of magnitude of investment requirements for various sectors from the literature



Legend: blue bar stands for incremental needs and orange bar stands for total needs.

Sources: UN DESA (2013),

Source: DESA (2013)[179].

Existing reviews highlight the heterogeneity of financing models across sectors and areas relevant to sustainable development. The main actors and sources of finance are different, and so are the main financial instruments and channels used. For example, in low and lower-middle income countries, households are the primary source of expenditure on health, overwhelmingly from out-of-pocket expenditures. This contrasts with sectors like infrastructure and renewable energy, where the majority of financing flows to large projects financed by corporations and governments. The importance of international public finance varies considerably across sectors. In terms of financing channels, there are obvious differences among sectors regarding the role of banks and other financial institutions, well capital markets and development banks (from national to regional to international). In sum, the heterogeneity of financial models and circuits both across and within sectors is a constitutive feature of development finance, and this has important implications for policy-making.

In order to improve the delivery of financing to support sustainable development objectives, knowledge of how financing works in different sectors, as well as knowledge of obstacles and bottlenecks will be an important prerequisite. Comprehensive reviews of financing sources, channels and instruments exist for sectors such as infrastructure, energy, climate change mitigation, and many others. Some of these reviews are undertaken by international organizations such as UN conventions or by international financing institutions. However, for many other sectors, no such reviews seem to exist.

In the future, it will be important to develop such reviews at the sector level, to complement existing reviews of financing flows at the macroeconomic level. Ideally, the goal should be to produce mappings of financial flows distinguishing among different sources and final uses, with channels and instruments in the middle. At the minimum, sector reviews should aim to address the following questions: What are the sources of financing flows in the sector? How are the flows being used within each sector? What are the channels and instruments used? What are the synergies and complementarities among flows? What are the future challenges?

Future editions of the Global Sustainable Development Report could synthesize such sector assessments, in line with the mandate of the high-level forum on sustainable development to review the status of existing commitments.

In terms of what developing countries need in the area of clean and 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 existing needs (see SG's Report A/68/310, 2013)[182].

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.

5. Measuring progress

"Nothing exists until it is measured." (Niels Bohr)

This chapter discusses broader and aggregate measures of sustainable development progress. There are three fundamentally different approaches to measuring overall progress toward sustainable development.

The first approach uses indicators and official data to measure progress against a number of internationally agreed commitments (section 5.1). Hence, whether a trend is being considered good progress depends primarily on the level of ambition in the original goal/target setting which is not necessarily rooted in scientific or objective criteria.

The second approach is based on aggregate indicators of sustainable development progress that have been suggested by analysts and scientists (section 0). This approach is also primarily based on official data. The aggregate indicators differ greatly in terms of their focus, reflecting the different perspectives and values of the individual analysts that created them. This report illustrates and quantifies a progress index that is a simple and minimal adjustment to GDP.

The third approach is complements the first and the second approaches. It complements official data from surveys with highly spatially disaggregated and temporally frequent non-official data from a variety of sources such as remote sensing, mobile telecommunication devices, road traffic, and user-based crowdsourcing. The third approach has cheaper marginal costs as it uses data already available and can more easily and more quickly fill data gaps in the poorest regions, but it is technically most demanding (section 5.3).

The three approaches are described in the following.

5.1. Measuring progress towards internationally agreed commitments

The first approach uses indicators and official data to measure progress against internationally agreed commitments. There are hundreds of such commitments, some quantifiable others not.

It should be noted that following Agenda 21's call for sustainable development indicators, the UN Commission on Sustainable Development (CSD) recommended a list of 140 indicators and a subset of 58 indicators, which aimed to cover the social, economic, environmental and institutional aspects of sustainable development, as captured in Agenda 21.[183] In order to measure progress, however, corresponding sustainable development goals and targets must also be defined.[184] "*…A given indicator does not say anything about sustainability, unless a reference value such as thresholds is given to it*". [185] Many such threshold targets have been agreed in Agenda 21, the MDGs, the Johannesburg Programme of Implementation and in other UN fora. Some of these thresholds originated from scientific studies, others were decided on a purely political basis. Hence, this approach measures whether progress was made against the agreed political commitments, but does not necessarily measure progress against what the scientific consensus considers essential for achieving sustainable development.

Most attention and resources have been dedicated to the Millennium Development Goals (MDGs) and measurement toward their achievement. In September 2000, world leaders adopted the UN Millennium Declaration which committed their nations to a global partnership to reduce extreme poverty and setting out a series of time-bound targets – to be achieved by 2015 – that have become known as the MDGs. Most of the goals had already been included in Agenda 21. The goals target at poverty and hunger eradication, universal primary education, gender equality, child and maternal health, HIV/AIDS combat, environmental sustainability and global partnership. Progress toward the 8 MDGs and their 20 targets are monitored by more than 60 indicators. The indicators for MDG 1-7 measure outcomes in developing countries and are thus indirect measures of the success/failure of the world community in achieving the goals. Ten out of the twelve indicators used to monitor MDG 8 "Develop a global partnership for development", can – with opposite signs – also be measured in the donor country in order to follow the development of their contribution to a more equitable world. These indicators show progress in official development assistance, market access and debt.

Section 3 above already presented the results of the most comprehensive review to-date of implementation of Agenda 21 and of the Rio Principles. It also provided an overview of progress towards achievement of agreed goals and targets for the 19 areas that were initially on the agenda of the General Assembly's Open-Working Group for the Sustainable Development Goals (The areas identified by Member States include poverty eradication, food security and sustainable agriculture, water and sanitation, energy,

education, health, employment, biodiversity, oceans, forest, sustainable consumption and production, and means of implementation. Table 24 shows that for each of the 19 areas there are existing goals and targets, as well international assessments and reports that provide information on trends that can be used to assess progress against the goals. We distinguish three categories:

On-track: the commitment is being implemented or expected to meet the target as planned, but further steps should be taken.

Off-track: slow progress – expected to meet the target beyond the agreed time-frame, or slipping backwards or stagnating.

Mixed-progress: due to reasons such as heterogeneity, difficult to evaluate the progress as a whole.

The trend information and projections from the global scenario literature (chapter 3) were then used to illustrate the consequences of dynamics-as-usual scenario. Based on suggestions in the scientific literature and results of sustainable development scenarios (chapter 3), potential future sustainable development goals were then suggested for 2030 or 2050 (Table 24).

Significant development gains have been achieved, even though some challenges are still daunting. For example, the MDG poverty reduction target was reached five years ahead of schedule, as the proportion of people living on $1.25 a day or less fell from 47% in 1990 to 24% by 2008, a reduction from over 2 billion to less than 1.4 billion people. The progress in developing East Asia has been especially rapid, with extreme poverty falling from over half the population in 1990 to 14% in 2008. [186,187] Africa has enjoyed growth in the past decade unprecedented by historical standards, and the average poverty rate has declined from 58% in 1999 to 48% in 2008.[186]

Several global environmental problems have become more acute, including in the areas of food, energy, land, biodiversity, and climate. Scientists have pointed to thresholds (or "tipping points") in the Earth System beyond irreversible changes might have enormous impacts on humanity's livelihood. In particular, it was suggested that at least three planetary boundaries had already been breached.

Box 6. SDGs criteria agreed by member States in the Rio+20 outcome document

In paragraph 246 of the Rio+20 outcome document, member States agreed that a set of SDGs must:

i. Be based on Agenda 21 and the Johannesburg Plan of Implementation
ii. Fully respect all the Rio Principles
iii. Respect national policies and priorities
iv. Be consistent with international law
v. Build upon commitments already made
vi. Contribute to the full implementation of the outcomes of all major summits in the economic, social and environmental fields, including the [present] outcome document
vii. Focus on priority areas for the achievement of sustainable development, being guided by the outcome document
viii. Address and incorporate in a balanced way all three dimensions of sustainable development and their interlinkages
ix. Be coherent with and integrated into the United Nations development agenda beyond 2015
x. Not divert focus or effort from the achievement of the Millennium Development Goals
xi. Include active involvement of all relevant stakeholders, as appropriate.

It was further agreed that SDGs must also be:

i. Action-oriented
ii. Concise
iii. Easy to communicate
iv. Limited in number
v. Aspirational
vi. Global in nature
vii. Universally applicable to all countries, while taking into account different national realities, capacity and levels of development, and respecting national policies and priorities.

Source: Rio+20 outcome document.[188]

Currently, there is no single, universally agreed set of sustainable development goals or targets. It should also be noted that – while there are several proposals - there is no agreed metric of overall sustainable development progress (section 0). The Rio+20 outcome document called for Sustainable Development Goals that would be "*global in nature and universally applicable to all countries*" (The Future We Want, para 247), address in a balanced way all three dimensions of sustainable development (social, the economic and the environmental) and satisfy 18 criteria (see Box 6).

Table 24. Progress towards internationally agreed commitments and potential future goals in the areas on the agenda of the Open-Working Group on Sustainable Development Goals[189]

Thematic areas identified by Member States	Selected international reports and assessments	Past trends and current status	Existing goals or commitments	Existing targets	Current status	Dynamics-as-usual (trend) pathway from 2010 to 2050	Potential future goals/ targets suggested by scientists
1. Poverty eradication (MDGs)	UN *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports*	The world's poverty reduction target was reached 5 years ahead of schedule. The proportion of people living on less than $1.25 a day in developing countries fell from 47% to 22% between 1990 and 2010. In 2012, more than 1 billion people still lived in extreme poverty which was, however, 700 million fewer people than in 1990. Progress has been uneven among regions and within countries.	Eradicate poverty	Reduce extreme poverty by half by **2015**	MDG goal achieved, but still 1 billion people in extreme poverty	Progress in poverty reduction is fast enough to compensate for the growing world population, but the absolute number of poor people will stay roughly at the 2010 level of almost 3 billion people living on <US$2 per day.	Eliminate poverty worldwide by 2030
2. Food security and sustainable agriculture (MDGs and beyond)	UN *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports;* FAO *State of World Reports; the State of Food Insecurity Reports;* UNCCD Reports	The relative hunger reduction target (halving the proportion of people suffering from hunger by 2015) is within reach. The proportion of undernourished people in developing countries decreased from 23.2% in 1990-92 to 14.9% in 2010-2012. But one in eight people in the world remain chronically undernourished today.	World free of hunger	Reduce hunger by half by **2015**	On-track in the MDGs context	The number of people going hungry will be reduced by 550 million people, still leaving 250 million with insufficient food intake (down from 800 million in 2010).	Halve the proportion of people who suffer from hunger by 2015, further halve it by 2030, and eradicate hunger by 2050
3. Water and sanitation (MDGs)	UN *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports;* UN *World Water Development Report*	The MDG drinking water target was met five years ahead of schedule despite significant population growth. The proportion of the global population using such sources reached 89% in 2010, up from 76% in 1990. Progress towards the sanitation target has been good, but not good enough to meet the MDG target.	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**.	On-track in the MDGs context	> 240 million people (mostly in rural areas) will be 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/sanitation) will decrease, but Sub-Saharan Africa will lag behind.	Universal access to improved water source and basic sanitation by 2050.
4. Health (MDGs)	UN *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports* WHO *World Health Report*	Good progress has been made on child mortality, less on maternal mortality. Access to reproductive health services shows slow progress. Despite the progress made in MDG-related health, the coverage of health services and financial risk protection falls far short of universal coverage.	Reduce child mortality; improve maternal health; combat HIV/AIDs etc.	Reduce by two thirds, between 1990 and **2015**, the under-five mortality rate.	On-track in the MDGs context	Global premature mortality from malaria halved to 0.4 million from 2010 to 2050.	Universal access to health care.
5. Education (MDGs)	UN *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports*	The number of children out of school declined by almost half between 2000 and 2011, but progress in reducing the number of children out of school has slowed. The world is unlikely to reach universal primary education by 2015.	Universal primary schooling	By **2015**, children everywhere (boys and girls alike) will be able to complete a full course of primary schooling	Off-track	Universal primary education by 2020, universal secondary education by 2050. Women will account for the majority of higher-level degrees worldwide.	Universal primary education by 2020. Universal secondary education by 2030.
6. Employment (MDGs, JPOI)	ILO *Global Employment Trends;* World Bank *World Development Reports*	Global unemployment increased by another 4 million over the course of 2012. A quarter of this increase was in the high-income economies, three quarters in developing countries.	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.	Off-track	1 billion new "livelihoods" to be created from 2010 to 2030 (BAU estimate).	Create 63 million decent *new* jobs per year until 2050, achieving full, productive and decent employment for all.
7. Oceans (Ch. 17 of Agenda 21; JPOI; Aichi Targets 6, 10 and 11; Target 7.B of MDG)	UNGA *Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socio-economic Aspects*; UNEP *Keeping Track Reports*	Oceans have become more acidic, which has impacted corals and marine life. Oceans have warmed and sea-levels risen. Today, 80% of global fisheries are either fully exploited or overexploited. Other challenges include marine pollution, invasive aquatic species, coastal area development, safety of navigation, maritime security, working conditions and impacts from resource extraction.	Protection of the oceans and all kinds of seas	By **2015**, the multiple anthropogenic pressures on coral reefs are minimized, so as to maintain their integrity and functioning.	Off-track	Global collapse of ocean fisheries before 2050.	Eliminate overfishing by 2025 and restore fish stocks.
8. Biodiversity (Aichi Targets;	CBD *Global Biodiversity Outlooks*	The target agreed by Governments in 2002, "to achieve by 2010 a significant reduction of the current rate of	20 Aichi Goals of halting	Achieving, by **2010**, a significant reduction in	Off-track	Biodiversity (measured as terrestrial mean species abundance) will decline	Stabilize biodiversity at the 2020/2030 level

Thematic areas identified by Member States	Selected international reports and assessments	Past trends and current status	Existing goals or commitments	Existing targets	Current status	Dynamics-as-usual (trend) pathway from 2010 to 2050	Potential future goals/ targets suggested by scientists
Target 7.B of MDGs)		biodiversity loss at the global, regional and national levels …", has not been met. Biodiversity continues to decline in all three of its main components – genes, species and ecosystems.	global biodiversity loss	the rate of biodiversity loss.		by 10% (highest losses in Asia, Europe, and Southern Africa). The area of natural land converted to agriculture will decrease after 2030 ("peak farmland"), but biodiversity impacts will continue thereafter.	(depending on region) by 2050.
9. Forest (Aichi Targets on forest; Four shared global objectives on forests at UNFF in 2006.)	UN Forest Forum Reports CBD *Global Biodiversity Outlooks;* FAO *Global Forest Resources Assessments*	Today, forests cover 31 percent of the global land area and are a safety net for the poor. The rate of deforestation has decreased and large-scale planting of trees is significantly reducing the global net loss of forest area. Several countries in South America and Africa continue to have the large net losses of forest.	Forest component of Aichi targets: reducing deforestation	25% reduction in annual global deforestation and degradation rates by **2015,** compared with the 2000-05 average	Off-track	Primary forests will continue to disappear. The overall rate of global deforestation will decrease, leading to no net forest loss after 2020. Continued lack of understanding of the complex non-linear dynamics of ecosystems.	No net forest loss and no more destruction of primary forests by 2020.
10. Sustainable consumption and production (SCP) (Ch.4 Agenda 21; and Ch. 3 of JPOI)	UN *Trends Reports: Towards Sustainable Consumption Production;* World Business Council for SD: *Vision 2050 Report*; UNEP: *The Marrakech Process Progress Report*	The 10YFP on sustainable consumption and production patterns was adopted at Rio+20 (§226). Progress has been made in greening production chains and in procurement policy. Global eco-efficiency has continuously improved while the absolute scale of material consumption has increased unabated.	Changing unsustainable patterns of consumption and production	International plan of action is in place, but no time-bound target.	Off-track	Doubling or tripling of total material consumption. Primary energy use will increase by 80%, water demand by 55% (mainly from manufacturing (+400%), electricity (+140%) and domestic use (+130%)).In the face of competing demands, there will be little scope for increasing irrigation. Global eco-efficiency will increase by a factor 1.5 to 2.	Stabilize global material consumption at 2015 levels. Increase global eco-efficiency by a factor of 3.2 (or 4) by 2050.
11. Means of implementation (MDGs, Rio+20; Copenhagen Accord)	UNCTAD *Trade and Investment Reports; MDG Gap Task Force Reports*; World Bank *World Development Reports*; IPCC Reports; WIPO *Annual Reports*	Progress has been made, but gaps remain in the implementation of global commitments in the areas of aid, trade, debt relief, and access to new technologies and affordable essential medicines. The financial, food and energy crises have reversed some of the earlier progress. The proportion of net ODA in donor's GNI increased from 2000 to 2010, but decreased thereafter to 0.29% in 2012, with the poorest countries being most adversely affected.	Develop a global partnership for development	Meet the 0.7% ODA/GNI target now; $100 billion per year for climate change by **2020**	Off-track	Net ODA will remain at around 0.3% GNI of donors. Technology performance will continue to increase too slowly to compensate for increasing demand. Gaps in access to technology will hardly narrow, implying technology diffusion rates well below what would be needed to achieve even existing goals.	Achieve 0.7% ODA/GNI, focusing on the poorest and most vulnerable. Mobilize resources for a SDG fund commen-surate with needs by 2018. Universal access to sustainable technolo-gy by 2030. Global tech-nology performance im-provement by a factor 4 by 2050.
12. Sustained and inclusive economic growth (Rio+20)	UN DESA *World Economic and Social Survey;* UNIDO *Industrial Development Report*	Partly due to the recent financial crises, financing has fallen short in areas that are critical for sustainable growth: long-term investment, research and development, and investment in riskier sectors, such as SMEs.	Achieve SD promoting sus-tainable, inclu-sive and equi-table economic growth.	Sustained real economic growth in all countries.	Mixed progress.	Gross world product will quadruple to US$300 trillion, with BRICS accounting for 40%. Within country inequality will increase as will the gap between the poorest and richest countries.	GDP per capita > US$10,000 PPP in all countries by 2050. Sustained increase in Genuine Progress Indicator per capita.
13. Needs of countries in special situations, and middle-income countries (Istanbul	SG's Report on Implementation of the Programme of Action for the LDCs; UN-OHRLLS *Reports on LDCs, LLDCs and SIDS*. ADB: *African Development*	The economic growth performance of LDCs has improved considerably over the last decade, as did enrolment in primary education. The LLDCs and SIDS have made progress, but they are not on track to achieve many of the MDGs by 2015. The middle-income countries continue to face a range of development challenges, including an expectation to increase their role as development donors.	Address the special needs of Africa, LDCs, LLDCs and SIDSs.	Range of targets	Mixed progress among and between these groups.	Continued challenges faced by the poorest and most vulnerable countries.	Achieve graduation of all LDCs by 2050. Reduce the vulnerability of SIDS to the average of developing countries by 2030.

Thematic areas identified by Member States	Selected international reports and assessments	Past trends and current status	Existing goals or commitments	Existing targets	Current status	Dynamics-as-usual (trend) pathway from 2010 to 2050	Potential future goals/ targets suggested by scientists
Programme of Action; Rio+20)	*Reports*						
14. Human rights, the right to development and global governance (Rio+20)	UNDP *Human Development Reports;* World Bank *World Development Reports*	Differences in rights and basic opportunities across nationality, race, gender, and social groups have persisted.	Respect, protect and promote human rights and fundamental freedom for all	Range of targets	Mixed progress.	Human rights regime may face additional pressure due to conflicts arising from global competition for natural resources.	Implement existing human rights commitments
15. Equality (MDGs)	*Human Development Reports;* UN-Women *Progress of the World's Women;* UN *Millennium Development Goals Reports;*	There has been progress on some of the MDGs with rapid gains in education, and poverty reductions and child mortality. However, world inequality, by some measures, is high and rising within and among countries. Gains from growth are unequally distributed.	Promote gender equality and empower women	Equal girl's enrolment in primary school; women's share of paid employment etc. by **2015**	Mixed progress.	Rising world middle-income class. GDP per capita increases from US$33,000 to 69,000 in OECD, from US$7500 to 37,000 in BRICS, US$11,100 to 33,000 globally.	GDP per capita > US$10,000 PPP in all regions by 2050. Sustained increase in intergenerational earnings, wage and educational mobility.
16. Energy (Rio+20 Outcome Document)	*Global Tracking Framework Report* IIASA *Global Energy Assessment;* IEA *World Energy Outlooks;* IPCC Working Group III Reports	Today, 2.4 billion people have no access to modern energy services. It continues to be difficult to reconcile this necessity and demand for energy with its impact on the natural resource base in order to ensure that sustainable development goals are realized.	Make sustainable energy for all a reality	(Informal) sustainable energy for all targets	Off-track	Primary energy use increases by 80%. Mix remains fairly stable: fossil fuels (85%), modern renewable sources (10%), nuclear (5%). Energy intensity improvements outstripped by energy demand.	Universal access to modern energy services by 2030. Double the global rate of improvement in energy efficiency. Double the share of renewable energy in the global energy mix.
17. Sustainable cities, transport. (MDGs and beyond)	UN-HABITAT: *Global Reports on Human Settlemen*t IEA: *World Energy Outlook* – BLUE Shift	In the past 12 years alone, cities for 770 million people (equivalent to 93 New York cities) have been built, more than in any decade before. Urbanization increased from 29% in 1950 to surpass 50% in 2007. Demand for freight and passenger transport has grown 1.5 to 2 times faster than GDP since the early 1990s. In Asia and he Pacific region alone, transport investment requirements are $292 billion per year, up from $137 billion in the early 1990s.	Improve the lives of slum-dwellers	Achieve, by **2020**, a significant improvement in the lives of at least 100 million slum dwellers	Off-track	Urbanization reaches 70% (+2.8 billion people in urban areas, -0.6 billion in rural areas). Transport will continue to grow considerably faster than GDP.	Reduce the number of slum dwellers to close to 0 by 2050.
18. Climate Change and Disaster Risk Reduction (Copenhagen Accord)	*IPCC Assessment Reports;* UNFCCC Independent Reports; UNEP: *Emission Gap Reports;* World Bank: *Turn Down the Heat Reports;* UNISDR *Global Assessment Reports*	Since 1850, global use of fossil fuels has increased to domestic energy supply, leading to a rapid growth in greenhouse gas emissions. Greenhouse gas emissions have increased at an accelerated rate in the 2010s. By 2012, CO2 concentration had surpassed 400 ppm (39% above pre-industrial levels). Lower-income countries are disproportionally affected by disaster risk.	Hold global mean temperature increase below 2°C .	By **2050** or longer term based on scientific evidence	Off-track	Atmospheric GHG concentrations reach 685 ppmv (CO2-equ.), (eventually leading to 3-6 degree Celsius warming).	Keep atmospheric GHG concentration below 450 ppm CO2-eq. from 2010 to 2100.
19. Conflict prevention, post-conflict peace-building	*Human Security Report*	The global level of fragility declined worldwide by some 20 percent between 1995 and 2010 according to the State Fragility Index. The deadliness of warfare has declined over the last 50 to 60 years, and there are now significantly fewer armed conflicts around the world than during the peak of the early 1990s. The average number of high-intensity conflicts per year dropped by half from the 1980s to the new millennium.	Maintain international peace and security – UN Charter	Maintain international peace and security	Significant progress, but different views on progress	Continued, significant number of State-based armed conflicts. Continued reduction in the number of deaths from non-State armed conflicts. Possibly more frequent and ever more intense conflicts in the long-run.	Ensure international peace and security

Source: adapted from the Open Working Group the Sustainable Development Goal process (2013) and various publications mentioned above.

The "Expert Group Meeting for the UN Global Sustainable Development Report - Engaging National Assessments" which was hosted by the Government of China in Beijing from 12 to 13 December 2013 referred in its Chair's Summary to a list of potential future goals and targets for the next two generations that have been suggested by scientists based on existing assessments that analyzed past trends and future options (see Box 7). It also suggested that these goals and targets might be considered by the SDG OWG and which might "draw upon the scientific community of sustainable development scenario analysts to inform them on trade-offs and synergies between suggested goals and targets." (Annex 4).[190] It should be noted that the list of goals and targets suggested is rather similar to that provided in Table 24.

Box 7. Potential sustainable development goals/targets that have been suggested by scientists

1. Eliminate extreme poverty worldwide by 2050
2. Halve the proportion of people who suffer from hunger by 2015, further halve it by 2030, and eradicate hunger by 2050
3. Universal access to improved water source and basic sanitation by 2050
4. Universal health coverage
5. Universal primary education by 2020. Universal secondary education by 2030.
6. Create 63 million decent new jobs per year until 2050, achieving full, productive and decent employment for all.
7. Eliminate overfishing and restore fish stocks.
8. Stabilize biodiversity at the 2020/2030 level (depending on region) by 2050.
9. No net forest loss and no more destruction of primary forests by 2020.
10. Stabilize global materials (e.g. non-renewable resource) consumption at 2015 levels.
11. Achieve 0.7% ODA/GNI (OECD countries), focusing on the poorest and most vulnerable countries. Mobilize resources for a global SDG fund commensurate with estimated needs by 2018.
12. GDP per capita > US$10,000 PPP in all countries by 2050.
13. Reduce the wide disparity of per capita GDP between developed countries and developing countries.
14. Sustained increase in intergenerational earnings and educational mobility.
15. By 2030, ensure universal access to modern energy services; double the global rate of improvement in energy efficiency; and double the share of renewable energy in the global energy mix.
16. Reduce the number of slum dwellers to close to 0 by 2050.
17. Hold global mean temperature increase below 2 degrees Celsius.
18. Increase science and technology innovation capacity through knowledge sharing and technology transferring.

Source: Chair's Summary of the "Expert Group Meeting for the UN Global Sustainable Development Report - Engaging National Assessments", Beijing, China, 12-13 Dec. 2013.

5.2. Global initiatives on measuring overall progress

The second approach to measure progress is based on aggregate indicators of sustainable development progress that have been suggested by analysts and scientists. This approach is primarily based on official data. The aggregate indicators differ greatly in terms of their focus, reflecting the different perspectives and values of the individual analysts that created them. Next we provide an overview of a number of global initiatives for progress measurement driven by the need to complement GDP since 1990s. Thereafter, we'll also illustrate and quantify a progress index that is a simple and minimal adjustment to GDP – measuring the "good" GDP and wealth. We conclude with a novel, technology-based approach that allows assessment of sustainable development progress at multiple scales (section 5.3).

5.2.1. Overview of metrics

Since the 1970s, analysts and scientists have proposed many pilot metrics of sustainable economic progress, development progress, environmental progress, well-being, and of life satisfaction which have been adopted or been subject of various global initiatives (Table 25). These metrics are described in more detail in this section, based on a 2011 report of the European Statistical System Committee.[191]

UNDP has developed a Human Development Index (HDI) to benchmark countries based on combined measurement of GDP, health and education. The World Bank with its calculation of genuine savings has pioneered the inclusion of social and environmental aspects when assessing the wealth of nations. In 1995, in response to the call of Commission for Sustainable Development, the United Nations developed a set of 134 national Indicators of Sustainable Development (CSD Indicators). The United Nations Statistical Commission has initiated a multi-year process of revision to the System of Environmental-Economic Accounting (SEEA). The OECD is running the Global Project on Measuring the Progress of Societies fostering the use of novel indicators in a participatory way. Several NGOs measure the "ecological footprint" – a measurement that has been formally recognised as a target for environmental progress by some public authorities (Commission of the European Communities, 2009).[192]

Table 25. Broad overview of perspectives, scope, dimensions and purpose of selected global initiatives to measure overall progress

International initiatives		SDGs and post-2015	Commission for Sustainable Development: indicators of SD	UNSC: System of Environmental Economic Accounting	WB: Wealth accounting and adjusted net saving	Stiglitz-Sen-Fitoussi Commission report	EU GDP and Beyond (e.g. GPI)	OECD Better Life Initiative	UNECE/ OECD/ Eurostat TFSD	UN MDGs	Human Development Index (HDI)
Scope	Perspective	Sustainability	Sustainable development informed by Agenda 21	Environment sustainability	A necessary condition for sustainability	Economic performance and social progress	Progress	Well-being and progress of societies	Sustainable development	Ending global poverty	Human development
	Intra-generational equity	X	X (equity, health, education, housing, security, stabilized population)	n.a.	X	X	X (economic performance, families, and security)	X	X	X	X (income, health and education)
	Inter-generational sustainability	X	X (climate, clean air, land productivity, ocean productivity, fresh water, and biodiversity)	X	X	X	X (clean air, land, and water)	X	X	X (environ. sustainab.)	Indirectly
Dimensions adapted from the Stiglitz report	Main concern	Sustainable development	Human development	Environment and economic accounting	Economic development / macroeconomic performance	Well-being / quality of life	Policy relevance	Material well-being and quality of life	Current and future well-being	Ending poverty	Wealth, education and health
	Economic performance	XXX	X	XXX	XX	X	X	X	X	X	X
	Societal well-being (human & social aspects)	XXX	XXX	--	XX	X	X	X	X	XXX	X
	Environment	XXX	XXX	XXX	XXX	X	XX	X	XX	X	-
Note	Purpose	Monitoring global common set of goals	Monitoring progress	Improving statistics relevance	Monitoring	Improving statistics relevance	Improving statistics relevance	Fostering better policies	Uniformity in measures for comparability	Monitoring goals	Evaluating dev. incl. human well-being
	Limitation	Limited number goals to cover a broad range of issues.	Time frame: sporadic references to 2015		e.g. human capital = edu. expenditure	Weak in environmental sustainability	e.g. did not count depreciation of 'human-health capital'	n.a.	n.a.	Weak in environmental sustainability	Environment factors are missing

Source: adapted from European Statistical System Committee (2011).[193, 191]

5.2.2. European Union's Beyond GDP initiative

Work to complement GDP has been going on for many years, both at national and international levels. In view of the dominance of GDP as the most prominent measure of progress today, these metrics aim to implicitly or explicitly complement or replace GDP as a measure of progress. It should also be noted that GDP is a measure of economic activity and was not designed as a measure of progress in economic welfare. GDP is a powerful and widely accepted indicator for monitoring short to medium term fluctuations in economic activity. While it is still the best single measure of how the market economy is performing, it has not performed well as a good measure of long-term economic, social and environmental progress.

The EU *Beyond GDP* initiative is about developing indicators that are more inclusive of environmental and social aspects of progress. It highlighted the need to improve, adjust and complement GDP with indicators that concisely incorporate social and environmental achievements (e.g., improved social cohesion, accessibility and affordability of basic goods and services, education, public health and air quality) and setbacks (e.g., increasing poverty, more crime, depleting natural resources). It focused on a number of short- to medium term actions to incorporate social and environmental dimensions in measuring progress:

- Complementing GDP with environmental and social indicators;
- Gathering near real-time information for decision-making;
- Providing more accurate reporting on distribution and inequalities;
- Developing a European Sustainable Development Scoreboard;
- Extending national accounts to environmental and social issues.

The newly developed "Europe 2020" strategy defines measurable targets for several indicators that go beyond GDP. As with approaches to green growth, these measurement actions aim to improve the relation between economic activities and their impact on the environment and social inclusion. A well-known example that was considered by the EU's Beyond GDP initiative is the Genuine Progress Indicator (GPI) which is presented next.

5.2.3. Measure of Economic Welfare (MEW), Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI)

The Measure of Economic Welfare (MEW), the Genuine Progress Indicator (GPI) and the Index of Sustainable Economic Welfare (ISEW) are three variations of the same idea to adjust GDP to measure consumption and ultimately economic welfare, rather than production and the overall level of commercial activities.

Table 26. Calculation of the Measure of Economic Welfare

Calculation		Comment
+ Gross National Product (GNP)		Market value of goods and services produced during a given period of time.
- capital consumption		Part of the output included in GNP is needed to repair and replace the existing stock of capital goods
= Net National Product (NNP), National Income and Product Accounts (NIPA)		
- NIPA final outputs reclassified as regrettables and intermediates		Regrettables include expenditures for national and civilian security, prestige or diplomacy that do not directly increase the economic welfare of households. Intermediates are goods and services that are completely counted in the values of other goods and services.
	- Government	Major portion of government purchases (e.g., national defense, space research, international affairs, civilian safety).
	- Private	Personal business expenses, some transportation expenses, etc.
+ Imputation of items not included in NIPA		
	+ Leisure	Consumption of leisure
	+ Nonmarket activity	e.g., household production, meals, own repairs, etc.
	+ Services of public and private capital	GNP only includes imputation of services of owner-occupied housing. MEW also considers services from government structures excluding military and services from consumer durables.
	- Disamenities	Social costs of urbanization that are not included in the costs of producing consumption goods and services (e.g., pollution, litter, congestion, noise, insecurity). Can be estimates by observed income differentials between cities and rural areas.
- Additional capital consumption		
- Growth requirement		
= Sustainable Measure of Economic Welfare (MEW)		

Source: Nordhaus and Tobin (1972)[194]; Stewart (1974)[195].

The Nordhaus-Tobin concept of sustainable Measure of Economic Welfare (MEW) "*provides a measure of the amount of consumption in any year that is consistent with sustained steady growth in per capita consumption at the*

trend rate of technological progress" (Stewart, 1974, p. 21).[195] Table 26 provides an overview of how MEW is calculated starting from Gross national product (GNP).[196] While GNP is a measure of production, some have pointed out that MEW is primarily a measure of consumption.[197] "*Welfare would depend on the amount of total satisfaction one receives from total consumption, and, among other things would depend also on the distribution of income*" (Stewart, 1974, p. 22).[195] However, income distribution was not considered in the MEW, as its authors recognized that they "*cannot… estimate how well individual and collective happiness are correlated with consumption*."[194] Today, this continues to be a challenge and points to the need to track GDP, measures of consumption and economic welfare, and people's subjective levels of happiness and life satisfaction.

Daly and Cobb built on the previous work of Nordhaus and Tobin and suggested the Index of Sustainable Economic Welfare (ISEW) in 1989.[198] In contrast to the MEW, the ISEW took account of the changing income distribution by weighting personal consumption. In contrast to MEW, ISEW and GPI are consistent with Fisher's concept of income and capital and hence are based on a firm theoretical foundation.[199] There are only minor differences between the ISEW and the so-called Genuine Progress Indicator (GPI). In fact, differences in the most recent applications of the GPI are as wide as those between ISEW and GPI. Hence, we will use them interchangeably.

Table 27. Calculation of GPI (as used for Baltimore city)

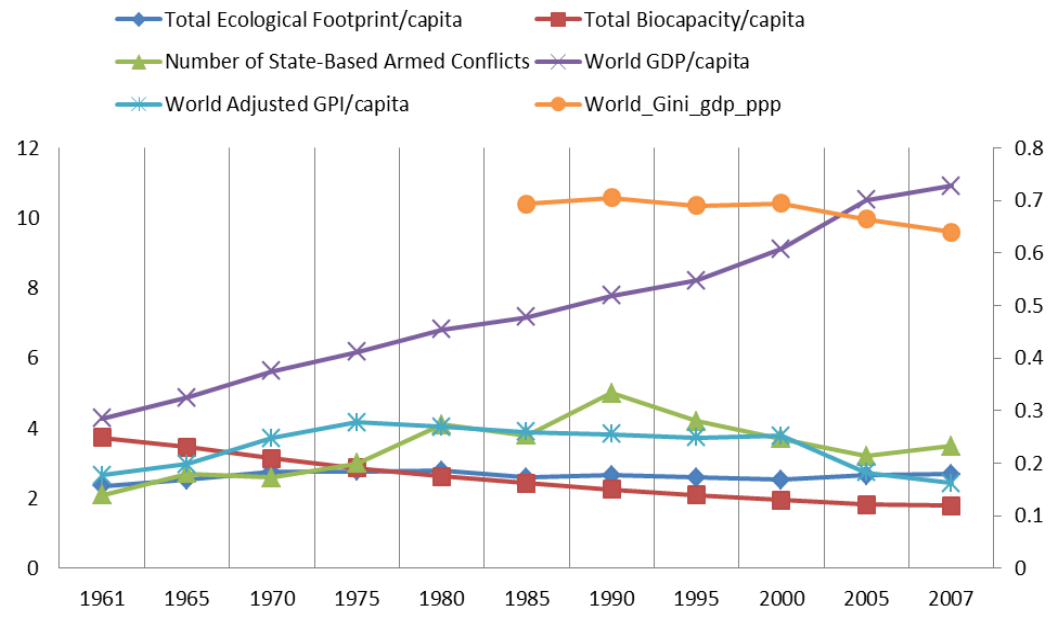
Dimension	Components and calculation	Explanations
Economic	+ Personal consumption expenditure weighted by income distribution index	
	+ Value of household work and parenting	Services provided by volunteer (e.g., non-remunerated community work) and non-paid household work (e.g., parenting, elder-care, cleaning, house repair)
	+ Value of volunteer work	
	+ Value of higher education	
	+ Services of household capital	Services yielded by existing consumer durables (e.g., value added by previously purchased consumer durables);
	+ Services of highways and streets	Services yielded by publicly provided human-made capital (e.g., libraries, museums, roads and highways)
	+ Net capital investment	Net capital investment (a contentious component, but constrained to the increase in the stock of producer goods above the amount required to keep the quantity of producer goods per worker intact)
	- Net foreign borrowing	
Social	- Cost of crime	Disservices generated by economic activity (e.g., cost of noise pollution, commuting, crime, underemployment and unemployment, lost leisure time);
	- Loss of leisure time	
	- Cost of underemployment	
	- Cost of commuting	
	- Cost of consumer durables	The cost of consumer durables (e.g., expenditures paid in the current year on cars, refrigerators, household furniture);
	- Cost of household pollution abatement	Defensive and rehabilitative expenditures (e.g., cost of household pollution abatement, vehicle accidents; family breakdown; in some cases a certain percentage of private health expenditure assumed to constitute a form of defensive expenditure);
	- Cost of automobile accidents	
	- Cost of family breakdown	
Environmental	- Cost of air pollution	Cost of noise, water and air pollution
	- Cost of water pollution	
	- Cost of noise pollution	
	- Loss of wetlands	Cost of sacrificed natural capital services
	- Loss of forest cover	
	- Loss of farmland	
	- Cost of non-renewable resource depletion	
	- Cost of long-term environmental damage	
	- Carbon dioxide emissions damage	Cost of pollution
	- Cost of ozone depletion	
Total	**= GPI**	

Source: Posner and Constanza (2011)[200]
Note: Individual components, that increase (+) and decrease (-) the value of index.

Table 27 provides an overview of the economic, social and environmental components of GPI, using the example of Baltimore city.[201] GPI is derived from personal consumption expenditure weighted by an income distribution index (typically an indexed Gini). A number of items are added: services yielded by existing consumer durables; services yielded by publicly provided human-made capital; services provided by volunteer and non-paid household work; net capital investment. Others items are subtracted: the cost of consumer durables; disservices generated by economic activity; defensive and rehabilitative expenditures; net foreign borrowing; cost of sacrificed natural capital services. Table 4 in Annex 4 presents data sources for calculating GPI, using United States as an example. It shows a wide range of data sources used in order to capture values of all components of GPI.

Figure 16 provides an overview of global trends in a number of aggregated metrics of progress from 1961 to 2007. The metrics are described in more detail later. While the world's average GDP per capita increase threefold since 1961, the world's genuine progress indicator which aims to measure "genuine" economic welfare almost doubled until 1978, but has actually decreased since. It should be noted that the GPI estimates were extrapolated based on national estimates for 17 countries representing all continents and 53% of the world population.[202] Interestingly, the second half of the 1970s is also when the global ecological footprint increased beyond bio-capacity. The number of state-based armed conflicts peaked at the beginning of the 1990s and has decreased since.

