Chapter 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 towards 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 considered to be 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 5.2). 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 the GDP.

The third 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. 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 the most demanding (section 5.3).

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 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*.[199] In order to measure progress, however, corresponding sustainable development goals and targets must also be defined.[200] *"...A given indicator does not say anything about sustainability, unless a reference value such as thresholds is given to it".*[201] Many such threshold targets have been agreed in *Agenda 21*, the MDGs, the Johannesburg Programme of Implementation and in other United Nations forums. 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 to be essential for achieving sustainable development.

Most attention and resources have been dedicated to the Millennium Development Goals (MDGs) and measurement towards their achievement. In September 2000, world leaders adopted the United Nations Millennium Declaration, which committed their nations to a global partnership to reduce extreme poverty and set 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 poverty and hunger eradication, universal primary education, gender equality, child and maternal health, HIV/AIDS combat, environmental sustainability and global partnership. Progress towards the 8 MDGs and their 20 targets are monitored by more than 60 indicators. The indicators for MDGs 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 ODA, market access and debt.

Chapter 3 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 OWG on SDGs. (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, it is difficult to evaluate 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 US$1.25 a day or less fell from 47 per cent in 1990 to 24 per cent by 2008, a reduction from over 2 billion to less than 1.4 billion people. The progress in developing Eastern Asia has been especially rapid, with extreme poverty falling from over half the population in 1990 to 14 per cent in 2008.[202, 203] Africa has enjoyed

growth in the past decade unprecedented by historical standards, and the average poverty rate has declined from 58 per cent in 1999 to 48 per cent in 2008.[202]

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's system beyond which irreversible changes might have enormous impacts on humanity's survival. In particular, it was suggested that at least three planetary boundaries had already been breached.

Box 6. SDG 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:

- Be based on *Agenda 21* and the Johannesburg Plan of Implementation (JPOI);
- Fully respect all the *Rio Principles*;
- Respect national policies and priorities;
- Be consistent with international law;
- Build upon commitments already made;
- Contribute to the full implementation of the outcomes of all major summits in the economic, social and environmental fields, including the Rio+20 outcome document;
- Focus on priority areas for the achievement of sustainable development, being guided by the outcome document;
- Address and incorporate in a balanced way all three dimensions of sustainable development and their interlinkages;
- Be coherent with and integrated into the United Nations development agenda beyond 2015;
- Not divert focus or effort from the achievement of the Millennium Development Goals;
- Include active involvement of all relevant stakeholders, as appropriate.

It was further agreed that SDGs must also be:

- Action-oriented;
- Concise;
- Easy to communicate;
- Limited in number;
- Aspirational;
- Global in nature;
- 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[204].

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 5.2). The Rio+20 outcome document called for SDGs that would be "*global in nature and universally applicable to all countries*" (*The Future We Want*, paragraph 247), address in a balanced way all three dimensions of sustainable development (social, economic and environmental) and satisfy 18 criteria (see Box 6).

The "Expert Group Meeting for the United Nations Global Sustainable Development Report - Engaging National Assessments", which was hosted by the Government of China in Beijing from 12 to 13 December, 2013, referred 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 analysed past trends and future options (see Box 7). It also suggested that these goals and targets might be considered by the OWG on SDGs, which, it suggests, 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).[206] It should be noted that the list of goals and targets suggested is rather similar to that provided in Table 24.

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).

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. Ensure universal access to improved water source and basic sanitation by 2050;
4. Ensure universal health coverage;
5. Ensure 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. Ensure 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 greater than 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. Ensure a 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 zero by 2050;
17. Hold global mean temperature increase below 2°C;
18. Increase science and technology innovation capacity through knowledge sharing and technology transfer.

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

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. [207]

The United Nations Development Programme (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).

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[205]

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)	United Nations *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports*	The world's poverty reduction target was reached five years ahead of schedule. The proportion of people living on less than US$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 there are 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)	United Nations *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)	United Nations *Millennium Development Goals Reports*; World Bank-IMF *Global Monitoring Reports*; United Nations *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)	United Nations *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	On track in the MDGs context.	Universal access to health care
5. Education (MDGs)	United Nations *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, Johannesburg Plan of Implementation [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 (business-as-usual 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)	United Nations General Assembly *Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic 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

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
8. Biodiversity (Aichi Targets; Target 7.B of MDGs)	CBD *Global Biodiversity Outlooks*	The target agreed by Governments in 2002, "to achieve by 2010 a significant reduction of the current rate of 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.	20 Aichi Targets of halting global biodiversity loss	Achieving, by 2010, a significant reduction in the rate of biodiversity loss	Off track	Biodiversity (measured as terrestrial mean species abundance) will decline 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.	Stabilize biodiversity at the 2020/2030 level (depending on region)by 2050
9. Forest (Aichi Targets on forest; Four shared global objectives on forests at United Nations Forum on Forests in 2006.)	United Nations Forest Forum Reports CBD *Global Biodiversity Outlooks*; FAO *Global Forest Resources Assessments*	Today, forests cover 31 per cent 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	Biodiversity (measured as terrestrial mean species abundance) will decline 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.	Stabilize biodiversity at the 2020/2030 level (depending on region)by 2050
10. Sustainable consumption and production (Ch.4 *Agenda 21*; and Ch. 3 of JPOI)	United Nations *Trends Reports: Towards Sustainable Consumption and Production*; World Business Council for SD: *Vision 2050 Report*; UNEP: *The Marrakech Process Progress Report*	The 10-Year Framework of Programmes 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; US$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 commensurate with needs by 2018. Universal access to sustainable technology by 2030. Global technology performance improvement 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, R&D, and investment in riskier sectors, such as small and medium enterprises.	Achieve sustainable development promoting sustainable, inclusive and equitable 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 GPI per capita

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
13. Needs of countries in special situations, and middle-income countries (Istanbul Programme of Action; Rio+20)	Secretary-General's Report on Implementation of the Programme of Action for the LDCs UN-OHRLLS *Reports on LDCs, LLDCs and SIDS.* African Development Bank: *African Development Reports*	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 SIDS	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
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*; United Nations *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 Settlement* 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 US$292 billion per year, up from US$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	Since 1850, global use of fossil fuels has increased to domestic energy supply, leading to a rapid growth in GHG emissions. GHG emissions have increased at an accelerated rate in the 2010s. By 2012, CO_2 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 2ºC	By 2050 or longer term based on scientific evidence	Off track	Atmospheric GHG concentrations reach 685 ppmv (CO_2-equ.), (eventually leading to 3-6 degree Celsius warming).	Keep atmospheric GHG concentration below 450 ppm CO_2 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 per cent 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 - United Nations 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 on the Sustainable Development Goals process (2013) and various publications mentioned above.