Figure 16. Global trends in GPI and other aggregate metrics of progress since, 1961-2007



Source: GPI/capita and GDP/capita are from Kubiszewski *et al*. (2013)[203]; Number of State-based Armed Conflict is from Human Security Report (2012); global ecological footprint and bio-capacity hectares per person is from www.footprintnetwork.org/atlas; World Gini is calculated by Branko Milanovic of the World Bank.

Note: among the six time series data above, five of them are rescaled to the unit on the left Y axis; while only World Gini point uses Y axis on the right. For GDP/capita and GPI/capita, the unit is US$1,000, for Number of State-based Armed Conflict, the unit is 10 cases, for global ecological footprint and bio-capacity hectares per person, the unit is 1 hectare. GPI/capita was estimated by aggregating data from the 17 countries (see end note about the 17 countries) for which GPI had been estimated, and adjusting for discrepancies caused by incomplete coverage by comparison with global GDP/capita data for all countries. All estimates are in 2005 US$.

A number of weaknesses of GPI and ISEW have been pointed out. Valuation methodologies of the various components are not standardized and are subject to large uncertainties. The variable application of GPI/ISEW highlights different views on which components to include. For example, it was suggested that measures of investment and depreciation of "human-health capital" are not factored in systematically.[204] There are particularly strong views on whether and how income inequality should be included. Yet, there is no reason why it would not be

possible to standardize GPI/ISEW, e.g., through the UN Statistical Commission similar to the historical experience with GDP. A minimal approach to adjusting GDP might be a useful way forward. Furthermore, it is, of course, possible to measure GPI globally without having established national GPI processes.

5.2.4. World Bank's wealth estimates and adjusted net savings

In addressing the questions "*Where is the wealth of nations?*" and "*How does wealth change with development?*", the World Bank estimated total national wealth as composed of:

- Produced capital: the sum of machinery, equipment, structures and infrastructure, and urban land;
- Natural capital: e.g., land resources, forests and sub-soil assets;
- Intangible capital: e.g., human capital, quality of institutions, and governance.

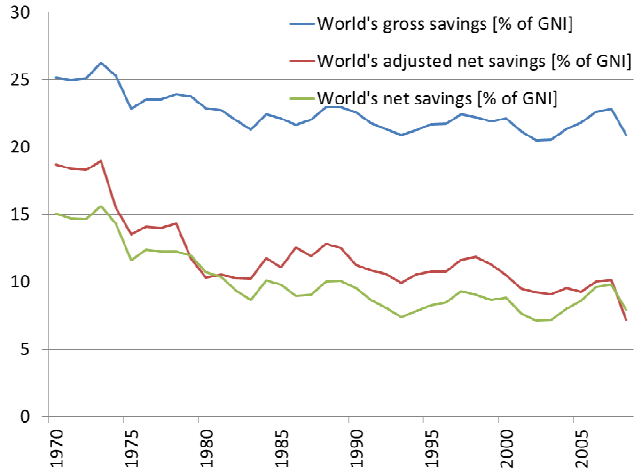
According to the World Bank, in all countries, intangible capital is, by far, the largest share of wealth. However, for the poorest countries, natural capital is more important than produced capital, indicating a need for natural resource management in development strategies.

The World Bank also calculated adjusted net savings (ANS) - also known as "genuine savings" - which is a sustainability indicator building on the concepts of green national accounts.[205] Adjusted net savings measure the rate of savings in an economy after taking into account investments in human capital, depletion of natural resources and damage caused by pollution. Table 28 provides details of the definition of adjusted net savings, together with the estimated size of its components in 2008.[206] The world's public expenditures in education was similar to the value of resource depletion and environmental damage, leading to an adjusted net savings rate of 7.2% of GNI, not very different from net national savings of 7.9% of GNI. It is positive, hence, adjusted wealth continued to increase, according to this metric. A Comparison of GPI with Adjusted Net Savings shows that GPI includes a lot more elements, especially in the social areas. Adjusted net savings makes the trade-off between growth and environment explicit. Figure 17 shows the world's trends on gross saving and adjust net saving since 1970.

Table 28. Calculation of adjusted net savings.

Dimension	Components and calculation	World adjusted net savings in 2008 [% of GNI]	Explanation
Economic	+ Gross national savings(GNS)	20.9%	Difference between GNI and public and private consumption plus net current transfers.
	- Depreciation	13.0%	Replacement value of capital used up in the process of production.
	= Net national saving (NNS)	7.9%	Difference between gross national saving and the consumption of fixed capital.
Social	+ Education expenditure	4.2%	Public current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment.
Environ-mental	- CO_2 damages	0.4%	A conservative figure of $20 marginal global damages per ton of carbon emitted was taken from Fankhauser (1994).
	- PM damages	0.2%	Willingness to pay (WTP) to avoid mortality and morbidity attributable to particulate emissions
	- Energy depletion	3.9%	Ratio of present value (PV) of rents, discounted at 4%, to exhaustion time of the resource. Rent is calculated as the product of unit resource rents and the physical quantities of energy resources extracted. It covers coal, crude oil, and natural gas.
	- Mineral depletion	0.5%	Ratio of present value of rents, discounted at 4%, to exhaustion time of the resource. Rent is calculated as the product of unit resource rents and the physical quantities of mineral extracted. It covers tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate.
	- Net forest depletion	0.03%	Product of unit resource rents and the excess of roundwood harvest over natural growth.
Total	**= Adjusted Net Savings (ANS)**	**7.2%**	**Net national saving plus education expenditure and minus energy depletion, mineral depletion, net forest depletion, carbon dioxide damage, and particulate emissions damage.**

Figure 17. The world's gross savings vs. adjusted net savings, 1970 – 2008.



Data Source: the World Bank.[207]

Criticisms of the World Bank's adjusted wealth and adjusted net savings have been similar to those of GPI. It should be noted that adjusted wealth estimates estimate "stocks" and thus complement the "flow" estimates of GPI.

5.2.5. UN Commission for Sustainable Development (CSD) - Indicators of sustainable development

In 1995, in response to the call of CSD, the Division for Sustainable Development and the Statistics Division, both of the United Nations Department of Economic and Social Affairs, in close collaboration with experts from international organisations and UN member states, developed a set of 134 national Indicators of Sustainable Development (CSD Indicators). From 1996 to 1999, 22 countries from across the world pilot-tested the indicator set. In order to facilitate this process, the DSD developed guidelines for the implementation of the CSD indicators, initiated a series of regional training workshops, and encouraged the organization of national workshops and twinning arrangements between testing countries.

The CSD Indicators and their methodology[208] have since been revised twice, in 2001 and in 2006. The current CSD indicators contain a core set of 50 indicators, and these core indicators are part of a larger set of 96 indicators of sustainable development. The indicators reflect the chapters of Agenda 21 and were originally developed on the basis of the pressure-state-response-model. Pressure-State-Response-model was developed by OECD. It was first used in the organisation's preliminary set of environmental indicators in 1991. It is based on the fact that humans exert pressures on the ecosystem and the society, which alter their state and call for certain responses.

In 2006, the indicators were modified to reflect 14 themes and sub-themes: poverty; natural hazards; economic development; governance; atmosphere; global economic partnership; health; land; consumption and production patterns; education; oceans, seas and coasts; demographics; freshwater; biodiversity (Table 29).

Table 29. UN CSD sustainable development indicators.

Theme	Sub theme	Core CSD indicator	Other CSD indicators
Poverty	Income poverty	Proportion of population living below national poverty line	Proportion of population below $1 a day
	Income inequality	Ratio of share in national income of highest to lowest quintile	
	Sanitation	Proportion of population using an improved sanitation facility	
	Drinking water	Proportion of population using an improved water source	
	Access to energy	Share of households without electricity or other modern energy services	Percentage of population using solid fuels for cooking
	Living conditions	Proportion of urban population living in slums	
Governance	Corruption	Percentage of population having paid bribes	
	Crime	Number of intentional homicides per 100,000 population	
Health	Mortality	Under-five mortality rate	Healthy life expectancy at birth
		Life expectancy at birth	
	Health care delivery	Percent of population with access to primary health care facilities	Contraceptive prevalence rate
		Immunization against infectious childhood diseases	
	Nutritional status	Nutritional status of children	
	Health status and risks	Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis	Prevalence of tobacco use
			Suicide rate
Education	Education level	Gross intake ratio to last grade of primary education	Life-long learning
		Net enrolment rate in primary education	
		Adult secondary (tertiary) schooling attainment level	
	Literacy	Adult literacy rate	

Theme	Sub theme	Core CSD indicator	Other CSD indicators
Demo-graphics	Population	Population growth rate	Total fertility rate
		Dependency ratio	
	Tourism		Ratio of local residents to tourists in major tourist regions and destinations
Natural hazards	Vulnerability to natural hazards	Percentage of population living in hazard prone areas	
	Disaster preparedness and response		Human and economic loss due to natural disasters
Atmosphere	Climate change	Carbon dioxide emissions	Emissions of greenhouse gases
	Ozone layer depletion	Consumption of ozone depleting substances	
	Air quality	Ambient concentration of air pollutants in urban areas	
Land	Land use and status		Land use change
			Land degradation
	Desertification		Land affected by desertification
	Agriculture	Arable and permanent cropland area	Fertilizer use efficiency
			Use of agricultural pesticides
			Area under organic farming
	Forests	Proportion of land area covered by forests	Percent of forest trees damaged by defoliation
			Area of forest under sustainable forest management
Oceans, seas and coasts	Coastal zone	Percentage of total population living in coastal areas	Bathing water quality
	Fisheries	Proportion of fish stocks within safe biological limits	
	Marine environment	Proportion of marine area protected	Marine trophic index
			Area of coral reef ecosystems and percentage live cover
Freshwater	Water quantity	Proportion of total water resources used	
		Water use intensity by economic activity	
	Water quality	Presence of faecal coliforms in freshwater	Biochemical oxygen demand in water bodies
			Wastewater treatment
Biodiversity	Ecosystem	Proportion of terrestrial area protected, total and by ecological region	Management effectiveness of protected areas
			Area of selected key ecosystems
			Fragmentation of habitats
	Species	Change in threat status of species	Abundance of selected key species
			Abundance of invasive alien species
Economic Develop-ment	Macroeconomic performance	Gross domestic product (GDP) per capita	Gross saving
		Investment share in GDP	Adjusted net savings as percentage of gross national income (GNI)
	Sustainable public finance	Debt to GNI ratio	
	Employment	Employment-population ratio	Vulnerable employment
		Labor productivity and unit labor costs	
		Share of women in wage employment in the non-agricultural sector	
	Information and communication technologies	Internet users per 100 population	Fixed telephone lines per 100 population
			Mobile cellular telephone subscribers per 100 population
	Research and development		Gross domestic expenditure on R&D as a percent of GDP
	Tourism	Tourism contribution to GDP	
Global economic partnership	Trade	Current account deficit as percentage of GDP	Share of imports from developing countries and from LDCs
			Average tariff barriers imposed on exports from developing countries and LDCs
	External financing	Net Official Development Assistance (ODA) given or received as a percentage of GNI	Foreign direct investment (FDI) net inflows and net outflows as percentage of GDP
			Remittances as percentage of GNI
Consump-tion	Material	Material intensity of the economy	Domestic material consumption

Theme	Sub theme	Core CSD indicator	Other CSD indicators
and production patterns	consumption		
	Energy use category	Annual energy consumption, total and by main user	Share of renewable energy sources in total energy use
		Intensity of energy use, total and by economic activity	
	Waste generation and management	Generation of hazardous waste	Generation of waste
		Waste treatment and disposal	Management of radioactive waste
	Transportation	Modal split of passenger transportation	Modal split of freight transport
			Energy intensity of transport

Source: UN (2006)[209]. Note: 2006 revision.

The CSD Indicators have assisted member States in their work of reviewing their existing indicators or developing new indicators to measure progress towards nationally defined goals for sustainable development. They continue to be a source of reference for future work in this area. In fact, many of the CSD indicators are needed to calculate the aggregate progress indicators presented in this chapter.

5.2.6. United Nations Statistical Commission - the System of Environmental-Economic Accounting project (SEEA)

A multi-year process of revision to the System of Environmental-Economic Accounting (SEEA) was initiated by the UN Statistical Commission in 2003. The revised SEEA consists of three parts: the Central Framework, which was adopted by the UN Statistical Commission as the first international standard for environmental-economic accounting; Experimental Ecosystem Accounting and Applications and Extensions of the SEEA. Subsystems of the SEEA framework elaborate on specific resources or sectors, including: energy, water, fisheries, land and ecosystems, and agriculture. These sub-systems are fully consistent with the over-arching SEEA, but provide further details on specific topics and try to build bridges between the accounting community and the community of experts in each specific subject area.[210]

Global consultation on the SEEA Central Framework completed in 2011 and it was adopted by the United Nations Statistical Commission, at its 43rd Session in 2012, as the first international standard for environmental-economic accounting. The white cover version of the SEEA Central Framework was published in May 2012. Work on the additional portions of the SEEA, namely Experimental Ecosystem Accounts and Applications and Extensions, was presented in the 44th Session of the Statistical Commission in February 2013.

Table 30. SEEA classification of environmental activities.

Group	Classes
Environ-mental protection	Protection of ambient air and climate
	Wastewater management
	Waste management
	Protection and remediation of soil, groundwater and surface water
	Noise and vibration abatement (excl. workplace protection)
	Protection of biodiversity and landscapes
	Protection against radiation (excluding external safety)
	Research and development for environmental protection
	Other environmental protection activities
Resource manage-ment	Management of mineral and energy resources
	Management of timber resources
	Management of aquatic resources
	Management of other biological resources (excl. timber and aquatic resources)
	Management of water resources
	Research and development activities for resource management
	Other resource management activities

Source: UN et al. (2012)[211]

By its very design the SEEA focus on the economy and environment and does not aim to capture the social dimension of sustainable development. Table 30 provides an overview of which environmental issues are covered in the SEEA. The advantage of the SEEA is that it is fully consistent with the national accounts and that it is has been standardized and agreed at the UN level.

5.2.7. Joint UNECE/OECD/Eurostat Working Group on statistics for sustainable development – Task Force on measuring sustainable development

In 2009, the Joint UNECE/Eurostat/OECD Working Group published its work on measuring sustainable development. The report proposed a broad conceptual framework for sustainable development measurement based on capital. The capital approach to measure sustainability aims at accounting for a broader set of capital assets than those

assets already recognized in the current System of National Accounts (SNAs). In particular, a set of environmental assets, human capital and social capital are added. The group proposed a set of sustainable development indicators as a basis for international comparisons. The set is consistent with both the capital approach and common elements of existing policy-based indicator sets. The set takes into account monetary indicators of economic wealth and physical indicators of climate, air quality, water quantity/quality, ecological integrity, biological diversity, educational attainment and health status. It should be noted, however, that no indicators related to social capital were included.

Table 31 presents a "*small set of sustainable development indicators that might be consistent with the capital approach, relevant from the policy perspective and suitable for comparing performance among countries*"[212] that was proposed by the group in 2009.

A Task Force for Measuring Sustainable Development was set up in 2009 to further develop the capital approach with a broader perspective to include the distributional and quality-of-life aspects of sustainable development. Work has advanced on the measurement of human and social capital and in refining the set of sustainable development indicators proposed by the Working Group. At present, the analysed set of sustainable development indicators cover the "needs of the present generation", the "needs of the future generations" and the "international dimension". In 2013, the working group published three recommended indicator sets – one small set of 24 indicators (Table 32) and another two with 60/90 indicators arranged by either themes or concepts.[213]

Table 31. "Small set" of indicators proposed by UNECE, Eurostat and OECD in 2009

Indicator domain	Stock indicators	Flow indicators
Foundational well-being	Health-adjusted life expectancy	Index of changes in age-specific mortality and morbidity (placeholder)
	Percentage of population with post-secondary education	Enrolment in post-secondary education
	Temperature deviations from normal	Greenhouse gas emissions
	Ground-level ozone and fine particulate concentrations	Smog-forming pollutant emissions
	Quality-adjusted water availability	Nutrient loadings to water bodies
	Fragmentation of natural habitats	Conversion of natural habitats to other uses
Economic well-being	Real per capita net foreign financial asset holdings	Real per capita investment in foreign financial assets
	Real per capita produced capital	Real per capita net investment in produced capital
	Real per capita human capital	Real per capita net investment in human capital
	Real per capita natural capital	Real per capita net depletion of natural capital
	Reserves of energy resources	Depletion of energy resources
	Reserves of mineral resources	Depletion of mineral resources
	Timber resource stocks	Depletion of timber resources
	Marine resource stocks resources	Depletion of marine resources

Source: UNECE et al. (2009)[212]

Table 32. "Small set" of indicators proposed by UNECE/Eurostat/OECD task force on measuring SD in 2013

Theme	Indicator	No. of countries for which data available	Data source
Subjective well-being	Life satisfaction	135	World Happiness Database
Consumption and income	Final consumption expenditure	210	UN
	Official Development Assistance (ODA) paid	143	World Bank
	Imports from developing countries		UN
	Income inequality	134	UN MDG database
	Gender pay gap	68	UN
Nutrition	Obesity prevalence	160	UN
Health	Life expectancy at birth	185	UN
Labour	Employment rate	145	UN
Education	Educational attainment	184	UN
Housing	Living without housing deprivation	91	UN MDG database
Leisure	Leisure time	20	Multinational Time Use Survey Database
Physical safety	Death by assault/homicide rate	186	UN
Land and ecosystems	Bird index	214	World Bank WDI

Theme	Indicator	No. of countries for which data available	Data source
Water	Water abstractions	93	UN
Air quality	Urban exposure to particulate matter	173	UN
Climate	GHG-emissions	229	World Bank
Energy resources	Energy consumption	187	UN
Non-energy resources	Domestic material consumption	200	Sustainable Europe Research Institute
Trust	Generalised trust	82	World Bank WDI
Institutions	Voter turnout	194	Int'l Inst. for Democracy and Electoral Assistance
Physical capital	Gross capital formation	156	UN
Knowledge capital	R&D expenditures	116	UN
Financial capital	Consolidated government debt	84	World Bank WDI

Source: UNECE et al. (2013).[213]

5.2.8. OECD Better Life Initiative: Measuring well-being and progress

Building on almost ten years of work on measuring progress, including the Istanbul Declaration in 2007, the OECD launched *The OECD Better Life Initiative*. This initiative presented a set of well-being indicators. It combined various work streams, including a compendium of OECD well-being indicators and the "*How's Life?*"-report. The indicator set included in the *Better Life Initiative* will be improved over the years, in line with the outcomes of methodological OECD projects. The conceptual framework of the Better Life Initiative identified three pillars for understanding and measuring the well-being of individuals and households: (i) material living conditions; (ii) quality of life; (iii) and sustainability. The approach drew closely on the framework recommended by the Stiglitz-Sen-Fitoussi Commission on measuring progress and on previous OECD work and is consistent with the approach proposed by the Sponsorship Group of Eurostat. Table 33 provides an overview of the components of OECD's Better Life Index.

Table 33. Components of OECD's "Better Life Index"

	Component	Indicator
Material well-being	Income and wealth	Household net adjusted disposable income
		Household net financial wealth
	Jobs and earnings	Employment rate
		Personal earnings
		Job security
		Long-term unemployment rate
	Housing	Rooms per person
		Dwellings without basic facilities
		Housing expenditure
Quality of life	Health status	Life expectancy
		Self-reported health
	Work-life balance	Employees working very long hours
		Time devoted to leisure and personal care
	Education	Educational attainments
	and skills	Years in education
		Student skills
	Social connections	Social network support
	Civic engagement and governance	Consultation on rule-making
		Voter turn-out
	Environmental quality	Air pollution
		Satisfaction with water quality
	Personal security	Reported homicides
		Assault rate
	Subjective well-being	Life satisfaction
Sustain-ability of well-being	Natural capital	Mineral and energy resources; land; soil resources; timber resources; aquatic resources; other biological resources; water resources; atmospheric CO2 concentrations; state of the ozone layer; land use; species abundance; threatened species; urban exposure to particulate matter; water quality; availability of recreational and green space
	Human capital	Lifetime Income Approach estimates for select OECD countries; highest educational level attained; PISA student skills and PIAAC adult skills; Life expectancy at birth; Healthy life years.
	Economic capital	Produced assets, including knowledge capita; Assets minus liabilities.
	Social capital	Trust in others; quality of institutions and processes to engage citizens; shared values and expectations that underpin societal functioning and enable mutually beneficial co-operation – e.g. tolerance and reciprocity.

Source: OECD (2013).[214, 215]

5.2.9. UN Development Programme: Human Development Index (HDI) and Human Sustainable Development Index (HSDI)

The Human Development Index (HDI) is not an aggregate indicator of global development progress. Instead, it ranks countries by the quality of life of their people. It is a composite index that considers income, health and education. The wealth of a nation is measured by GNI (earlier by GNP), health is quantified by life expectancy at birth, and years of schooling indicate education.

Table 34. Components of the UNDP's HDI and HSDI

Variant	Indicator components
HDI	Life expectancy at birth
	Gross National Income (GNI)
	Years of schooling
HSDI includes also	Per capita carbon emissions

Source: UNDP.

The index has been undergoing reviews which aimed to take into account recent findings, notably those of the Stiglitz-Sen-Fitoussi report and the GDP and Beyond initiative (see above). Proposed changes included the revision of the classic HDI; inequality-adjusted HDI and gender-inequality adjusted HDI indices; and efforts to capture more comprehensively the dimensions sustainable development. In 2010, a Human Sustainable development Index (HSDI) was created by adding a fourth parameter to the HDI - per capita carbon emissions (Table 34).[216]

5.3. Monitoring development from space and beyond: filling data gaps in the poorest countries with "big data" approaches

The third approach to measure progress (also called 'big data' approach) complements the first and the second approaches. It complements official data from surveys with highly spatially disaggregated and temporally frequent non-official data from a variety of sources such as remote sensing, mobile telecommunication devices, road traffic, and user-based crowdsourcing. It can provide snapshots of the well-being of the population or of our planet's features at high-frequency and at fine geographical resolutions, thus providing an opportunity to gain real-time insights on sustainable development.

The traditional ways of measuring sustainable development progress described up to this point all share a number of serious shortcomings:

- *High costs of official statistics and capacity constraints:* They are based on official statistics collected through traditional means like surveys which means they are expensive and require a high level of statistical capacity in all countries. Many poor countries lack both the resources and capacity, despite decades of international statistical support. Although many countries boosted their statistical capacity with the MDG initiative, the result of more than a decade of international statistical support to developing countries is still sobering, as evidenced by the data gaps evident in the UN's regular MDG report.[217,218] For example, even the most simple of data, a population headcount, is expensive - the 2010 US population census cost US$13 billion, the 2010 Chinese census US1.4 billion and that of India cost US$400 million.[219] The UN Statistical Commission supported a standardized system of national accounts (SNA) since 1953[220], yet even today many developing countries do not regularly produce the full SNA due to capacity and cost constraints. The situation is even worse for implementation of the newer and more specialized indicators. Data quality remains a serious limiting factor in all countries.
- *Low spatial resolution:* Data is collected for provinces/states and typically only national-level data is shared and distributed by the UN and other international organizations. Although the data may be available at sub-national level in the respective countries, global data sets often do not permit analysis of trends and trade-offs at the local level. In addition, some statistics, like those used for GDP estimation, are typically only measured for the whole country thus impeding analysis at sub-national levels of trends in for instance economic growth.
- *Low temporal frequency:* Most of the indicators are estimated annually or once every few years. The only possible exceptions are certain higher frequency economic data. In addition, data are typically one or several years old once they become available. Consequently, most of these official data cannot serve an early warning function. This is exacerbated by the fact that the traditional statistical system is inflexible and does not quickly accommodate new issues. Instead, these issues will typically be covered by scientists in an ad-hoc fashion for years until they may be implemented by the statistical system. One example is offshore-outsourcing which was a topic very high on the political

agenda in Europe a decade ago, but for years there were no official data available at all to inform the debate.

- *No tracking of interactions between spatial and temporal scales*: The traditional approaches aim to measure progress at the national or global scales. Yet, some have made the case that sustainability is essentially local and that it might be more important to understand the interactions between local progress/failures and those at higher levels. In fact, different sustainable development issues do have different, intrinsic spatial and temporal scales at which they are operating (Table 2 in chapter 1). And integrated assessment has shown the importance of capturing the interactions between these issues. Hence, it appears that traditional approaches miss out the importance of integration at various scales which may very well hold one of the most important insights into why some policies and actions are successful and others not.

In view of these shortcomings, it is highly unlikely that comprehensive, high-quality data for traditional progress indicators will be available for *all* (or even most) countries within the next twenty years, even if global agreement were reached on a "perfect" sustainable development progress index. To be clear, traditional progress indexes are useful tools, but it is important to recognize their equally important shortcomings. In fact, the above shortcomings are common to most socio-economic data, especially in developing countries.

Fortunately, scientists and engineers have recently suggested new ways to overcome the limitations of the traditional approaches.[221] This section illustrates selected examples that were provided to us by a group of geographers at Lund University (Magnus Andersson, Souknilanh Keola, Ola Hall and Anders Ahlström) in response to the Global Sustainable Development Report's call for innovative ways of measuring sustainable development progress They make use of remote sensing (satellite-based) and of communications technologies to illustrate a much cheaper – but technically demanding - way to fill data gaps in the poorest regions.

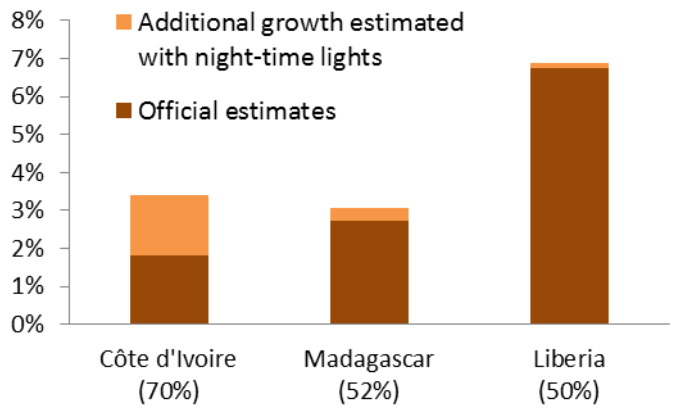
Remote sensing obtains information about objects from a distance. It uses satellites, aerial photography, and in broader sense, data from mobile phones, the World-Wide Web, and other communication technologies and sensors. Remote sensing data typically have a high spatio-temporal resolution, are information-rich and have increasingly become available freely or at low cost to researchers across the world, particularly since open access policy introduced to archived satellite images by US government in 2008.[222] in the past twenty years. Remote sensing data has been used extensively by environmental scientists (e.g., to study land-use changes), but its use to study socio-economic changes has been rare. Hall and Andersson provide a review of the use of remote sensing in the social sciences.[223]

Early examples of using remote sensing in the social sciences were the use of night-time light data to estimate population[224,225] urban extent[226], energy-related CO_2 emissions[227], GDP[228],[229] and PPP[224,], poverty[230], electricity[224] and energy use at various spatial scales. Night-time light data for the globe are available from the US Defence Meteorological Satellite Program (DMSP) with a spatial resolution of 1 to 2 kilometres and a temporal frequency of twice a day, covering the period since 1992.[231] Figure 20 shows a recent world map of night-time light data. From 1992 and 2009, the dimly lit surface grew by 49 per cent and the bright area expanded by 19 per cent, and the planetary centre of light has moved toward the East at about 60 kilometres per year.[232] Applications of night-time light data to infer socio-economic data have been quite successful, due to universal patterns in human settlements across several orders of magnitude.

The estimation of GDP is still challenging in some developing countries, even though GDP estimates are produced from one of the best established statistical system worldwide, national accounts. Data required for national accounts come typically from administrative records – which can be deficient – and economic and household surveys – which can be costly and infrequent. Moreover, in many developing countries, a significant portion of the economy may occur outside the formal sector and therefore may not be captured in national accounts. For example, in Côte d'Ivoire, 70 per cent of those employed in the non-agricultural sector, work for the informal sector.[233] With such a large activity in the informal sector, can the official GDP measures fully capture economic growth? To obtain more insight into informal and formal economic activity, scientists have been looking at ways to produce improved estimates of economic growth.[228] Night-time lights captured by satellite images have been used as proxies for economic activity and changes in the intensity and coverage of lights over time as proxies for changes in economic growth.[228] By combining official GDP data with data from night-time lights, revised

estimates of income growth were produced for a number of countries.[228] For Côte d'Ivoire, the official estimates pointed to a GDP growth of 1.8% from 1992/3 to 2005/6, whereas additional information from changes in night-time lights provided a higher estimate, 3.4%, up 1.6% from the official estimate. For other countries with smaller informal sectors, the two estimates were closer (Figure 18).

Figure 18. Income growth, estimated by official sources and by using night-time lights data, 1992/3 to 2005/6.



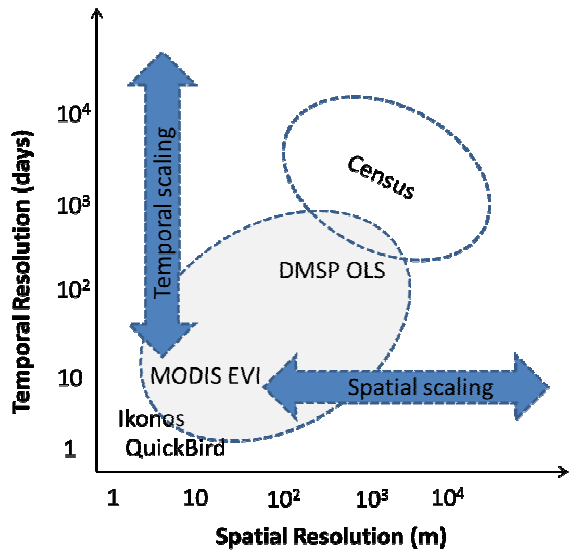
Note: Percentages of persons employed in the informal sector, among those employed in the non-agricultural sector, are indicated in brackets.

Sources: Compiled by the United Nations Division for Sustainable Development from Henderson et al. (2012)[228] and ILO (2012).[233]

However, an important drawback of night-time light data is that they say little about development among the poorest, agricultural areas. Yet, the poorest, agricultural areas are also those with the biggest data gaps. Figure 21 illustrates this point in the case of the Lao People's Democratic Republic (Lao PDR) which is a Least Developed Country in Asia. While the areas in neighbouring Thailand and Viet Nam have "lit up" greatly in 2010 compared to 1992, the changes in night-time lights in Lao PDR are sparse and concentrated around the capital Vientiane and a few urban centres, even though the Lao economy has developed dynamically over these 18 years. Except for the year 1998, it grew at rates of 5.5 to 8.6 per cent per year (in real terms). While night-time light map captures well growth in non-agricultural areas, such as major human settlements, mineral mines, and hydroelectric dams, it failed to reflect growth of agriculture and forestry surrounding them (Figure 21).

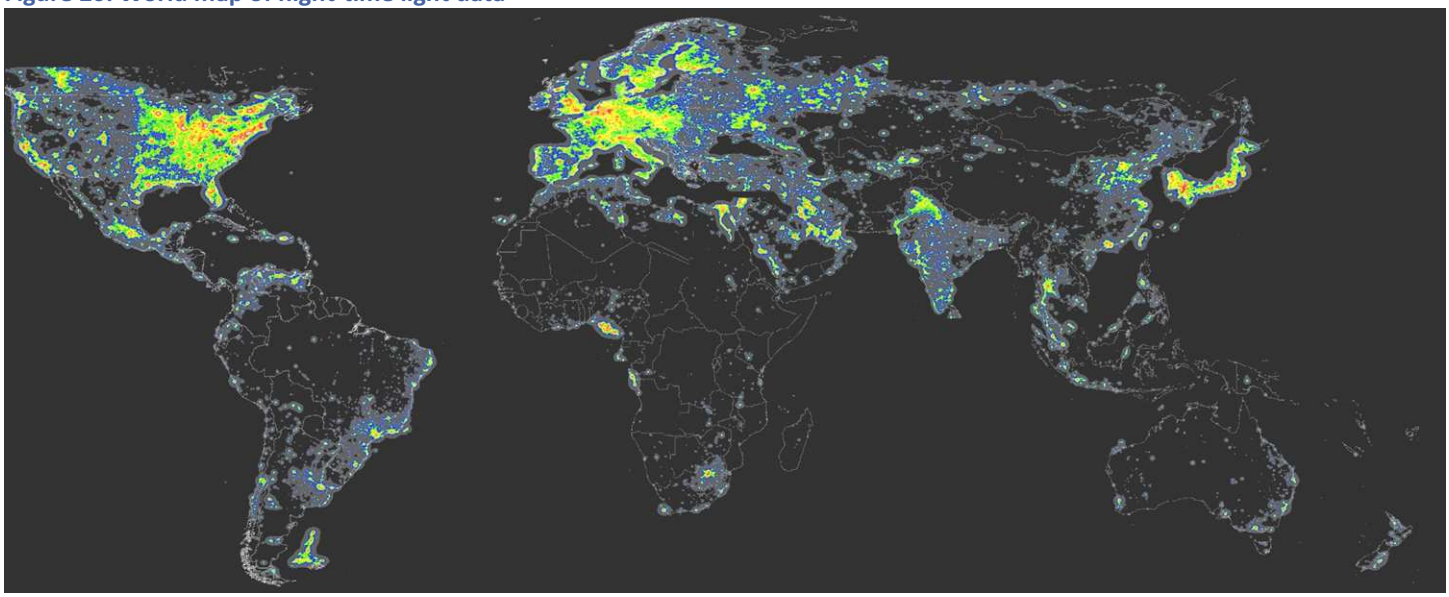
In contrast, land cover data account for much wider parts of the Lao PDR (Figure 22). Many Satellites provide images that may be used to generate land cover data. MODIS stands out in terms of spatiotemporal definitions in addition to its free to use policy. It provides, for example, land cover data and an enhanced vegetation index (EVI). Various data products are available. For example, MOD13Q1 is vegetation index data which is available at a spatial resolution of 250 meters and global coverage every 16 days[234] (Figure 19). MODIS global land cover data (MCD12Q1) are annual data with a resolution of 500 metres, available from 2001. Net primary productivity data (MOD17A3) have a resolution of 1,000 metres once a year, whereas gross primary productivity data (MOD17A2) are available at resolution of 1,000 metres every 8 days.

Figure 19. Temporal and spatial resolution of data sources



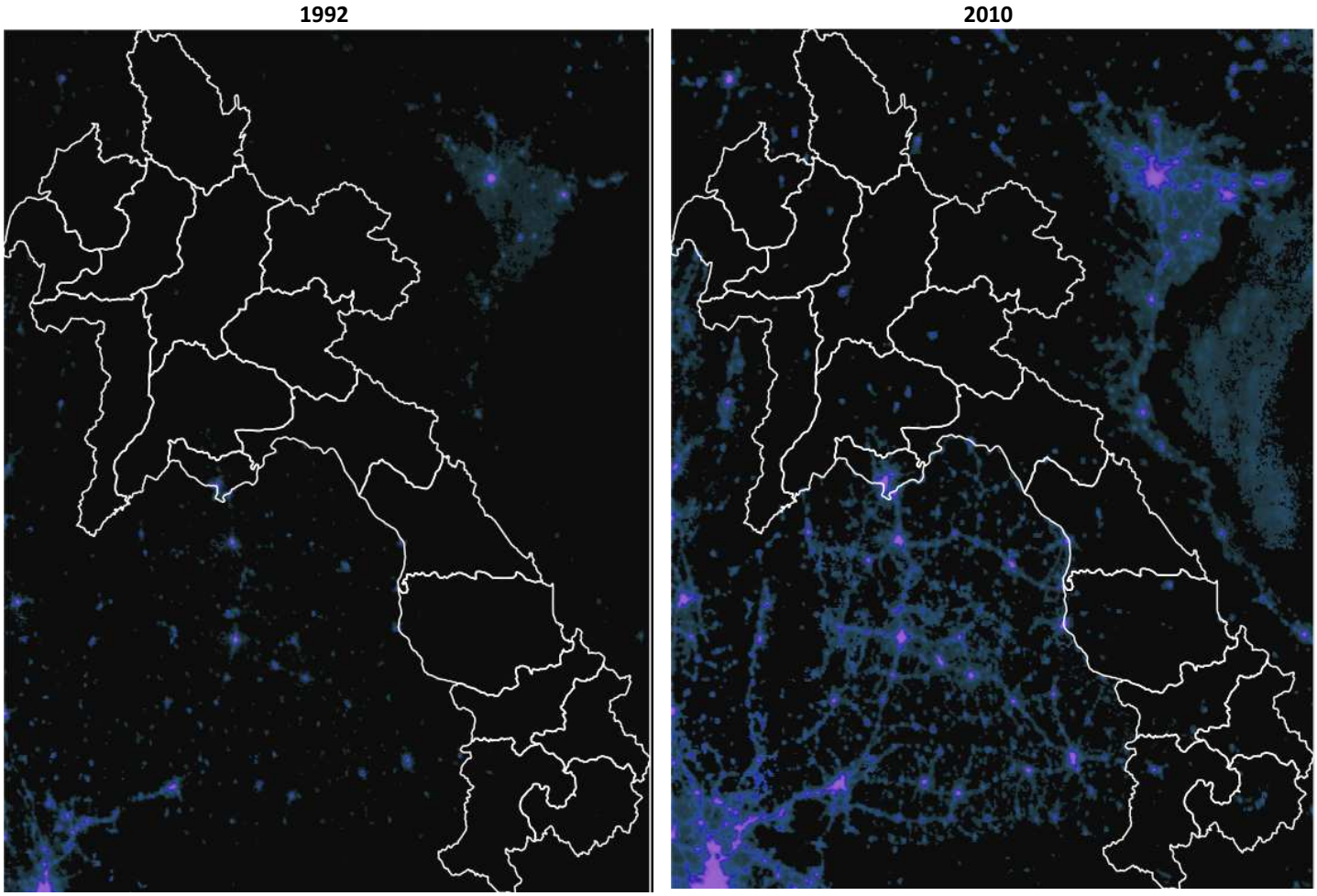
Against this background, Keola, Andersson and Hall explored combining night-time light data with MODIS land cover data and with official GDP data and demonstrated estimating economic growth of agriculture vs. non-agriculture for administrative areas of any shape or size in the world.[235] MODIS land cover data captures agriculture's growth well for poor and middle-income countries, but not so well in developed countries. Keola, Andersson and Hall illustrated the usefulness of their approach for estimating growth at the district level for Lao PDR[236] and Cambodia[235]. Their results are very encouraging for filling the gaps in availability, quality and timeliness of data. In fact, the data are available almost in real-time, in contrast to official data.