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 recognized as a target for environmental progress by some public authorities.[208]

5.2.3. The 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 European Union's *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:

- Complement GDP with environmental and social indicators
- Gather near real-time information for decision-making
- Provide more accurate reporting on distribution and inequalities
- Develop a European Sustainable Development Scoreboard
- Extend national accounts to environmental and social issues.

The newly developed "Europe 2020" strategy defines measurable

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	United Nations Security Council: System of Environmental Economic Accounting	World Bank: Wealth accounting and adjusted net saving	Stiglitz-Sen-Fitoussi Commission report	5.2.2. European Union GDP and Beyond (e.g. GPI)	OECD Better Life Initiative	UNECE/ OECD/ Eurostat Task Force for Measuring Sustainable Development (TFSD)	United Nations 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)
	Intergen-erational 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 (environmen-tal sustain-ability)	Indirectly
Dimensions adapted from the Stiglitz report	Main concern	Sustainable development	Human development	Environment and economic accounting	Economic development / macro-economic 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 and social aspects)	XXX	XXX	_	XX	X	X	X	X	XXX	X
	Environment	XXX	XXX	XXX	XXX	X	XX	X	XX	X	_
	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
Note	Limitation	Limited number goals to cover a broad range of issues	Time frame: sporadic references to 2015	_	e.g. human capital = education 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

X: slightly covered; XX: moderately covered; XXX: extensively covered. Source: Adapted from European Statistical System Committee (2011)[209, 207].

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 European Union's Beyond GDP initiative is the genuine progress indicator (GPI), which is presented next.

5.2.4. Measure of economic welfare, index of sustainable economic welfare and genuine progress indicator

The Measure of Economic Welfare (MEW), the Index of Sustainable Economic Welfare (ISEW) and the Genuine Progress Indicator (GPI) are three variations of the same idea to adjust the 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 account (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 defence, 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
+ Non-market 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 estimated by observed income differentials between cities and rural areas
- Additional capital consumption	
- Growth requirement	
= Sustainable measure of economic welfare	

Sources: Nordhaus and Tobin (1972)[210]; Stewart (1974)[211].

The Nordhaus-Tobin concept of sustainable 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).[211] Table 26 provides an overview of how MEW is calculated starting from gross national product (GNP).[212] While GNP is a measure of production, some have pointed out that MEW is primarily a measure of consumption.[213] "*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).[211] 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.*"[210] 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.

Building on the work of Nordhaus and Tobin, Daly and Cobb suggested the ISEW in 1989.[214] 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.[215] 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)

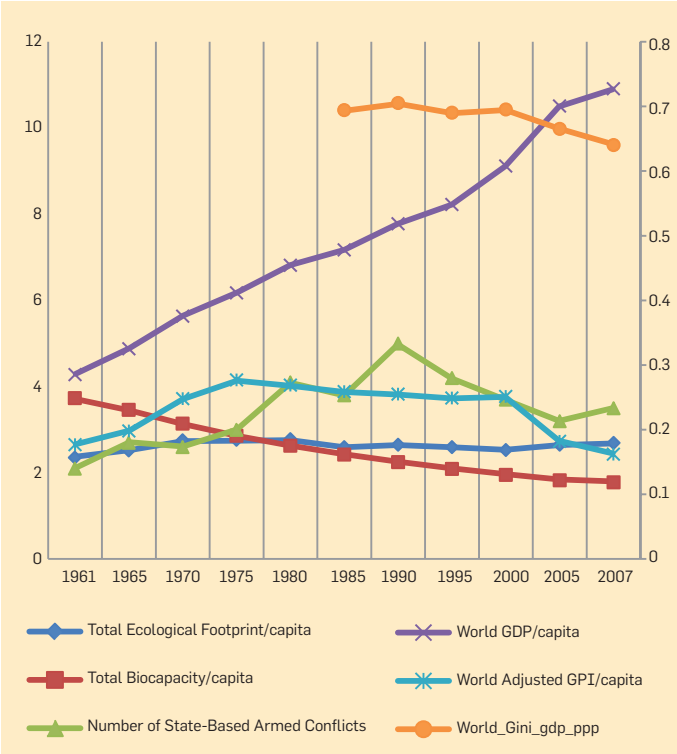
Dimension	Components and calculation	Explanations
Economic	+ Personal consumption expenditure weighted by income distribution index	-
	+ Value of household work and parenting	Services provided by volunteer (e.g. non-remunerated community) work and non-paid household work (e.g. parenting, elder care, 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 Costanza (2011)[216]. Note: Individual components 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.[217] 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; and net capital investment. Others items are subtracted: the cost of consumer durables; disservices generated by economic activity; defensive and rehabilitative expenditures; net foreign borrowing; and the cost of sacrificed natural capital services. Table 50 in Annex 4 presents data sources for calculating GPI, using the 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 has increased threefold since 1961, the world's GPI - 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 per cent of the world population.[218] Interestingly, the second half of the 1970s is also when the global ecological footprint increased beyond biocapacity. 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, 1961-2007



Sources: GPI per capita and GDP per capita are from Kubiszewski et al. (2013)[130]; Number of state-based armed conflict is from *Human Security Report* (2012); global ecological footprint and biocapacity 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 per capita and GPI per capita, the unit is US$1,000, for Number of state-based armed conflict, the unit is 10 cases, for global ecological footprint and biocapacity hectares per person, the unit is 1 hectare. GPI per 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 per capita data for all countries. All estimates are in 2005 US dollars.

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.[219] 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 United Nations Statistical Commission similar to the historical experience with GDP. A minimal approach to adjusting GDP might be a useful way forward. Further, it is, of course, possible to measure GPI globally without having established national GPI processes.

5.2.5. World Bank 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 - also known as "genuine savings" - which is a sustainability indicator building on the concepts of green national accounts.[220] 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.[221] The world's public expenditure in education was similar to the value of resource depletion and environmental damage, leading to an adjusted net savings rate of 7.2 per cent of GNI - not very different from net national savings of 7.9 per cent 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 savings and adjusted net savings since 1970.

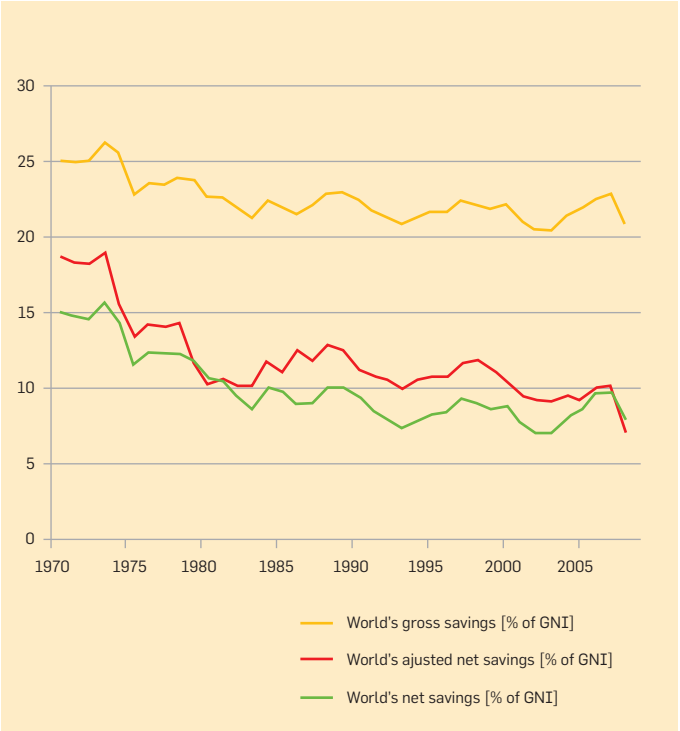
Criticisms of the World Bank's adjusted wealth and adjusted net savings have been similar to those of GPI. It should be noted that

Table 28. Calculation of adjusted net savings

Dimension	Components and calculation	World adjusted net savings in 2008 (% of GNI)	Explanation
Economic	+ Gross national savings	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
Environmental	- CO_2 damages	0.4%	A conservative figure of US$20 marginal global damages per ton of carbon emitted was taken from Fankhauser (1994)
	- PM damages	0.2%	Willingness to pay to avoid mortality and morbidity attributable to particulate emissions
	- Energy depletion	3.9%	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 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**	**7.2%**	**Net national saving plus education expenditure and minus energy depletion, mineral depletion, net forest depletion, CO_2 damage and particulate emissions damage**

Sources: World Bank technical notes; Bolt et al. (2002)[222].

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



Source: Authors' presentation based on World Bank data.[223]

adjusted wealth estimates estimate "stocks" and thus complement the "flow" estimates of GPI.

5.2.6. United Nations 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 UN DESA, in close collaboration with experts from international organizations and United Nations 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 United Nations Division for Sustainable Development 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[224] 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 developed by the OECD. It was first used in the organization's preliminary set of environmental indicators in 1991. It is based on the fact that humans exert pressures on the ecosystem and society, altering their state and requiring 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;

Table 29. United Nations Commission for Sustainable Development sustainable development indicators

Theme	Sub theme	Core CSD indicator	Other CSD indicators
Poverty	Income poverty	Proportion of population living below the national poverty line	Proportion of population below US$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	

Theme	Sub theme	Core CSD indicator	Other CSD indicators
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	Percentage 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	Lifelong learning
		Net enrolment rate in primary education	
		Adult secondary (tertiary) schooling attainment level	
	Literacy	Adult literacy rate	
Demographics	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	GHG emissions
	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	Percentage 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 development	Macroeconomic performance	GDP per capita	Gross saving
		Investment share in GDP	Adjusted net savings as percentage of GNI
	Sustainable public finance	Debt to GNI ratio	
	Employment	Employment–population ratio	Vulnerable employment
		Labour productivity and unit labour 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 people
			Mobile cellular telephone subscribers per 100 population
	Research and development		Gross domestic expenditure on R&D as a percentage of GDP
	Tourism	Tourism contribution to GDP	

Theme	Sub theme	Core CSD indicator	Other CSD indicators
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 ODA given or received as a percentage of GNI	Foreign direct investment net inflows and net outflows as percentage of GDP
			Remittances as percentage of GNI
Consumption and production patterns	Material consumption	Material intensity of the economy	Domestic material 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: United Nations (2006)[225]. Note: 2006 revision

land; consumption and production patterns; education; oceans, seas and coasts; demographics; freshwater; and biodiversity (Table 29).

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.

5.2.7. United Nations Statistical Commission's System of Environmental-Economic Accounting project

A multi-year process of revision to the System of Environmental-Economic Accounting (SEEA) was initiated by the United Nations Statistical Commission in 2003. The revised SEEA consists of three parts: (1) the Central Framework, which was adopted by the Statistical Commission as the first international standard for environmental-economic accounting; (2) experimental ecosystem accounting; and (3) 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 subsystems are fully consistent with the overarching 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. [226]

Global consultation on the SEEA Central Framework was 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 at the 44th Session of the Statistical Commission in February 2013.

By its very design the SEEA focuses 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 has been standardized and agreed at the United Nations level.

Table 30. System of Environmental-Economic Accounting classification of environmental activities

Group	Classes
Environmental 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 management	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: United Nations et al. (2012)[227].

5.2.8. 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*"[228] that was proposed by the group in 2009.

A Task Force for Measuring Sustainable Development (TFSD) 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.[229]

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	GHG 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).[228]

Table 32. "Small set" of indicators proposed by UNECE/Eurostat/OECD task force on measuring sustainable development 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	United Nations
	ODA paid	143	World Bank
	Imports from developing countries	-	United Nations
	Income inequality	134	United Nations MDG database
	Gender pay gap	68	United Nations
Nutrition	Obesity prevalence	160	United Nations
Health	Life expectancy at birth	185	United Nations
Labour	Employment rate	145	United Nations
Education	Educational attainment	184	United Nations
Housing	Living without housing deprivation	91	United Nations MDG database
Leisure	Leisure time	20	Multinational Time Use Survey Database
Physical safety	Death by assault/homicide rate	186	United Nations
Land and ecosystems	Bird index	214	World Bank World Development Indicators (WDI)
Water	Water abstractions	93	United Nations
Air quality	Urban exposure to particulate matter	173	United Nations
Climate	GHG emissions	229	World Bank
Energy resources	Energy consumption	187	United Nations
Non-energy resources	Domestic material consumption	200	Sustainable Europe Research Institute
Trust	Generalized trust	82	World Bank WDI
Institutions	Voter turnout	194	International Institute for Democracy and Electoral Assistance
Physical capital	Gross capital formation	156	United Nations
Knowledge capital	R&D expenditures	116	United Nations
Financial capital	Consolidated government debt	84	World Bank WDI

Source: UNECE et al. (2013).[229]

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

Building on almost 10 years of work on measuring progress, including the Istanbul Declaration in 2007, the OECD launched the 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: (a) material living conditions, (b) quality of life and (c) sustainability. The approach drew closely on the framework recommended by the Stiglitz-Sen-Fitoussi Commission on measuring progress and on previous OECD work, and it 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.