Figure 20. World map of night-time light data



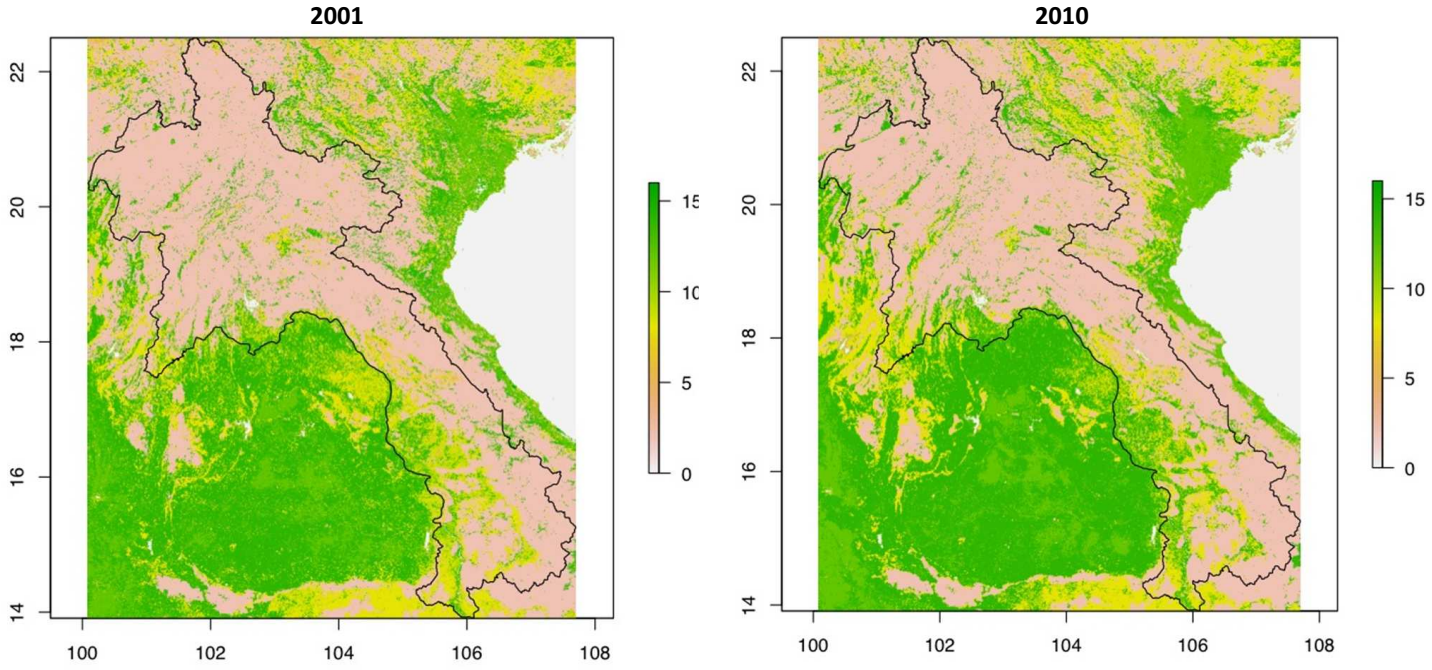
Credit: P. Cinzano, F. Falchi (University of Padova), C. D. Elvidge (NOAA National Geophysical Data Center, Boulder). Copyright Royal Astronomical Society. Reproduced from the Monthly Notices of the RAS by permission of Blackwell Science.[237]

Figure 21. Lao People's Democratic Republic at Night, 1992 and 2010.



Source: Keola, Andersson and Hall, based on DMSP-OLS and FAO's GAUL.

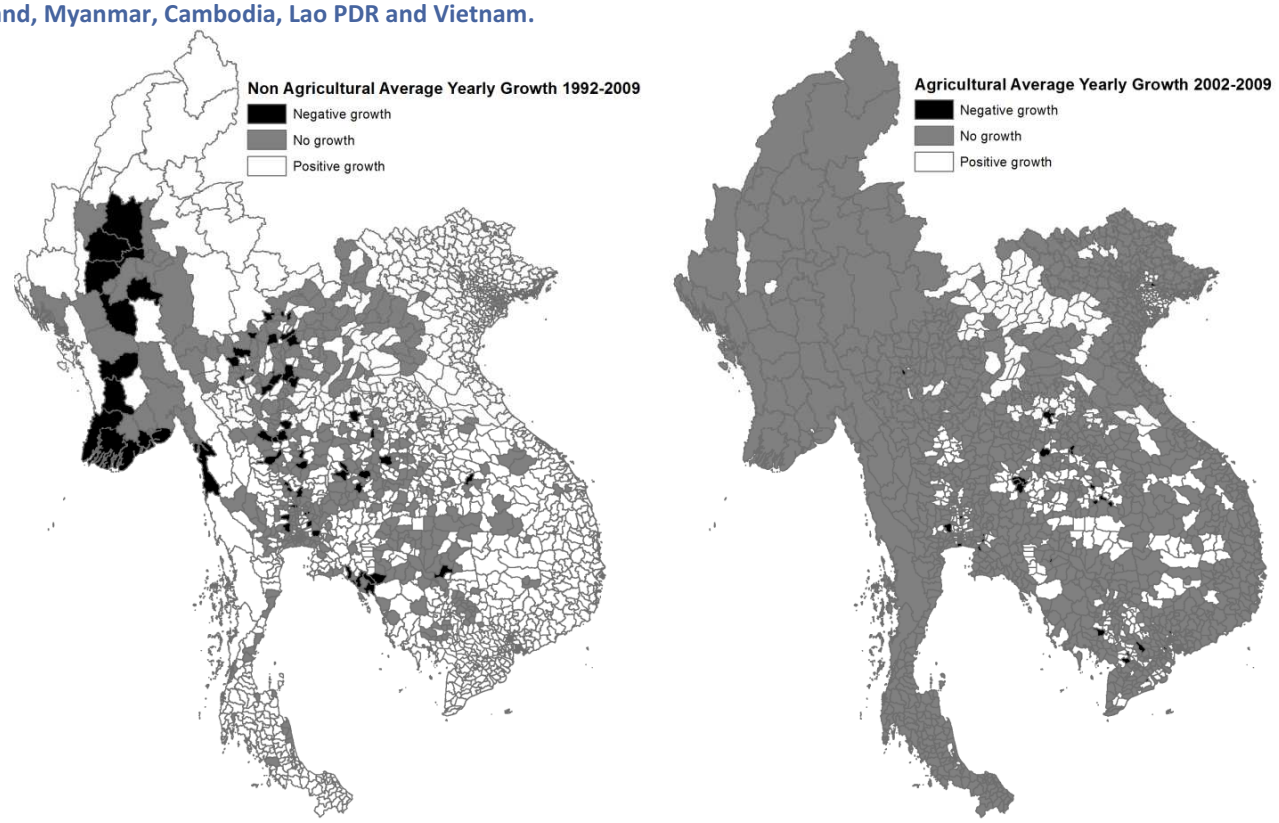
Figure 22. Land cover data for the Lao People's Democratic Republic, 2001 and 2010.



Scale: 0: Water, 1-5: Forest, 6-7: Shrubland, 8-9: Savannas, 10: Grassland, 11: Wetland, 12: Crop land, 13: Urban area, 14: Cropland/Natural Vegetation Mosaic, 15: Snow and Ice, 16: Barren or sparsely vegetated.

Source: Keola, Andersson and Hall, based on MODIS Land Cover Dataset (MCD12Q1) and FAO's GAUL.

Figure 23. Estimation of economic growth at the sub-national level for agriculture and non-agricultural sectors growth in Thailand, Myanmar, Cambodia, Lao PDR and Vietnam.



Source: Andersson et al., 2010.

Another even higher spatio-temporal data generated from MODIS is enhanced vegetation index (EVI) with a spatial resolution of about 250 meters and global coverage every 16 days. MODIS satellite sensors provide two gridded vegetation indices to the scientific communities: the enhanced vegetation index (EVI) and the normalize difference vegetation index (NDVI).

MODIS EVI allows indentification of man-made and various natural land covers (Figure 22). It can be used to study functional and structural characteristics of land cover, global cycles of energy and matter, shifts in the spatial distribution of bio-climatic zones, and human expansion and development change. The EVI-index can also be linked to biomass and used to measure net primary production (NPP) and thus allows measurement of that important sustainability indicator at any spatial scale, see Figure 23 for an illustration.

The MODIS NDVI provides a crude estimate of vegetation health and a means of monitoring changes in vegetation over time. It remains the most well-known and used index to detect live green plant canopies in multispectral remote sensing data.

MODIS data can also be used for early warning for agriculture and to estimate economic impacts of flooding and other natural disasters (Figure 25).

Estimation of growth at the sub-national level can be estimated for any geographic sub-division. Land cover data is more ubiquitous than night time light. This allows estimation of growth in poor areas where night time lights are not observable. Figure 23 show estimation results for economic growth for agriculture and non-agricultural sectors growth in Thailand, Myanmar, Cambodia, Lao PDR and Vietnam at the district level (administrative level 2) to. Among 3538 districts, about 92% registered positive average growth in agriculture between 2002 and 2009, and about 86% did so in non-agriculture sectors between 1992 and 2009.[238]

At the UN Expert Group Meeting on innovative ways of measuring sustainable development progress, held at Lund University on 26-27 May 2013, Andersson, Keola, Hall and Ahlström also illustrated combination with other "big data sources" such as mobile phone data. It is the combination of data sources that make these "big data" approaches so useful also for the estimation and interpolation of socio-economic data.

Table 35 below displays examples of use of big data to monitor issues relevant to the priority areas for SDGs officially suggested by government.

Table 35. Big data examples which can be useful to monitor the priority areas for SDGs

Priority areas for SDGs officially suggested by governments	Past uses of big data	Advantages of using big data
Energy	Satellite data to estimate electric power consumption	Regular updates
Poverty eradication	Satellite data to estimate poverty	International comparable data, which can be updated more frequently
	Internet-based data to estimate consumer price index and poverty rates[239]	Cheaper data available at higher frequencies
Poverty eradication and Beyond GDP	Cell-phone records to predict socio-economic levels[240]	Data available more regularly and cheaper than official data; informal economy better reflected
Health	Internet-based data to identify disease breakouts[241]; cell-phone data to model malaria spread[242]	Real-time data; captures disease cases not officially recorded
Climate change	Satellite scan to monitor population and energy related greenhouse gas emissions	Separate emissions of urban populations from other sources; more regular updates
	Satellite images to measure net primary production[243,]	Regular updates
Cities and housing, Land management	Light emissions picked up by satellites to estimate urban extent	Globally consistent way to map urban extent; more regular updates
Economy and macroeconomic stability	Light emissions picked up by satellites to estimate GDP growth	Informal economy better reflected; information available at sub-national level; improves estimates for countries with poor national accounts data
	Internet-based data to monitor inflation in real time	Cheaper data available at higher frequencies
Disaster risk reduction	Satellite images to identify flood risk areas	Data available frequently

Figure 24. Net primary production 2012

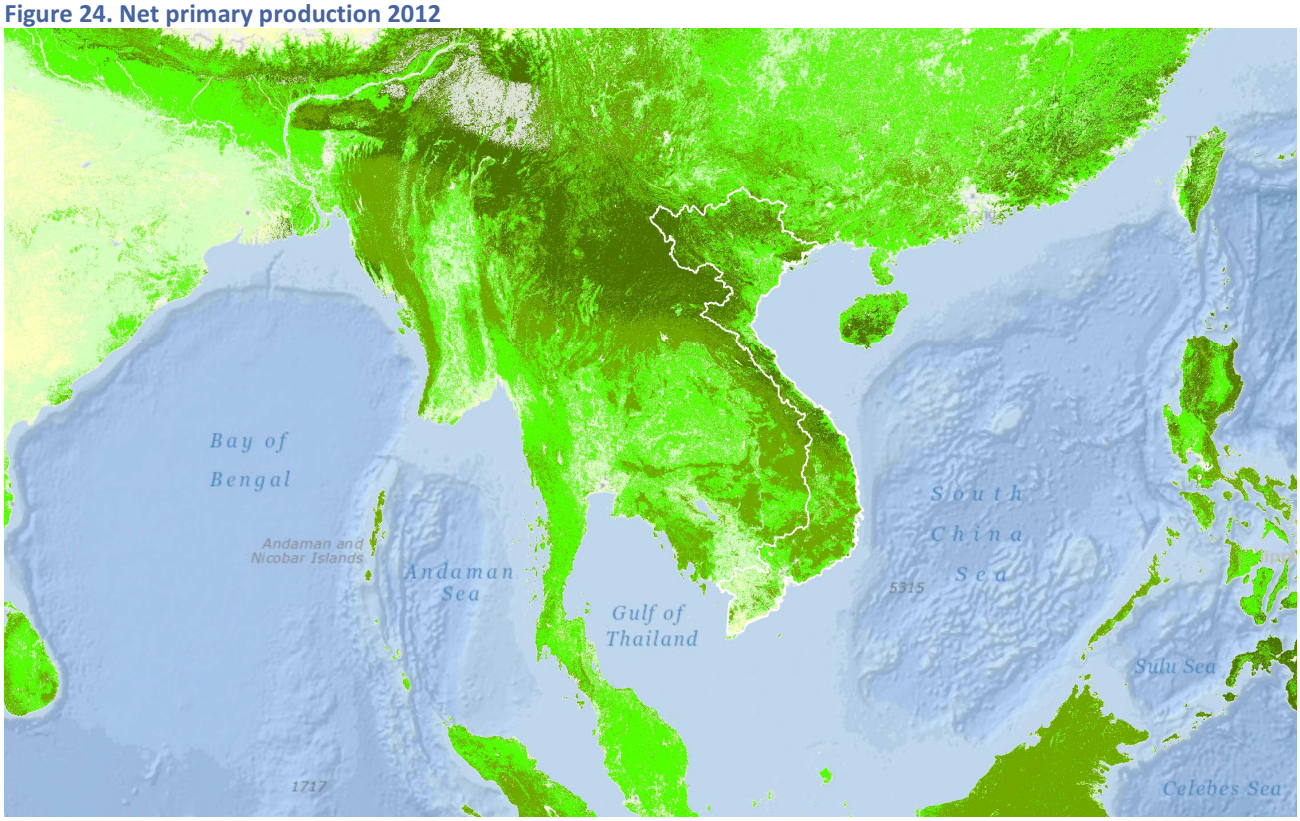
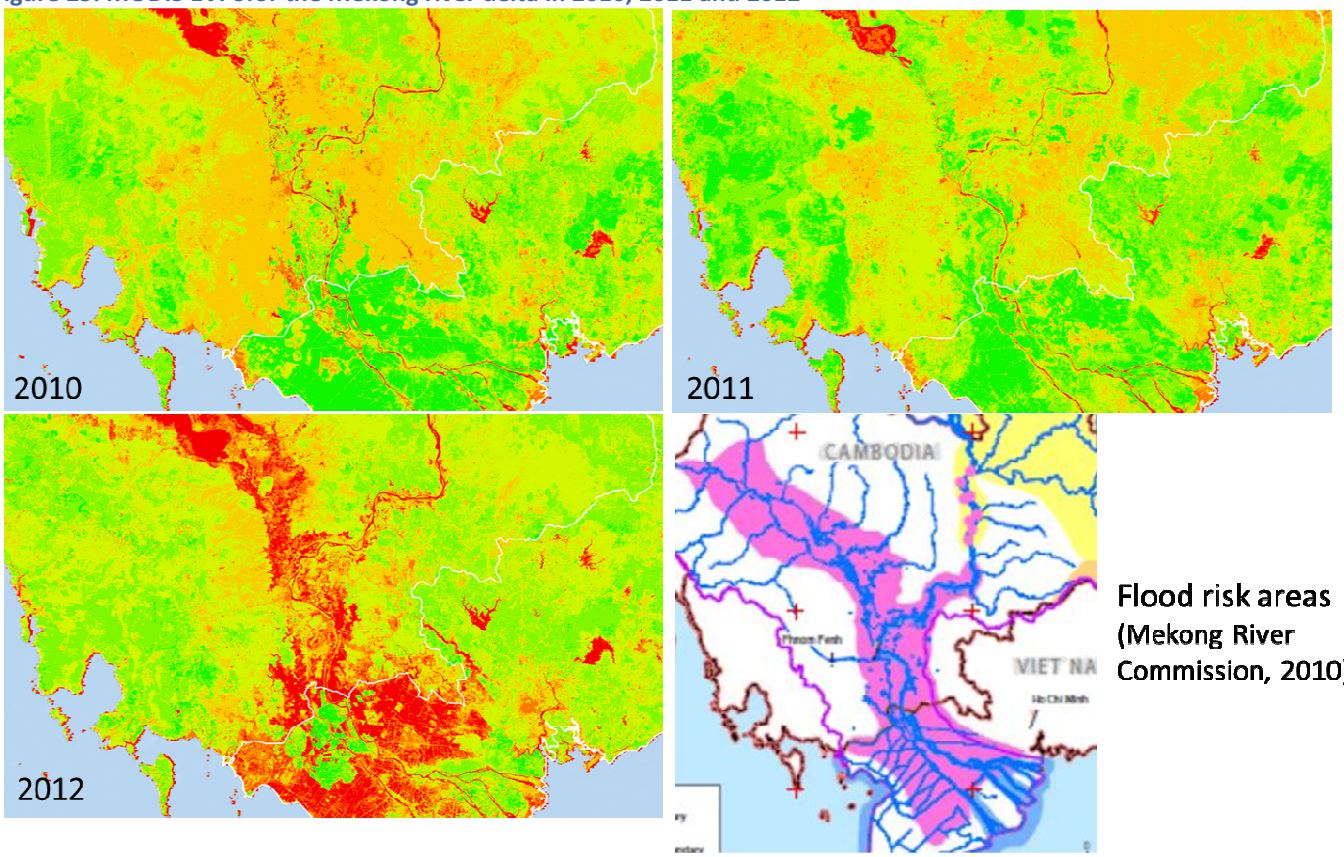


Figure 25. MODIS EVI ofor the Mekong river delta in 2010, 2011 and 2012

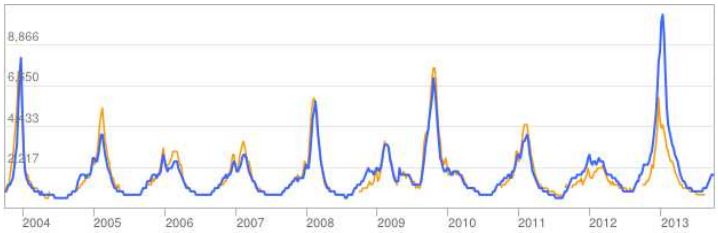


Note: Red color denotes water.

Other examples of the use of big data include the use of Google Web searches to estimate and predict influenza cases (Figure 26), as well as the use of mobile phone data to show the movement and people and spread of contagious diseases (Figure 27).

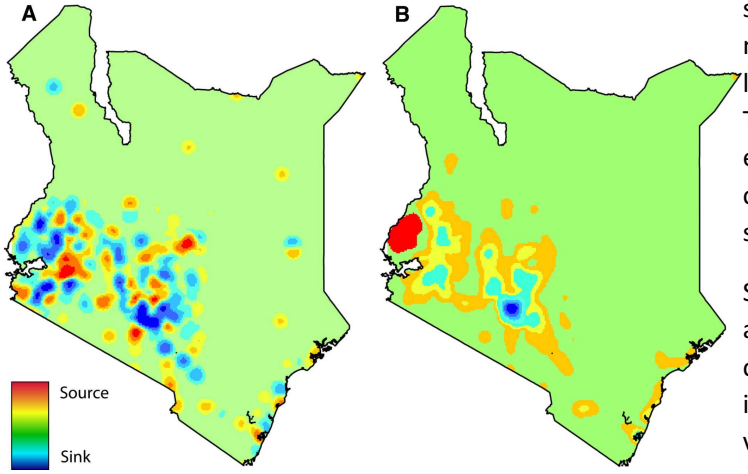
In conclusion, remote sensing and other "big data" approaches have great potential for assessing long-term sustainable development progress - not just for short-term and emergency relief (as has been the focus of the UN Global Pulse so far). For that purpose, remote sensing data should be more open. Applications are promising to complement and improve official statistics. For example, the featured approaches could be used to estimate an aggregate SD index at various spatial and temporal scales.

Figure 26. Google prediction (blue) vs official data (orange) of influenza cases in the US



Source: Google Flu Trends (http://www.google.org/flutrends); methodology described in Ginsberg et al. (2009).[244]

Figure 27. Use of cell-phone data in Kenya to show movements of people (A) and carrying of malaria parasites by humans (B).



Source: From Wesolowski *et al*. (2012).[245] Reprinted with permission from AAAS.

Note: Red areas are net emitters and blue areas are net receivers of people (A)/parasites (B).

5.4. The way forward

Since the 1990s, the number of initiatives aiming at measuring progress, well-being, sustainable development or parts of these concepts is growing. Each of these initiatives use their own frameworks and indicator sets. The need for coherent and broader measures of progress to complement GDP has been increasingly recognised and is the focus of a number of international initiatives. In particular, this also received significant attention at Rio+20, and resulted in a request in §38 of the outcome document to the UN Statistical Commission to launch a new process in this regard. Furthermore, §250 of the Rio outcome document specifically points to the need for tracking progress towards the SDGs by identifying targets and indicators.

There is a need for capacity building to improve the availability and quality of data on sustainable development. High quality and sustainably produced statistics are crucial both for setting targets and for monitoring progress. Measuring progress requires comprehensive monitoring and a robust accountability mechanism. Further investment in national statistical systems and capacity development may be needed for national data collection, data processing and analysis, and to capture high quality, further disaggregated data.

Importantly, the two agendas—the agenda on defining sustainable development goals and the agenda on progress measurement—are linked, and if properly coordinated can lead to strengthened synergy and stronger overall progress. This is also supported by a growing global community engaged in revising indicator systems based on the concepts of sustainability, genuine progress, net adjust savings, and human well-being.[246]

Sustainable development indicators derived from a set of agreed international goals or commitments, and a composite indicator, which is the compilation of individual indicators into a single index, are considered to be a good vehicle in helping to measure and monitor sustainable development and progress achieved in it. Indicators corresponding to the future SDGs are most important for monitoring future progress, but they will need to be complemented by composite indices of sustainable development progress.

All these indicators are meant to present complex data and trends in simplified form to policy makers. They can inform policy formulation on the basis of information which is

transparent and evidence-based. The challenges, among others, are to develop and agree upon the fully integrated framework of measurement at the global level, which includes both goals and a set of indicators for and assessing needs and tracking progress of sustainable development.

Also, inaccuracies in measurements introduce uncertainty. No measurement is fully accurate — the instruments used, the biases in people's responses to surveys, all introduce inaccuracies. Uncertainties also arise from the complexity of some Earth systems or the complex interactions among the vast array of social, economic and environmental factors. Uncertainties resulting from lack of knowledge can arise in situations of low availability of data. Despite these uncertainties, most scientific models are accurate enough to deserve credibility.

Remote sensing and other "big data" approaches have great potential for assessing long-term sustainable development progress and to complement and improve official statistics. It would enable estimation of the proposed aggregate sustainable development index at various spatial and temporal scales.

A toolbox for monitoring sustainable development progress will need to be developed, in order to help decision makers. In this context, it is noteworthy that academics have proposed a dynamic SDG monitoring system that is based on comprehensive and differentiated data collection reflecting the operational realities at different levels of each country. It would make use of all three types of approaches for measuring sustainable development that are presented in this chapter.[247]

6. Special theme: The climate-land-energy-water-development nexus

"Land, energy and water are our most precious resources…" (Howells et al., 2013)[267]

Sustainable development highlights the need for integrated approaches to finding solutions that are commensurate with the challenge of achieving economic, social and environmental goals that are often interlinked. The climate-land-energy-water-development (CLEWD) nexus is of great importance for sustainable development.

Water, energy and land are needed to grow food. Some food crops can also be used as biofuel. Power plants require water. Energy-intensive seawater desalination increasingly provides water for drinking and agriculture. Water and energy infrastructure is needed to spur development and vice versa. In many parts of the world, a changing climate exacerbates some of these already strained links. Increasing droughts call for increased energy inputs for irrigation and limit the use of hydro-power plants. In some Smalls Island Developing States (SIDS), as well as in drought-sensitive areas, these impacts of a changing climate are already a reality. In many cases, these links are so significant that they cannot be neglected by policy and call for integrated approaches.

The case studies presented in this chapter highlight the importance of scientific evidence in supporting sustainable development policy.

6.1. From integrated assessment to the climate-land-energy-water-development nexus

There are many relevant sustainable development issues that need to be considered in principle (table 2, chapter 1). Integrated sustainable development assessments aim to capture all of these issues and to take into account the inter-linkages among them. This can be daunting task, as the inter-linkages are complex and context specific and depend, inter alia, on the issues under consideration, the geographic and temporal scales, population density and the existing technology systems.

Since the 1970s, quantitative models and other decision-support tools have been increasingly used to understand better the trade-offs and synergies of various policy options. Scenario models and related tools allow a systematic analysis using scientific findings and data from all relevant disciplines. They provide decision makers with access to scientific knowledge in an actionable way without requiring a full understanding of the underlying science.

In practise, however, there is a limit to what can be modelled, to what can be easily understood, and to what will be trusted by decision-makers. For example, changing the scope of issues to be considered can greatly alter the findings and the resulting policy conclusions. In the specific example of the IPCC process, various series of emissions scenarios have informed climate policy over the years. These scenarios were developed with sophisticated global scenario models which typically captured the energy, land/food, and air pollution issues, but which did not model - in detail - water, materials use, biodiversity issues, poverty, trade, and some other issues.[248] As a result, these IPCC scenarios were not designed to identify integrated solutions that can resolve trade-offs and build on synergies across the wide range of sustainable development issues. Instead, they were developed to explore alternative emission trajectories and emissions mitigation options. If goals other than emission targets were considered, such as energy, water and food resource targets and development objectives, then the overall results would change.

Clearly, fully integrated assessment continues to be a complex and challenging undertaking. This partially explains why it has not been used to the extent that was originally envisaged in Agenda 21 which was agreed by Governments in 1992. In fact, at the national level, planning and assessment continue to follow exclusively sectoral and/or thematic lines in most countries.

Consequently, an increasing number of scientists have started to promote a second-best option to fully integrated assessment in recent years. They suggest focusing initially on smaller clusters of interlinked issues that are considered most important for policy action.

Food, water, energy, poverty eradiation, and climate change are issues in the top-ten of the priority areas that were suggested by Governments for the *Sustainable Development Goals* in December 2012 (Figure 28). They are also some of the key issues that were highlighted by Governments in the Rio+20 outcome document. Similarly, according to the *State of the Planet Declaration,* climate, land, energy and water are central to development.[249] The World Economic Forum outlined several interrelated global risks arising from the interconnected food, water and energy security issues.[250] It should be noted, in particular, that Governments have engaged in a number of nexus initiatives in recent years. For example, a Task Force on the Water-Food-Energy-Ecosystem Nexus was created under the UNECE Water Convention[251]; the German government

launched a water, energy and food security resource platform[252]; and a series of international "nexus" meetings has been convened.[253] Against this background, the CLEWD nexus was chosen as a special theme for the present prototype report.

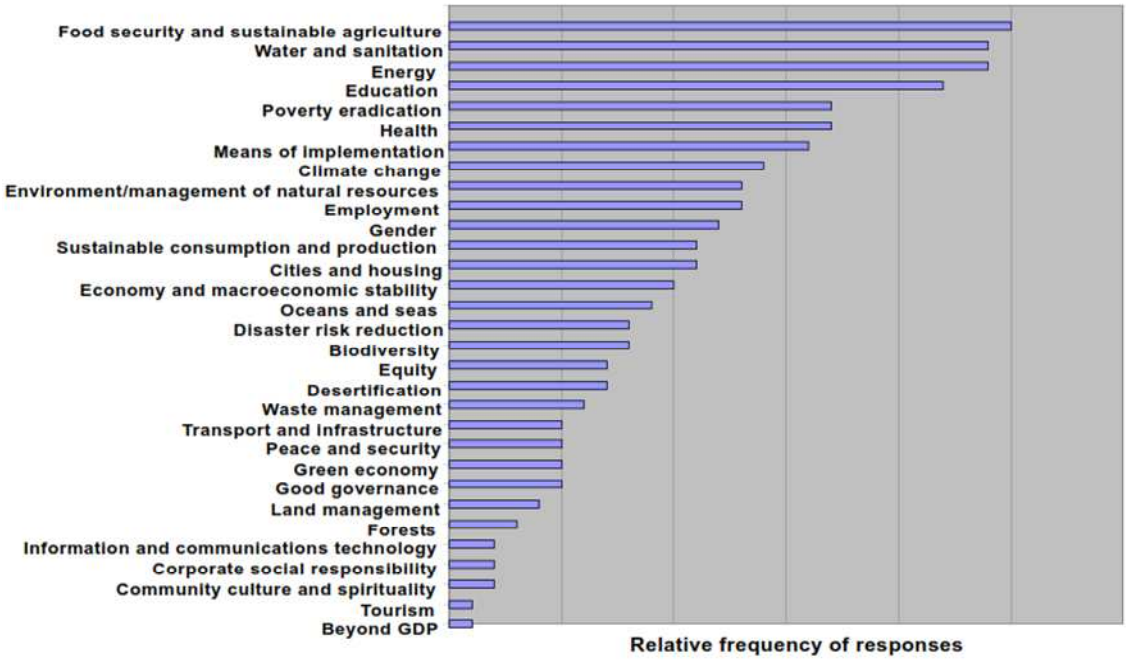
It is important to note that different terminologies are being used to refer to similar CLEWD nexus approaches. For example, energy analysts typically refer to climate-land-energy-water strategies (CLEWS) or energy-food-water strategies, whereas water analysts tend to refer to the "nexus" and in particular the water-energy-food security nexus (WEF). Analysts with a food security perspective as a starting point have used a combination of the above.

Ideally, the strength of inter-linkages among issues and the policy priorities of governments might define the most suitable cluster of issues to be analysed. Hence, the "right" cluster of issues is case specific. In some cases, the cluster can be narrower (e.g., energy-water) or wider (e.g., including biodiversity).

At the same time, energy, water and food resources have a number of important common characteristics: there are billions of people without access to modern sources; global demand for these resources has increased rapidly leading to concerns over resource limits; all are "global goods" and involve international trade; all operate in heavily regulated markets and are linked to security issues; all are closely linked to environmental issues including climate change.[254]

Finally, it should be noted that the climate-land-energy-water-development nexus is but one of a number of clusters of strongly interlinked issues of great relevance for sustainable development. Future editions of a global sustainable development report could address these clusters in turn.

Figure 28. Priority areas for SDGs officially suggested by Governments in December 2012.



Source: Responses by UN member States to a questionnaire on priority areas for the SDGs carried out in December 2012. The results are summarized in the Report of the UN Secretary General (A/67/634 of Dec. 2012).

6.2. Interlinked issues: climate, land/food, energy, water, materials, and development

Many of the national submissions in preparation for the Rio+20 Conference in 2012 highlighted food, energy, water and development among the highest priority areas. Yet, the mentioned national plans and initiatives were primarily along sectoral or thematic lines as were the proposed solutions and recommendations contained in the submissions. This is illustrated for eight developing countries (Table 36). These and other countries would benefit from an integrated assessment of the CLEWD cluster.

Table 36. Selected CLEWD content in national submissions in preparation for Rio+20.

Country	Priority challenges	Policy plans	Identified gaps and recommendations
Jamaica	• *Energy:* high energy intensity, low efficiency, 90% of energy needs come from imported oil. • *Water:* contamination of water resources by industry and human-activity. • *Food:* Weakening capacity of local food supplies by agriculture losing land to other sectors such as housing and tourism.	• Vision 2030 Jamaica. • National Energy Policy 2009-2030	• have the developed countries renew their commitments for the transfer of financial resources and affordable technology to support all sustainable development. • Reduce dependence on exports and diversification of the economy. • In the energy field, implementing technological innovation.
Dominica	• *Energy:* high cost of electricity • *Water*: growing demand for water, inadequate institutional structure, ineffective land-use management, limited public understanding of Integrated Water Resource Management (IWRM), a lack of data and information to support decisions, climate variability, legislation that needs updating, and a lack of adequate human and financial resources • *Food:* Dominica is fundamentally an agrarian economy but declining banana export	• While there is not a Sustainable Development Ministry in Dominica, sustainable development initiatives are common placed.	• The main gap in the implementation of sustainable development in Dominica is the absence of a coordinating mechanism.
Tanzania	• *Water:* A high degree of water resource variability, particularly from rainfall, both spatially and temporally. • *Energy:* Low per capita consumption of commercial energy and high dependence on non-commercial energy including biomass fuels (90%) • *Food:* Lack of mechanization and inadequate support services to the agricultural sector	• The Tanzania Development Vision 2025 • The National Environmental Policy (NEP), 1997	• Encourage financial institutions to support farmers to finance irrigation projects. • Be aware of biofuel's threats to food security. • Strengthen implementation of policies and strategies in agricultural production.
Lebanon	• *Water:* Vulnerable to water contamination, unsustainable water management practices, population growth, urbanization, pollution • *Energy:* Net energy importer, rely on dirty fuels and heavy fuel oil in primary energy mix • *Food:* global rise in food price, low food subsidies	• National Water Sector Strategy (NWSS). • Four initiatives related to the energy sector: Electricity Sector Policy Paper, 12% Renewable Energy pledge, National Energy Efficiency Action Plan, and Energy Conservation Law.	• Encourage R&D, offer subsidies to organic farming, reducing taxes on sustainable products • Designate each governorate a prosecutor • Improve crops and irrigation
Bhutan	• Tremendous hydropower is highly vulnerable to the impacts of climate change. • Lack of access to affordable clean technology due to high cost • 5.9% of the Bhutanese population is subsistence poor and under food poverty line.	• Block tariff pricing system of power consumption for low-income group. • Bhutan Sustainable Hydropower Development Policy 2008. • National Framework for Organic Farming in 2007	• Development of clean energy by harnessing hydropower and renewable energy resources • Strengthening Local Government Institutions and service delivery • Partnerships with the Civil Society and Private Sector
Ethiopia	• Population growth pressure • Chronic food insecurity in rural Ethiopia • The conflict between keeping the trends of increasing agricultural productivity to meet food security and attaining the green economy strategy.	• National Growth and Transformation Plan (GTP) • Climate Resilient Green Economy (CRGE) Strategy	• Continue on development programs and projects by committing own financial sources. • Collaborate with development partners and deal with financial issues. • Develop natural resources such as water, geothermal, solar and wind resources.
Cambodia	• *Energy:* Increasing gap between supply and demand, high cost of electricity, difficulty attracting investors to non-hydro-renewable energy, low levels of electrification. • *Water:* Low access to urban drinking water and rural sanitation. • *Food:* Lack of proper milling infrastructure, storage facilities and irrigation systems.	• An Institutional Development Plan for Water and Sanitation (2003-2012) • The Strategy for Agriculture and Water (SAW) for the period 2010-2013.	• Develop policies to foster investment in energy resources; Hold regional discussions on energy gaps; Continue building capacities. • Improve the efficiency of water management on existing water resources. • Develop rules, regulations and institutional mechanisms for effective and integrated management of water resources.
Nepal	• *Energy:* Although Nepal has huge hydro potential, its share of renewable energy and hydropower is less than 3%. • *Water:* water shortage and increasing contamination of drinking water. • *Food:* Nepal is among the countries worst affected by the global food crisis due to deteriorating quality of imported foods and rising costs.	• The energy programs include Promotion and Development of Renewable Energy, Energy Sector Assistance Program and Energy Conservation Programs. • Nepal has formulated various policies and strategies for hydropower, such as the Task Force Reports for Generating 10,000/25,000 MW Hydropower in 10/20 Years. • The Agricultural Perspective Plan (APP) (1995-2015)	• Nepal needs additional international support in financing, technology transfer and capacity building. • Nepal should provide incentives and attract foreign as well as domestic investors in hydropower generation.

There are complex interconnections between resources, such as ground water and biomass availability, and processes such as climate change or geochemical flows.[255] Changes in resource availability typically have their worst effects on poor people.[256,257,258,259] On the other hand, increasing wealth alters consumption and production patterns which has impacts on resource consumption and greenhouse gas emissions. Yet, it should be noted that providing universal access to clean and affordable energy services would not significantly increase global pollution loads. In fact, it would reduce indoor air pollution and not significantly increase global greenhouse gas emissions which are almost exclusively the consequence of "excessive" resource consumption by a minority.[260,261] Various types of extreme events, such as droughts, floods, or energy crises, have impacts on poverty, food security and the potential for conflicts.[262]

Table 37 lists important inter-linkages in the climate-land-energy-water-development nexus, as well as linkages with materials consumption. An extensive list of relevant inter-linkages has been assembled by the US Pacific Northwest National Laboratory.[263]

Table 37: Selected inter-linkages between climate, land/food, energy, water and materials

Impacts of the issues listed below on those listed on top.	**Climate**	**Land/Food**	**Energy**	**Water**	**Materials**
Climate		Climate change and extreme weather affect crop productivity and increase water demand in most cases.	Climate change alters energy needs for cooling & heating and impacts the hydropower potential.	Climate change alters water availability and the frequency of droughts and floods.	Climate change alters material demand choices due to GHG emissions mitigation efforts, adaptation and changing technology choices.
Land/Food	Greenhouse gas emissions from land use change (vegetation and "soil carbon") and fertiliser production.		Energy is needed for water pumping, fertiliser and pesticide production, agricultural machinery and food transport.	Increased water demand due to intensification of agriculture, and effects on the N/P cycles.	Land use regulation and other uses of land compete with extraction of resources and materials.
Energy	Fuel combustion leads to GHG emissions and air pollution.	Land use for biofuels and renewable energy tech. (solar, wind, hydro, ocean), crop/oil price correlation.		Changes in river flow, evaporation in hydropower dams, biofuels crop irrigation, fossil fuel extraction (esp. unconventional).	Materials used in energy sector for construction, operation, transmission and distribution.
Water	Changes in hydrological cycles affect local climates.	Changes in water availability for agriculture and growing competition for it affect food production.	Water availability for biofuels, energy use for desalination but also storage of renewable energy as fresh water.		Materials needed for water sector (extraction, desalination, purification, pumping etc.) .
Materials	Emissions from materials fabrication and resource extraction.	Land degradation due to extraction of resources and pollution and yield increases due to fertiliser/pesticide availability.	Material-embedded energy and high energy intensity of new materials.	Mining, refining and production processes lead to water consumption and pollution.	

Source: Adapted by authors from Weirich (2013)[264], based on Rogner (2010), Hoff (2011)[265], and Howells & Hermann (2011)[266].

The scale of the CLEWD issues affects billions of people. There are 1.4 billion people without access to electricity, 3 billion without access to modern energy services, 0.9 billion without access to safe water, 2.6 billion without improved sanitation, 0.9 billion that are chronically hungry and 2 billion who lack food security from time to time.[254]

The scale of inter-linkages between CLEWD issues is also large. At the global level, seven per cent of commercial energy production is used for managing the world's freshwater supply, including for extraction, purification, distribution, treatment and recycling.[254] About 70 per cent of human water use is for irrigation, and 22 per cent is for industry most of which is for thermal cooling in power plants and manufacturing.[267,268] Roughly four per cent of final energy use is in agriculture[269], and food processing and transportation uses an increasing additional energy amount.[270] About half of the demand increase for maize and wheat has been due to biofuel production.[271] Energy use for desalination and pumping for irrigation constitutes a large share of energy use in some developing countries.