5.2.10. United Nations Development Programme (UNDP): Human development index (HDI) and human sustainable development index (HSDI)

The 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.

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).[232]

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

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 and skills	Educational attainments
		Years in education
		Student skills
	Social connections	Social network support
	Civic engagement and governance	Consultation on rule-making
		Voter turnout
	Environmental quality	Air pollution
		Satisfaction with water quality
	Personal security	Reported homicides
		Assault rate
	Subjective well-being	Life satisfaction
Sustainability of well-being	Natural capital	Mineral and energy resources; land; soil resources; timber resources; aquatic resources; other biological resources; water resources; atmospheric CO_2 concentrations; state of the ozone layer; land use; species abundance; threatened species; urban exposure to particulate matter; water quality; and 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 cooperation - e.g. tolerance and reciprocity

Source: OECD (2013)[230,231].

Table 34. Components of the human development index and human sustainable development index

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

Source: Authors' elaboration.

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 United Nations regular MDG report.[233, 234] For example, even the most simple of data, a population headcount, is expensive - the 2010 United States of America population census cost US$13 billion, the 2010 Chinese census cost US$1.4 billion and that of India cost US$400 million.[235] The United Nations Statistical Commission supported a standardized SNA since 1953,[236] 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 are collected for provinces/states and typically only national-level data are shared and distributed by the United Nations and other international organizations. Although the data may be available at subnational 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 subnational levels of trends in, e.g. 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 on 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 20 years, even if global agreement were reached on a "perfect" sustainable development progress index. To be clear, traditional progress indices are useful tools, but it is important to recognize their shortcomings. In fact, the above shortcomings are common to most socioeconomic data, especially in developing countries.

Fortunately, scientists and engineers have recently suggested new ways to overcome the limitations of the traditional approaches.[237] 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.

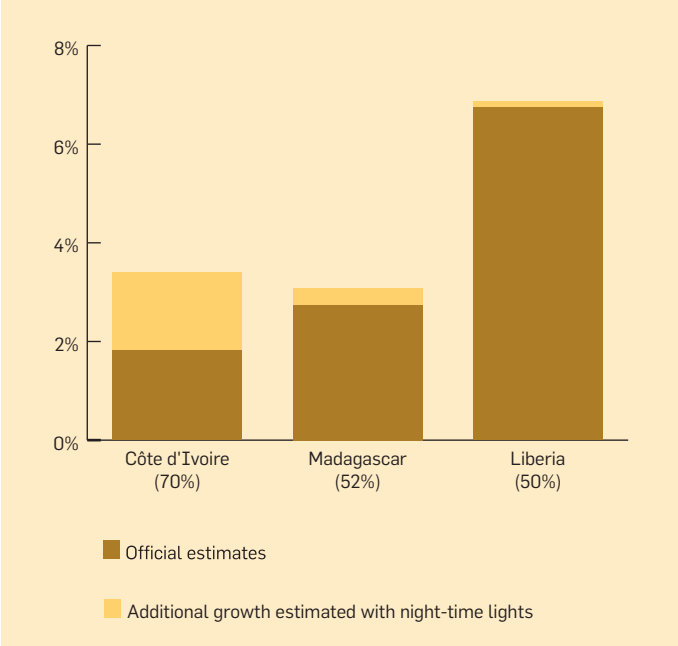
Remote sensing obtains information about objects from a distance. It uses satellites, aerial photography and, in a broader sense, data from mobile phones, the Internet, and other communication technologies and sensors. Remote sensing data typically have a high spatial-temporal resolution, are information-rich and have increasingly become available freely or at low cost to researchers across the world, particularly since open access policy was introduced to archived satellite images by the United States Government in 2008[238] Remote sensing data have been used extensively by environmental scientists (e.g. to study land-use changes), but their use in studying socioeconomic changes has been rare. Hall and Andersson provide a review of the use of remote sensing in the social sciences. [239]

Early examples of using remote sensing in the social sciences include: the use of night-time light data to estimate population,[240, 241] urban extent,[242] energy-related CO_2 emissions,[243] GDP,[244, 245] and PPP,[240] poverty,[246] electricity[240] and energy use at various spatial scales. Night-time light data for the globe are available from the United States Defense 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.[247] 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 towards the east at about 60 kilometres per year.[248] Applications of night-time light data to infer socioeconomic 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.[249] 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.[244] 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.[244] By combining official GDP data with data from night-time lights, revised estimates of income growth were produced for

a number of countries.[244] For Côte d'Ivoire, the official estimates pointed to a GDP growth of 1.8 per cent from 1992/3 to 2005/6, whereas additional information from changes in night-time lights provided a higher estimate, 3.4 per cent, up 1.6 per cent 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.