Correlations between energy, water and food prices are further evidence for close interconnections. In particular,

the fuel and food crises of recent years have illustrated a close relationship between food and oil price indexes, which reflects the use of oil for fertilizer production and agricultural machinery, as well as the impact of oil price increases on biofuels demand.[254]

6.3. Hierarchy of assessments

In 1992, in Agenda 21, Governments agreed to promote integrated assessment that would encompass economic, social and environmental dimensions. However, twenty-two years later, truly integrated approaches are not yet common, except in certain niches. Table 38 provides a stylized overview of today's assessment practises at various levels in the world.[272] It shows that climate-land-energy-water-development assessments at the national level fill an important gap in the existing hierarchy of assessments.

At the national level, planning and assessment has followed primarily sectoral lines in most countries. There are only few national multisector applications, some of which are presented in this chapter. However, strategic environmental assessment has become mandatory In Europe and the comparative assessment of development options (CADO) is being piloted in some developing countries.

At the regional and global levels, a moderate number of multi-sectoral integrated assessments have been carried out.[273] Most energy, land-use and water models continue to be sectoral. The UN system is actively engaged in environmental and poverty impact analysis and various types of integrated assessment at the programme level. At the international level, integrated assessment of projects is still more the exception than a rule, but has been increasingly used for cross-border projects.

At the subnational level, most assessments are carried out at the project level, as environmental impact analysis has become mandatory almost everywhere. In contrast, there are only isolated examples of subnational assessments at the program, or policy level. Interestingly, there is a significant number of academic studies that include a multi-sectoral assessment at the subnational level.

To ignore inter-linkages among sectors and across national borders, however, has meant that success in one area or location has often come at the expense of increasing problems elsewhere. The links among food, fuel, and climate crises are a case in point. Energy, water and food security, land use issues, development policy, and climate policy continue to be addressed in isolation. The result has been a "trial-and-error-approach" by policy makers to muddle through addressing trade-offs. A prime example is the early promotion of highly ambitious biofuel targets in many developed countries and changes in sugar policy in Europe, only to be followed by food prices shocks and concerns about global food security.

In conclusion, a hierarchy of assessments has evolved that focuses on the project level at the expense of a strategic higher-level (Table 38), which has caused unnecessary costs. Opportunities have been missed, as a significant part of (suboptimal) infrastructure has already been built in developing countries. The window of opportunity is decreasing. Case studies of the CLEWD nexus at the national level fill an important gap in the assessment hierarchy and could potentially replace some of the lower-level assessments.

Sustainability science provides evidence of the interaction of sustainability issues at various spatial and temporal scales. Hence, it is true that sustainable development is essentially local, but it has interrelated aspects at various geographical levels all the way up to the global level. Hence, a human geography perspective using "big data" approaches might be adopted also for analysing the CLEWD nexus (see chapter 5).

Table 38. Stylized review of integrated assessment practices

	Subnational	National	Regional and global
Project	EIA, ESIA, almost universal and mandatory		Ad hoc IA of cross-border projects
Programme	Isolated examples	SEA mandatory in Europe and selected countries; CADO in selected countries	EIA and PIA by UN, development banks and global funds. IA by OECD, UNEP and G20.
Policy			
Sector	Conventional sectoral planning	Conventional energy and infrastructure planning	Many energy, land-use and water models
Multisector	Significant number of academic applications	Few examples. Recent CLEWD case studies	Moderate number of IAs

Note: CADO (comparative assessment of development options); CBA (cost–benefit analysis); EIA (environmental impact assessment); ESIA (environmental and social impact analysis; HIA (health impact assessment); IA (integrated assessment); PIA (poverty impact assessment); SEA (strategic environmental assessment); SIA (social impact analysis).

Source: Howells et al. (2013)[267], based on ESCAP (2006)[274] and OECD (2006)[275].

6.4. Global CLEWS model – an open source, open-data approach

In preparation for the present report, a global CLEWD model was developed as an open-source, open-data tool for research cooperation on global sustainable development, and to support the emerging national and regional applications: The **G**lobal **L**east-cost **U**ser-friendly **C**LEWs **O**pen-**S**ource **E**xploratory (GLUCOSE) model. The model is currently being developed further. The result will be a user-friendly Web interface and a widened scope of the model to capture all the goals that will eventually be agreed by the UN Open-Working Group on the Sustainable Development Goals. The envisaged user interface follows the approach used for the "2050 Pathways Calculator" of the UK's Department of Energy and Climate Change, in order to enable access to the model for a non-technical audience.[276] The original model was developed by researchers from the Royal Institute of Technology (KTH) in Sweden in cooperation with the UN Division for Sustainable Development.

Annex 5 provides a description of the GLUCOSE model and of a number of global integrated scenarios that were developed - a baseline scenario, CO_2 tax scenario, and 2°C, 4°C and 6°C scenarios. Most importantly, results are compared between the global integrated model and a separate energy model. Interestingly, when CLEWD inter-linkages are taken into account, greenhouse gas mitigation costs turn out to be much less than currently suggested by separate global energy models. When we are realistic about trade-offs between different resources under a changing climate, most of the cheaper sectoral baseline scenarios will not be feasible. Feasible baseline scenarios without climate mitigation policies will require higher investments, and integrated approaches that achieve a range of sustainable development goals may turn out to be cheaper than the feasible business-as-usual alternatives.

6.5. Landscape of CLEWD nexus applications: subnational, national, regional, and cross-border river basins

A pioneering pilot assessment of the climate-land-energy-water-development nexus in Mauritius has shown the practical benefits of integrated analysis for policy making. The assessment of the climate-land-energy-water-development nexus has helped in identifying innovative policy that avoids costly mistakes of isolated sectoral policy making. This is a good example of a strong science-policy interface in action.

In a very short time, the Mauritius case study has inspired many similar climate-land-energy-water-development nexus applications. The expert group meeting held in Stockholm in support of the present report assessed case studies in Australia, Brazil, Burkina Faso, Canada, Cuba, Chile, China, Germany, India, Jamaica, Lithuania, Mauritius, Qatar, South Africa, Syria, Thailand, USA, UK, Tarawa/Kiribati, Comoros, Madagascar, Seychelles, Zanzibar, California, and the river basins of the Danube and the Nile, as well as a number of local applications. These applications use different entry points – energy security, water security or food security – but they share the same overall integrated approach. Selected cases are presented in this chapter.

It should be noted that recent initiatives to apply the CLEWD approach are being carried out by a number of organizations within and outside the UN system. In particular, a coordinated research project of IAEA supports cooperation among ten national entities. The Royal Institute of Technology, Sweden, has carried out an impressive number of applications in various world regions and has also provided technical support to various UN initiatives. The Stockholm Environment Institute has a long tradition in nexus applications, especially with a water perspective as a starting point. The Food and Agriculture Organization (FAO) of the UN has leveraged cooperation between different departments within the organization that focus on the various CLEWD resources. FAO and LIPHE4 (a spin-off of the Autonomous University of Barcelona) have developed a Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism approach to assess 'nexus' problems in Mauritius; the Punjab region of India; and South Africa. UNECE supported the creation of a task force under the UNECE Water Convention which aims to support CLEWD applications for river basins. And the Secretariat of the UN Convention on Biological Diversity has worked on the nexus and biodiversity. UNESCO has carried out nine local (subnational) case studies[277] of the climate-land-water-development nexus in the context of the Sustainable Management of Marginal Drylands (SUMAMAD) project.

Table 41 provides an overview of ongoing or recently completed CLEWD case studies at the national level. While all these applications share the same overall integrated analysis framework, their focus and model implementations vary greatly (Table 39 and Table 40). Next some of the case studies are summarized.

Table 39. Coverage of CLEWD issues in selected national case studies

Country	Bioenergy		Climate vulnerability		Energy and water		Water for agriculture and bio-energy	Land-use representation	Development
	Liquid biofuels	Solid biofuels	Small Island States	Other	Water for power generation	Energy for water			
Australia									
Brazil	X			X			X	X	X
Cuba		X	X		X	X	X	X	X
Germany	X	X		X	X		X	X	
India									X
Mauritius	X	X	X		X	X	X	X	X
Lithuania	X	X			(X)			X	
South Africa				X	X	X	X	X	
Syria									X
Thailand	X						X	X	X
Qatar				X		X	X	X	X

Source: authors and IAEA input.

Table 40. Tools and models used in the selected CLEWD case studies

Country	LEAP	WEAP	MESSAGE	MAED	MAWD	GAEZ	CROPWAT	CGE	Climate	WEF
Australia										
Brazil	X						X	X	X	
Cuba	X?	X	X	X	X?	X			X	
Germany									X	
India										
Mauritius	X	X				X	X		X	
Lithuania	X?	X?	X	X		X?	X?			
South Africa	X	X						X	X	
Syria			X							
Thailand	X					X	X			
Qatar										X
Nile basin	X	X				X				

Source: authors and IAEA input

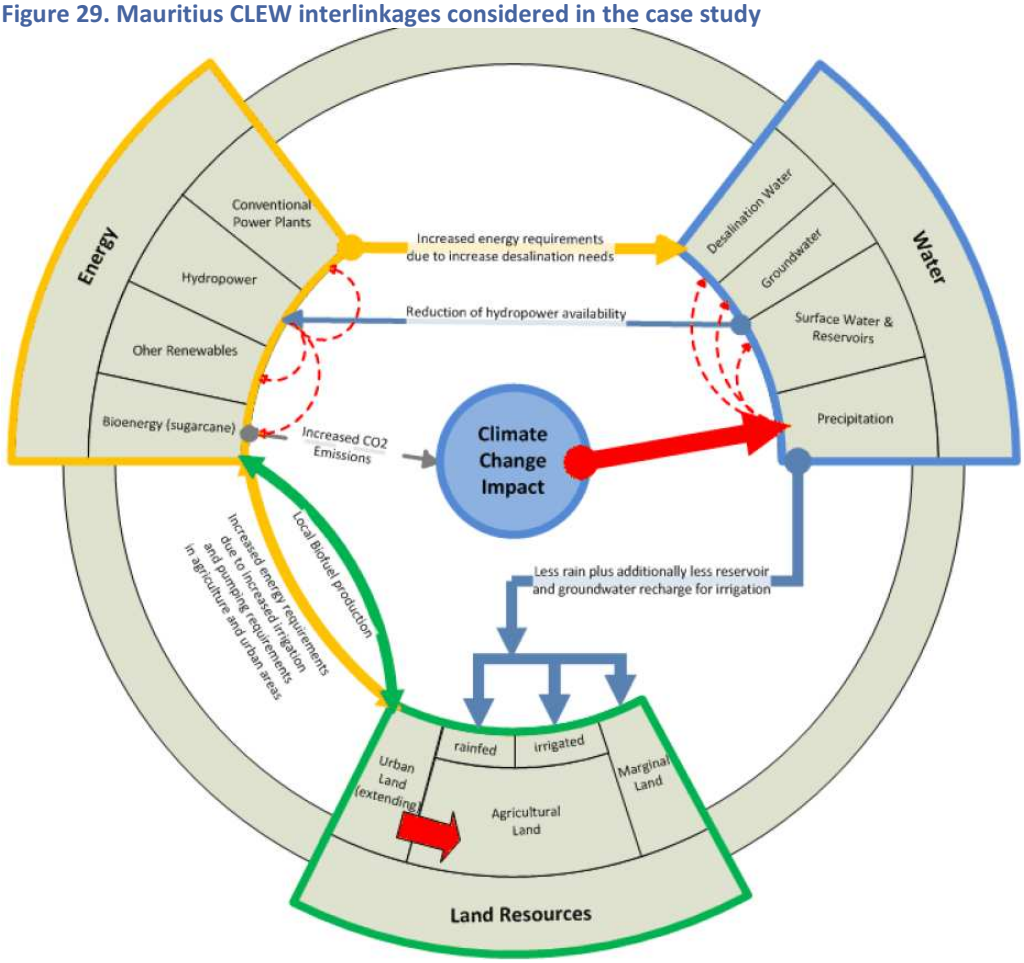
Table 41. Selected national and subnational CLEW applications (on-going or recently completed)

Case study	Research	Innovative	Approach/models	Partners	Sources
Australia *(On-going)*	Australia case study	Governance issues	Qualitative	University of Technology, Australia	Sharma (2013)
Brazil *(On-going, preliminary results)*	CLEW analysis of sugarcane cultivation for bio-ethanol production in Brazil.	"Product" focused CLEW analysis	Set of models (LEAP, Cropwat, CGE, own climate and land use models)	Energy Planning Program, COPPE/UFRJ; Sponsor: IAEA	Pereira (2013)
Burkina Faso *Country report finalised and published – scope for more detailed analysis*	Looking at CLEWs – what are sustainable development pathways for a resource constrained country taking into account population growth and potential effects of climate change	National resource strategy relevance	Set of models (LEAP, AEZ)	IAEA, KTH	Hermann et al. (2012)[278]
Canada (and rest of world) *(completed, ongoing)*	Water-energy-food nexus	Highly sophisticated systems model	ANEMI model with 8,000 feedbacks	University of Western Ontario, Canada	Simonovic (2013).
Chile *(ongoing)*	Energy-water nexus in Chile	Designed for policy advice	Set of models	Universidad Diego Portales, Santiago, Chile	Minoletti (2013)[279]
China *(preliminary results)*	Water-land-energy-climate nexus		Surveys.	Centre for Chinese Agricultural Policy, Chinese Academy of Sciences; various universities.	Wang et al. 2012)[280]
Cuba *(On-going)*	CLEW analysis of Cuba based on securing energy supply.	Coordinated policy	Set of models (MESSAGE, MAED, LEAP, WEAP, AEZ)	Cubaenergia, Cuba. Several ministries Sponsor: IAEA	
Germany	Integrated assessment of climate impact,	CLEW Indicators	Own indicator based	Jülich Research Centre	Schlör and

Case study	Research	Innovative	Approach/models	Partners	Sources
(on-going)	land, energy and water use (CLEW systems) in Germany against the background of the UN green economy model and Germany's sustainability strategy.		approach	Sponsor: IAEA	Hake (2013)[281]
India *(On-going)*	CLEWs in India: An analysis focusing on the Climate Change drivers and effects (mitigation and adaptation) on different CLEW resources.	Climate change centered CLEW	Set of models	Bhabha Atomic Research Centre, Mumbai. Sponsor: IAEA	Pandit (2013)[282]
Jamaica *Country briefing and first results available*	Sugarcane cultivation in Jamaica under potential CC and increased irrigation efficiency efforts – influences on the water and energy balance.	"Product" focused CLEW analysis	Set of models (LEAP, AEZ)	KTH	Morrison (2012)[283]
Lithuania *(On-going)*	CLEW analysis of bioenergy potentials in Lithuania: a detailed analysis of different biofuel feedstock in Lithuania – an environment that is not water but temperature constrained.	CLEW using the MESSAGE energy systems model	MESSAGE, MAED	Lithuanian Energy Institute, Lithuania. Sponsor: IAEA	Galinis (2013)[284].
Mauritius *Completed*	Which implications does shift to local biofuels (sugarcane) have on other CLEW resources? What is the influence of potential climate change on CLEW resources (water, agriculture, energy) in the future?	First ever national case study	Set of models (LEAP, WEAP, AEZ)	Agricultural Research and Extension Unit, Mauritius. Various ministries. Sponsors: IAEA, KTH	Ramma (2013), Howells et al. (2013)[267], Welsch et al. (2014)[285]
Thailand *(On-going)*	CLEW analysis different biofuel solutions for Thailand: This analysis investigates different biofuel crop options in the country. The impact (and resilience) of different biofuel feed stocks (ethanol and biodiesel options are considered) on other CLEW resources is evaluated.	Support for policy implementation	LEAP, AEZ, CROPWAT	Naresuan University, Thailand. Sponsor: IAEA	Wattana (2013)[286]
Cape Town, South Africa *(first results and regional report available)*	CLEW analysis at subnational level focusing on the Cape Town region in South Africa.	"High resolution"	Set of models (LEAP, WEAP, CGE)	Energy Research Centre, University of Cape Town. Sponsor: IAEA	Stone et al. (2013)[287]
Syria **(***on-going on hold due to difficult political situation)*	CLEW analysis of Syria focusing on highly constraints water resources	Water focused CLEW	Set of models, (MAED, MAWD, MESSAGE)	Atomic Energy Commission of Syria. Sponsor: IAEA	Omar et al. (2013).[288]
Qatar *(completed)*	Integrated food self-sufficiency scenarios, taking into account the water-energy-food nexus.	Food security perspective. Web tool.	WEF web tool	Qatar Environment and Energy Research Institute (QEERI)	Daher and Mohtar (2013)[289]
Tarawa/Kiribati	Water-land-energy nexus	Water efficiency	?	IRENA	Skwierinski (2012)[290]
USA *(completed)*	Climate and Energy-Water-Land System Interactions	Comprehensive review		Pacific Northwest National Labs. Sponsor: USDOE	Skaggs and Hibbard (2012)[291]

Source: authors.

Figure 29. Mauritius CLEW interlinkages considered in the case study



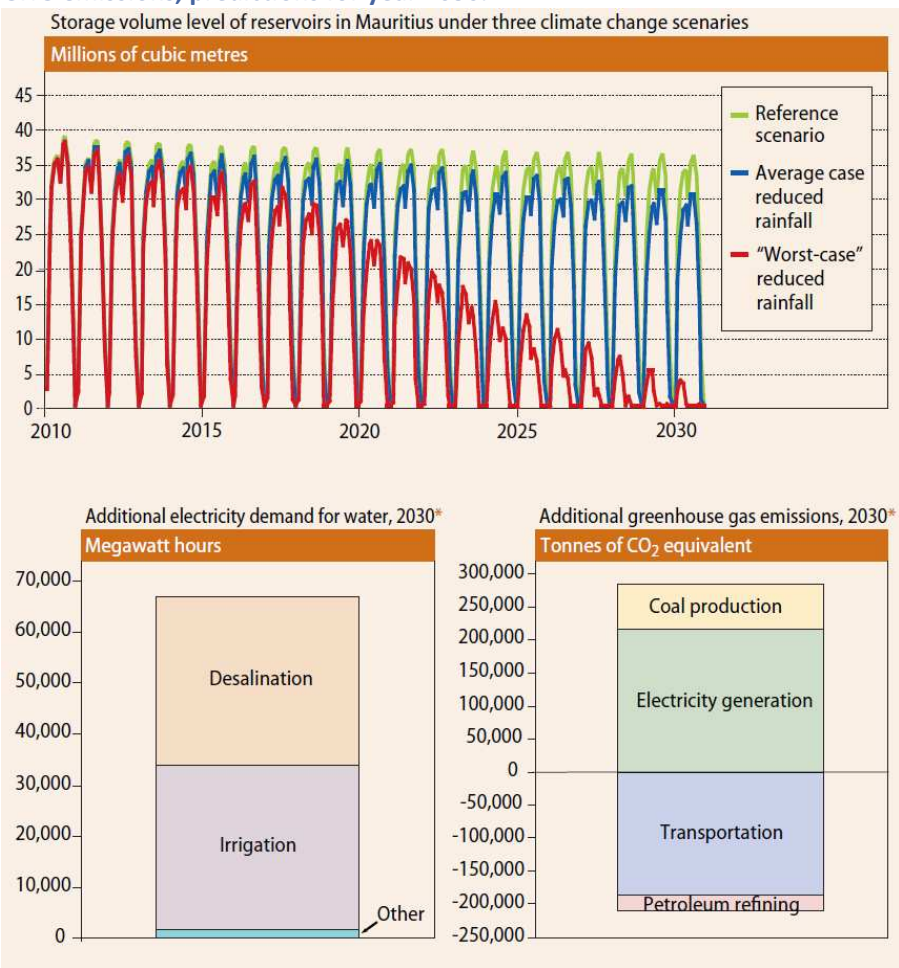
Mauritius

In Mauritius a national biofuel policy that made sense from a best practice energy, land and water planning point of view was shown to be strongly inconsistent. This was only discovered when government and international analysts modelled these systems in an integrated manner – especially in response to climate change induced reductions in precipitation. The change in rainfall patterns, led to an increase in water withdrawals that in turn led to higher demand for energy to drive pumps to bring the water from its source to the fields and to power water desalination plants. A positive feedback loop means that this leads to increased demand for cooling of thermal power plants and thus additional withdrawals of water (unless they are cooled by seawater). If the increase in electricity demand is met with coal-fired power generation as planned then the GHG benefits of the ethanol policy are eroded by increased emissions from the power sector. Higher coal imports also have a negative impact on energy security. The benefits of this policy – aimed to reduce energy import costs and emissions – are thus clearly vulnerable to the impacts of climate change and the long term viability of this strategy is at risk if rainfall were to decrease further and droughts continue. In this event, producers would either have to scale back production or resort to expensive water desalination. Both of these options negatively impact the expected climate and energy security benefits of the policy and both would be detrimental to the sugar and ethanol industry.

The water constrained scenario does however also lead to better prospects for renewable electricity generation. Wind and photovoltaic electricity generation is typically much less water intensive than fossil fuel generation. Furthermore, if power consumption for water desalination facilities makes up a significant share of total system load, intermittent resources such as wind could be integrated more easily. Since water is cheap and easy to store, it is not important that it is produced at a specific time. It could therefore be treated as an interruptible load and shut down in the event that wind generation is unavailable during times of high system load.

In response, the Government of Mauritius appointed a high level CLEWs panel to ensure consistency between its climate, land, energy and water strategies.[267]

Figure 30. Predicted impact of climate change on water availability in Mauritius, water related energy consumption and GHG emissions, predictions for year 2030.



Notes: ***Upper graph:*** Storage volume levels in reservoirs in Mauritius Under 3 climate change scenarios (in Million m3).
Left graph: Additional electricity demand (compared to scenario without climate change impacts) under worst-case climate change scenario (in MWh). The additional water requirements in the "worst case" climate change scenario leas to an increase in energy demand. This is mainly due to additional desalination requirements and the need for irrigation in sugar cane plantations.
Right graph: Additional greenhouse gas emissions (compared to scenario without climate change impacts) under worst-case climate change scenario (in ton CO2-equivalents). The additional energy demand leads to an overall increase in greenhouse gas emissions. The additional demand is largely met by coal-based electricity generation. The resulting emissions outweigh the emission benefits of the 2nd generation ethanol production.
Source: UN (2013) and Howells (2013).

Burkina Faso

In Burkina Faso, a country with rapid deforestation, growing energy insecurity and greenhouse gas emissions, we find that a measure with damaging direct effect on each of these has disproportionately positive knock on effects. This solution is uncovered as integrated modelling of a system where nationally appropriate development actions are possible.

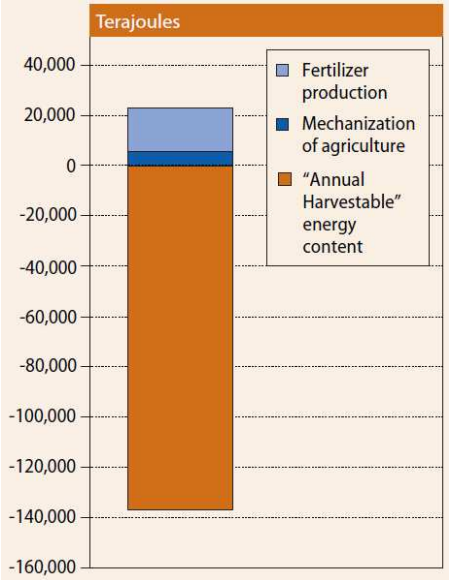
Agriculture is expanding rapidly eating into forests, a natural 'carbon-sink'. Forests supply vital fuel wood used for cooking and heating. With forests being displaced, people are forced to use oil for their energy needs which is expensive and imported. Emissions are increasing as a carbon sink is disappearing and oil use is increasing. Energy security is reduced as more oil is imported and energy poverty is increased as the price of the new energy source (oil) is relatively expensive.

However, agriculture in Burkina Faso is not intensive. The land requirements for similar outputs can be significantly reduced by changing practices. Those changes would include higher application of fertilizer and mechanization.

Incidentally the conventional production and application is highly GHG intensive and increased mechanization requires higher volumes of oil use in tractors and other equipment.

Figure 31 illustrates the changed energy balance due to reduced land-use change in the scenario for Burkina Faso in 2020. An intensification of agriculture associated with "intermediate input levels" would require an increased energy input for mechanization and as well for the production of fertilizer. This increase is small compared to the biomass energy that could be sustainably harvested from the land that would otherwise have been converted to crop land. The biomass energy potential is calculated based on harvestable yields of different land types (e.g., forest, savannah, meadows) which are subject to potential future change into agricultural land.

Figure 31. Changed energy balance due to reduced land-use change in Burkina Faso in 2020.



Notes: Based on the following assumptions: an additional energy input for mechanization of 1 GJ/ha; an additional fertilizer input of 50 kg N/ha; a fuel wood yield in savannah and mixed vegetation of 35 m^3/ha and 250 m^3/ha in forests.
Source: UN (2013) and Hermann et al. (2012).

Qatar

Qatar is a nation currently enjoying a period of unprecedented growth and advancement governed by set national visions and goals. Qatar is well recognized for its oil and gas abundance, yet also known for its aridity, water scarcity, and harsh environmental conditions. Qatar has an arid desert type climate with hot and humid summers. Average annual rainfall is only 75mm. Permanent surface water is practically non-existent. Agricultural development is limited by water scarcity, low water quality, unsuitable climatic conditions, unfertile soils and poor water management which contribute to low crop yields. Most agricultural food products are being imported. Population and GDP have grown rapidly (9.6 and 8.6 per cent, respectively, in 2010). Qatar has one of the highest energy consumption and carbon emissions per capita.

Qatar's General Vision 2030 issued by the Secretariat for Development Planning aimed to choose "*the development path that carefully balances the interests of the current generation with the interests of future generations".* The Qatar National Food Security Program highlighted the necessity of reducing the nation's food imports which currently represent about 90 per cent of the total national consumption.

The starting objective of the case study was to identify water, energy, agricultural and economic strategies to achieve food self-sufficiency. Present agricultural practices use exclusively fresh ground water, with extraction rates more than one hundred times the natural replenishment rate. Therefore, agricultural intensification to increase food self-sufficiency would require energy-intensive desalination as an alternative source of water.

The case study initially looked at eight locally produced food products, grown with different water and energy sources, and imported from several countries. The food products are typical of a Middle Eastern diet: tomato, eggplant, lettuce, carrots, watermelon, cucumber, potato, and green onion. Multiple scenarios showed that increasing the self-sufficiency of the studied food products by only 10 per cent would increase land requirement by 153 per cent and water requirement by 82 per cent (Figure 32). Throughout the case study the scientific discussion and the policy narrative changed from trying to achieve national full self-sufficiency to searching for the right mix of local production and international trade.

Figure 32. Qatar case study of the water, energy and food nexus.

Combined self-sufficiency = 15% (2010)

Tomato and **Cucumber** are partially done in protected agriculture

Groundwater is main source for agriculture

Natural Gas is main source of energy

Imports secured from **15 different countries**

WATER (m3)	5,783,797
LAND (ha)	792
E1 (kJ)	24,699,706,932
E2 (kJ)	15,000,733,177
C1 (ton CO2)	3,039,436
C2 (ton CO2)	1,089
F Local (QAR)	48,940,200
F Import (QAR)	3.68E+08
E IMP (kJ)	1.2117E+12
C IMP (ton CO2)	92,987

Source: Daher and Mohtar (2013)[289]

Thailand

The Thai case study focused on analysing bioenergy policies.[292] The Thai government developed an Alternative Energy Development Plan (AEDP) for the period 2012–2021. The aim is for biofuels to eventually substitute 44 per cent of national oil consumption. According to the AEDP, ethanol production (primarily from cassava and sugar cane) would increase from 1.3 million litres per day in 2012 to 9 million litres per day in 2021. The production of biodiesel (primarily from crude oil palm) would increase from 1.62 million litres per day in 2012, to 5.97 million litres per day in 2021. The expectation is also to produce 25 million litres per day of new fuel for diesel substitution in 2021. The new fuel development strategies include new energy crop development, including jatropha and micro algae, the development of oil conversion technology, and ethanol blending for diesel oil.

Baseline scenarios were developed for ethanol and biodiesel following the AEDP assumptions. Alternative scenarios explored a range of assumptions regarding energy crops for biofuel production (leaving all other assumptions fixed). The baseline scenarios (following AEDP) suggest that in order to meet ethanol target, demand for sugar cane and cassava production in 2021 will grow by 8 per cent and 26 per cent, respectively, from 2012. Future land requirement for growing sugar cane and cassava in 2021 will increase by 16 per cent. To achieve the biodiesel target, demand for oil palm production in 2021 will rise by 82 per cent from 2012. Future land requirements for growing oil palm would increase by about 106 per cent, i.e. more than double from 2012.

Regional case studies and river basins

A number of regional case studies are being undertaken in the Pacific, the Indian Ocean, Africa, Europe and Central Asia (Table 42). Several case studies focus on river basins, including for the Danube, the Nile, and the Mekong basin. In the context of the nexus task force under the UNECE Water Convention, assessments of another thirteen river basins have been proposed in Europe, Asia and Africa (Table 43).

Table 42. Regional CLEWD case studies and river basins (on-going or recently completed)

Case	Research	Approach	Partners	Source
Nile Basin *(on-going, first results expected in 3rd quarter 2013)*	Assessing trans-boundary water – energy interlinkages and options to optimize water resources.	Interlinkages of LEAP and WEAP	Sponsors: KTH, SEI (Cooperation between SEI (responsible for water modelling) and KTH (responsible for energy) with connections to FAO	Hoff (2013)
Pacific Islands *(initiated)*	Development of a CLEW model for small island developing states to address multidimensional resource shortages.	Indicator based approach (AEZ, LEAP)	KTH, IRENA	
ISLANDS project in the Eastern and Southern African and Indian Ocean Region	Integrated case studies in Comoros, Madagascar, Mauritius, Seychelles, Zanzibar	Systems dynamics model. Nesting learning-by-doing, multi-stakeholder approach	Indian Ocean Commission; Ecological Living In Action Ltd (ELIA); Sponsor: EU' European Development Fund	Deenapanray and Bassi (2014)[293]
CLEWs in Africa *(on-going)*	Indicator based CLEW approach to define resource constrained regions.	GIS based approach (AEZ)	KTH	Howells (2013).
Trans-boundary CLEW Analysis in Europe and Central Asia *(initiated)*	Looking at CLEWs from the water perspective: finding ways of integrating resource assessments from the perspective of trans-boundary river basin regions.	Set of models	UNECE (together with FAO, SEI and KTH)	
Middle East *(ongoing)*	Water, energy, drought & climate change	Technical cooperation project, WEF web tool	Qatar Environment and Energy Research Institute (QEERI)	Daher and Mohtar (2013)
Danube basin *(ongoing)*	Water-agriculture-energy- ecosystems nexus. Biophysical and economic assessment	Set of models. Participatory scenario building. POLES model	Joint Research Centre of the European Union (JRC-IES), IPTS, IET	Bidoglio (2013)[294]
Mekong basin *(ongoing)*			Mekong River Commission	

Table 43. Proposals for basins to be assessed (Water-Food-Energy-Ecosystems Nexus) under the UNECE Water Convention

River	Riparian countries	Proposed by
Sava	Albania, Croatia, Bosnia and Herzegovina. Montenegro, Slovenia	Sava River Commission
Narva	Estonia, Latvia, Russian Federation	Ministry of the Environment of Estonia
Dniester	Republic of Moldova, Ukraine	Moldovan Environment Ministry
Alazani	Azerbaijan, Georgia	State Agency for Water Resources under the Ministry of Emergency Situations of Azerbaijan
Araks	Armenia, Azerbaijan, the Islamic Republic of Iran, Turkey	State Agency for Water Resources under the Ministry of Emergency Situations of Azerbaijan
Ural	Kazakhstan, Russian Federation	Water Resources Committee
Chu and Talas	Kazakhstan, Kyrgyzstan	Water Resources Committee
Aral Sea Basin	Afghanistan, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan	Executive Committee of the International Fund for Saving the Aral Sea, Scientific Information Centre of the Interstate Committee for Water Coordination
Vakhsh, Pyanj, Kunduz (upper Amu Darya)	Afghanistan, Kyrgyzstan, Tajikistan	Ministry of Land Reclamation and Water Resources, Tajikistan
Mejerda	Algeria, Tunisia	Ministry of Agriculture, Tunisia
Niger	Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger and Nigeria	Niger Basin Authority and the Wetlands International
Sesan, Srepok and Sekong rivers (Mekong)	Laos, Vietnam and Cambodia	Conservation International
Marowijne	Suriname, France (Department of French Guiana)	Conservation International

Source: UNECE (2013)[295].

6.6. Conclusion

Innovative, pragmatic solutions

The CLEWD case studies illustrate the benefits of integrated approaches. In particular, they helped identifying innovative and better solutions. CLEWD results also provide important lessons for the ongoing discussions on the definition of SDGs. In fact they indicate a need to include clusters of strongly interlinked issues in the SDG discussions, beyond the sectoral and thematic approach.

Concerns have been voiced about an increasingly complex hierarchy of assessments, which is perceived as burdensome by some parts of many Governments and the private sector. In order to make scenario modelling relevant and sustainable at the same time, this problem must be acknowledged and some of the lower level (project) assessments might be replaced by fewer higher-level, strategic assessments.

The CLEWD nexus approach is a pragmatic approach to integrated assessment for selected clusters of strongly interlinked issues. It is not specific to the particular set of issues. It should be noted, however, that the “right” cluster of themes is case specific. In some cases, these clusters can be narrower (e.g., energy-water), in others they need to be wider (e.g., including biodiversity). Carrying out a CLEWD-type nexus assessment requires cooperation among different disciplines and various parts of government, with potentially important overall governance and economic benefits.

Financing the nexus

A number of simple lessons can be learned from CLEWD nexus case studies presented above. Integrated approaches that focus on clusters of strongly interlinked issues, such as the climate-land-energy-water (CLEW) nexus, can help identify innovative and sustainable solutions. Innovative CLEW nexus solutions are "cheaper" in terms of mitigation costs, but may mean shifts of investments across sectors. There are typically both "winners" and "losers" from integrated solutions, potentially leading to political economy issues. Since components of CLEW nexus solutions depend on what happens in other parts of the system, investors may face additional uncertainty and risks, which might make nexus solutions less attractive to investors. Benefits of integrated approaches differ greatly between and within countries, and thus good financing strategies have to be tailored to country situations. CLEW nexus projects are expected to face important challenges in tapping into financial resources provided by local and international financing institutions and funds due to the existing fragmentation by narrowly defined sectors and activities.

Hence, the following may be considered for effective financing of the CLEWD nexus.

Coordination risks can be mitigated, compensated or shared by a range of actions, such as sustainability certifications and risk guarantees.

Small islands and countries in water stressed regions subject to significant additional stresses from climate change would benefit the most. It could justify preferable access for these countries to international public funds.

CLEW nexus solutions may require rethinking the international public finance architecture in support of development and climate change, as well as a reconsideration of current practices of local and international financial institutions, including in terms of financial engineering.

Efforts at the national and sub-national levels to build financial engineering and financial management capacities will be required to enable integrated solutions to emerge in practice. Bottom-up networks of practice, supported as necessary by the international community, could help in this regard.

The intergovernmental follow-up to Rio+20 and the post-2015 development agenda should consider the issue of financing CLEW and other relevant, interlinked issue clusters. There may also be a need for a technical support mechanism for financing CLEW.

7. Selected science digests

Another potential function of the Global Sustainable Development Report may be to provide digests of recent scientific findings to government officials who follow the UN sustainable development debate.

A group of young researchers from New York University (SUNY-ESF), Yale University, and Tufts University in the United States of America; Wageningen University in the Netherlands, and the Royal Institute of Technology in Sweden (KTH-dESA), contributed to this report. The group of young researchers was very international with the majority of them originally from developing countries. They prepared, inter alia, a series of science digests/briefs that were validated by science peers from both developed and developing countries. The full text of the science digests will be available at the UN Website. As an example, Table 44 lists the briefs that were selected and prepared by team at Wageningen University in the Netherlands. Three of these briefs are presented as illustrative examples in this chapter: (a) ocean acidification, (b) marine microbial ecology and bioreactors, and (c) protein substitutes and the livestock sector.[296] The briefs introduce and explain the issues, describe the scientific debate and suggest issues for consideration. They have been minimally edited, in order to illustrate what can be realistically expected with this approach. If a wide group of young researchers were mobilized in this way across the world, a very useful library of high-quality briefs could be developed, possibly in a range of languages.

Table 44. Overview of science digests provided for this report by young scientists at Wageningen University

Rio+20 theme	Science digest
Oceans	(i) Ocean acidification
	(ii) Marine microbial ecology and bioreactors
Sustainable consumption and production	(iii) Biocatalysis
	(iv) E-waste
Food security	(v) Protein substitutes
	(vi) Large-scale land investments
	(vii) Phosphorus Security

Source: Team of young researchers (Dec. 2013).[297]

The potential value added of science digests is to shed light on specific aspects of broader themes highlighted in intergovernmental documents such as the Rio+20 outcome document, which more often than not do not go too deep into detail. For example, most of items in Table 44 were not mentioned in the Rio+20 outcome documents, including bioreactors, bio-catalysis, protein substitutes and phosphorus security. It is interesting to note that the young researchers chose many issues that did not only highlight problems, but that were also scientific-technological solutions (e.g., bioreactors and protein substitutes). This is a very encouraging indication for the future.

The Science Digests were geared towards a public audience composed of senior government officials and policy makers with an interest in learning more about new scientific insights and concerns on sustainable development. The author first selected the broader topic (e.g. sustainable production and consumption of livestock products) based on personal background, interest and preliminary ideas on the impact of the issue regarding sustainable development. To check if the selected topics were in fact emerging within the scientific community, the topic was put into several scientific databases (e.g., Scopus, ISI Web of Knowledge, and Google Scholar). Within the broader topic, emerging issues were determined on the basis of findings in recent literature (from 2009 onwards) and exploratory interviews, and again, the emergence of the issue was checked with the graph resulting from the number of publications over time. The Science Digests were built on literature study and exploratory interviews with experts, conducted in person or via telephone or email, depending on the availability and location of the interviewee. The experts were chosen on the base of their background, expertise and knowledge on the topic, and some of them were authors of articles that had been part of the literature review for the Science Digests. Experts were from both developed and developing countries. Expert interviews were also used as a method to validate the content of the Science Digest.

If science digests become part of a global sustainable development report, attention need to be given to the process used to prepare science digests, including who frames the question and what knowledge is included.