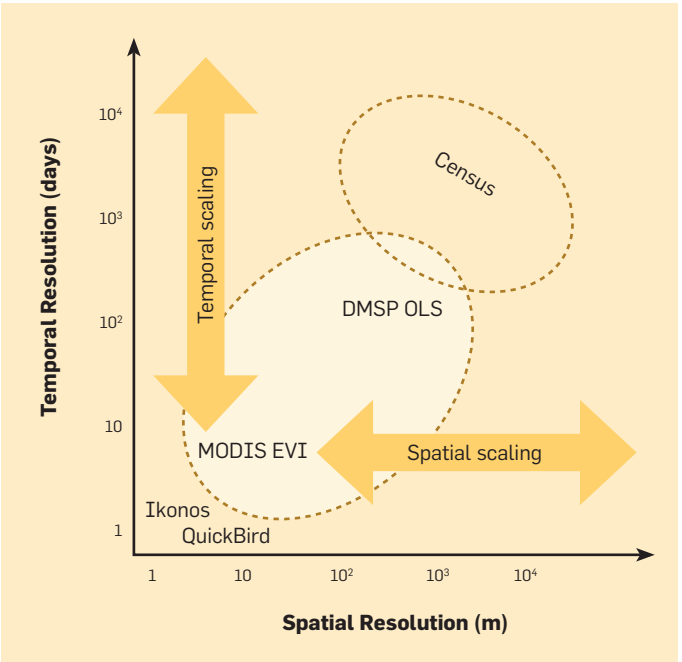
Source: Compiled by the United Nations Division for Sustainable Development from Henderson et al. (2012)[244] and ILO (2012)[249].

However, an important drawback of night-time light data is that they say little about development among the poorest agricultural areas - areas with the biggest data gaps. Figure 21 illustrates this point in the case of the Lao People's Democratic Republic (Lao PDR) which is an LDC 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 5.5-8.6 per cent per year (in real terms). While night-time light map captured growth well 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. Moderate Resolution Imaging Spectroradiometer (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 are available at a spatial resolution of 250 meters and global coverage every 16 days[250] (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 eight days.

Figure 19. Temporal and spatial resolution of data sources



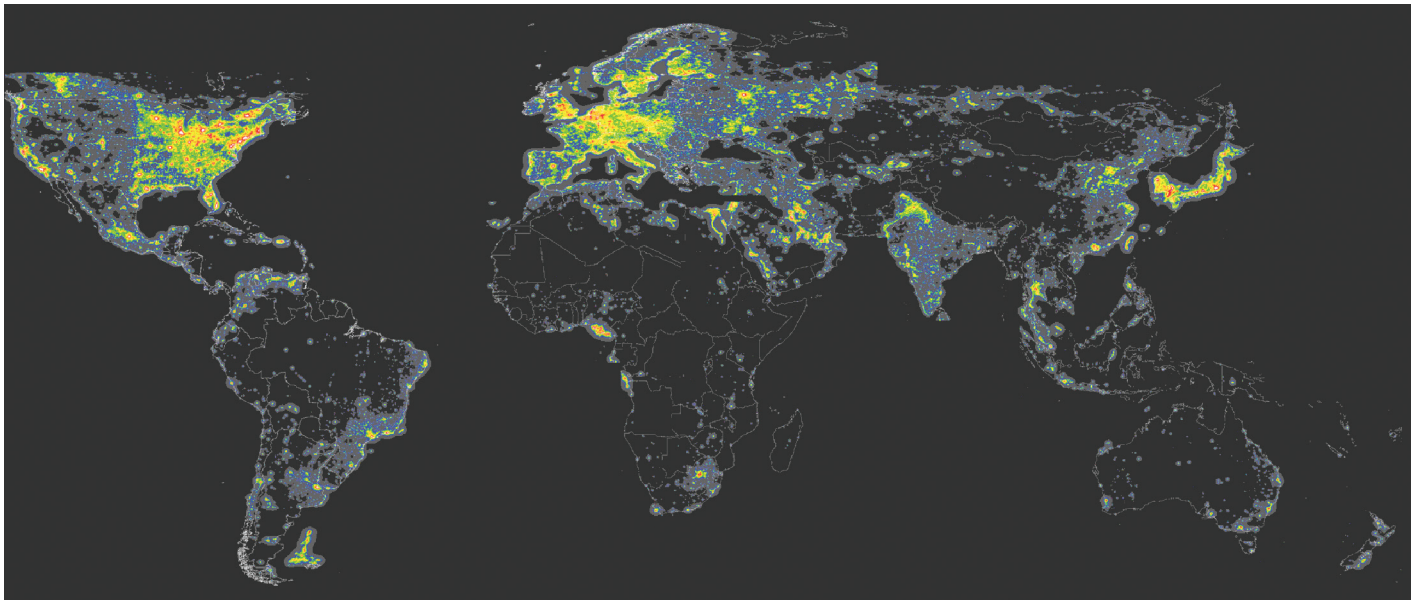
Source: Authors' elaboration.

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.[251] 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[252] and Cambodia.[251] 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.

Another even higher resolution type of 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 EVI and the normalized difference vegetation index (NDVI).

MODIS EVI allows identification of human-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 bioclimatic 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).

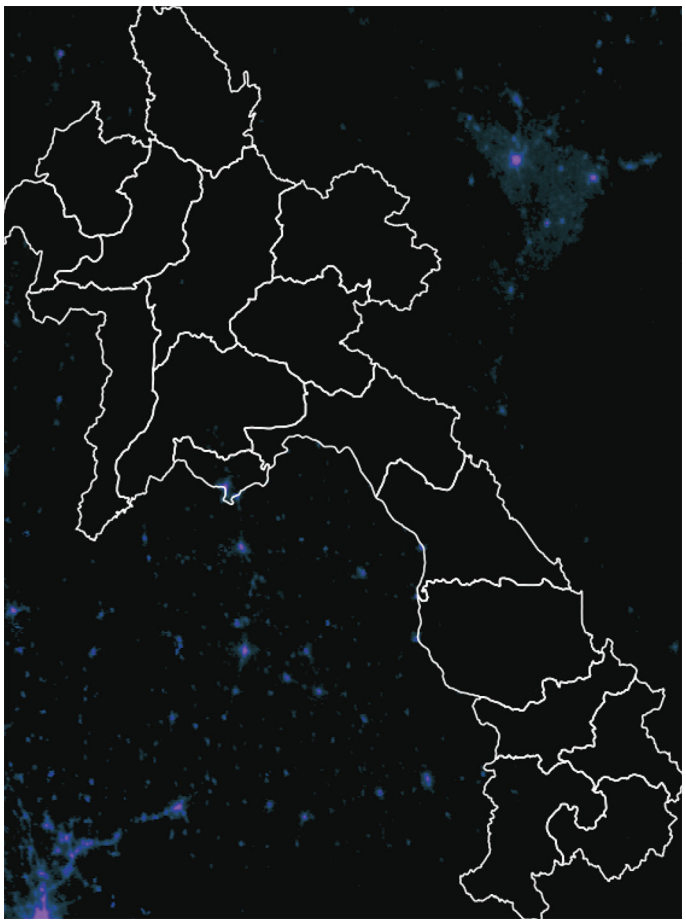
Figure 20. World map of night-time light data



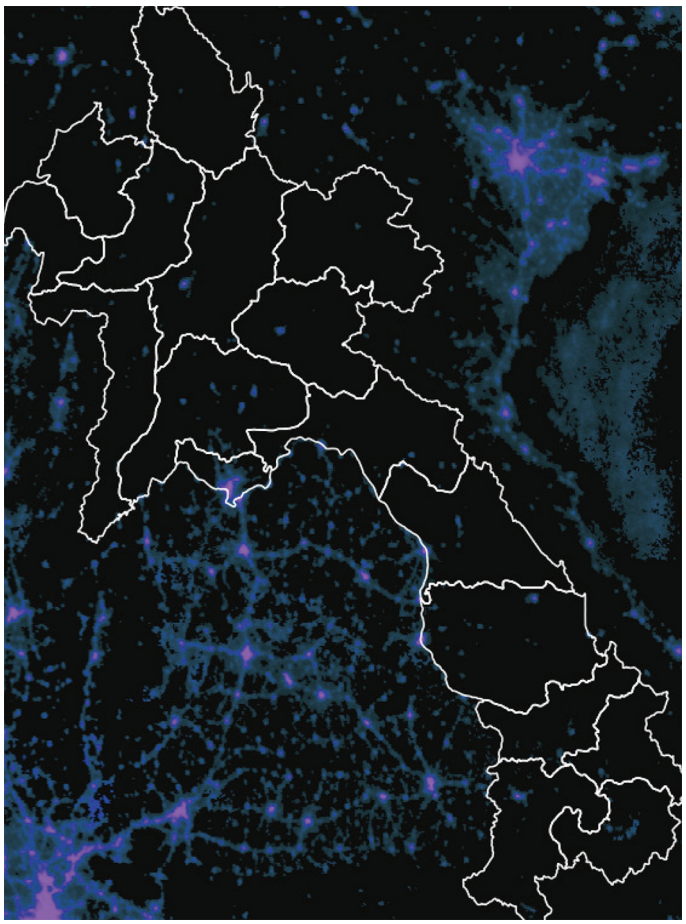
Sources: P. Cinzano, F. Falchi (University of Padova), C. D. Elvidge (National Oceanic and Atmospheric Administration National Geophysical Data Center, Boulder< CO, USA). © Royal Astronomical Society. Reproduced from the Monthly Notices of the RAS by permission of Blackwell Science.[253]