7.1. Ocean Acidification

Ocean acidification was highlighted in §166 of the Rio+20 outcome document: "*We call for support to initiatives that address ocean acidification and the impacts of climate change on marine and coastal ecosystems and resources. In this regard, we reiterate the need to work collectively to prevent further ocean acidification, as well as to enhance the resilience of marine ecosystems and of the communities whose livelihoods depend on them, and to support marine scientific research, monitoring and observation of ocean*

acidification and particularly vulnerable ecosystems, including through enhanced international cooperation in this regard." However, no reference was made to the extent of the problem or possible solutions to it. The following science digest provides an overview of scientific findings to support an informed discussion among decision-makers in the follow-up to Rio+20.[298,297]

Introduction

The problem of ocean acidification, also called "the other CO_2 problem"[299], is seen as one of the largest threats to marine ecosystems and organisms.[300] Oceans have the natural ability to absorb carbon dioxide (CO_2). When CO_2 dissolves in the ocean, it forms carbonic acid, which leads to a reduction in seawater pH and thus more acidic conditions in the oceans. Since preindustrial times, there has been a 30 per cent increase in ocean acidity.[301] This natural buffering is being used as a means to mitigate anthropogenic climate change, but the speed and magnitude of the ocean acidification process adversely affects marine ecosystems and species.[302]

The consequences of ocean acidification are far-reaching and multi-dimensional, affecting the marine environment directly and indirectly.[303] Ecosystems' functioning will be hampered due to ocean acidification, especially those who form shells and plates.[302] Subsequently, other organisms that feed on them will face changes in the availability and composition of nutrients as a result of the increased acidity.[303]

Furthermore it is expected that ocean acidification will affect various economic sectors such as fisheries, aquaculture and tourism,[304] and consequently food security.[305] Among the most affected are communities living in areas highly dependent on fisheries, mostly coastal communities in developing countries. 26 out of the 30 countries that are the most dependent on fish as a protein source are developing countries.[306]

Ocean acidification facts & figures

- Over the past 50 years, the oceans have absorbed between 24% and 33% of the CO_2 emissions.[307]
- There has been a 0.1 pH unit reduction since pre-industrial times, and an additional decrease of 0.4 pH is expected for the upcoming 100 years.[301]
- Especially organisms that form shells and plates, such as plankton, corals and coralline algae will be among the most affected.[299]

Scientific Debate

Researchers already have been making efforts to find measures to adapt to and mitigate ocean acidification. There are several options to take action against ocean acidification, ranging from solar radiation management to improving ecosystem resilience. The options of 'reducing CO_2 emissions' and 'removing atmospheric CO_2' have the greatest potential. [304] However, political and social feasibility of reducing CO_2 emissions raises concerns and therefore, depending on the viewpoint, feasibility can be considered relatively high or low.[304]

This is mainly because of the difficult positioning of ocean acidification in scientific and political debates. Ocean acidification is linked to the climate change agenda as well as to the marine pollution agenda.[308] In both regimes ocean acidification is partly regulated, but the problem in its entirety is addressed by neither. This phenomenon is called the 'international twilight zone' in which ocean acidification is placed.[308, 309]

It can be illustrated by looking at the positioning of ocean acidification within the climate change debates.

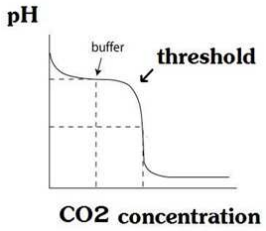
Ocean acidification is frequently linked to climate change in policy frameworks, since the climate system is defined to include the oceans.[309] What is important to stress out is that ocean acidification is not an effect of climate change, it rather shares the same cause as climate change: an increase of atmospheric CO_2. [309]

Consequently, actions to mitigate adverse effects of climate change do not necessarily contribute to mitigation of ocean acidification.[310] Current agreements do not prioritize reductions in CO_2 emissions, but work with overall reduction of greenhouse gas emissions.[304] Ocean acidification can only be tackled by a reduction in CO_2 emissions, and this has not been incorporated in current agreements. Therefore current agreements may not necessarily lead to a reduction in ocean acidification.[309]

The geophysical processes of ocean acidification are generally well known.[311] From this information, scientists proved that there will likely be a threshold value for the uptake of CO_2 concentration in the oceans.[311] A threshold is defined as a transition in the functioning of an environmental system.[312, 313] Oceans can thus be used as buffers for CO_2 concentration, but as soon as the maximum of this buffer is reached, dramatic declines in the pH level will follow (Figure 33), leading to a rapid increase in ocean acidity. Reaching the threshold value then leads to shifts in an ecosystem that are irreversible. "*Currently we don't*

know the position of the threshold. Furthermore we don't know when we notice that the threshold value is reached, and if this will be noticed in time. This means that currently we also have no clear idea on the time that is left to take action against ocean acidification".[314]

Figure 33. Effect of CO_2 on pH value



J. Rockström et al. [311] define possible planetary boundaries within which we can expect that human-induced CO_2 emissions can be handled without the risk of reaching the threshold. However, the article also expresses the uncertainty of this planetary boundary, because the response of ecosystems is still unclear.

Food for thought on ocean acidification
• Reducing CO_2 emissions is not the only way to take actions against ocean acidification, but cannot be compared to the other actions in relation to scale. Therefore a reduction in CO_2 emissions is much more effective • Mitigation of climate change does not necessarily equate to mitigation of ocean acidification. • It is vital that ocean acidification will be better incorporated in the climate change debate. This can easily be done by focusing more on CO_2 emission reduction • The "safe" level of atmospheric CO_2 with respect to ocean acidification is yet unknown.[311]

Issues for further consideration

The following issues were suggested by the team of young researchers for consideration by policy makers:

- There is a need for extended research on the effects of ocean acidification focusing on interdisciplinary issues of ecological and socio-economic impacts
- There should be put a larger emphasis on the reduction of CO_2 emissions by policy makers and within the current climate change debate
- There is a need for information on the threshold pH value for concentration of CO_2 in the oceans.

7.2. Marine microbial ecology and bioreactors

The Rio+20 outcome document – in §158 - expressed a general commitment to protect and restore marine ecosystems: *"…We therefore commit to protect, and restore, the health, productivity and resilience of oceans and marine ecosystems…"* However, no reference was made to the marine microbial ecology or the potentials of bioreactors. The following science digest provides an overview of scientific findings to support an informed discussion among decision-makers in the follow-up to Rio+20.[315, 297]

Introduction

The oil spill in the Gulf of Mexico in 2010, where the equivalent of 4.9 million barrels of oil was released into the environment, attracted a lot of attention among policy makers and civil society. However, the impacts on the ecosystem turned out to be less catastrophic than expected due to marine microbes digesting the oil spill, even though there are signs of permanent damage.[316] This is a clear example of the adaptive properties of bacteria and the wide range of compounds they can feed on.[317] Microbes also have a very diverse range of substances they can produce and are at the base of healthy, stable, ecosystems all over the world. Marine Microbial Ecology, while still a relatively new field of research, is rapidly uncovering the importance of microbial life in nutrient availability in ecosystems. This is no different for marine environments in which, for example, processes such as nitrification[318] and CO_2-fixation[319] are mainly regulated by microorganisms. Seeing as how over 90% of the ocean's biomass is estimated to be microbial life[320], it is no surprise that their role is crucial in ecosystems. However, because this field has only become an important topic in the last 10 years or so[321], in-depth research is still lacking and only general findings exist in terms of marine biodiversity[322] or in relation to human health.[323]

Marine microbial ecology and bioreactors: facts & figures
• Over 90% of marine biomass consists of microbial life. • An estimated 50-80% of all biomass is found under the ocean surface. • Microbial phytoplankton makes up the basis of the marine food chain and is responsible for producing 50% of the world's oxygen. • Microorganisms are also the main drivers behind nutrient availability in marine ecosystems. • However, microbial community dynamics are still poorly understood.

Scientific Debate

Within the scientific community there is still debate on the determination of microbial species due to having only small amounts of genetic material to work with [324] In addition, one of the difficulties is determining marine microbial

biodiversity, as the sheer number of species is very high and the data of different areas is not properly integrated.[325] There are also the technical difficulties of measuring a large area like the ocean, which naturally comes forth from the trade-off of either covering a large area or getting a detailed description.[325] However, it is becoming more clear that a large microbial biodiversity is not necessarily the main reason for a healthy ecosystem. Rather, the composition of a certain microbial community may be a stronger indicator than biodiversity [326] and microbial community dynamics change when influenced by other factors, such as an increase in CO_2-levels.[327] As such, a change in a microbial community might have a big effect on the ecosystem's nutrient cycles[328] and, due to this, on the other organisms living there as well.

There have been suggestions of connecting the current assessments of marine biodiversity into a single global assessment on marine biodiversity. Such a systems approach is needed in order to establish the importance and function of microbial communities in ecosystems. If this is known this knowledge can possibly be applied in increasing ecosystem resilience or assisting in ecosystem restoration, such as the oil spill.[329] This would not only help in improving the current assessments on marine life but also in linking the data on marine ecosystem health at all different levels "*from microbes to whales, […] to entire ecosystems*".[325]

Where on the one hand microbial communities are to be studied and researched in order to determine their interactions with the ecosystem, on the other hand there is an ever growing interest in the scientific community in bioreactors. A bioreactor is a machine that optimizes a natural environment for growth of specific microbial species and communities. The marine bioreactors focus on microbial life that needs such specific living conditions (high salt concentrations, high pressure, etc.), that they cannot be cultured in a laboratory.[330] By positioning the bioreactor off the coast on the sea floor, the bioreactor's microbial life is able to thrive under its natural conditions. These bioreactors could even lead to a system in which the ocean is used in the sustainable production of medicine or other chemical substances, clean energy, or even food.[330] Moreover, increased use of bioreactors could lead to production of energy or biological compounds in a sustainable manner without damaging the ecosystem where the bioreactor is positioned.

In short, more efficient research into microbial communities and their interactions with the environment can be attained through biodiversity assessments. This could lead to better utilization of bioreactor technology. Finally, a better understanding of microbial ecology can help us in many fields, from ecosystem resilience and restoration to even a higher yield in seafood production.[331]

Food for thought on marine microbial ecology and bioreactors

- Microbial communities, while not yet completely understood, are at the base of a healthy ecosystem.
- A global biodiversity assessment network helps in understanding the dynamics in microbial communities.
- A good understanding of microbial community dynamics can lead to new ways of ecosystem restoration and resilience.
- Bioreactors combine the 'special talents' of certain microbial species with the native marine environment to produce chemicals and energy without damaging the ecosystem.
- Stimulation of use of bioreactors can lead to enhanced a use of ocean for sustainable production.

Issues for further consideration

The following issues were suggested by the team of young researchers for consideration by policy makers:

- Establishment of a global assessment on marine biodiversity, with special attention to microbial biodiversity
- Stimulation and promotion of research in application of bioreactors in marine environments
- Improved understanding and functioning of marine microbial communities

7.3. Protein substitutes and the livestock sector

The Rio+20 outcome document expressed a general commitment to food security and nutrition in §108 to 118. However, no specific reference was made to protein substitutes and the livestock sector. The following science digest provides an overview of scientific facts to support an informed discussion among decision-makers in the follow-up to Rio+20.[332, 297]

Background

Livestock products have been, and continue to be important elements of the human diet. At the same time, it is the agricultural sector with the highest negative impact on the environment and human health, particularly in countries where intensive agricultural methods prevail.[333] The sector is associated with nutrient losses, pesticide leakage and utilization of large tracts of agricultural land, water and fossil fuels. These systems contribute to GHG

emissions[334] and climate change[335], threatening sustainable development.

Facts and figures - protein substitutes

- The livestock sector is responsible for about 18% of the total worldwide GHG emissions, it uses about 70% of the available agricultural land and represents about 8% of global water usage;[336]
- Feed production is responsible for 50-85% of climate change, 64-97% of eutrophication potential, 70-96% of energy use in the whole animal production system;[337]
- 2 to 15 kg of plant material is needed to produce 1 kg of animal products(low energy conversion);
- 40% to 50% of the global grain harvest is used for feed production; 338
- Regarding land use, eutrophication and acidification, consumption of livestock products is responsible for 43%, 51%, and 60%, respectively, and impacts, the entire food domain.[339]

However, in response to a rising demand for livestock products, intensive livestock production has expanded steadily in the last half century, both in developed and developing countries.[340] According to the FAO,[341] the global demand for animal products, and subsequently demand for feed, is expected to double by 2050, due to an increasing world population, rising incomes and further urbanization, but constrained by climate change (this can negatively affect productions). With this, the increased competition for land for other application will result in increased food and feed losses.[342]

Developed countries experience high levels of overconsumption and intensive production of livestock products. However, there is low growth or even stagnation of growth in the sector, while developing countries experience an increase in production and consumption, and the sector is shifting from an extensive pattern towards an intensified one. Increasing numbers of people in developing nations express a desire for a more Western-style diet, and, consequently, the pressure on natural resources accelerates.[343]

In the livestock sector, feed production (cultivation, processing and transport) and livestock consumption represent the main sources of impacts regarding GHG emissions and use of resources such as land, water, energy, nutrients and biodiversity.[338, 337, 344] This paper aims to provide mitigation options, represented by sustainable protein substitutes for food and feed related to the livestock sector.

Scientific Debate

The discussion revolves around how to combine reduction in the negative impact of the livestock sector using technological measures, and reduction in livestock production and consumption, without undermining food security.[336] In the entire chain of production and consumption of livestock products, feed production and livestock consumption by humans are by far the most important contributors to environmental impacts in the sector. In this paper attention focusses on one of the new potential mitigation options: novel and/or more sustainably produced protein substitutes for food and feed that are now more widely available, than ever before.[338,345, 346]

A human diet based on the exchange of the meat portion in the diet with meat substitutes, has lower climate and land use related impacts, than a diet with food products of animal origin.[347] Substitutes such as legumes, pulses, vegetables and cereals, eggs, or novel protein sources like insects, algae, duckweed, and rapeseed or products based on plant proteins present lower impacts compared to livestock products, and could completely substitute these.[345, 348, 349, 350]

Food for thought - protein substitutes

- "Identification of new feed resources is crucial for sustainable animal production and future viability";[342]
- Protein intake in the European Union is 70% higher than the levels recommended by the World Health Organization;[351]
- Given the low energy conversion and the high demand for land associated with livestock production, reduction in livestock product consumption could reduce the need for more food;[335]
- A global transition towards low-meat diets may reduce the costs of climate change mitigation by as much as 50% in 2050;[352]
- The transition towards more sustainable food production and consumption requires cooperation of multiple actors: policymakers, NGOs, traders, farmers, and consumer. This transition will encounter cultural, political, and commercial resistance.[353]

It is also important to orient research towards the development of new feed substitutes that can replace cereals as major source of nutrition for pigs, poultry, dairy cows and cattle.[354] Use of agricultural co-products, by-products, insects, duckweed, seaweed or microalgae that have less impact related to emission and resource use (e.g. land) than conventional feed, can be an alternative for importing feed from other countries, and can transform an inedible product into an edible one.[338, 346, 350, 342, 355] V. Smil states that "*assuming that the area now devoted to feed*

crops were planted to a mixture of food crops, and only their milling residues were used for feeding"[356], food could be provided for 1 billion people. Some co-products are already being used in diets of livestock. In 2007 in the Netherlands, 22% of livestock diets were composed of co-products (e.g. beet tails).[357] The main barriers in the use of novel sustainable protein substitutes are legislations, technical and processing challenges, and limited knowledge about possible food safety hazards, including a range of contaminants.[346] T

New technologies and innovations in food production needs to be combined with a shift in consumption, since technology and society cannot be considered to be independent of one another.[344] Increased awareness of the environmental impact of food, concrete choices in favour of alternative sources of protein and eco-friendly products and a general global consensus on the importance of decreasing food waste and over-consumption, is needed.[336, 358, 359, 360, 361]

Further issues for consideration

The following issues were suggested by the team of young researchers for consideration by policy makers:

- Increase availability and presence in the market of protein substitutes in human food and animal feed through the use of policy instruments, subsidies, research for their development, improvements of legislation and regulation regarding safety and use aspects of new proteins;
- Decrease impact due to feed production and increase awareness of farmers about the impact of different feeds;
- Influence reduction in meat and dairy consumption in western countries and environmental awareness about livestock product consumption both in developed and in developing countries.

8. Issues for Consideration

"No society can surely be flourishing and happy, of which the far greater part of the members are poor and miserable." (Adam Smith).

8.1. Lessons-learnt from the preparation of the present prototype

There are thousands of relevant scientific assessments at various temporal and geographic scales. Most of them focus on specific systems and sectors. For example, there are 1,023 assessments in the database of the Assessment of Assessments on Oceans and 182 assessments at multiple scales in the database of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. These lists are growing and have to be updated on a regular basis.

Assessments differ greatly in terms of scope, scale, organization, process, participation, resources and perceived policy relevance (Table 6). Three broad groups can be distinguished: intergovernmental scientific assessments; scientific-technocratic assessments; and scientific research collaborations. When asked about their preferred assessment model for future editions of the Report, experts typically suggested either the conventional UN flagship publications model, a multiple stakeholder model with national contributions, or the IPCC model. Experts from developing countries tended to be more sceptical of the IPCC model, in view of its focus on peer-reviewed knowledge dominated by Western journals (accounting for 97 per cent of the references in IPCC reports).

Many countries and some regions have established processes to prepare sustainable development reports, many of which are supported by local scientific communities and feature local priorities. Hence, a bottom-up approach for the global Report would benefit from such rich and dispersed local policy-relevant knowledge.

"Crowdsourcing" proved a useful tool to identify new and emerging issues that scientists would like decision-makers to consider for action. The identified issues differed significantly from issues highlighted in the ad-hoc expert group meetings and from issues identified by the young researchers. Hence, for a balanced result, the global Report may want to allow for a wide range of participation through multiple channels and feature a wide range of perspectives. Yet, crowdsourcing has its limitations. Protocols for evaluating non-conventional sources of scientific knowledge might be needed.

The review of sustainable development progress provided evidence that impressive gains in some areas have come at the expense of worsening trends in other areas in recent decades. Hence, integrated assessment is needed to monitor inter-linkages between issues and themes.

Scientific assessments of progress can sometimes lead to rather different results compared to institutional assessments of progress against agreed goals or commitments. Both are important, but are different in nature. Hence, a traditional monitoring report focused on progress towards SDGs might not by itself strengthen the science-policy interface, let alone strengthen the science-policy-society interface which also requires involvement of stakeholders.

Views differ across governments, civil society groups, academia, and the public on the progress made, remaining gaps and ways forward toward sustainable development. Some of the differences arise from the adoption of different system boundaries and time scales, ranging from current, local actions all the way to the Earth's biota and a perspective of thousands of years. Interactions between system boundaries and time scales are non-trivial, and, in fact, policy recommendations derived from short-run and narrower approaches are often contradictory to those predicated on long-run, broader considerations.

A global scale and the time frame of the next two generations until 2050 – together with intermediate milestones – has proven to be a reasonable choice for addressing – in an inter-generationally equitable way – many of the issues on the sustainable development agenda, such as eliminating poverty and hunger; enabling livelihoods; feeding, nurturing, housing, and educating everyone; securing peace, security and freedom; and preserving the Earth's life support systems.

Separate assessments and goals do already exist for all the thematic areas currently on the agenda of the Open Working Group on SDGs. However, an integrated assessment is lacking that could identify alternative "future pathways" that resolve trade-offs and build synergies between policy actions. In this context, scenarios can be

useful and help in reducing uncertainties over the required levels of investment and international cooperation for achieving SDGs. Hence, the Report might promote in-depth cooperation on sustainable development scenarios. Implementation of modern Integrated Sustainability Assessment (ISA) could be considered (see Box 8).

Box 8. Integrated Sustainability Assessment

"ISA is a cyclical, participatory process of scoping, envisioning, experimenting, and learning through which a shared interpretation of sustainability for a specific context is developed and applied in an integrated manner in order to explore solutions to persistent problems of unsustainable development."[362] ISA consists of iterative stages:

Scoping stage: This involves a problem definition and a context-specific interpretation of sustainability acceptable to stakeholders. It requires integrated systems analysis. The project team and stakeholders may have different perspectives arising from differences in norms, values and perceptions. Models and other tools can be useful to find common ground regarding the problem perception.[363]

Envisioning stage: Scenarios or visions explicitly aiming at sustainability are developed with the stakeholders. Most often a picture of a desirable future is developed first and then pathways towards are elaborated it in a second step ("backcasting"). Stakeholder input can also be used to formulate policy options in the scenarios, and to make a first narrative assessment of the sustainability impacts of these proposals

Experimenting stage: The sustainability visions and policy proposals are tested in terms of consistency, adequacy, robustness and feasibility. Transition pathways from drivers to sustainability goals, the sustainability impact of policy proposals and trade-offs are tested and explored. Quantitative models and qualitative methods can be used, or options could be tested in real life. The knowledge of stakeholders can help to choose the appropriate set of tools and to ensure that the assessment is capable of answering questions that stakeholders think are important.

Learning, evaluating and monitoring stage: Learning experiences and lessons are made explicit. Besides internal evaluation, the views of the stakeholders are elicited. Evaluation of the composition of the stakeholder group and the methods of engagement also takes place at this stage.

The next ISA-cycle can potentially lead to a reframing of the shared problem perception, an adjustment of the sustainability vision and related pathways, and a reformulation of the experiments to be conducted.

Scientists and UN entities have promoted a long list of sectoral as well as aggregate indicators. They have been developed with different objectives and organizational interests in mind. In particular, there has been no agreement on a comprehensive, aggregate indicator of sustainable development progress that might complement GDP. Remote sensing and other "big data" approaches beyond official statistics show strong potential for assessing long-term sustainable development progress at various spatial and temporal scales, especially in the poorest parts of the world where official data is scarce.

Selected science digests might be a useful way to involve scientists in highly specialized fields to engage in the broader science-policy interface at the HLPF.

Case studies of the climate-land-energy-water-development nexus illustrate the benefits of integrated approaches focusing on issue clusters rather than sectors or themes. They can help in identifying innovative and better solutions. As the "right" cluster of issues for integrated policy is case specific, future editions of the Report might analyse and identify other important issue clusters. Looking at these issues in an integrated way may support efforts for more integrated decision-making.

8.2. Selected issues

The following are selected issues for consideration on the overall direction.

Potential overall directions

In the future, the Global Sustainable Development Report could provide science-based inputs for deliberations of the high-level political forum on sustainable development. It can also contribute to agenda-setting of the forum by identifying new and emerging issues that would need addressing at the global level, as well as identifying new developments in issues currently under consideration. The report could report on global progress in the achievement of the SDGs, once adopted in 2015. In addition, it could provide scientific evidence for linking global goals with the means to achieve them. Ultimately, the Report will help in improving the science-policy interface for sustainable development, as called for at Rio+20. Ideally, it might even contribute to improving the science-policy-society interface.

Regular assessment of assessments to identify common ground and different views

Decision-makers may want to task assessment processes, in the context of this assessments of assessments on sustainable development, not only to identify scientific consensus, but equally to focus on describing differences in view, including from minority groups of scientists, extending beyond the dominant peer-reviewed academic journals.

Various types of knowledge and many perspectives

Various types of knowledge and many perspectives could be taken into account, especially those of scientists in developing countries including the poorest and most

vulnerable countries. This requires taking into account a wider range of social and natural sciences as well as sources of knowledge. It also requires going beyond the peer-reviewed literature and to inclusion of local and traditional knowledge, including knowledge of practitioners. Eliciting the knowledge held by government officials and policy makers, and fostering closer interaction between the science and policy making communities from the beginning of assessment processes and also involving various stakeholders, would also support the function of strengthening the science-policy-society interface.

Wide range of participation through multiple channels.

A wide range of participation could be encouraged through multiple channels. Tapping into the expertise of the whole UN system and a wide range of scientific communities will be important. In order to allow for participation by a wide range of scientists and stakeholders, multiple channels of input should be open, such as through crowd-sourcing using online and offline methods. Protocols for evaluating such non-conventional sources of scientific knowledge will be needed.

New technologies and approaches.

The full range of new technologies and methodologies might be employed not only to facilitate participation in scientific assessments but also possibly for monitoring progress. Examples include monitoring sustainable development progress from space (by combining remote sensing with other data) and employing multiple methodologies and approaches, for example, for aggregate measures of sustainable progress beyond GDP. Different methodologies can lead to rather different conclusions, as illustrated in the full report with the case of monitoring poverty trends. Ethical aspects might also be considered.

UN institutional platform for sustainable development models and scenarios

The present report argues for a major effort to draw on the wider range of global modelling capabilities, in order to assess various sets of sustainable development objectives and eventually the set of SDGs ultimately agreed by Member States, and explore pathways toward their achievement, including in terms of technology and financing needs. A UN institutional home, or platform, for SDG-related scenarios and global models could prove beneficial, especially if it is connected to the Global Sustainable Development Report. The Report could look at other clusters of strongly-interlinked issues, in addition to the climate-land-energy-water-development nexus, which would benefit from an inter-agency capacity building initiative to support national planners.

This would provide a direct link between global and national policy, fostering joint action and mutual learning.

Multi-stakeholder approach

The UN's "SD21 study" in preparation for Rio+20 provided a good basis for future sustainable development reports. In particular, it provided elements of a multi-stakeholder approach to coherently address sustainable development at all relevant levels. The suggested framework takes into account the wide range of different perspectives and values of stakeholders, yet it aims to support coherence of actions for sustainable development at all levels. Annex 7 provides elements of the framework.

8.3. Options for scope and methodology of a global sustainable development report

Finally, several options are put forward for the scope and methodology of a global sustainable development report. These options are based on responses by Member States and UN system entities to a questionnaire on the subject (Annex 6), and also draw on lessons learned from the exploratory, multi-stakeholder process to produce the present prototype. The options have been recommended by the UN Secretary General in his report on "*Options for scope and methodology of a global sustainable development report*" which was prepared pursuant to General Assembly resolution A/RES/67/290 of 9 July 2013 on the "Format and organizational aspects of the high-level political forum on sustainable development".

Member States, the UN system and many scientists already agree on many of the elements that define the scope and methodology of a global sustainable development report. These elements are summarized in Table 45 and could be considered in the way forward.

Table 45. Common elements of majority agreement on scope and methodology of the Report

Element	Agreement
Added value	Easy access for decision-makers to findings of many scientific assessments. Highlight synergies and trade-offs between policy actions in various settings.
Focus	Focus on implementation, obstacles to progress, good practises of integrated policy
Capacity needs	Joint UN effort to support developing countries' participation
Audience	Policy makers, senior government officials and wide range of stakeholders
Scope in terms of issue focus	Priority issues identified in the Rio process, including Agenda 21, the Rio+20 outcome, as well as other internationally agreed goals and commitments. Supports HLPF and implementation of future SDGs and post-2015 development agenda
Geographic scope	Global and five UN regions, with analysis for groups of countries in special situations
Time horizon	Medium- (10 years) to Long-term (20 to 50 years)
Global issues covered	HLPF agenda, Rio+20 outcome document, Agenda 21, future SDGs and post-2015 development agenda
New and emerging issues	Identification based on sound scientific evidence
Coordination of report process	UN task team coordinated by the HLPF Secretariat (DESA's Division for Sustainable Development) at the global level and Regional Commissions at the regional level
Type of content	Past and future trends; lessons-learnt; scientific findings indicating potential areas for policy action; opportunities and challenges for implementation
Periodicity	In-depth report every four years coinciding with HLPF sessions under the GA, and focused report contributions for the HLPF sessions under the auspices of ECOSOC.
Normative or descriptive	Policy-relevant content and options, but not normative policy recommendations
Monitoring and accountability framework for SDGs/post-2015 development agenda	The Report possibly to become one of several contributions to the framework. Details are to be decided after 2015
Scientific methods	Multidisciplinary, integrated approach in the spirit of sustainability science. Precise methods to be decided by scientists, but prototype report illustrates a useful basis on the methodological side for future editions
How to inform the work of the HLPF	To be integrated in and provide scientific evidence for the deliberations of the HLPF. The Report to become one of several inputs

Taking into account the different views on a number of elements, the following options could be considered (Table 46).

- Option 1: Conventional UN flagship publication model
- Option 2: Multi-stakeholder model linked to voluntary national processes
- Option 3: Intergovernmental Panel on Sustainable Development

Option 1 follows the conventional approach for UN flagship publications. The Report is drafted by UN staff who also select experts for ad-hoc contributions. Knowledge inputs comprise peer-reviewed literature and UN system expertise. The Report is peer-reviewed internally and approved by senior UN management. Inputs from Member States and stakeholders are based on ad-hoc requests and based entirely on existing UN structures, including those of the Regional Commissions. Advantages of Option 1 include its low cost (can be implemented within existing resources), quick turn-around times, no need for new structures or working methods, and the representation of a wide range of perspectives. Disadvantages include limited consultations, weak linkages to existing assessments and initiatives, and a potential for overlapping activities.

Option 2 goes further in terms of involving stakeholders and linking to voluntary national reviews. The Report would be drafted by a team of UN staff comprising all UN-ECESA Plus members, with contributions from scientists, government officials and stakeholders. The Report would undergo an external, multi-stakeholder peer-review process and be approved by UN senior management and/or a multi-stakeholder advisory group. Advice would be provided by representatives of academia, major groups, UN system and other international organizations. This might include the chairs of major international assessment initiatives (e.g., IPCC, IPBES), research programmes (e.g., SDSN, Future Earth), and academies of sciences (e.g., World Academy of Sciences, prominent national academies); representatives of major groups (ICSU, ISSC, WBCSD); and young scientists; chairs of key UN groups (e.g., CDP, London group, SG's SAB, SEA4all, GEO board); representatives of key UN reports and outlooks (RCs, UNCTAD, UNEP, UNESCO, UNDP, WB, IMF, CBD, UNFCCC); and representatives of relevant non-UN organizations (South Centre, OECD, regional development banks, European Commission). UN regional commissions are encouraged to hold regional consultations and prepare contributions to the Report. Existing national processes and/or voluntary national reviews under HLPF will become important partners. Most activities under Option 2 could be implemented within existing resources with in-kind contributions, but additional resources might be needed for expert participation and capacity support to ensure effective participation of developing countries. Advantages include higher legitimacy, moderate cost, and strong link between international assessments, national reviews and policy making. Disadvantages include longer turn-around times due to extensive consultations and limited acceptance by certain scientific communities.

Option 3 follows an IPCC-style model in which member States nominate scientific experts to a writing team which drafts the Report to be adopted by member States. Cooperation agreements may be sought with existing assessment initiatives. Lessons-learnt from IPCC reviews can be taken into account in the design of the Panel. In particular, there may be a need to compensate authors for their contributions, in order to avoid conflicts of interests. Advantages of Option 3 include a larger mobilization of scientific communities and of resources, and an institutionalized science-policy interface. Disadvantages include a higher cost (similar to those of other intergovernmental panels), inertia in the process due to a very large number of scientists involved, as well as the fact that the IPCC's consensus model based on peer-reviewed literature does not necessarily encourage the presentation of emerging issues or diverse views.

Table 46. Overview of differences between the three options

Element	Option 1: Conventional UN flagship publication model	Option 2: Multi-stakeholder model linked to voluntary national processes	Option 3: Intergovernmental Panel on Sustainable Development
Report drafted by	UN staff	Team of UN staff with contributions from scientists, government officials and stakeholders.	Scientists nominated by member States
Experts selected by	UN staff	UN staff, assessment initiatives, member States, major groups	Member States
Peer-review	Internal to UN system	External, multi-stakeholder peer review (open process) including UN system	Peer review by participating scientists and external academic reviewers
Report approved by	UN senior management	UN senior management and/or multi-stakeholder advisory group	Member States
Scope of scientific knowledge	Peer-reviewed literature and UN system knowledge	All kinds of knowledge	Peer-reviewed literature
Regional priority issues identified by	Regional consultations coordinated by Regional Commissions	Multi-stakeholder regional consultations coordinated by Regional Commissions	Scientists
National priority issues identified by	Responses by member States to UN questionnaires	Voluntary, national consultations coordinated by Member States and supported by UN capacity building	Scientists
How to organize national and regional contributions	Desk study conducted by UN staff and inputs through ad-hoc UN request for inputs. Based on existing structures	Based on existing structures using existing focal points or channels for nominations. Organized by interested Member States with capacity support from UN system	New, formal group of scientists nominated by member States
Choosing thematic focus of each edition	UN senior management	HLPF in consultation with scientists and stakeholders	HLPF
National sustainable development process	No direct link	Partly based on voluntary processes and reports	No direct link
Scientific advisory group or working group	UN internal with ad-hoc external contributions	Multi-stakeholder group, including representatives of academies of sciences, SAB, CDP, and of key int'l assessments	New group of scientists nominated by governments

Annex 1: Outcomes and/or summaries of selected meetings held in preparation of this report

The following is a collation of the key outcomes and/or summaries of a number of meetings organized by UN-DESA in preparation of this report.

Dubrovnik Declaration - Regional perspective on science-policy interface for a sustainable future

The *Dubrovnik Declaration* was adopted by the "Expert Group meeting for the Global Sustainable Development Report - Future directions and formalization of network of scientific contributors" which was hosted by the Government of Croatia in Dubrovnik from 21-22 October 2013:

9. We, government representatives, experts, scientists and civil society representatives in Europe and the Mediterranean basin364, and representatives of international institutions, having met in Dubrovnik, Croatia, on October 21-22, 2013, one year after the Rio+20 Conference, have resolved the following.

10. Within the common objective of sustainable development to which we all aspire, each region faces specific challenges. We believe that acceptance of sustainable development as a paradigm and progress towards more sustainable outcomes will best be enabled by a clear recognition of this diversity of challenges and priorities at the regional and sub-regional levels, and a better reflection of these differences in discussions at the global level.

11. The Mediterranean, as a cradle of civilizations and a crossroads of cultures, reminds us that development must be designed so as to equitably meet the needs of present generations while preserving the right of future generations to meet their own needs.

12. During the meeting, we have identified common challenges for the next decades within our region, which include the following areas: the management and monitoring of our shared Mediterranean Sea, including the pressures imposed on it by various land-based and sea-based activities; regional economic integration and its impacts; equity, employment and social issues; education, including education for sustainable development, tourism and culture; the climate, land, energy, water nexus; and more broadly, sustainable consumption and production.

13. We agree that we need, in order to reach the future we want, implementable programmes for sustainable development. We believe that going forward; these will be best addressed through integrated, interdisciplinary approaches. In our region, these include, for example, integrated coastal zone management and sustainable consumption and production policies.

14. We acknowledge the important contribution of good governance, rule of law and human rights to sustainable development and we recognize that peace and security are critical for development and a major component of it.

15. We consider empowerment of women and girls and a protection of their rights important for sustainable development.

16. This need for integrated visions, strategies, planning and decision-making requires well-functioning and healthy science-policy dialogues in our countries. Such dialogues can facilitate cooperation in the collection, management, analysis, use and exchange of scientific information, facilitate the further development of internationally agreed indicators, and support the preparation of science-based advice and the development of policy options.

17. We also believe that the pool of scientific knowledge and policy experience in our region could be better utilized to benefit from each other's experiences and work more closely on topics of common interest, in particular those that require trans-national cooperation.

18. We commend the efforts of the UN system to improve the science-policy interface for sustainable development in response to the Rio+20 mandate, and in particular the efforts to produce regular Global Sustainable Development Reports that go beyond existing assessments and integrate environmental, social and economic aspects in a way that enables easier evidence-based policy-making. We believe that such reports can contribute to improving evidence-based decision making at all levels, including through the high-level political forum on sustainable development at the global level. We think that, in order for such assessments to be useful at the national and regional levels, future editions of the Global Sustainable Development Report should build on and highlight regional and sub-regional priorities for sustainable development, challenges and potential for collaboration on the science and policy fronts at those geographical levels.

We resolve to work closely together in the coming years to:

19. Improve our collaboration and exchanges of ideas on common challenges for the region, including those identified during the meeting, and reach out to other regional networks for that purpose in order to facilitate the implementation of common regional dialogue platform;

20. Improve exchanges of ideas and practices among national and regional scientists and policy makers, with a

view to promoting interdisciplinary dialogue and cross-fertilization for sounder policy making at the national level;

21. Mobilize existing scientific networks in the region to: (i) provide inputs to future editions of the Global Sustainable Development Report produced by the United Nations Secretariat; (ii) ensure that the voice and unique perspective of the region is reflected in global debates on sustainable development; and (iii) transpose the outcomes of global science-policy debates on sustainable development into regionally and nationally relevant frameworks for thinking and action, in order to inform national policy-making and contribute to the implementation of international commitments on sustainable development.

We call on national governments in the region to:

22. Facilitate science-policy dialogues and promote a stronger institutionalized science-policy interface at the national level, using national expertise (such as peer reviews, impact assessments, policy evaluations) and promoting interdisciplinary approaches and policy perspectives;

23. Provide enhanced support to regional scientific networks working on common priorities for the region, in order to fully utilize the regional pool of expertise.

24. Support and strengthen inter-ministerial policy coordination for sustainable development.

25. Engage in policy consultations for sustainable development with Major Groups such as economic actors and civil society organizations.

26. Regularly engage in consultations with other Government on sustainable development policies.

27. We further call on the relevant regional and international institutions including the United Nations, in particular through the Mediterranean Commission on Sustainable Development, to:

28. Fully integrate regional and sub-regional perspectives in their analytical and policy work, technical assistance and capacity-building programmes, for example by examining more systematically the implications for regional and national policy-making of intergovernmental commitments on sustainable development taken at the global level;

29. Provide support to regional scientific networks whose work focuses on regional and sub-regional priorities for sustainable development, and to their interaction with policy-makers;

30. Provide support to interdisciplinary exchanges targeted at building integrated visions and sustainable development strategies at the national level, in order to facilitate intra-regional capacity building.

Chair's summary of the Beijing meeting on engaging national assessments

The following is the Chair's Summary of the "Expert Group Meeting for the UN Global Sustainable Development Report - Engaging National Assessments" which was hosted by the Government of China in Beijing, China from 12 to 13 December 2013:

1. Scientists and experts met in Beijing, China, from 12 to 13 December 2013, one year after the Rio+20 Conference.

2. Many supported the global aspiration for the next two generations to eliminate poverty and hunger; to feed, nurture, house, educate 9 billion people by 2050; to secure inclusive growth, equity and development, and to preserve the Earth's life support systems.

3. During the meeting, some identified a number of common challenges for the next decades including poverty eradication, sustainable consumption and production, employment and learning, inclusive growth, income distribution, social equity and security, education, health care, science and technology innovation, urbanization, energy, water, climate change, land use and soil protection, forests, oceans and seas, marine protection and fishing

4. Natural and social scientists have raised early awareness of emerging issues and have been suggesting sustainable development goals and targets for more than forty years. Many of these have already been addressed by decision-makers, but more needs to be done to inform decision-makers of emerging issues that scientists consider are currently not well represented on the agenda.

5. Scientists have suggested potential future goals and targets for the next two generations, based on existing assessments that analyzed past trends and future options (see Box). Many scientists suggested that they might be considered by the SDG OWG to take this into consideration and to draw upon the scientific community of sustainable development scenario analysts to inform them on trade-offs and synergies between suggested goals and targets.

6. Many agreed that building this "common future we want" requires effective cooperation following the principle of the common but differentiated responsibility (CBDR) at the global, regional and national levels, in particular on "means of implementation" for sustainable development such as technology, finance and capacity building.

7. Some expressed the need to draw on the wider range of global modeling and scenario analysis capabilities, in order to assess various sets of SDGs and pathways toward their achievement, including in terms of technology and financing needs. Scenarios can also help interpreting progress towards Sustainable Development Goals once agreed.

8. Some expressed the idea for the UN Division for Sustainable Development to provide a UN institutional home for SDG scenarios and global models, in order to inform the Global Sustainable Development Report in particular and the deliberations of the high-level political forum on sustainable development in general.