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

1992

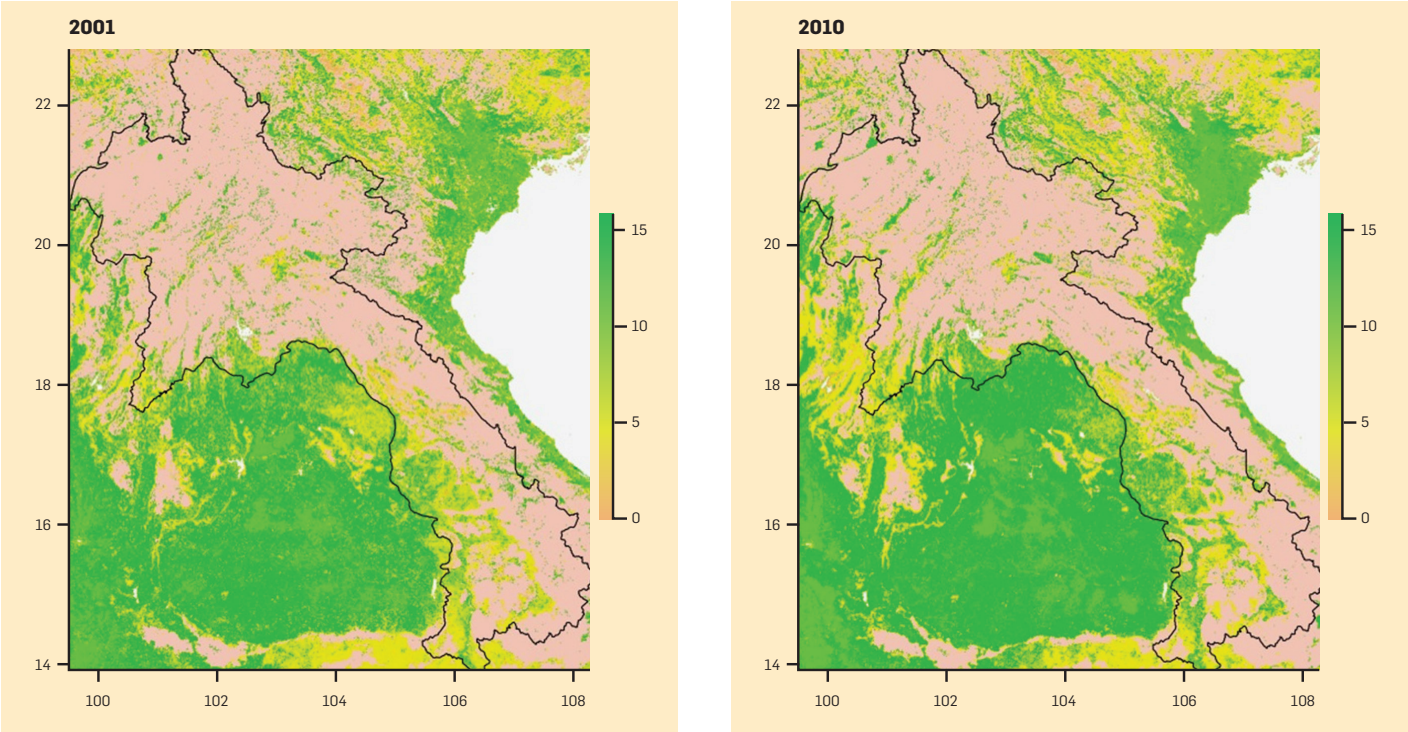


2010



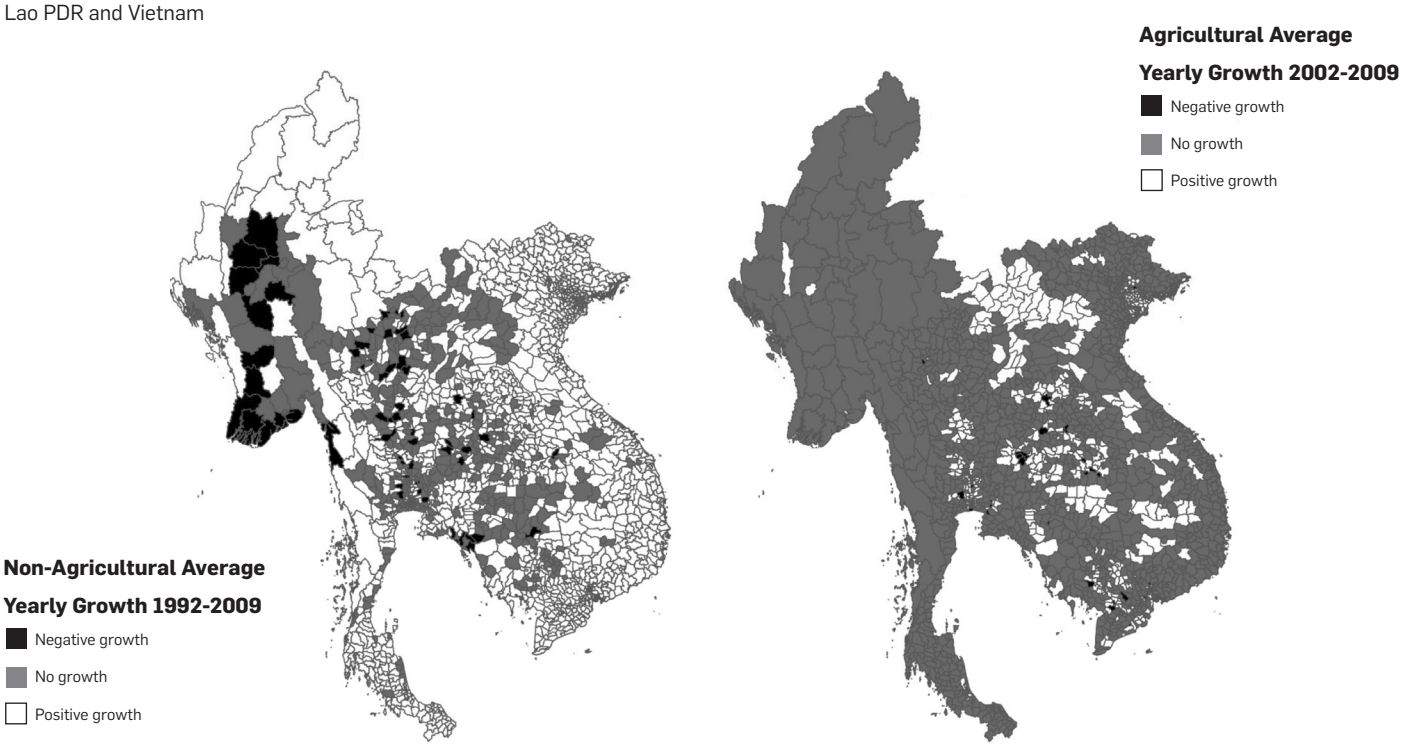
Source: Keola, Andersson and Hall, based on DMSP-OLS and FAO's GAUL.

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



Scale: 0: Water, 1-5: Forest, 6-7: Shrub land, 8-9: Savannahs, 10: Grassland, 11: Wetland, 12: Cropland, 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 subnational level for agriculture and non-agricultural sectors growth in Thailand, Myanmar, Cambodia, Lao PDR and Vietnam



Source: Andersson et al. (2010)[254].

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).

Growth at the subnational level can be estimated for any geographic subdivision. Land cover data are 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 Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam at the district level (administrative level 2) to. Among 3,538 districts, about 92 per cent registered positive average growth in agriculture between 2002 and 2009, and about 86 per cent did so in non-agriculture sectors between 1992 and 2009.[254]

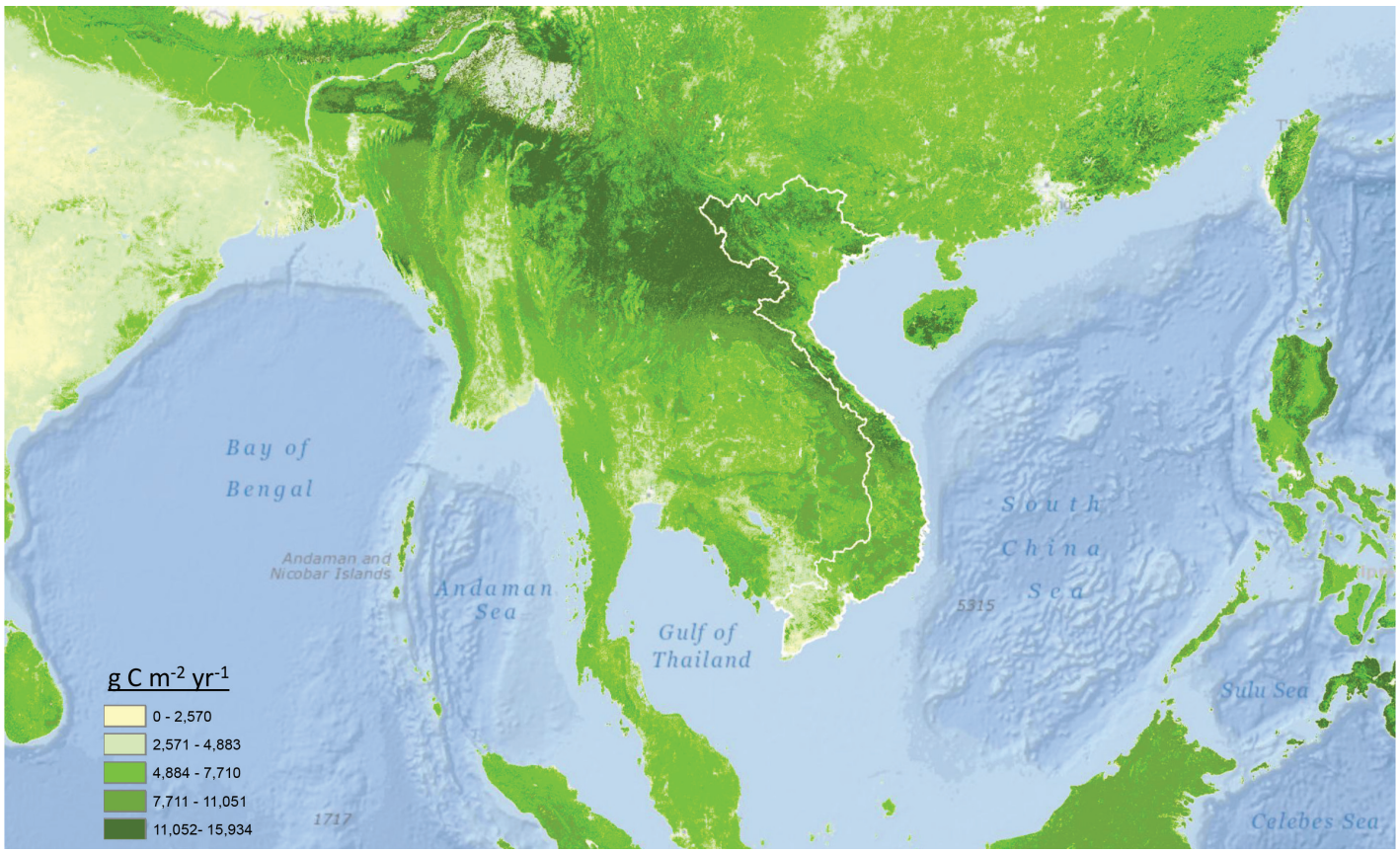
At the United Nations Expert Group Meeting on innovative ways of measuring sustainable development progress, held at Lund University on 26-27 May 2013, Andersson, Keola, Hall and Ahlström also illustrated the combination of MODIS data with other "big data" sources such as mobile phone data. It is the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