Box: Potential sustainable development goals/targets that have been suggested by scientists:

- Eliminate extreme poverty worldwide by 2050
- Halve the proportion of people who suffer from hunger by 2015, further halve it by 2030, and eradicate hunger by 2050
- Universal access to improved water source and basic sanitation by 2050
- Universal health coverage
- Universal primary education by 2020. Universal secondary education by 2030.
- Create 63 million decent new jobs per year until 2050, achieving full, productive and decent employment for all.
- Eliminate overfishing and restore fish stocks.
- Stabilize biodiversity at the 2020/2030 level (depending on region) by 2050.
- No net forest loss and no more destruction of primary forests by 2020.
- Stabilize global materials (e.g. non-renewable resource) consumption at 2015 levels.
- Achieve 0.7% ODA/GNI (OECD countries), focusing on the poorest and most vulnerable countries. Mobilize resources for a global SDG fund commensurate with estimated needs by 2018.
- GDP per capita > US$10,000 PPP in all countries by 2050.
- Reduce the wide disparity of per capita GDP between developed countries and developing countries.
- Sustained increase in intergenerational earnings and educational mobility.
- By 2030, ensure universal access to modern energy services; double the global rate of improvement in energy efficiency; and double the share of renewable energy in the global energy mix.
- Reduce the number of slum dwellers to close to 0 by 2050.
- Hold global mean temperature increase below 2 degrees Celsius.
- Increase science and technology innovation capacity through knowledge sharing and technology transferring.

Note: see also http://sustainabledevelopment.un.org/globalsdreport

9. Many expressed the views that national and regional sustainable development assessments, wherever available, may be important inputs for a Global Sustainable Development Report. There are big differences in terms of national priorities under the sustainable development agenda. Developing countries continue to face a capacity challenge to synthesize lessons-learned from sectoral or issue-based assessments. Developed countries need to change their unsustainable patterns of consumption and production. These national priorities, of both developed and developing countries must be adequately reflected in the Global Sustainable Development Report.

10. It was mentioned that there are thousands of international assessments that differ in terms of scope, scale, organization, process, participation, resources and perceived policy relevance. It was noted by some that the IPCC model of scientific assessments has served as an institutional model for an increasing number of assessments, including at the national level. It was also underlined that the United Nations flagship publication model has advantages of low cost, wider stakeholder participation, and a plurality of views.

11. Several experts expressed the need for a regular assessment of assessments to identify common ground and different views. The efforts of the UN Division for Sustainable Development to improve the science-policy interface for sustainable development were commended, including through its production of a prototype of the Global Sustainable Development Report and its readiness to continue producing regular editions of the Global Sustainable Development Report to bring together existing assessments to support evidence-based policy-making.

12. Many experts stressed the importance for future editions of the Global Sustainable Development Report to take into account various types of knowledge (beyond peer-reviewed knowledge) and take into account the full range of perspectives, especially those of scientists in developing countries including the poorest and most vulnerable countries. To this end, a wide range of participation through multiple channels could be encouraged. The Report could also highlight national and regional sustainable development priorities and make use of new technologies and approaches. Many suggested that Governments and other relevant stakeholders consider in their deliberations the options for future editions of the Global Sustainable Development Report illustrated in the prototype Report.

13. Many suggested the idea that national Governments carry-out regular national sustainable development reports that draw on the available scientific knowledge and to include all relevant stakeholders, to communicate their reports to the United Nations, and to cooperate with other Governments and other relevant stakeholders in building excellent national capacities. In this regard, the exemplary efforts of the Government of China and all others that submitted sustainable development reports were commended. Many suggested that the UN, donors and all relevant development partners support national sustainable development reports and related initiatives that provide ideas for improved policies.

14. Regional sustainable development reports can highlight regional priorities and support regional voices in

the global deliberations. Some suggested that all Regional Commissions continue these efforts and cooperate closely with the national sustainable development report processes and with the UN Division for Sustainable Development.

15. The idea was expressed that all United Nations system entities integrate regional and sub-regional perspectives in their analytical and policy work, technical assistance and capacity-building programmes, for example by examining more systematically the implications for regional and national policy-making of intergovernmental commitments on sustainable development taken at the global level.

16. It was suggested that the UN Division for Sustainable Development continue engaging with scientists, experts, Governments and civil society to undertake in-depth analysis and evaluation of trends and scientific analysis in the implementation of sustainable development, including lessons learnt, best practices and new challenges, and cross-sectoral analysis of sustainable development issues. In particular, the idea was expressed that the Division continue leading the regular preparation of the UN Global Sustainable Development Report in an inclusive way as an entry point for the wide range of relevant scientific communities to the high-level political forum on sustainable development. It was emphasized that it is important to also involve younger scientists. It was suggested that the entire UN system and especially the UN Regional Commissions, UNESCO, UNCTAD, UNIDO and UNEP to join the effort.

17. Some expressed the need for national Governments to engage in the preparation of the Global Sustainable Development Report; facilitate science-policy dialogue; try to strengthen inter-ministerial policy coordination; to provide support to scientific networks and cross-border networking for sustainable development; to cooperate with other Governments on policies, technology and finance for sustainable development; and to consider the options illustrated in the prototype Global Sustainable Development Report.

18. Most expressed the need to consider the creation of a working group or advisory group to guide the preparation of future editions of the UN Global Sustainable Development Report. The group could include science and technology focal points nominated by each national Government.

19. Many shared the view that it is necessary to work closely together in the coming years to actively engage in and contribute to the UN Global Sustainable Development Report; to raise awareness and mobilize scientific communities in our countries to provide their inputs; to improve our collaboration and exchange of ideas on sustainable development challenges between us and between scientists and policy makers in general; to support the voice and unique perspective of our respective regions to be reflected in global debates on sustainable development; and to bring the outcomes of global science-policy debates into relevant national-level policy-making.

20. All participants expressed their gratitude for the excellent arrangements and the warm hospitality by the meeting host, the Administrative Centre for China's Agenda 21, and acknowledged the efforts of the UN Department for Economic and Social Affairs to convene this important meeting.

Annex 2: List of UN/IO publications and outlooks

The following is a list of the publications and outlooks considered in the present report. Direct Web links are provided for ease of reference.

Selected UN flagship reports

World Development Report 2013 (WB) (Messages | Full report)

Human Development report 2013 (UNDP) (Summary | Full report)

Global Mountain Biodiversity Assessment (CBD)

Expert group on the role of biodiversity in sustaining the water cycle (convened by SCBD in cooperation with the Scientific and Technical Review Panel of the Ramsar Convention)

Regulatory framework for climate-related geoengineering relevant to the Convention on Biological Diversity (CBD)

Impacts of climate-related geoengineering on biological diversity (CBD)

Connecting Biodiversity and Climate Change Mitigation and Adaptation (CBD)

Interlinkages between biological diversity and climate change (CBD)

Scientific Synthesis on the Impacts of Underwater Noise on Marine and Coastal Biodiversity and Habitats (CBD)

Scientific Synthesis of the Impacts of Ocean Acidification on Marine Biodiversity (CBD)

Scientific Synthesis of the Impacts of Ocean Fertilization on Marine Biodiversity (CBD)

Series of regional workshops for describing ecologically or biologically significant marine areas (EBSAs) (CBD)

IMF Research Bulletin

Economic Report on Africa 2013 (ECA)

African Governance Report II (ECA)

Combating Corruption, Improving Governance in Africa (ECA)

The Role of Parliament in Promoting Good Governance (ECA)

African Women's Report (ECA)

Sustainable Development Report on Africa III (ECA)

The Renewable Energy Sector in North Africa (ECA)

Annual Report (ECE)

Lviv Forum Report (ECE)

Forest and Economic Development (ECE)

Euro-Asian Transport Linkages, Phase II, Expert Group Report (ECE)

Foreign Direct Investment in Latin America and the Caribbean 2012 (ECLAC)

Social Panorama of Latin America 2012 (ECLAC)

Economic Survey of Latin America and the Caribbean 2012 (ECLAC)

Latin America and the Caribbean in the World Economy 2011-2012 (ECLAC)

A future within reach: reshaping institutions in a region of disparities to meet the Millennium Development Goals in Asia and the Pacific (ESCAP)

Asia and the Pacific Beijing+10 Selected Issues (ESCAP)

Asia Pacific Disaster Report 2010 - Protecting Development Gains (ESCAP)

Green Growth, Resources and Resilience Environmental Sustainability in Asia and the Pacific (ESCAP)

Economic and social survey of Asia and the Pacific 2013 (ESCAP)

ESCWA Annual Report – 2013 (ESCWA)

Summary of the survey of economic and social developments in the Arab region, 2013-2014 (ESCWA)

Progress Made by the ESCWA Member Countries on Financing for Development (ESCWA)

The Arab Millennium Development Goals Report: Facing Challenges and Looking Beyond 2015 (ESCWA)

Inventory of Shared Water Resources in Western Asia (ESCWA)

Priority adaptations to climate change for Pacific fisheries and aquaculture (FAO)

Report of the Fourth Meeting of the Regional Fishery Body Secretariats Network (RSN-4) (FAO)

Guide for Policy and Programmatic Actions at Country Level to Address High Food Prices (FAO)

FAO, forests and climate change (FAO)

Forests and water (FAO)

Guidance Note: Integrating the RIGHT TO ADEQUATE FOOD into food and nutrition security programmes (FAO)

Making agriculture work for nutrition - Synthesis of guiding principles (FAO)

Proceedings from the International Scientific Symposium on Food and Nutrition Security information: from Valid Measurement to Effective Decision Making (FAO)

Enabling environments for agribusiness and agro-industries development. Regional and country perspectives (FAO)

Food Wastage Footprint. Impact on Natural Resources. Summary report (FAO)

Climate Change Adaptation and Disaster Risk Management in Agriculture (FAO)

The impact of commodity development projects on smallholders' market access in developing countries (FAO)

Report of the first regular session of the United Nations System Chief Executives Board for Coordination for 2013 (CEB)

What Climate Change Means for Africa, Asia and the Coastal Poor (WB)

Annual report 2012 (IFAD)

Smallholders, food security, and the environment (IFAD)

Destination green – driving progress through action on aviation and the environment (ICAO)

Global Wage Report 2012-13 (ILO)

World of Work Report 2013: "Repairing the economic and social fabric" (ILO)

International workshop on environmental management needs for exploration and exploitation of deep seabed minerals (ISA)

Global Assessment Report on Disaster Risk Reduction 2013 (UNISDR)

Synthesis report on consultations on the post-2015 framework on disaster risk reduction (HFA2) (UNISDR)

Towards a Post-2015 Framework for Disaster Risk Reduction (UNISDR)

Building resilience to disasters through partnerships (UN Task Team on the post-2015 UN development agenda: IOM, ITU, OHCHR, UNESCO, UNEP, UNISDR, UNFPA, WMO)

Trends in Telecommunication Reform 2013: Transnational aspects of regulation in a networked society (ITU)

Annual report 2012 (ITC)

World Investment and Political Risk 2012 (MIGA, WB)

Better Than Cash Alliance (UNCDF)

2012 Annual Report: A Year of Innovation (UNCDF)

The State of the World's Children 2013: Children with Disabilities (UNICEF)

Humanitarian Action for Children 2013 (UNICEF)

Possible future work in the area of public-private partnerships (PPPs) (UNCITRAL)

Microfinance: creating an enabling legal environment for micro-business and small and medium-sized enterprises (UNCITRAL)

Trade and Development Report 2012 (UNCTAD)

World Investment Report 2013 - Global Value Chains: Investment and Trade for Development (UNCTAD)

Least Developed Countries Report 2012 - Harnessing Remittances and Diaspora Knowledge to Build Productive Capacities (UNCTAD)

Technology and Innovation Report 2012 - Innovation, Technology and South-South Collaboration (UNCTAD)

Trade and Environment Review 2009/2010 (UNCTAD)

Information Economy Report 2012 - The Software Industry and Developing Countries (UNCTAD)

Economic Development in Africa Report 2013 - Intra-African Trade: Unlocking Private Sector Dynamism (UNCTAD)

Review of Maritime Transport 2012 (UNCTAD)

UNCCD 2nd Scientific Conference Background Document: The Economics of Desertification, Land Degradation and Drought: Methodologies and Analysis for Decision-Making (UNCCD)

Zero Net Land Degradation: Sustainable Development Goal for Rio+20. To secure the contribution of our planet's land and soil to sustainable development, including food security and poverty eradication. UNCCD secretariat recommendations in the run-up to Rio+20 (UNCCD)

Land: a tool for climate change adaptation (Policy Brief 1) (UNCCD)

Land: a tool for climate change adaptation (Policy Brief 2) (UNCCD)

Managing environmentally-induced migration in drylands: The Win-Win Strategy (UNCCD)

Mitigating Climate Change in Drylands – The Case for Financing Carbon Sequestration (UNCCD)

World Drug Report 2013 (UNODC)

UNESCO Science Report 2010 (UNESCO)

The Fifth Global Environment Outlook (GEO-5) (UNEP)

Our Planet: Rio+20: From Outcome to Implementation (UNEP)

UNEP Year Book 2012:Emerging Issues in our Global Environment (UNEP)

Blending Climate Finance Through National Climate Funds (UNEP)

A summary of current climate change findings and figures (UNEP)

Feed-in tariffs and a policy instrument for promoting renewable energies and green economies in developing countries (UNEP)

Moving Towards a Climate Neutral UN: The UN Systems Footprint and Efforts to Reduce It (2011 edition) (UNEP)

Ready, willing and able. Empowering countries to meet the climate challenge (UNEP)

Green Economy in a Blue World (UNEP)

Greening the Blue Helmets: Environment, Natural Resources and UN Peacekeeping Operations May 2012 (UNEP)

Advancing justice, governance and law for environmental sustainability. Rio+20 and the World Congress of Chief Justices, Attorneys General and Auditors General (UNEP)

Towards a Life Cycle Sustainability Assessment: Making informed choices on products (UNEP)

Sustainable, Resource Efficient Cities. Making it Happen! (UNEP)

The Business Case for the Green Economy: Sustainable Return on Investment (UNEP)

Sustainable Consumption and Production for Poverty Alleviation (UNEP)

Annual Report of the United Nations Office for Partnerships (UNFIP)

The Global Report 2012 (UNHCR)

Global Appeal 2013 (UNHCR)

Gender and Prosperity of Cities , State of Women in Cities (UN-HABITAT)

The State of Urban Youth 2012/2013 , Youth in the Prosperity of Cities (UN-HABITAT)

Urban World: Cities and Land Rights (UN-HABITAT)

Industrial Development Report (UNIDO)

Annual Report 2011 United Nations Mine Action Service (UNMAS)

A Guide on Transitioning Mine Action Programmes to National Ownership (UNMAS)

Delivering sustainable results (UNOPS)

Business Action to Stop Counterfeiting and Piracy (BASCAP) , Confiscation of the Proceeds of IP Crime: A modern tool for deterring counterfeiting and piracy (UNICRI)

State of World Population 2012: By Choice, Not By Chance: Family Planning, Human Rights and Development (UNFPA)

The Demography of Adaptation to Climate Change (UNFPA)

Combating Poverty and Inequality (Beyond 2015 Brief No. 1) (UNRISD)

Inequalities and the Post-2015 Development Agenda (Beyond 2015 Brief No. 2) (UNRISD)

Social Policy and Employment: Rebuilding the Connections (Beyond 2015 Brief No. 3) (UNRISD)

Biological mechanisms of radiation actions at low doses. A white paper to guide the Scientific Committee's future programme of work (UNSCEAR)

Progress of the World's Women (UNWOMEN)

World Survey on the Role of Women in Development (UNWOMEN)

World Hunger Series: Hunger and Markets (WFP)

World Health Report (WHO)

WIPO Magazine (WIPO)

WMO Bulletin (WMO)

MeteoWorld (WMO)

World Trade Report (WTO)

"Measuring sustainable development", Report of the Joint UNECE/OECD/Eurostat Working Group on Statistics for Sustainable Development (UN/OECD, 2008) (PDF)

The changing wealth of nations: measuring sustainable development in the New Millennium, (WB, 2011) (PDF)

Outlooks

World energy outlook (IEA)

Global biodiversity outlook (CBD) GBO-3 , GBO-4

World Water Futures until 2050 (UNWWAP)

Water Scenarios for Europe and for Neighbouring States (SCENES)

IMF World Economic Outlook (WEO) Update -- Growing Pains, July 2013

OECD Economic Outlook, Volume 2013 Issue 1

African Economic Outlook 2013 : Structural Transformation and Natural Resources

Perspectives on Global Development 2013 : Industrial Policies in a Changing World (OECD)

African Economic Outlook 2013 (ECA)

Transport Trends and Economics 2011-2012 (ECE)

Preliminary Overview of the Economies of Latin America and the Caribbean 2012 (ECLAC)

Asia-Pacific Trade and Investment Report 2012: Recent Trends and Developments (ESCAP)

OECD-FAO Agricultural Outlook (FAO)

Crop Prospects and Food Situation (FAO)

Food Outlook. Biannual report on global food markets (FAO)

Nuclear Safety Review for the Year 2012 (IEAE)

Global Employment Trends 2013: Recovering from a second jobs dip (ILO)

Update (UNAIDS)

Global Mercury Assessment 2013: Sources, emissions, releases, and environmental transport (UNEP)

Global Land Tool Network Issue Jan-April 2013 Securing Land and Property Rights for All (UN-HABITAT)

Cities and Climate Change Initiative Newsletter (September 2012)
Cities and Climate Change Initiative Newsletter (UN-HABITAT)

World Economic Situation and Prospects (WESP) (DESA)

World Economic and Social Survey (WESS) (DESA)

Annex 3: Information on selected assessments

Table 47. Key assessments carried out under the Convention on Biological Diversity

Assessment	Characteristics of assessment process and outcome	Use of scenarios and other tools	Policy impact	Capacity needs identified and addressed
Comprehensive assessments				
GBO-3 [365]	GBO-3 was based on peer reviewed scientific literature, national reports, work on indicators by the Biodiversity Indicators Partnership and a commissioned review of models and scenarios. Each part of the final report was reviewed at least twice. Its preparation was overseen by an independent advisory group. The report identifies uncertainties. Preparation process and impact were independently evaluated.[366]	Biodiversity Scenarios: Projections of 21st Century Change in Biodiversity and Associated Ecosystem Services - A Technical Report for the Global Biodiversity Outlook 3 [367]	COP welcomed the report and took note of the conclusions (decision X/4), which also provided the rationale for Strategic Plan for Biodiversity 2011-2020 (decision X/2)	The preparation process revealed the need to strengthen the ability of countries to assess biodiversity change and to develop policies that are capable of addressing undesired change. Improved capacities to conduct national/sub-regional scenario analysis would help to support decision-making. The GBO-3 process did not contribute to capacity-building in a significant way.
GBO-4 [368]	The preparation process for GBO-4 has only started. An independent advisory group is being established. [369]. The document will be peer-reviewed prior to its finalization	Planned, building on the experience of GBO-3	TBD	The capacity needs identified through the GBO-3 process persist. A series of regional workshops is planned to assist countries in the preparation of their fifth national reports, identifying relevant information for possible use in GBO-4, and on the application of regional scenarios to support decision-making.
Assessments of marine and coastal biodiversity				
Series of regional workshops for describing ecologically or biologically significant marine areas (EBSAs) [370]	Description of ecologically or biologically significant marine areas through the application of the Azores scientific criteria in annex I of decision IX/20 [371] as well as other relevant compatible and complementary nationally and inter-governmentally agreed scientific criteria, as well as the scientific guidance on the identification of marine areas beyond national jurisdiction, which meet the Azores scientific criteria.	Various, including GIS	TBD. (Once endorsed by the CBD COP, as envisaged in decision X/29, descriptions will be submitted to the United Nations General Assembly and particularly its Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction, as well as relevant international organizations, Parties and other Governments.	Need to improve data coverage; need to improve compatibility of data sets. The regional workshops on the description of ecologically or biologically significant marine areas contribute to capacity building, by providing exchange of information, sharing of data and through the compilation and peer-review of the report.
Scientific Synthesis of the Impacts of Ocean Fertilization on Marine Biodiversity [372]	The assessment is based on a review and synthesis of existing literature and other scientific information carried out by the UNEP World Conservation Monitoring Centre, followed by a peer review by Parties, other Governments and organizations as well as the inputs from international scientific experts and was then considered by SBSTTA-14. The report identifies uncertainties.	Review of scenarios and models underlying fertilization experiments.	COP welcomed the report and provided guidance on ways to fill gaps in knowledge (decision X/29 (para 13 (e) and 57 to 62))	Need to improve models underlying fertilization experiments. The assessment did not contribute to capacity-building in a significant way.
Scientific Synthesis of the Impacts of Ocean Acidification on Marine Biodiversity [373]	The assessment is based on a review and synthesis of existing literature and other scientific information jointly carried out by SCBD and the UNEP World Conservation Monitoring Centre, followed by a peer review by Parties, other Governments and	Review of IPCC scenarios (Special Report on Emissions Scenarios – SRES) and	COP welcomed the report, took note of conclusions and established processes to monitor and assess the impacts of ocean acidification on	Need to better understand impacts of ocean acidification on calcification of different organisms and life stages, as well as on the communities of which they are part.

Assessment	Characteristics of assessment process and outcome	Use of scenarios and other tools	Policy impact	Capacity needs identified and addressed
	organizations as well as the inputs from international scientific experts and was then considered by SBSTTA-14. The report identifies uncertainties.	circulation models of the IPCC (IPCC IS92a).	marine and coastal biodiversity (decision X/29 (para 63 to 67))	The assessment did not contribute to capacity-building in a significant way.
Scientific Synthesis on the Impacts of Underwater Noise on Marine and Coastal Biodiversity and Habitats [374]	The assessment is based on a review and synthesis of existing literature and other scientific information by a technical expert commissioned by SCBD, followed by a peer review by Parties, other Governments and organizations as well as the inputs from international scientific experts and was then considered by SBSTTA-16. The report identifies gaps in knowledge and uncertainties.	N/A	SBSTTA recommended that COP welcome the report, took note of key conclusions, and recommends an expert process to improve and share knowledge and develop further guidance (recommendation XVI/5 (paras. 14 to 20))	Need for a consistent terminology to describe underwater noise and need to fill gaps in existing guidance. The assessment did not contribute to capacity-building in a significant way.
Assessments of links between biodiversity and climate change				
Interlinkages between biological diversity and climate change [375]	The assessment draws on a technical paper on climate change and biodiversity prepared by IPCC, a review of literature including the IPCC Third Assessment Report, the Special Report on Land Use, Land-Use Change and Forestry and available literature not covered by previous IPCC assessments, carried out by an ad hoc technical expert group through three meetings and intersessional work. The draft report was submitted for peer-review to Governments using the channels of both the CBD and UNFCCC, and to the wider scientific community. At its third meeting, the expert group considered and took into account the comments of the reviewers to finalize its report.	Review of IPCC scenarios (third assessment report)	SBSTTA welcomed the report, took note of key conclusions, asked for the report to be brought to the attention of SBSTA of UNFCCC and provided detailed guidance to COP on the implications of the findings (rec. IX/11) which formed the basis of COP decision VII/15. SBSTA of UNFCCC noted the report and recommended its use by UNFCCC Parties.	Need for additional guidance and tools that can be used to evaluate the economic, social and environmental impacts of climate change mitigation and adaptation activities and those of biodiversity conservation activities. Additional details are summarized in the section on *Lessons learned from case-studies* (page 11-13 of the report). The participation of experts from the biodiversity and the climate community increased mutual understanding of the processes and the respective status of knowledge.
Connecting Biodiversity and Climate Change Mitigation and Adaptation [376]	The assessment provides an update of earlier work in the light of new evidence. It draws on the report on Interlinkages between biological diversity and climate change, [377] submissions by Parties and a review and synthesis of available literature carried out by the UNEP World Conservation Monitoring Centre, and was carried out by an ad hoc technical expert group (AHTEG) through three meetings and intersessional work. The draft report was submitted for peer-review to Governments and to the wider scientific community. At its third meeting, the expert group considered and took into account the comments of the reviewers to finalize its report. The draft report, including main messages as compiled by the AHTEG was initially made available to participants of UNFCCC COP-14 and, an expanded UNFCCC SBSTA-30.	Review of IPCC scenarios, including the Fourth Assessment Report	SBSTTA 14 considered the report as part of the in-depth review of the work on biodiversity and climate change and prepared Rec. XIV/5 on the basis of which COP took note of the report and prepared guidance below on ways to conserve, sustainably use and restore biodiversity and ecosystem services while contributing to climate change mitigation and adaptation (decision X/33).	Knowledge and information gaps that prevent the integration of biodiversity considerations into climate change-related activities are identified by Parties through their national reports. Specifically there is need for guidance on the design and implementation of ecosystem-based approaches for mitigation and adaptation. The participation of experts from the biodiversity and the climate community increased mutual understanding of the processes and the respective status of knowledge.
Impacts of climate-related geoengineering on biological diversity [378]	The assessment compiles and synthesizes available scientific information on the possible impacts of a range of geoengineering techniques on biodiversity and has been prepared by a group of experts and the Secretariat of the Convention on Biological Diversity, taking into account comments from two rounds of review by Parties, experts and	Climate-change scenarios provide relevant controls for assessing the risks and benefits of geoengineering,	Through recommendation XVI/9 SBSTTA recommended that COP takes note of the report on the impacts of climate related geoengineering on biological diversity and of the main messages,	In addition to the technical questions the report highlighted in particular the need to better understand the social, economic, cultural and ethical considerations of climate-related geoengineering.

Assessment	Characteristics of assessment process and outcome	Use of scenarios and other tools	Policy impact	Capacity needs identified and addressed
	stakeholders. Uncertainties were highlighted throughout the report.	including the implications for biodiversity	[379] and that relevant sections be brought to the attention of related organizations and processes, and that additional work be undertaken in collaboration with partners.	
Regulatory framework for climate-related geoengineering relevant to the Convention on Biological Diversity [380]	This study has been prepared by a technical expert commissioned by SCBD. Review comments and additional contributions from a group of experts and two rounds of review by Parties, experts and stakeholders were taken into account in the final version.	N/A	Through recommendation XVI/9 SBSTTA recommended that COP takes note of the report on the regulatory framework for climate-related geoengineering and of the main messages, [381] and called for further work to be undertaken on this matter.	There is a need to address the gaps in the current regulatory framework for climate-related geoengineering
Assessment related to biodiversity of inland waters				
Expert group on the role of biodiversity in sustaining the water cycle (convened by SCBD in cooperation with the Scientific and Technical Review Panel of the Ramsar Convention) [382]	Impartial, independent review of scientific peer reviewed literature on the role and functions of biodiversity re. sustaining the water cycle and the delivery of water-related ecosystem services. Sections of the report and final report peer-reviewed. Sections on: wetlands, grasslands, forests, cities, institutions and enabling mechanisms. The report identifies levels of certainty and knowledge gaps.	No. Review of current knowledge only.	To be considered at CBD COP-11 (document UNEP/CBD/COP/11/30 and UNEP/CBD/COP/11/INF/2).	Considerable institutional constraints and capacity needs identified. Follow-on work recommended focusing on coordination, awareness raising and capacity development. Key technical capacity-building areas: understanding the key hydrological functions of ecosystems and how they influence, and can therefore be used as solutions to, water resources challenges (including managing the quantity and quality of water available); and the economics of "natural infrastructure" solutions to water management.
Assessment related to mountain biodiversity				
Global Mountain Biodiversity Assessment [383]	The Global Mountain Biodiversity Assessment is an ongoing programme on research, inventorying and monitoring mountain biodiversity, guided by a scientific steering committee.	IPCC scenarios	COP, in decision X/30 took note of progress made by the Global Mountain Biodiversity Assessment and provided guidance on further work	Need to increase capacity to develop and use geo-referenced biodiversity data for integrated analysis and spatial visualization of biodiversity information in relation to climate, land use, physiography and other important parameters. Need to increase capacity for hosting regional platforms for mountain biodiversity information for various mountain ranges (e.g the Hindu Kush-Himalayas, the Andes etc. Need to increase capacity to provide easy and open access to biodiversity information of via GBIF/GMBA Mountain Biodiversity Portal and the Mountain Geo-Portals of other institutes as a gateway to biodiversity information with meta database.

Source: Contribution by the CBD Secretariat to this report, April 2013.

Table 48. Production steps of UNEP's GEO-5 report

No.	Production steps
1	Intergovernmental & Multi-stakeholder Consultation
2	Nomination of experts for GEO-5
3	Selection of experts and set up of Chapter Working Groups
4	Set up High-Level Intergovernmental Panel
5	Set up Science & Policy Advisory Board
6	Set up Data and Indicators Working Group
7	1st Meeting of High-Level Intergovernmental Advisory Panel to agree on internationally agreed goals
8	Regional Consultations to identify priorities and goals
9	Nominations and selections of regional experts for GEO-5
10	1st Production & Authors Meeting to agree on annotated chapter outlines
11	Authors develop Draft 0
12	Internal review of Draft 0 (UNEP, authors & collaborating centres)
13	Science and Policy Advisory Board to conduct mid-term evaluation of content and methodology
14	Science and Policy Advisory Board to deliver their evaluation report to Secretariat
15	Authors develop Draft 1 – Chapter Working Groups process internal review comments
16	External review of draft 1 – High-Level Intergovernmental Advisory Panel, Government & stakeholder review on Draft 1
17	2nd Meeting of High-Level Intergovernmental Advisory Panel to discuss content, structure and identify key messages for the Summary for Policy Makers (SPM)
18	Authors process external review comments on Draft 1
19	Authors interact with Principal Science Reviewers and Chapter Coordinators in preparing Draft 2
20	2nd Production & Authors Meeting to harmonize approaches and work on Draft 2
21	Authors finalize Draft 2
22	External Expert Review of Draft 2
23	External Government Review of Draft 2
24	Authors interact with Principal Science Reviewers (PSRs) & Chapter Coordinators to process scientific review & government comments. ESSP and Author sign off
25	Outstanding Issues submitted to Science & Policy Advisory Board for advice
26	Science and Policy Advisory Board to conduct final evaluation of content and methodology
27	Finalise SPM & submit draft SPM 6 weeks in advance of Intergovernmental Meeting
28	Intergovernmental Meeting to endorse SPM
29	GEO-5 SPM: Production process: final editing, design, layout including proof-reading, translation and final sign-off by UNEP; printing and shipment to venue
30	SPM Launch at GC Special Session 2012
31	GEO-5 Main report: Production process: final editing, design, layout including proof-reading, translation and final sign-off by UNEP; printing and shipment to venue
32	Launch of GEO-5 RIO+20

Source: UNEP

Annex 4: Note on data sources, statistical methods and uncertainty

"The data that are available mould our perceptions" (Dudley Seers)

This Annex provides selective notes on data sources, statistical methods and uncertainty.

Data sources

So far, monitoring progress toward international commitments has essentially made use of official statistics, i.e. statistics "approved" by national statistical offices, by statistical units in relevant governmental ministries or developed by international agencies. Monitoring of the MDGs for example fully relies on official statistics.

However, if only official data are used, data gaps remain in key areas of sustainable development. Even for the MDG monitoring, which has benefited from a great increase of data availability over the years, in 2013, still 38% of developing countries did not have enough data to analyse trends for 25 or more MDG indicators.[384] While this indicates a need to continue investing in statistical capacity for official statistics, new official statistics can take many years until it is effectively operational. In the meantime, other alternatives need also be considered in order to fill the gaps left by official statistics, to improve official statistics of insufficient quality, and to cover areas untapped by official statistics.

Two alternative data sources have been considered in this report to complement official statistics: (i) data compiled for ad-hoc scientific studies; (ii) big data combined from the web, by satellites, sensors, credit card transactions, electronic devices, etc. These alternative data can either be used on their own (in the absence of any official data) or to complement and improve existing official statistics. For practical reasons, sustainable development policy will have to draw from all available data as long as they are reliable and their degree of uncertainty is taken into account. Big data in particular can provide snapshots of the well-being of the population or of our planet's features at high-frequency and at fine geographical resolutions, thus providing an opportunity to gain real-time insights on sustainable development.

Table 49, Table 50 and Table 51 provide an overview of important data sources that are referenced in the text in chapters 3, 4 and 5.

Table 49: Data sources of estimates of total, global investment needs (chapter 4.5)

Rio+20 thematic areas and cross-sectoral issues	Selected sources and references
Poverty eradication	Background paper 1, Section III.1.
Food security and nutrition and sustainable agriculture	Background paper 1, Section III.5.
Water and sanitation	WHO, 2012, Global costs and benefits of drinking-water supply and sanitation interventions to reach the MDG target and universal coverage, WHO/HSE/WSH/12.01, Geneva.
Energy	Background paper 1, Section III.6.
Sustainable tourism	N.A.
Sustainable transport	Background paper 1, Section III.4.
Sustainable cities and human settlements	N.A. This covers a wide range of sectors and activities.
Health and population	Background paper 1, Section III.2. Jamison, D. et al., 2013, Global health 2035: A world converging within a generation, The Lancet, 2013; 382: 1898–955
Oceans and seas	Background paper 1, Section III.8.2.
Least developed countries	Background paper 1, Section IV.
Africa	Background paper 1, Section IV.
Climate change	Background paper 1, Section III.7.
Forests	Background paper 1, Section III.8.2.
Biodiversity	Background paper 1, Section III.8.1.
Education	UNESCO, 2013, Education for All Global Monitoring Report 2013, Teaching and Learning: Achieving quality for all.
Gender equality and women's empowerment	Background paper 1, Section III.8.1.

Table 50. Data sources for GPI components, USA (chapter 5.2)

Item	Source
Personal consumption expenditures (PCE)	Bureau of Economic analysis (NIPA).
Income distribution index	Census Bureau.
Weighted Personal Consumption (+)	Derived from the above two components. Personal consumption expenditures divided by income distribution index.
Value of Household Work and Parenting (+)	Robert Eisner, 1985.
Value of higher education (+)	Hill et al (The Value Of Higher Education: Individual And Societal Benefits 2005); Moretti (2004); and Population data from census Bureau.
Value of volunteer work (+)	Population survey of Bureau of Labor Statistics (1965, 1974, and 1989); American Time Use Surveys from 2003-2004; and Independent Sector, 2006 (to estimate the value of an hour of volunteer time in 2000).
Services of consumer Durables (+)	Bureau of Economic analysis.
Services of highways and Streets (+)	Bureau of Economic analysis.
Cost of Crime (-)	Bureau of Justice; Statistics National Crime Survey; Laband and Sophocleus (1992); and Security Distributing and Marketing (SDM).
Loss of leisure Time (-)	Leete-Guy and Schor (1992); and Mishel et al. (1996).
Cost of Underemployment (-)	Leete-Guy and Schor (1992); Economic Policy Institute; and Bureau of Labor Statistics.
Cost of Consumer durables (-)	National Income and Products Accounts.
Cost of Commuting (-)	US Department of Transportation; Statistical Abstract of the United States(Census Bureau); BEA's National Income and Product Accounts; Leete-Guy and Schor, (1992); National Household Transportation Survey (NHTS) from 1983, 1990, 1995, and 2001; and National Center for Transit Research (NCTR) at the University of South Florida.
Cost of Household Pollution Abatement (-)	Bureau of Economic Analysis (Vogan, 1996).
Cost of Automobile Accidents (-)	Statistical Abstract by the National Center for Statistical Analysis (NCSA, 2004); and National Safety Council (NSC, 2004).
Cost of Water Pollution (-)	Freeman, 1982; Rutledge and Vogan, 1994; Uri and Lewis (1999); National Resources Inventory, conducted by the Soil Conservation Service in conjunction with Iowa State University; Hagerman (1992); and Adams et al. (2006).
Cost of Air Pollution (-)	Myrick Freeman's (1982); and EPA (EPA, 1998).
Cost of Noise Pollution (-)	World Health Organization (Congressional Quarterly, Inc. 1972).
Loss of Wetlands (-)	Woodward and Wui (2000); and U.S. Fish and Wildlife Service (USFWS), 1997.
Loss of Farmland (-)	American Farmland Trust; National Agricultural Statistics Service; USDA's National Agricultural Lands Study; Farm Information Center; Ready et al. (1997); Costanza et al. (1997) ; and Sampson, 1981.
Loss of Primary Forests and Damage from Logging Roads (-)	Outcalt and Sheffied (1996); USFWS (2003); USDA, 2005; Beardsley, et al. (1999); Tongass National Forest; USFS, 1980; Costanza et al. (1997); and Vincent, et al. (1995).
Depletion of Non-renewable Energy Resources (-)	Energy Information Administration; and USDA (1988).
Carbon Dioxide Emissions Damage (-)	Tol (2005); Oak Ridge National Laboratory; and Intergovernmental Panel on Climate Change.
Cost of Ozone Depletion (-)	NOAA's Climate Prediction Center, 2006; Alternative Fluorocarbons Environmental Acceptability Study EPA; United Nations Environmental Programme; and U.S. Congress.
Net Capital Investment (+/-)	Bureau of Labor Statistics; and Bureau of Economic Analysis.
Net Foreign Borrowing (+/-)	Bureau of Economic Analysis.

Source: GPI update in USA (2006) by Dr. John Talberth, Clifford Cobb, and Noah Slattery.

Table 51. List of data sources for chapter 3

Indicators	Source Link	Remark
Number of people living in absolute poverty (less 1.25 US$(PPP) per day)	World Bank—PovcalNet: Regional aggregation using 2005 PPP and $1.25/day poverty line. http://iresearch.worldbank.org/PovcalNet/index.htm?1	Data is available only 1990, 1999 and 2010.
Number of people living in less US$2.15 per day	Same source as above	Data is different in WB site
Total number of employed people living below $1.25 (PPP) per day	MDG Report 2013	
Number of people below relative poverty line in developing world	???	
Hungry	FAO: Food Security Indicators Statistics http://www.worldhunger.org/articles/Learn/world%20hunger%20facts%202002.htm#Number_of_hungry_people_in_the_world http://www.fao.org/hunger/en/ (undernourished people) http://www.fao.org/docrep/016/i3027e/i3027e.pdf (undernourished people) http://bit.ly/14FRxGV	FAO present data on hunger for range of years (Eg. 2010-2012). Annual data is not available

Indicators	Source Link	Remark
	http://www.fao.org/docrep/018/i3434e/i3434e.pdf	
Access to sanitation by 2050	http://www.oecd.org/env/indicators-modelling-outlooks/49846090.pdf	
Number of people with no safe drinking water	MDG Report 2013	But data (proportion) is available only for 1990 and 2011. In the report there exist data for 2012??
Energy-Number of people with no access to electricity Number of people who use Traditional biomass for cooking	World Energy Outlook 2013 http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/	Data is available only for 2011.
Migration	http://esa.un.org/unmigration/TIMSA2013/Data/UN_MigrantStock_2013.xls http://www.unfpa.org/pds/migration.html 214 million people lived outside their country of origin	
Number of people > 60 years of age	Population Facts (No. 2012/4) December 2012, DESA/PD http://www.un.org/en/development/desa/population/publications/pdf/popfacts/popfacts_2012-4.pdf	
Number of Internet users	http://www.internetworldstats.com/stats.htm International Telecommunication Unit (ITU) http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2013/ITU_Key_2005-2013_ICT_data.xls	
Number of people living in Slum dwellers	http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3387 (Developing Regions) http://ww2.unhabitat.org/programmes/guo/documents/Table4.pdf (Global) http://ww2.unhabitat.org/programmes/guo/statistics.asp (Global)	Data used in the report is for developing nations only
Urban population forecast 2050	World urbanization prospects: The 2011 revision: http://esa.un.org/unup/pdf/WUP2011_Highlights.pdf	
Number of people living in Least developed countries	http://esa.un.org/unpd/wpp/unpp/panel_population.htm	2012 data not available in population division DB
World population	Source DESA Population division http://esa.un.org/unpd/wpp/unpp/panel_population.htm	2012 data not available in population division DB
Life Expectancy	http://apps.who.int/gho/data/view.main.690?lang=en http://www.earth-policy.org/datacenter/xls/indicator1_2011_8.xls http://www.earth-policy.org/data_center/C21	Data found in the web has small differences with the one used in the report. **comparison between Africa and Eurpoe is also different based on data from these sources
Maternal Mortality rate	MDG Report 2013	The comparison between developing and developed region is more than 10fold (~15 MMR)
Health and aging Prevalence of HIV (between age 15-49)	http://www.who.int/gho/hiv/epidemic_status/prevalence_text/en/ http://www.nia.nih.gov/sites/default/files/global_health_and_aging.pdf	
Proportion of children under 5 with fever who are treated with appropriate anti-malarial drugs. Successfully treated tuberculosis patients	MDG Report 2013	
Improved global health	No source found	
GDP & GDP per capita	UNSD: http://unstats.un.org/unsd/snaama/selbasicFast.asp	
ODA amount	OECD: ODA Performance in 2012 http://dx.doi.org/10.1787/dcr-2013-en http://www.oecd-ilibrary.org/development-assistance-committee-members-oda-performance-in-2012_5k3wh9mnw3tc.pdf;jsessionid=3r4u18b8w9g0q.x-oecd-live-01?contentType=&itemId=%2Fcontent%2Fchapter%2Fdcr-2013-21-en&mimeType=application%2Fpdf&containerItemId=%2Fcontent%2Fserial%2F20747721&accessItemIds=%2Fcontent%2Fbook%2Fdcr-2013-en	According to the report (Development Co-operation Report 2013 Ending Poverty: OECD_ Table A10) share of ODA to LDC is about 50%--In the report it is one third.
Water withdrawal	http://unesdoc.unesco.org/images/0018/001819/181993e.pdf#page=29	In this report (pp101) it said in the last 50 years it is tripled. However, in the report it says increased six times???
Water use for Agriculture	http://www.unwater.org/downloads/TFIMR_Annex_FinalReport.pdf The report one above also have the same amount	
Research and Development expense	http://databank.worldbank.org/data/views/reports/tableview.aspx	Slight difference from the

Indicators	Source Link	Remark
		figure used in the report.
Employment data	MDG Report 2013	
National Parliaments seats occupied by women	MDG Report 2013	
Adolescent birth rate	MDG Report 2013	
CO2 emissions	http://edgar.jrc.ec.europa.eu/news_docs/pbl-2013-trends-in-global-co2-emissions-2013-report-1148.pdf	A slight difference compared to data used in the report
CO2 concentration	http://co2now.org/ (only for 2012) http://www.iea.org/publications/freepublications/publication/CO2EmissionsFromFuelCombustionHighlights2013.pdf	
Enrolment ratio, literacy	MDG Report 2013	
Endangered species	The ICUN Red List of Threatened Species http://cmsdocs.s3.amazonaws.com/summarystats/2013_2_RL_Stats_Table1.pdf http://www.endangeredspecieshandbook.org/pdfslive/esh_chapter4.pdf	Not used for correction?? Data is different from the one used in the report.
Biodiversity	http://cmbc.ucsd.edu/content/1/docs/Pimm_et_al_1995.pdf	
Land cover	http://landscape.forest.wisc.edu/courses/readings/Ellis_etal_2008.pdf	%of land cover is slightly different in the report. Cropland(19%), forest (20%)…
protected terrestrial and marine areas	MDG Report 2013	
People living in river basin with severe water stress	http://www.globalwaterforum.org/wp-content/uploads/2012/05/Water-Outlook-to-2050_-The-OECD-calls-for-early-and-strategic-action-GWF-1219.pdf http://www.oecd.org/env/resources/49006778.pdf	
Arable land	http://www.fao.org/fileadmin/templates/solaw/files/thematic_reports/TR_01_web.pdf	
Ground water depletion	March 2012: ENVIRONMENTAL OUTLOOK TO 2050 http://www.oecd.org/env/indicators-modelling-outlooks/49844953.pdf	
Number of people at Flood risk in 2050	March 2012: ENVIRONMENTAL OUTLOOK TO 2050 http://www.oecd.org/env/indicators-modelling-outlooks/49844953.pdf	
The value of assets at risk due to flood	March 2012: ENVIRONMENTAL OUTLOOK TO 2050 http://www.oecd.org/env/indicators-modelling-outlooks/49844953.pdf	
Premature death due to Particulate Matter	March 2012: ENVIRONMENTAL OUTLOOK TO 2050 http://www.oecd.org/env/indicators-modelling-outlooks/49844953.pdf	
Increases in sulphur dioxide (SO2) and nitrogen oxides (NOx) emissions	March 2012: ENVIRONMENTAL OUTLOOK TO 2050 http://www.oecd.org/env/indicators-modelling-outlooks/49844953.pdf	
Impact of human to marine ecosystem	http://www.nceas.ucsb.edu/GlobalMarine	
Deforestation	http://foris.fao.org/static/data/fra2010/KeyFindings-en.pdf http://www.fao.org/docrep/013/i1757e/i1757e.pdf	

Statistical methods

Chapter 3 presents a review of progress toward global sustainable development by presenting and analysing trends of several indicators on people, the economy, society, nature, life support, community as well as for the focus areas discussed in the open working group on the SDGs. This approach draws on policy-based indicators, i.e. indicators established to respond to information needs of specified sustainable development strategies. The close connection between these indicators and the strategies defined is their main strength. However, it is difficult to discern inter-linkages across the indicators and to identify existing synergies and trade-offs.

Capital-based indicators grounded in national accounting systems have been utilized elsewhere. In that approach, sustainable development is defined as non-decreasing wealth per capita over time; and wealth is defined as the sum of financial capital, produced capital, natural capital, human capital and social capital. This approach requires measuring all capital stocks in one unit, money. It has the advantage of allowing direct comparison across different types of capital but has also methodological and ethical difficulties. Methodologically, it is not always straightforward to establish monetary amounts for natural, human and especially for social capital. Some argue - on ethical grounds - that natural capital (e.g., as related to biodiversity or forests), human capital (e.g., educated workforce), and social capital (e.g., social networks), have intrinsic values which cannot or should not be valued in monetary terms.

Several aggregate measures to assess progress toward sustainable development have been proposed in the literature – some are discussed in Chapter 5. These aggregate measures tend to bring together several indicators into a composite index. The index can be composed of policy-based indicators or capital-based indicators. For instance, the Human Development Index (HDI) uses policy-based indicators while the Genuine Progress Indicator (GPI), discussed in chapter 5, uses capital-based indicators. In comparison with the long list of

indicators which typically inform policy – like the CSD indicators - the aggregate measures have the advantage of providing an overall picture in a single number. Oftentimes, the selection of suitable measures is decided by data availability. Different aggregate measures have different global and time coverage (Table 52). When data are not available for all countries, statistical methods can be used to extrapolate available data and combine it with other relevant information to estimate a global value.

Table 52. Coverage of selected aggregated measures

Aggregate measures	Coverage
Human Development Index 2012[385]	199 countries/territories
Human Sustainable Development Index 2010[160, 386, 387]	163 countries/territories
Adjusted net savings 2005-9[388]	134 countries/territories
Ecological Footprint 2007[388]	109 countries/territories
Genuine Progress Indicator, 1950-2003[389]	17 countries/territories, representing around 53% of the world population

Uncertainty

The estimates used to assess progress toward sustainable development carry with them varying degrees of uncertainty. For instance, the atmospheric concentration of CO_2 is sampled with a high degree of accuracy whereas experts believe the accuracy of estimates of land carbon is only around ±30%.[390] Many socioeconomic aspects, like employment and poverty rates, are estimated through household sample surveys and bear a degree of uncertainty related to non-response, sample size and design. Censuses, albeit their theoretical universal coverage, also have quality and coverage issues. Presenting uncertainty is important across all data sources. In big data, uncertainty can arise from limited coverage or the use of proxies. For example, Soto et al. present estimates of socio-economic levels on the basis of cell-phone data with prediction rates of 80%.[391]

Inaccuracies in measurements also introduce uncertainty. No measurement is fully accurate — the instruments used, the biases in people's responses to surveys, all introduce inaccuracies. Uncertainties also arise from the complexity of some Earth systems or the complex interactions among the vast array of social, economic and environmental factors. For example, there is not enough information about clouds to determine with full accuracy how much solar energy reaches the Earth's surface. Uncertainties resulting from lack of knowledge can arise in situations of low availability of data. Some of those uncertainties may be reduced with more or better data, but in complex natural systems, like the Earth's weather, no practical amount of data will provide 100% certainty.

As we look into the future, estimates of forthcoming outcomes also come with a degree of uncertainty due to unknown contingencies and uncertainty about model and scenarios assumptions. Some of these uncertainties can be reduced, for instance by increasing data availability, but others are, again, inherent to the complexity of sustainable development.

Despite these uncertainties, most scientific models are accurate enough to deserve credibility. Having the additional information on the degree of uncertainty of each estimate or scenario will allow the findings to be adequately incorporated into policy-making. To reflect the degree of uncertainty associated with the estimates, most research provides uncertainty ranges and/or statements quantifying the probability that a certain outcome is likely to occur.

Annex 5: Global CLEWS model – an open source, open-data approach

In preparation for the present report, a global CLEWD model was developed as an open-source, open-data tool for research cooperation on global sustainable development, and to support the emerging national and regional applications: The **G**lobal **L**east-cost **U**ser-friendly **C**LEWs **O**pen-**S**ource **E**xploratory (GLUCOSE) model. The model is currently being developed further. The result will be a user-friendly Web interface and a widened scope of the model to capture all the goals that will eventually be agreed by the UN Open-Working Group on the Sustainable Development Goals. The envisaged user interface follows the approach used for the "2050 Pathways Calculator" of the UK's Department of Energy and Climate Change, in order to enable access to the model for a non-technical audience.[392] The original model was developed by researchers from the Royal Institute of Technology (KTH) in Sweden in cooperation with the UN Division for Sustainable Development. The remainder of this Annex draws heavily on background papers provided to DESA by Taliotis, Weirich and Howells of KTH.[393]

Overall approach compared to existing global integrated models

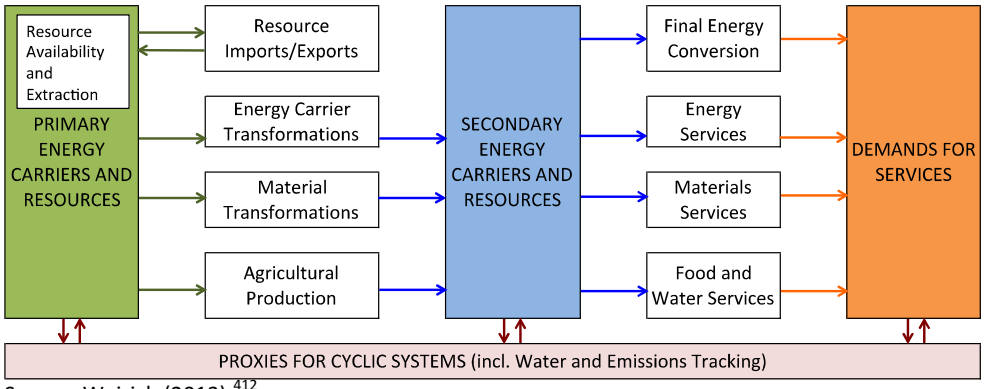
Most of the leading global integrated assessment models capture one sector in great detail – most often the energy sector – and integrate with other resources in a stylized way, such as through constraints, accounting relationships or through soft-linking to other sectoral models. They typically take other resource processes into account only as input or output factors on an aggregate level and without reconciling short-term, long-term and global objectives.[394, 265] While climate change, energy and water use may be included as separate manual inputs they are rarely included in an overarching model.[395, 396]

On the other hand, fully integrated systems models that capture climate, land, energy, water, and other socio-economic indicators typically lack the necessary technology detail needed to support planning and policy decisions or they are extremely complex requiring expensive software and special skills[395,397].

Up to date there have been few efforts to carry out a large-scale international materials analysis as part of wider integrated model. Some have collected country level data on industry emissions, innovation or efficiency improvement and economic prospects.[398,399,400,401] Yet, the life cycles of modern materials have a very significant impacts on climate, land, energy, water and development[402], demand changes through materials innovation[403], non-energy carbon is an important material[404], and the sector's economic importance is closely related to the materials extraction, processing and recycling.[405] Against this background, the GLUCOSE model was designed to also capture the life cycle of key materials.

The GLUCOSE model was developed as a transparent[406], accessible[407], modular[408] and scalable[409] model – features that support a further model development through crowdsourcing[410]. OSeMOSYS (the Open-Source energy MOdelling SYStem)[411] was selected as the software platform to develop the GLUCOSE model. It is transparent, accessible and easily extended. OSeMOSYS is a cost-optimization toolbox which is typically used for energy analysis, but it can be used to model any type of flows through systems.

Figure 34. Conceptual design of the GLUCOSE model.



Source: Weirich (2013).[412]

Model structure

The GLUCOSE model structure resembles that of the well-known TARGETS model[413]. The GLUCOSE model consists of three modules: the energy sector; land and food; and material production. It does not comprise separate water or climate modules (they are under development). Instead, the energy, land and materials modules account for and are affected by restrictions made in the model on water use and greenhouse gas emissions. Unlike previous CLEW-related work in Mauritius and elsewhere (see section 6.5), the different sectors of the GLUCOSE model are fully integrated. Figure 34 illustrates the conceptual design of the model.

Energy module

The energy module of the GLUCOSE model was developed in a similar way as the leading major global energy models (e.g., those used for the Global Energy Assessment, and by the International Energy Agency)[414,415,416] which inspired the choice of technology options and energy demand categories. Figure 35 shows a simplified version of the reference energy system (RES). Final energy demand was divided into electricity, heat and transport. Industrial heating demand was treated separately and linked to the materials production module. Transport was divided into maritime[417], aviation[418], railways[419], and road travel[427].

Technology specifications and initial energy demand projections were primarily based on IEA.[427,420,421] The power generation sector includes 26 technology options, while the heat generation sector has 20 technology options. Both centralized and decentralized options were considered. The model allows the assessment of future investment potentials in unconventional infrastructure and technology shifts in primary energy supply, such as coal or biomass gasification, coal-to-liquids and gas-to-liquids, and in generation, such as carbon capture and sequestration (CCS). The transport sector allows for market penetration of technologies using biofuels or electricity.[422]

Land module

The principal purpose of the land module was to provide linkages between agricultural production, its associated land-use, land degradation and energy use, and the production of biomass for energy purposes. Besides these links with the energy module, the land module is linked with the materials model, as it draws fertilizer from the materials module to increase yield of land. Figure 36 shows the reference land resource system of the GLUCOSE model.

The land module consists of twelve main land categories, which are characterized by different climatic conditions (Table 53). These are divided by temperature (cold, temperate, hot), yield (low, medium, high) and level of agricultural intensity (low, high). An additional land category has been added for forest cover to account for fuel-wood use.

Table 53. Land categories in the land module of the GLUCOSE model

Technology Name	Climate Category	Irrigation potential category	Yield 2010 (EJ/million ha)	Irrigation requirement (Gt/million ha)
L1	Cold/Arctic	-	0.067	0
L121	Cold/Arctic	Low	0.073	0.5
L122	Cold/Arctic	Medium	0.116	0.75
L123	Cold/Arctic	High	0.133	1
L2	Temperate	-	0.152	0
L221	Temperate	Low	0.167	1.5
L222	Temperate	Medium	0.266	5
L223	Temperate	High	0.304	10
L3	Hot/Tropical	-	0.228	0
L321	Hot/Tropical	Low	0.251	2
L322	Hot/Tropical	Medium	0.399	5
L333	Hot/Tropical	High	0.456	11
L4	Forests	-	0.106	0

Source: Weirich (2013).[412]

All the land categories produce biomass as output, which can either satisfy demand for meat and vegetarian food or be used for energy purposes. The consumption of both food types leads to the generation of combustible waste, which can also be utilized in the energy module. Yield improvement of land and food production was based on FAO projections, while demand for food was coupled with population projections.[423]

Materials module

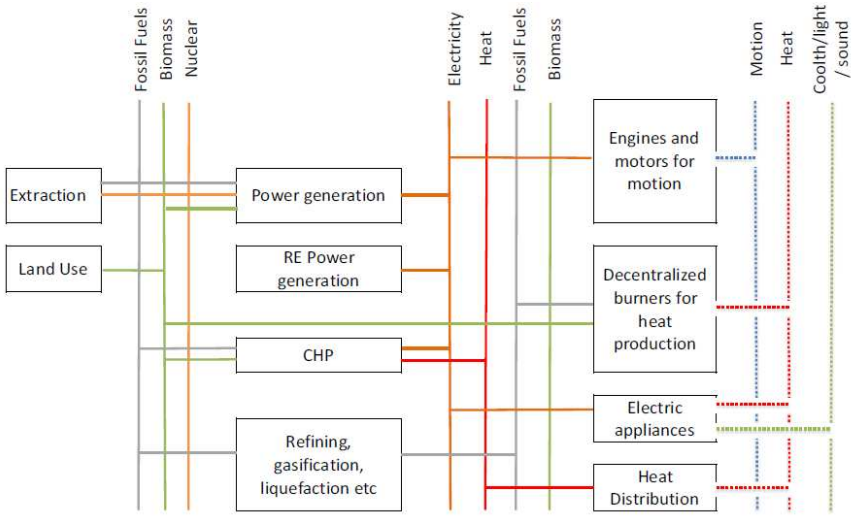
The extent of energy use and environmental loading, as well as the potential for material and energy efficiency improvements are significant.[424,425,426] Sustainable use of materials implies reduction in material consumption and associated energy flows, by addressing the supply (e.g., through efficiency improvements in manufacturing), or the demand side (e.g., altered consumer behaviour). This can be achieved to a considerable extent through adaptation in lifestyles and societal behaviour, improved system design, cooperation between industries for a decrease in waste heat and material losses, and the incorporation of policy frameworks that facilitate such changes.[427]

The materials sector is interconnected with the land and energy module in several ways. Extraction of raw materials results in land degradation, emission release and requires

energy input. Transformation of raw materials into consumer products is a very intensive process, while market globalisation means that products need to be shipped across great distances from source of supply to point of demand. At the same time, equipment requirements in energy and agricultural production processes affect the demand of certain key materials, such as aluminium, cement, iron and steel. Inclusion of all these aspects can guide informed decision-making.

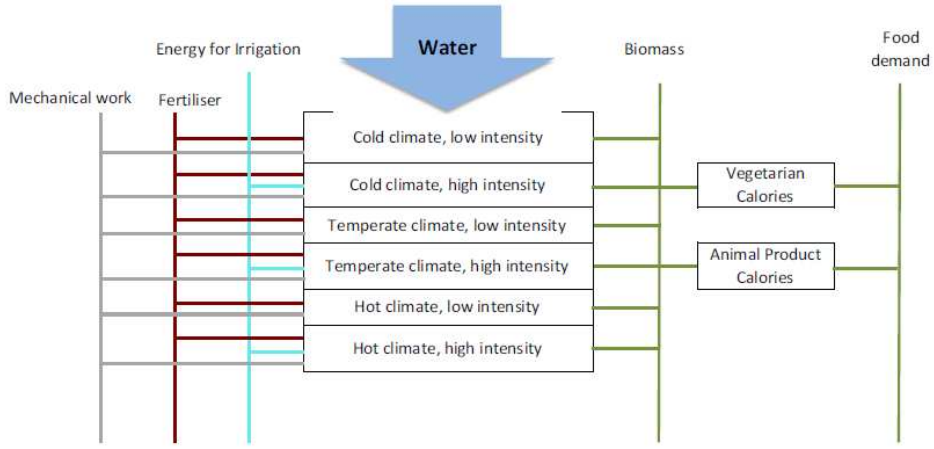
In the present version of the model, the materials module consumes energy. The pulp and paper, iron and steel, aluminium, cement, fertilizers and petrochemicals industries take in energy in various forms (i.e. heat, electricity, fuels) and use it either to drive conversion processes or as feedstock. [412,402] Efficiency improvements have been assumed based on existing projections.[427] Figure 37 shows the reference resource system for the materials module.

Figure 35. Simplified reference energy system of the GLUCOSE model



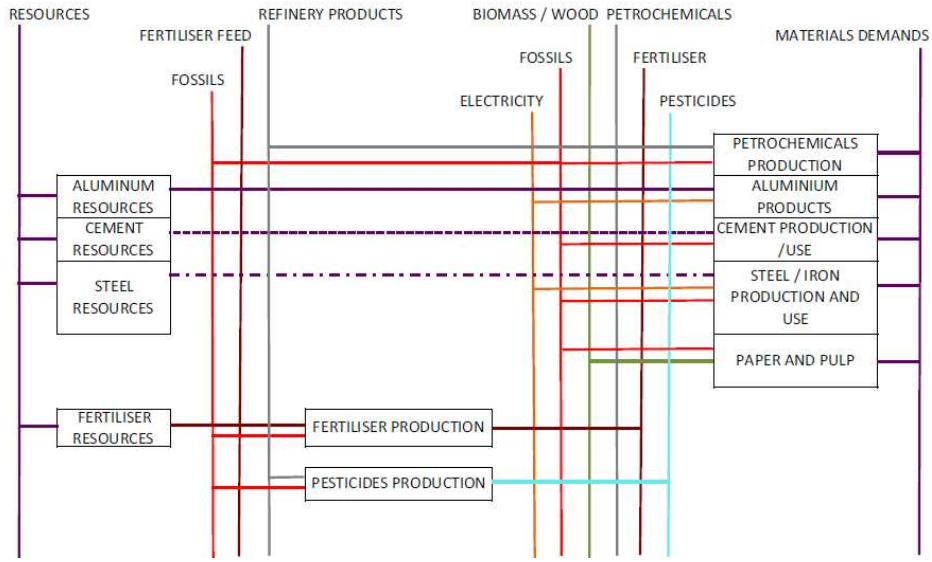
Source: Weirich (2013).[412]

Figure 36. Reference land resource system of the GLUCOSE model



Source: Weirich (2013). [412]

Figure 37. Reference resource system for the materials module of the GLUCOSE model



Source: Weirich (2013).[412]

Scenarios

A *baseline scenario* was developed that resembles the "business-as-usual" (BAU) scenarios of other modelling efforts[427] in that it does not enforce any new environmental regulations. Since the OSeMOSYS platform is a demand driven cost-optimization tool, it was decided that the solution for the baseline scenario would primarily be an outcome of the technological cost projections and the technology performance limitation.[428] The baseline scenario follows assumptions in the IEA technology perspectives publication for total primary energy supply and renewable energy generation potentials: the maximum penetration rate of renewable energy technologies and a minimum fossil fuel use follow two degree scenario, while a greenhouse gas emission limit was imposed based on a six degrees scenario. [427,429]

A number of *alternative scenarios* have been developed to evaluate the response of each module within GLUCOSE. These include varying degrees of land or water availability, greenhouse gas emission limits and the imposition of a global carbon tax. The scenarios were used to explore the impacts of these measures in the integrated CLEWs nexus case compared to the effects on individual sectors. The set of scenarios explores many factors, including political decisions, technology learning, access to modern energy services, behavioural changes, and demographic and socioeconomic conditions.

Scenario results

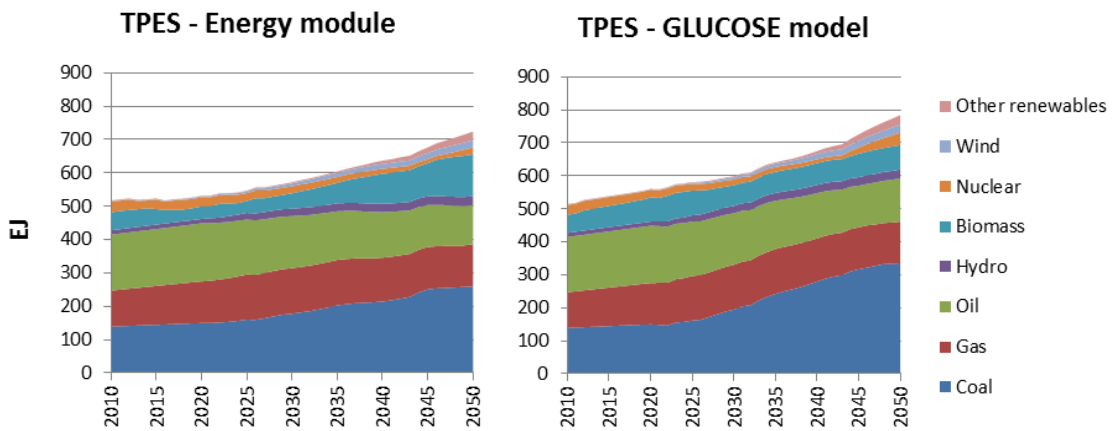
Results were compared from running the integrated GLUCOSE model with all modules to running the energy module independently. The difference is due to cross-sectoral effects and inter-linkages that are overlooked in individual sector assessment efforts. Additionally, scenarios with greenhouse gas emission limits and a global carbon tax are examined to assess effects on primary energy supply and power generation. It should be highlighted that results presented here are only indicative, as the aim is not to make predictions but to provide insights as to the system dynamics under particular circumstances.

Baseline scenarios

There are some interesting differences between the results of the integrated GLUCOSE model and the sectoral energy model, in terms of primary energy supply (TPES) (Figure 38). It should be noted that the actual differences are most likely significantly larger than suggested by the aggregate global model. At the global level, trade-offs can be resolved that it is not be possible to resolve at the national or subnational level. In 2050, biomass use in primary energy supply was projected to be 125 EJ in the global energy model and only 74 EJ in the GLUCOSE model. This divergence is an indication that biomass availability at cost-competitive prices for use in the energy sector is constrained by increasing food demand and production costs. Whereas in the separate energy module all biomass could theoretically be used for energy, in the integrated GLUCOSE model the most productive land categories are primarily used to produce biomass for food. Consequently, available land for fuel production has a lower yield and requires greater nutrients, water and energy inputs, resulting in elevated fuel costs for irrigation and mechanical

work. The results from the integrated GLUCOSE model show a significantly higher coal use after 2035. Oil is used for petrochemical production (in materials module) which leads to slightly lower volumes of oil available for energy purposes, particularly in transport, as opposed to the separate energy module. As a result, coal-to-liquids and to a lesser extent gas-to-liquids production increases to compensate for this. Liquid fuel production from coal and gas commences in 2031 in the GLUCOSE model and reaches a combined production of 58 EJ in 2050, in contrast to the first year of 2042 and total production of 31 EJ by 2050 when the energy module is assessed separately. In both the integrated GLUCOSE and the separate energy sector models the production of oil declines overtime, even though oil reserves[430] are not depleted by 2050. This is due to the expected higher cost of oil per unit of energy compared to natural gas and coal[415] in the future and the expected increase in production of coal-to-liquids and gas-to-liquids[431].

Figure 38. Total Primary Energy Supply in the baseline scenario of the separate energy module (left) and the integrated GLUCOSE model (right).

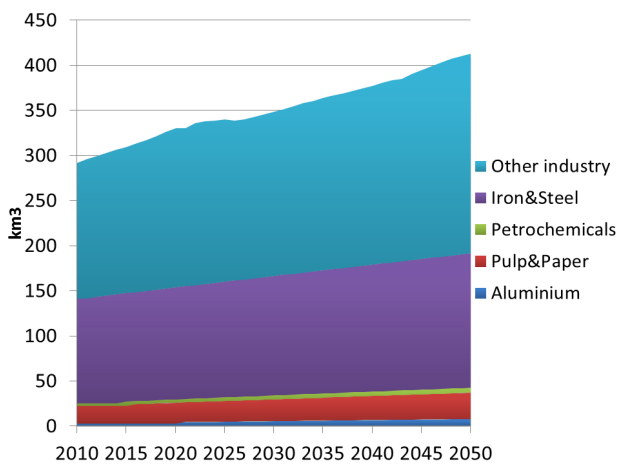


Source: Taliotis et al. (2013).

There are also some interesting differences between the results of the integrated GLUCOSE model and the sectoral energy model, in terms of power generation (Figure 41). One important difference is the lower use of gas in the GLUCOSE model, mainly compensated by coal-fired plants, which is visible in the last decade. Even though gas-fired electricity generation seems to outcompete coal plants in the energy module, results from the GLUCOSE model suggest that it is more cost-effective to use gas in the other sectors (i.e. materials module) instead.

Global water consumption in materials sector is expected to increase by half over the next forty years (Figure 39) and water consumption in the energy sector (excluding hydropower) almost double (Figure 40). Besides hydropower plants, coal power plants, iron/steel and industry are large water consumers at the global level.

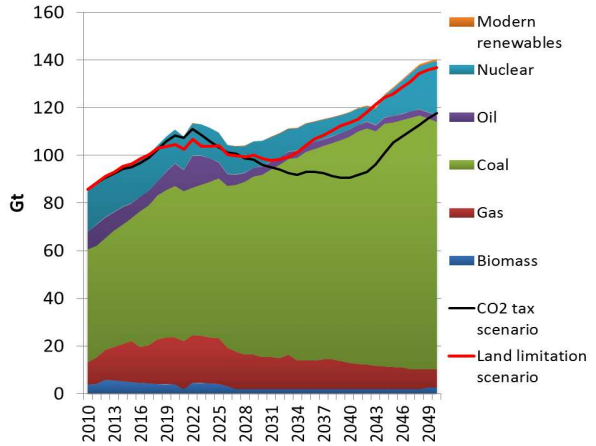
Figure 39. Water consumption in the materials sector in the baseline scenario



CO_2 tax scenarios

In the CO_2 tax scenario the differences are greater between the results for the integrated GLUCOSE model and the separate energy model. In other words, inter-linkages between resources become more pronounced as climate action is being taken.

Figure 40. Water consumption in the energy sector, excluding hydropower.



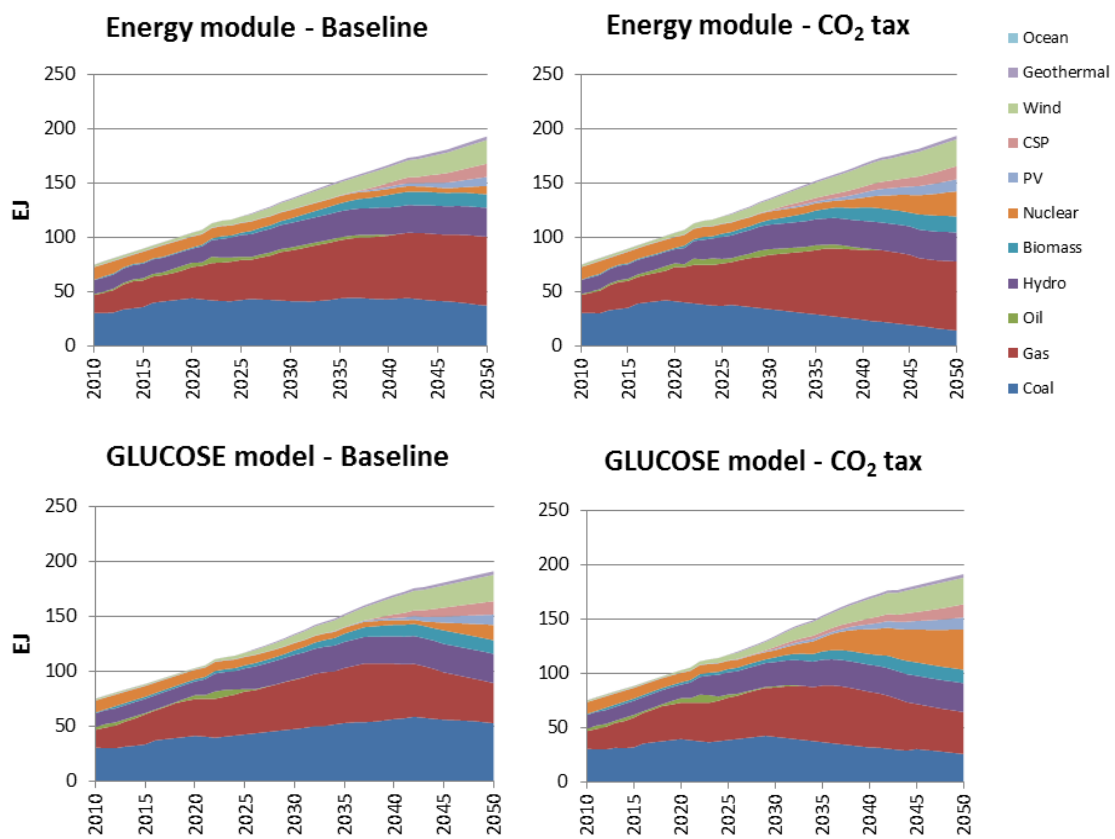
The CO_2 tax scenario assumes a global CO_2 tax linearly rising from US$1 per ton CO_2 eq.in 2016, to US$15 in 2030, and to US$25 in 2050. The assumed CO_2 tax is rather moderate. CO_2 taxes derived from global energy models for stabilization of CO_2concentrations are typically much higher, on the order of hundreds of US dollars. Despite the moderate CO_2 tax rate in our scenario, a significant reduction results in the share of coal in power generation due to the high emissions factor of coal. The reduction in coal-fired generation is compensated by investments in low and zero carbon power generation options. Low power densities and high water requirements for some renewable power generation options significantly changes the mix, as some options face scientific-technical and socio-political constraints.

The generation from solar thermal and wind power installations in the CO_2 tax scenario shows only a minimal increase compared to the baseline scenario. In fact, based on the assumed cost projections[427] these technologies will gain market competitiveness even in a scenario without carbon tax.[427]

2°C and 4°C scenarios

The integrated GLUCOSE model does not include a climate model. Instead, greenhouse gas emission constraints were applied. Figure 42 shows the total primary energy mix for the 2°C and 4°C scenarios.

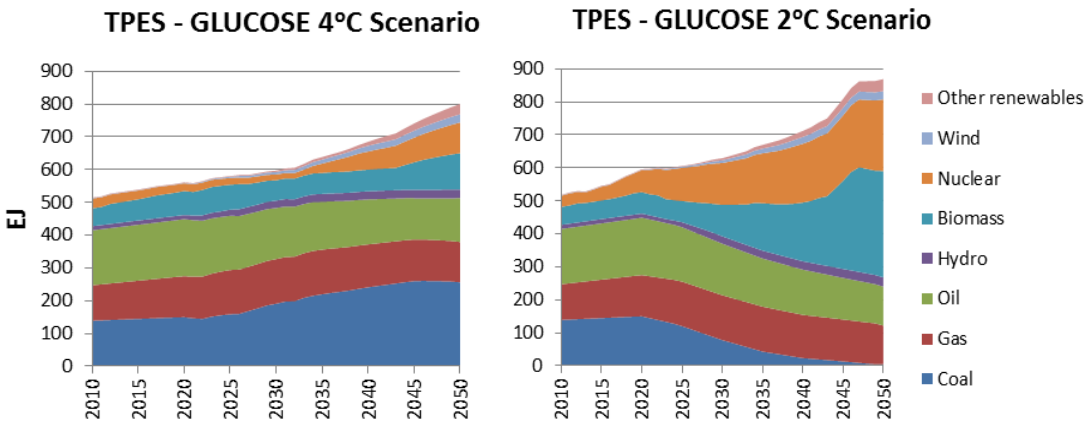
Figure 41. Power generation in the baseline (left) and CO_2 tax (right) scenarios.



Note: The graphs at the top show results from the individual energy module, while the bottom graphs show corresponding results in the combined GLUCOSE model.

Source: Taliotis et al. (2013).

Figure 42. Total primary energy supply in the GLUCOSE model for the 4°C (left) and 2°C scenario (right).



Source: Taliotis et al. (2013).

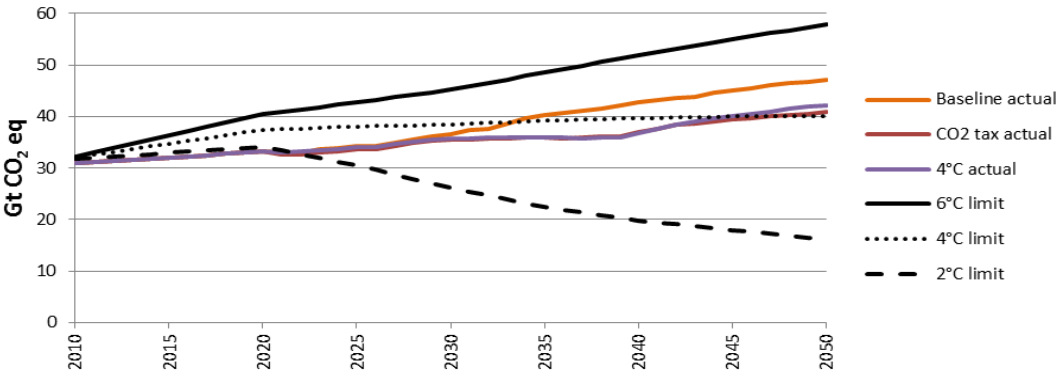
The differences between the 4°C scenario (Figure 42) and baseline scenario (Figure 38) are small. Some variances in total primary energy supply are visible post 2030 when the contribution of coal and gas is slightly lower and complemented with nuclear and biomass. This can be explained by the fact that even though the baseline scenario has a constraint of emission release corresponding to a 6°C temperature rise, the actual release is relatively close to the 4°C scenario (Figure 43). Similarly, emissions from the CO_2 tax and 4°C scenarios are almost identical, which means that even with a conservative CO_2 tax the investment portfolios can easily be directed towards cleaner technologies.

However, in order to limit emissions below a 2°C warming without any compromises on the demand side, the energy supply needs to be completely restructured. Results from the GLUCOSE model show that nuclear power and biofuels are part of the least-cost solution to achieve this. Coal use diminishes, while gas and oil retain a significant share of energy supply. By the end of the projection period, land-based transport sector relies mostly on electricity, while in roadway travel biofuel vehicles exceed 25% of the fleet by 2050. Once again though, there is the issue of feasibility. A system transformation of such scale requires immense political and financial support and surely costs will trickle down to the consumer base. As a result, it is uncertain how demand will respond to such a development and it is a dynamic which cannot be captured by the current GLUCOSE structure but will be implemented in future model enhancements.

Investment needs

Interestingly, when CLEWD inter-linkages are taken into account, greenhouse gas mitigation costs turn out to be much less than currently suggested by separate global energy models. When we are realistic about trade-offs between different resources under a changing climate, most of the cheaper sectoral baseline scenarios will not be feasible. Feasible baseline scenarios without climate mitigation policies will require higher investments, and integrated approaches that achieve a range of sustainable development goals may turn out to be cheaper than the feasible business-as-usual alternatives.

Figure 43. Emission constraints and actual emissions in selected scenarios.



Source: Taliotis et al. (2013).

Annex 6: Response to the questionnaire on the scope and methodology of a global sustainable development report

All Member States, political groups and all fifty-three UN organizations of ECESA-Plus were invited to make proposals on the scope and methodology of a global sustainable development report, inter alia, through a questionnaire. Written responses were received from China, Costa Rica, Croatia, the EU, Indonesia, Japan, Jordan, Russian Federation, Switzerland, Tunisia, and the UK, as well as from CDP, ECLAC, ESCAP, UNCTAD, UNEP and WMO.[432] In addition, related inputs were considered from experts and UN partners who participated in expert group meetings that were convened in support of the Report in 2013.[433] This includes, inter alia, written responses by CBD, ECE, FAO, IAEA, UNEP and UNESCO.

Overall direction

In their responses to the questionnaire, a number of member States and UN entities provide guidance on the overall direction for the Report.

Added value

Member States emphasize the need for the Report to be complementary to and to add value to existing processes and UN reports. In particular, a synthesising report is expected to add value and provide improved access to the findings of a large number of existing assessments and to highlight synergies and trade-offs between actions taken in various settings.

As an integrated assessment of assessments, the Report is expected to become a useful instrument for the HLPF, especially in agenda-setting and the post-2015/SDGs framework. The Report preparation process is expected to foster collaboration among analytical teams in the UN system, including the Bretton Woods institutions.

Focus and integration

Member States suggest focusing on the implementation of sustainable development and specifically the SDGs/post-2015 agenda, providing lessons-learnt and identifying good practices and challenges.

The emphasis should be on inter-linkages between issues and on tools to address them in an inter-generationally equitable way. This might include, in particular, cross-sectoral analysis of progress made, obstacles encountered and potential integrated policy options.

Capacity needs

High-quality data and analysis capacity remains an issue, especially in developing countries, and lessons are available from existing assessments in this regard. Member States envisage a consultative, participatory process that will require building data and analysis capacity for integrated assessments and future scenarios. A joint UN effort is needed to address and monitor data availability, quality and analytical methodologies.

Role of the report in the HLPF and post-2015

In line with the Rio+20 outcome document, member States envisage the Report to bring together findings of scientific assessments as input for the policy deliberations at the HLPF. The Report might have an important monitoring and accountability function and should be policy-relevant, but not make specific policy recommendations. Some member States also envisage the Report to become one of a number of contributions to supporting implementation of the future SDGs and post-2015 development agenda.

Audience

The audience would comprise policy makers, notably at the highest level, senior government officials, the UN system and a wide range of stakeholders.

Scope

Preferred scope in terms of issue focus

Many respondents suggest to capture the priority issues identified in the Rio process, including Agenda 21, the Rio+20 outcome document, as well as in other important internationally agreed goals and commitments.

Most respondents have a clear preference for a science-based, yet practical Report that identifies policy solutions and supports the deliberations of the HLPF, as well as the implementation of future SDGs and the post-2015 development agenda. The Report would focus on identifying opportunities and challenges/obstacles to sustainable development progress, and acknowledge the different priorities and capabilities of countries. Many respondents expect a focus on global issues considered by the HLPF, including new and emerging issues, whereas others suggest highlighting national and regional priorities.

One Member State suggests four sections for the Report: landscape, review of progress, opportunities and

challenges, and policy recommendations. The analytical focus should be on the interaction among economic, social and environmental dimensions, on key drivers of change, and on clusters of strongly inter-linked issues (e.g., the food-water-energy nexus). Most would like the Report to present good practices of integrated policies and some would also like to see in-depth sectoral analyses.

Many respondents expect an empirical analysis of progress on the means of implementation. In particular, the Report could present good practices of leveraging financing, technology, trade, capacity building, international cooperation and multi-stakeholder partnerships. Some suggest reviewing existing mechanisms in support of sustainability and highlighting their advances or failures at different levels and time scales, including an analysis of the efficiency, effectiveness and financial and technical contributions of the institutional framework to support the achievement of the MDGs and SDGs.

In addition, a number of specific issues are suggested for inclusion: poverty eradication; inclusive growth; sustainable management of natural resources (water, energy, biodiversity, land use and soil protection); sustainable consumption and production; terrestrial and marine ecosystems management; climate change; sustainable development goals; international, technical and financial cooperation; technology transfer; health; resilience-adaptation-sustainability-development nexus; decision-making tools; and enhancing preparedness and building resilience.

Geographic scope

Interlinked sustainable development issues operate at widely different, but interacting, geographic and time scales.

Most respondents agree that the Report should have a global and regional geographic scope, that it should be based on national reporting and use the five official UN regions and take into account the differences between developed and developing countries. Most respondents suggest DESA to continue coordinating the global scope and the UN regional commissions to assist with regional sections of the Report.

Many suggest to include analysis for country groups – for countries in special situations or with high vulnerability (e.g., SIDS, LDCs, LLDCs, SSA) and/or for country groups categorized by development stage (e.g., developing countries, developed countries, economies in transition) or by income (e.g., high-income, middle-income and low-income countries).

In view of the fact that global issues need to be addressed nationally and locally, many also suggest to report on trends and experiences at national and local levels, based on countries' own national sustainable development reports and/or local reports.

Time horizon

Most respondents recommend the report to adopt a long-term, transformative vision, while using a pragmatic, flexible approach to match the different time scales of sustainable development issues. Some define long-term as a time horizon of 20 to 30 or 50 years. In particular, it is suggested to report on or around 1992, today, 2030, and 2050, in order to reflect progress since Agenda 21, where we are now and where we will be heading. Other respondents suggest adopting the time horizon of the future SDGs. A particular focus might be on the 4 to 5 years leading up to the report. The vision should be the vision of "real people in real places, not a vision of experts" alone.

Scope of scientific knowledge

Respondents suggest establishing a scientific, coherent and robust assessment framework. The Report might comprise an easily readable executive summary and a detailed scientific analysis covering all dimensions of sustainable development.

One group of respondents suggests including different types of knowledge, ranging from peer-reviewed literature and existing international assessments to local and multi-stakeholder knowledge, reflecting the perspectives of scientific communities and science users across the world. Another group of respondents recommends an exclusive focus on peer-reviewed scientific information and research.

Key national, regional and global priority issues to be reflected in Report

Global priority issues to be reflected in the report should be linked to global challenges, such as those highlighted in Agenda 21, the Rio+20 outcome document, and the future SDGs and post-2015 development agenda. The Report would focus on policy coherence, integrated policy, inter-linkages and implementation challenges at all levels.

Regional priority issues should be defined by each of the regions and national priority issues identified in national development strategies. Member States could each

highlight the most important tasks which could then be reflected in the Report.

Respondents generally support a focus on the global aspiration for the next two generations to eliminate poverty and hunger; to feed, nurture, house, educate 9 billion people by 2050; to secure inclusive growth, equity and development; and to preserve the Earth's life support systems. In particular, respondents specifically referred to the following priority issues: poverty and hunger eradication; wealth creation; agriculture, food security and nutrition; sustainable consumption and production; resource intensity; employment and decent work; jobless growth; inclusive growth and income distribution; social equity and security; education and learning; health and sanitation; population; financing; ODA; international debt management; trade; green economy; science and technology innovation; access to and transfer of technologies; urbanization; energy; water; climate change; land use and soil protection; forests; oceans and seas; marine protection and fishing; ocean acidification; biodiversity and ecosystems; housing; sustainable tourism; waste management; infrastructure development; transport; universal access to safe water, sanitation, sustainable energy, quality education, health services; equality; social protection; resilience to the impacts of climate change; disaster risk reduction; resilient buildings and communities; urbanization; slums; land use; land degradation; desertification, drought and deforestation; environment-poverty-inequality nexus; resource management; mining; macro-economics; pricing; barriers and disincentives to sustainable industrialization; intergenerational equity and welfare systems; governance and institutions; ecological-civilization society; and peace and security.

Role of the Report in identifying new and emerging issues

All respondents do see a role for the Report in identifying and addressing new and emerging issues, through sound scientific evidence, assessments and forward-looking projections, taking into account ongoing discussions in other relevant UN fora. Some believe this role to be even imperative. Others emphasize the need for political independence and objectivity of the Report and believe that it should not be considered the only source for such analysis. Even those that want the Report to focus primarily on implementation believe that it will most probably need to raise new and emerging issues in the process of identifying barriers to progress.

In this context, respondents note a range of unexpected changes and shocks that typically lead to new and emerging issues. Examples include economic and financial crises, natural disasters, and social and political instability.

Many respondents suggest identifying new and emerging issues through a combination of analysis of existing assessments and peer-reviewed literature; expert surveys; multi-stakeholder inputs from scientific communities, government officials, decision-makers, and civil society (e.g., using crowdsourcing and local knowledge); analysis of international agreements, commitments, and meeting outcomes; and country-level consultations.

At the same time, several respondents emphasize that the identification of new and emerging issues has to be based on sound scientific evidence. Others suggest a process whereby each country would identify its emerging priority issues, based on evidence, followed by HLPF agreement on a list of emerging issues for the purpose of agenda setting.

Type of content

Most respondents suggest capturing past and future trends, policy lessons, and scientific findings indicating potential areas for policy action, in order to enable evidence-based decision-making of the HLPF. A particular focus might be determined for each edition of the Report.

The Report should provide policy-relevant advice, not policy recommendations per se. It should indicate how inter-linkages can be addressed and what the leverage points and gaps are for the implementation of SDGs and post-2015 agenda.

It might showcase good practices and innovative sustainable development policies, plans, programmes, initiatives and technologies from around the world, and identify enabling success criteria and conditions. Some suggest to emphasize both successful and unsuccessful national cases, and to capture the institutional and political dimension.

The Report is expected to feature scientific findings indicating potential areas for policy action. In this regard, it should take into account the work of independent, scientific advisory groups and cooperate with assessment initiatives.

Monitoring and accountability framework for SDGs and the post-2015 development agenda

Most respondents envisage the Report to be part of or to contribute to the monitoring and accountability framework

for the future SDGs and the post-2015 development agenda. They also expect the Report to engage a broad range of stakeholders. However, several respondents that favour this approach think that such decision would be premature, as the post-2015 framework will not be decided before 2015.

One member State outlines potential elements of a larger monitoring and accountability framework for the post - 2015 agenda:

a) National reporting by countries and national stakeholders. A synthesis of lessons learned based on national reviews of sustainable development commitments could feed into the Global Sustainable Development Report submitted to the HLPF session under the General Assembly every four years.
b) Monitoring of targets and indicators of the post-2015/SDG agenda at international level which is likely the role of the enlarged UNDG interagency report, as successor to the MDG reporting;
c) Sectorial in-depth reporting, as carried out by specialized agencies and others, such as the IPPC, UNEP/GEO, WHO, ILO, and others;
d) Analysis of inter-linkages, data availability, science policy interface etc., which could be the primary role of the GSDR.
e) Another respondent suggests to have a separate accompanying report prepared on monitoring and accountability, and to summarize it in the Report.

Several respondents emphasize the intergovernmental, member States-driven nature of the processes under the GA leading up to the SDGs and post-2015 development agenda. Against this background, they suggest that the Report might be used by these processes, but that it would not be part of a monitoring framework. Instead, the Report's primary function would be to support deliberations of the HLPF which provides political leadership and facilitates sustainable development implementation at the global level.

Periodicity of the report

Respondents differ in terms of preferred periodicity of the Report, ranging from one to five years. However, those that favour a multi-year cycle with an in-depth report to be prepared every four or five years do suggest intermediate and/or focused reports every one (or two) years, in order to support all sessions of the HLPF. An iterative approach might be chosen with an explicit evaluation and adjustment phase.

Most respondents suggest an in-depth report to be produced every four years coinciding with the convening of the HLPF in the GA. The periodicity must be based on the needs of the HLPF and the post-2015 development agenda and take into account national reporting capacities. In particular, they suggest additional reports to be drafted in case of unpredictable circumstances with major impacts.

Those that would like to see a role of the Report in monitoring and accountability suggest more frequent quantitative indicator updates once or twice each year.

Some suggest adjusting the periodicity of contributing reports and assessments, such as the GEO report which is being produced every five years.

Methodology

Organization of the preparation of the global report

Most respondents expect an important role for the UN system in the preparation of the Report. They suggest a joint UN system effort (including the Bretton Woods organizations), coordinated by DESA DSD as Secretariat for the HLPF. In particular, some respondents suggest the chief scientists (or equivalent) of relevant UN entities[434] to collaborate in the preparation process. The five UN regional commissions could coordinate consultative meetings to prepare regional reports as inputs for the global Report. Some welcome the preparation of the prototype edition as a good general direction for future editions of the Report.

Many suggest national focal points to be part of this process in one form or another, and emphasize the need for UN technical support for developing countries. Some suggest encouraging national sustainable development reports for synthesis at the regional and global levels, whereas others prefer the Report to be drafted by scientists chosen by member States or the UN Secretariat.

The report would build on existing reports and assessments, such as those mentioned in the prototype edition of the Report, including national sustainable development reports, UN publications and international assessments. Many respondents suggest a multi-stakeholder process engaging scientists, experts, governments and civil society in undertaking analysis and assessments, possibly through joint working groups.

Transparency and fairness of the process is seen as essential, including in terms of selection of the experts. The Report should undergo a peer review process by scientists, policymakers and other relevant stakeholders. Data

collection should be made through platforms spanning global, regional, national and local levels and engage international scientific platforms.

Choosing the thematic focus of a given edition of the Report

Many respondents suggest the thematic focus of a given edition of the Report to be related to or to coincide with the theme of the HLPF session. While some respondents suggest the HLPF to choose the thematic focus, others prefer a multi-stakeholder process under the HLPF which would include member States, relevant UN entities agencies, civil society, and regional consultations. Another suggestion is for the UN Secretariat to carry out a multi-stakeholder survey, the results of which would be considered and prioritized by member States.

Principles

Respondents suggest the Report to follow the spirit of the Rio Principles and of other internationally agreed principles. They further suggest using the same principles and methods which are being used for preparation of other UN reports, including objectivity and political independence of conclusions, as well as balanced reflection of country- and region-specific information and data.

In particular, respondents recommend the following guiding principles for the Report: universality; legitimacy; representativeness; common but differentiated responsibilities; uniformity; comparability; objectivity; accuracy; transparency; inclusivity; balance; accountability; clarity; accessibility; leadership by example; continuous improvement; and the right of each country to decide on their own development pathways. They emphasize the need for adequate funding. They suggest an integrated, scientific approach, timely information, and multi-stakeholder perspectives. Research presented should be replicable and verifiable; hypotheses must be tested; and analytical work should be peer-reviewed. Member States express a clear preference for a policy relevant – but not policy prescriptive – report that is aligned with public policy needs.

Legitimacy of the Report at the global level requires that the scientific organizations or the scientific advisory mechanisms involved are: representative of the scientific community worldwide; preferably have already some track record of providing scientific advice to policy making bodies; and the functioning of the organization and/or the process is fully transparent. Making participation in science-policy processes open, inclusive and geographically balanced is seen as indispensable for ensuring a politically legitimate product.

Scientific methods

Many respondents agree that the prototype edition that was presented at the 1st session of the HLPF in September 2013 provides a useful basis on the methodological side for future editions. They suggest a multidisciplinary, integrated approach in the spirit of sustainability science and to draw on a multitude of sources and data. Respondents also suggest to learn from existing international assessments, and to allow scientists and member States the flexibility to choose the relevant methods on a case-by-case basis.

Respondents specifically recommend to consider the following elements: report both scientific elements and official data, in order to create greater buy-in from stakeholders, experts and government representatives; statistical analysis and evaluation of past and future trends; use of global sustainable development scenario models to analyze trade-offs across policy objectives; inductive and empirical methods using quantitative and qualitative data; sustainable development indicators; backcasting; likelihood approach and capturing uncertainties.

Best way to organize national and regional contributions

Respondents comprise two groups with different views on the best way to organize national and regional contributions. However, both groups agree that the process would combine research, analysis and consultations.

One group emphasises the need to make use of existing structures avoiding new focal points and preparatory processes. In their view, the existing networks and focal points can facilitate discussions and consultations at all levels and would allow for external expert participation.

The other group would like to see the establishment of a targeted network of national and regional focal points/experts who would be nominated by governments. Regular consultations with the focal points would ensure the consideration of stakeholder inputs across the world. The focal points would gather data, review progress and conduct focus group discussions. Some would like to see an IPCC-style model in which the nominated experts would meet regularly and draft the Report.

Many respondents in the second group suggest countries and regions to develop their own national and regional sustainable development reports - on a voluntary basis - as input for the global report. In this model, the UN system would provide capacity building and technical support. UN

regional commissions would organize regional consultations. Existing national sustainable development councils or similar committees in charge of implementation of sustainable development would play an important role.

Some also suggest organizing a participatory process to define a template and web-based toolkit for national reporting for consideration by member States and supported by UN capacity building efforts.

Proposed concrete steps to involve scientists from a wide range of countries and regions

Respondents suggest a number of concrete actions. For example, the UN Secretariat might want to request countries to nominate candidates to the Report writing team which would ensure consideration of views of scientific communities, practitioners and policy-makers. Others suggest using existing mechanisms of government consultation with civil society in order to seek policy advice and to create scientific forums around specific policy questions in support of the Report.

Several respondents also suggest various institutions, communities or networks to be mobilized for the Report, such as the existing networks of national academies of science; networks of scientific institutions; scientists among UN staff; the Secretary-General's SAB; UN system networks and communities; the Future Earth Initiative; Indonesian Institute of Science; Joint Research Centre; Sustainable Development Solutions Network; and statistical offices.

Several respondents suggest to involve all sectors and major groups identified in Agenda 21, including the UN system; planning agencies; prominent universities, research institutes, and think thanks; professional societies; scientific associations; civil society and opinion makers; experts and scientists from national academia and line ministries; independent scientists; civil society networks; knowledge exchange platforms, and R&D institutions in private and public domain.

Scientific advisory group or working group

While respondents agree on the usefulness of some kind of scientific advisory group (or working group) to provide overall guidance, they express different views on the composition and expected role of the group.

Some believe that the existing networks of national academies of sciences would best serve the role of an advisory group and also be the appropriate mechanism to peer review the Report. Others prefer the group of chief scientists of relevant UN entities to play an important role and envisage a scientific advisory board under the auspices of DESA, UNESCO, UNEP, UNDP, ILO, WHO, FAO, CBD, UNFCCC, UNCCD and UNIDO that would be closely related to the HLPF. Some of them emphasize the need for a mix of representatives from governments, the UN system and representatives of civil society and academic institutions. Still others would like to see an involvement of the Secretary-General's SAB.

Another group of respondents would like to see a stronger ownership by Member States. They encourage the UN Secretariat to consider establishing a working group of experts nominated by governments. In particular, they suggest following the practice of the Open Working Group on SDGs, in order to take fully into account geographical balance and representation. The UN system and other international organizations could provide inputs to the draft and the working group of experts would arrange meetings to interact with stakeholders on a regular basis.

In another variant of the member States-driven approach with national focal points, each country would establish a national scientific advisory committee that could be involved in national and global reports for which the UN would provide technical assistance.

National sustainable development report processes

Many respondents would like to see voluntary national sustainable development report processes and national experiences featured in the Report. However, there is a link to future HLPF decisions, including on regular reviews on the follow-up and implementation of commitments and objectives and the registry of voluntary commitments.

There are different options available which have to reconcile the needs for flexibility, streamlined reporting, and national consultations. Respondents suggest the national reports to become building blocks of an international reporting system. An advisory group might guide the preparation of the national reports. National reports would address the SDGs/post-2015 agenda and all areas of the national sustainable development strategy. Developing countries should receive capacity building support. National processes might include inter-ministerial dialogues.

How should the report inform the work of the High-Level Political Forum?

Many respondents suggest the Report to be integrated in and to provide scientific evidence to the deliberations of the HLPF, in order to enhance the science-policy interface

for sustainable development. They would like to see the HLPF to consider the method of integration and to decide what role and follow-up it would see for future Reports.

The Report should play a role in providing the HLPF with scientific knowledge in an easily comprehensible way. It could be utilized by the HLPF as a source of scientific analysis for setting its agenda, but it would not be the only agenda-setting input.

Many respondents expect the Report to provide scientific analysis of issues on the HLPF agenda, to provide evidence in support of HLPF decision-making and follow-up analysis, to disseminate HLPF activities, to channel feedback from the international community, and to carry out scientific monitoring of the future set of post-2015 goals.

Annex 7: Selected Areas for Action identified in the SD21 study

Who? Where?	Sustainable development (SD)as the overall objective	Visions for sustainable development	Goals and strategies	Action plans	Implementation
Ideal overall aspiration	Agree that sustainable development is the over-arching paradigm, at national and int'l levels.	Many visions for sustainability coexist. Agree on what to develop and what to sustain. Agree on fair sharing rules for use of the global commons (e.g. open oceans, atmosphere).	Develop integrated strategies and strong institutions that can guide all actors towards global sustainability.	Sectoral action plans should be based on agreed integrated strategies.	Ensure coordina-tion of implement-tation of sectoral strategies.
Global level / UN	Reconfirm sustainable development as the overarching goal. Agree on a desired level of intergenerational equity and on thresholds for global planetary limits that should not be trespassed.	Agree on, or reconfirm, a minimal set of things to be developed and sustained. Re-examine the roles of various groups of countries in an updated allocation of rights and responsibilities.	Agree on division of labour between the international system and the national level. The UN, int'l community could focus on: (1) managing global commons; (2) interface with Member States on int'l rules that affect global human impacts on the environment (trade, corporations, financial and capital flows, pollution); (3) mechanisms for ensuring that national commitments on issues of global interest "add up". Adopt a small, consistent set of Sustainable Development Goals (SDGs).	Coherent action plans for the implementation of agreed strategies and goals.	Agree on credible mechanisms for enforcement of commitments.
Political commit-ment	Actively engage to eliminate the duality in "sustainable" and "mainstream" institutions, at national and int'l level. Inscribe the maintenance and development of natural capital into the core mandates of ministries of finance, economy and development.	Empower lower levels of governments to act on their own and try new approaches to sustainability.	Governments at all levels should lead by example by putting public procurement rules and practices in line with their publicly advertised sustainability goals. Re-orient public investment (e.g. infrastructure, transports) in a direction that facilitates sustainable choices and behaviours.	Ensure maximal impact of public procurement on sustainability objectives.	Mobilize the political will to manage natural resources sustainably.
Institutions and Society	Integrate global environmental limits and related risks in rules, institutions, and decision-making at all levels. Increase the voice given to future generations in institutions at all levels.	Incorporate resilience of social systems and ecological systems in decision-making Manage the global commons equitably and sustainably. Define ways in which conflicts between rules and institutions can be resolved in a way that is compatible with overarching sustainable development objectives. Design mechanisms that ensure that commitments from different groups and different levels on issues of global interest "add up".	Look for robust strategies instead of "efficient" strategies. Consider all relevant instruments at our disposal – from acting on values and tastes, to demand management, to production efficiency. Integrate sustainability thinking in educational curricula. Develop strong institutions. Use integrated approaches to evolve sectoral goals and strategies that are consistent with broader goals ("Nexus approaches"). Design systemic mechanisms to bring UN conventions into the debate.	Build flexibility into institu-tions so that their scopes and mandates can be readjusted periodically. Ensure consistency of sectoral development strategies with broader sustainability objectives.	Conducive rules and support for projects and initiatives.
Participatio n and civil society		Provide forums for discussion and decision-making among all parts of society to elicit long-term strategies that achieve strong buy-in. Re-introduce equity as a dimension of decision-making, as opposed to an add-on to economic choices.	Put participation at the heart of decision-making at all relevant levels.	Participation	Participation
Science	Improve the science-policy interface, including on global limits and tipping points.	Design an institutional framework that allows for monitoring of major sustainability areas and providing adequate feedback to decision-making on areas of global importance.	Design transparent, independent and participatory monitoring and evaluation systems that provide the needed information to re-adjust course as needed. Sharing data is needed.	Increase priority and resources for measurement and evaluation of action plans, institutions and standards.	Reinforce monitoring and evaluation capacity.
Private sector	Fully incorporate the concept of social responsibility.	Sharing a common vision	Improve the compatibility of the system of rules governing the private sector with SD objectives. Reassess roles for the public and private sectors in the economy. Commit to providing a level playing field for local, low-technology, and non-market solutions, in order to enable local knowledge, skills, and technologies	Improve regulatory systems for financial and capital markets and corporations. Ensure they do not discrimi-nate against local, low-tech, or non-market solutions.	Investments and projects.

Source: adapted from UN (2012). Back to Our Common Future. Sustainable Development in the 21st century (SD21) project. Summary for policy makers, 2012.[435]

Notes

[1] This section draws on a presentation on "Science and Sustainable Development" by Prof. Bob Kates at the UN Expert Group Meeting on the Science-Policy Interface, New York, 5 September 2013.
[2] Ulrich Grober (2007). Deep roots – A conceptual history of 'sustainable development' (Nachhaltigkeit), Best.-Nr. P 2007-002, Wissenschaftszentrum Berlin für Sozialforschung (WZB), February 2007, http://skylla.wzb.eu/pdf/2007/p07-002.pdf
[3] UN (1987). Report of the World Commission on Environment and Development: Our Common Future. World Commission on Environment and Development, Transmitted to the General Assembly as an Annex to UN document A/42/427 ("Development and International Co-operation: Environment", http://www.un-documents.net/wced-ocf.htm
[4] http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm
[5] http://sustainabledevelopment.un.org/content/documents/Agenda21.pdf
[6] It should be noted, however, that the concept was "pushed by scientific notions" and environmental research.
[7] Most members of the WCED were politicians, but two of them were scientists: Paulo Nogueira-Neto (ecologist, professor) and Istvan Lang (biochemist, academician, Secretary General of the Hungarian Academy of Sciences).
[8] Some scientific input was coordinated by the Secretariat for the for the 1992 World Conference on Environment and Development. For example, an international scientific meeting was held at IIASA and a scientific book published Population, Environment and Development that was a case study about Mauritius.
[9] U.S. National Research Council, Policy Division, Board on Sustainable Development, Our Common Journey: A Transition Toward Sustainability(Washington, DC: National Academy Press, 1999), http://www.nap.edu/openbook.php?record_id=9690
[10] It should be noted that the UN Division for Sustainable Development also served as the Secretariat for Rio+20. The SD21 study was the only project report under the official budget for Rio+20.
[11] SD21 study, http://sustainabledevelopment.un.org/sd21.html
[12] http://www.un.org/gsp/gsp/report
[13] http://sustainabledevelopment.un.org/rio20.html
[14] UN document A/66/288 and http://sustainabledevelopment.un.org/futurewewant.html
[15] UN document A/67/591.
[16] http://sustainabledevelopment.un.org/content/documents/975GSDR%20Executive%20Summary.pdf
[17] Salganik, M.J., and Levy, K.E.C (2012). Wiki surveys: open and quantifiable social data collection, http://arxiv.org/pdf/1202.0500v1.pdf
[18] Inputs can be made in English at http://sustainabledevelopment.un.org/globalsdreport#ideas, Spanish and Chinese.
[19] UN GA A/C.2/68/8 of 18 November 2013, http://www.un.org/ga/search/view_doc.asp?symbol=A/C.2/68/8
[20] This is a clear difference to the "Assessment of Assessments on Oceans".
[21] For example, aspects of the climate-land-energy-water nexus are also discussed at the national and local levels.
[22] Kates, Robert, Thomas M. Parris, and Anthony A. Leiserowitz. 2005. What is sustainable development? Environment 47 (3): 9-21. http://www.environmentmagazine.org/Editorials/Kates-apr05-full.html
[23] This provides a general, illustrative picture only. The smaller circles are not necessarily full included in the next larger circles. For example, there may well be communities that are totally unrelated from the economy. Ultimately all economic and social activities are related to life supporting functions and nature but this relation may be very remote in a large part of modern economies. However, this does not change anything about the overall message of that these areas are to a large extent embedded in each other and thus strongly interconnected.
[24] The idea of 3 pillars – social, economic, and environmental – was promoted by scientist and economist Mohan Munasinghe in the 1990s and adopted by UN member States in Paragraph 5 of the Johannesburg Declaration on Sustainable Development, Sept. 2002, A/CONF.199/20, http://www.un-documents.net/jburgdec.htm.
[25] http://portal.unesco.org/en/ev.php-URL_ID=13179&URL_DO=DO_TOPIC&URL_SECTION=201.html
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[28] The chapter draws on the inputs and perspectives of scientists contributing to the UN Expert Group Meeting on Sustainable Development Assessments, held in New York from 3 to 4 Sept. 2013.
[29] The table present one prominent suggestion to delineate assessments from reviews. It should be noted, however, that there is no general consensus on this delineation.
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[33] Cases in point are the "Limits to Growth" study and "Energy in a Finite World".
[34] http://environment.harvard.edu/docs/faculty_pubs/clark_sustainability.pdf
[35] Bettencourt, L.M.A, and J. Kaur (2011). Evolution and structure of sustainability science, 19540–19545 | PNAS | December 6, 2011 | vol. 108 | no. 49, http://www.pnas.org/content/108/49/19540.full.pdf+html?with-ds=yes. See also http://tuvalu.santafe.edu/~bettencourt/sustainability/

[36] As of 13 Sept. 2013, http://www.unep-wcmc-apps.org/GRAMED/DataResults.cfm
[37] http://catalog.ipbes.net/
[38] There are, of course, various views on which areas are of "importance" to sustainable development. The present statement is based on a consideration of the 17 areas currently being considered by the OWG on SDGs.
[39] http://sustainabledevelopment.un.org/globalsdreport
[40] This assumes a conservative estimate of US$ 10,000 per scientist per year for their in-kind contributions and travel costs to the meetings.
[41] http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Home-GEA.en.html
[42] Written submission to the Expert Group Meeting on the Sustainable Development Assessments (New York, 3-4 Sept. 2013)
[43] For example, the UNEP GEO series has traditionally had a strong focus on the description of trends and natural systems and associated problems. GEO-3 and GEO-4 extended that tradition into the future with future scenarios. The GEO-5 increased its solutions focus by monitoring progress towards policy goals contained in intergovernmental environmental agreements. Future GEO reports might focus on recommending specific policy options.
[44] Anecdotes of "negotiations" of scientists in the IPCC of primary energy shares are a case in point.
[45] For example, G20 is used in an IPCC report, apparently to use as proxy for the largest emitters. Yet, G20 is not country grouping with the twenty largest emitters.
[46] "Death of Rio Environmentalism" pp. 1-12. In: The Crisis of Global Environmental Governance, edited by J. Park, K. Conca and M. Finger (Routledge, 2008).
[47] Handmer, John and Stephen Dovers. 2008. "A Typology of Resilience: Rethinking Institutions for Sustainable Development." pp. 187-210 in The Earthscan Reader on Adaptation to Climate Change, edited by L. F. Schipper and I. Burton. London: Earthscan.
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[49] See : biological and cultural diversity in costal communities -exploring the potential of Satoumi for implementing the Ecosystem Approach in the Japanese Archipelago http://www.cbd.int/doc/publications/cbd-ts-61-en.pdf
[50] See : Recognising and Supporting Territories and Areas Conserved by Indigenous Peoples and Local Communities http://www.cbd.int/doc/publications/cbd-ts-64-en.pdf
[51] The UN System Chief Executives Board (CEB), the UN Development Group (UNDG), the Environmental Management Group (EMG) continue to coordinate system-wide follow-up activities in their respective areas.
[52] http://www.unep.org/geo/
[53] Full report at http://www.unep.org/geo/pdfs/geo5/GEO5_report_full_en.pdf and the Summary for Policy makers at http://www.unep.org/geo/GEO5_SPM.asp
[54] http://www.cbd.int/gbo3/
[55] http://sustainabledevelopment.un.org/rio20nationalreports.html
[56] http://sustainabledevelopment.un.org/index.php?menu=1621
[57] http://sustainabledevelopment.un.org/memberstates.html
[58] , http://www.sidsnet.org/resources
[59] Previously available at: http://www.johannesburgsummit.org/html/prep_process/natlassessrep.html
[60] http://www.undp.org/content/undp/en/home/librarypage/mdg/mdg-reports/
[61] http://www.ncsds.org/index.php/sustainable-development-councils/country-profiles
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[64] A definition of strategic environmental assessment appeared for the first time in the National Environmental Policy Act of the United States in 1969.
[65] OECD (2006). DAC Guidelines and Reference Series: Applying Strategic Environmental Assessment: Good Practice Guidance for Development Co-operation, Paris. http://www.oecd.org/dac/environment-development/37353858.pdf
[66] Dalal-Clayton, B. and B. Sadler (2005). Strategic Environmental Assessment : A Sourcebook and Reference Guide to International Experience, London, Earthscan.
[67] For example, an early policy decision submitted to SEA might deal with strategic issues on energy generation. An EIA of alternative power-generating options, such as a mix of thermal, hydro and wind sources of power would be complementary to the SEA and assist in the identification of the environmental costs and benefits and hence the selection of a preferred option (Abaza, Bisset and Sadler, 2004). Source: Abaza H, R. Bisset and B. Sadler (2004). Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach, UNEP, http://www.unep.ch/etu/publications/text_ONU_br.pdf

[68] http://www.unece.org/env/eia/sea_protocol.html
[69] COWI (2009), Study concerning the report on the application and effectiveness of the SEA Directive (2001/42/EC), Final report, European Commission, http://ec.europa.eu/environment/eia/pdf/study0309.pdf
[70] OECD DAC SEA Task Team (2010), Minutes of the 15th meeting of the OECD DAC Environet Task Team on SEA, held on 17-18 November 2010 at the Inter-American Development Bank, Washington, D.C.
[71] Ghanimé, L., N. Risse, T. Levine and J.J. Sahou (2010). « Using SEA to Enhance Poverty Reduction Strategies », In R. Aschemann, J. Dusik, T.B. Fischer, M.R. Partidário and R. Verheem (dir.), Handbook of Strategic Environmental Assessment, London, Earthscan.
Ghanimé, L. and N. Risse (2007). « Environmental Sustainability, Strategic Environmental Assessment and Poverty Reduction Strategies », In E.W.K. Au et al. (dir.), International Experience on Strategic Environmental Assessment. China's International Conference on Strategic

Environmental Assessment (SEA), Center of Strategic Environmental Assessment for China (Chinese University of Hong Kong), Hong Kong Institute of Environmental Impact Assessment and Research Centre for Strategic Environmental Assessment (Nankai University).

[72] Costs related to the preparation of an SEA vary depending on the type, scope and complexity of the assessment. In the United Kingdom for example, SEA costs were reported by COWI (2009) to be typically in the range EUR 35,000 (approximatively 49 000US$) to EUR 80,000 (approximatively 111 000US$).

[73] : Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Croatia, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Romania, Yugoslavia, Slovenia, Tajikistan, the former Yugoslav Republic of Macedonia, Turkmenistan, Ukraine and Uzbekistan

[74] For example, at the request of Morocco, UNECE has launched in 2012 the EPR of the country in cooperation with the UN Economic Commission for Africa. More recently, Tunisia expressed the hope to be reviewed under the third cycle of UNECE EPR programme with the support of UNESCWA, the latter being particularly interested to strengthen accountability for sustainable development and to initiate an EPR programme for member countries committed to renew their environmental policies with the perspectives of green economy transition.

[75] Clark, W.C., Linking Knowledge with Action for Sustainable Development - Synthesis of Scholarly Research from TWAS, US National Academies, Sustainability Science Program.

[76] Science Council of Japan Statement: Code of Conduct for Scientists – Revised Version (SCJ, 2013); available at http://go.nature.com/nhrnbb

[77] Gluckman, P., (2014). The art of science advice to government. Nature, Vol. 507, 13 March 2014, pp. 163-165

[78] Net primary productivity (NPP) is defined as the net flux of carbon from the atmosphere into green plants per unit time. NPP refers to a rate process, i.e. the amount of vegetable matter produced (net primary production) per day, week, or year…. NPP is a fundamental ecological variable, not only because it measures the energy input to the biosphere and terrestrial carbon dioxide assimilation, but also because of its significance in indicating the condition of the land surface area and status of a wide range of ecological processes.", see http://daac.ornl.gov/NPP/html_docs/npp_est.html .

[79] http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2014.pdf

[80] Informal report prepared by students of Wageningen University, Netherlands, and the State University of New York – College of Environmental Science and Forestry, December 2013.

[81] Further information on the CBD process to identify new and emerging issues is available here: https://www.cbd.int/emerging/

[82] CBD Technical Series 66 - https://www.cbd.int/doc/publications/cbd-ts-66-en.pdf

[83] CBD Technical Series 67 - https://www.cbd.int/doc/publications/cbd-ts-67-en.pdf

[84] CBD Technical Series 65 - https://www.cbd.int/doc/publications/cbd-ts-65-en.pdf

[85] CBD Technical Series 46 - https://www.cbd.int/doc/publications/cbd-ts-46-en.pdf

[86] CBD Technical Series 45 - https://www.cbd.int/doc/publications/cbd-ts-45-en.pdf

[87] document UNEP/CBD/SBSTTA/16/INF/12 - http://www.cbd.int/doc/meetings/sbstta/sbstta-16/information/sbstta-16-inf-12-en.doc

[88] 21 Issues for the 21st Century: Results of the UNEP Foresight Process on Emerging Environmental Issues. http://www.unep.org/publications/ebooks/foresightreport/Portals/24175/pdfs/Foresight_Report-21_Issues_for_the_21st_Century.pdf

[89] http://sustainabledevelopment.un.org/content/documents/1880sidsegm2.pdf

[90] Please refer to the full report for details of the crowdsourcing results.

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[92] http://data.un.org/

[93] With permission of the authors.

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[142] http://undesadspd.org/IndigenousPeoples/ThematicIssues/Culture.aspx
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[144] The discussion in this section is based on the SD21 study.
[145] SD21 study, http://sustainabledevelopment.un.org/sd21.html

[146] "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].
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[177] 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.

[178] 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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[407] Accessibility - In connection to the previous feature, the developed model should be accessible to all interested members from the scientific, policy-framing or public community. As such, the model and its produced results should not be exceedingly difficult to comprehend, which leads to the necessity for simplicity.
[408] Modularity - The model should consist of an ensemble of modules that can function both as isolated and interconnected parts of the entire model. These modules can be thought of as pieces of a puzzle and assess different sectors of the economy. In this way, the model can easily be disassembled and modified to alter the focus given to a particular set of technologies or sector of the economy.

[409] Scalability - A generic model structure should be established to allow the use of the model in varying degrees of aggregation (i.e. global, regional, national). In the primary stage of GLUCOSE model development a high aggregation has been employed, as the globe is represented in a single region.
[410] Crowdsourcing - The interdisciplinary nature of any integrated assessment effort entails a great deal of input from a number of fields of expertise. The four aforementioned criteria serve as the means to promote and encourage this final feature. Consequently, the proposed model can be seen as a constantly evolving tool, where stakeholders can populate the model with their own data and test their own assumptions.
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[434] e.g., UNDESA, UNEP, UNDP, ILO, WHO, FAO, CBD, UNFCCC, UNESCO, UNCCD and UNIDO
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