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

Other examples of big data include the use of Google Web searches to predict influenza outbreaks (Figure 26), as well as the use of mobile phone data to show the movement of 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 United Nations 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 sustainable development index at various spatial and temporal scales.

Figure 24. Net primary production 2012 in the Greater Mekong Subregion



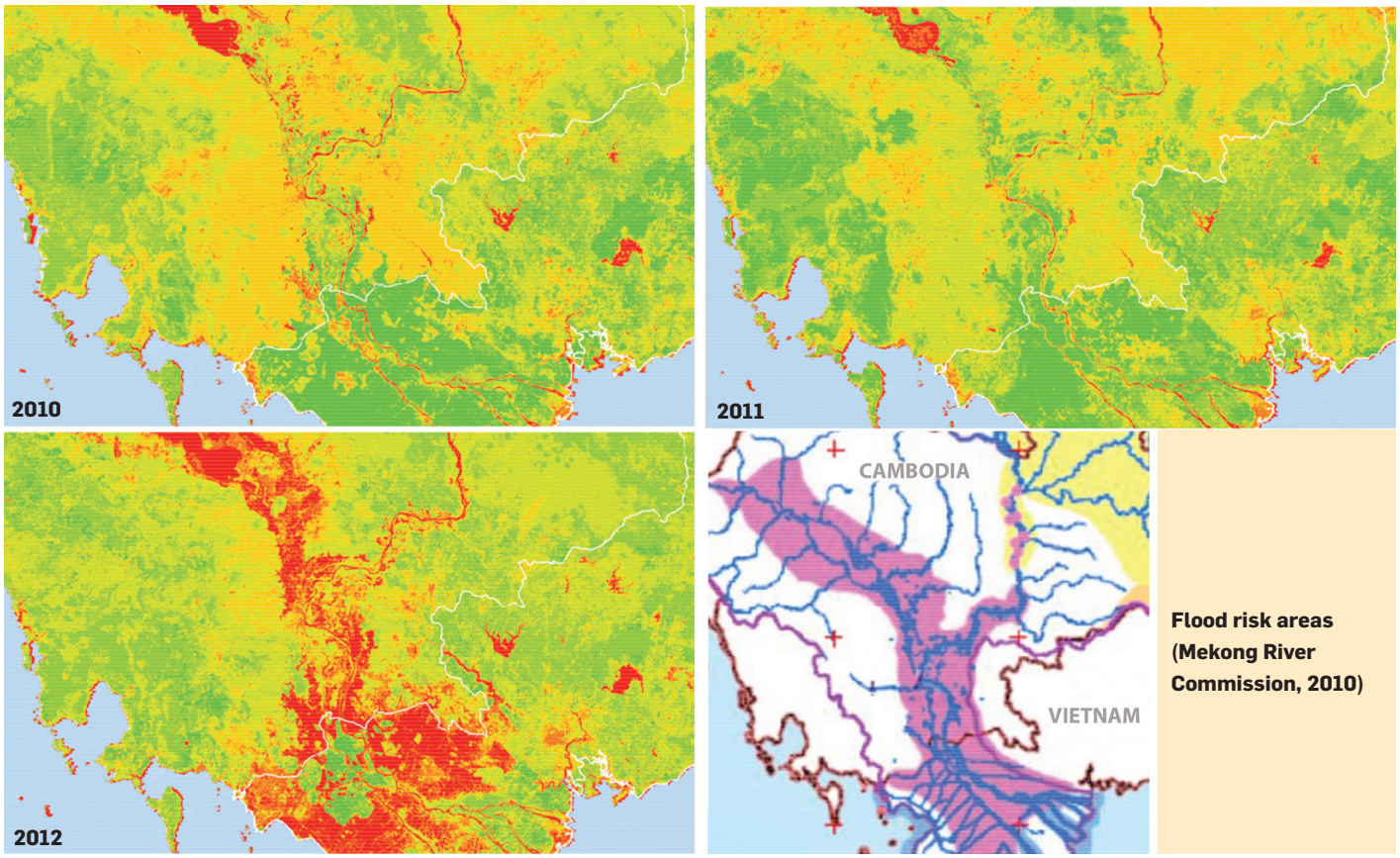
Source: M. Andersson, O. Hall and S. Keola, based on MODIS and GAUL data, from private communication.
Note: Darker green represents more primary production.

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[240]	Regular updates
Poverty eradication	Satellite data to estimate poverty[246]	International comparable data, which can be updated more frequently
	Internet-based data to estimate consumer price index and poverty rates[255]	Cheaper data available at higher frequencies
Poverty eradication and Beyond GDP	Cell-phone records to predict socioeconomic levels[256]	Data available more regularly and cheaply than official data; informal economy better reflected
Health	Internet-based data to identify disease breakouts;[257] cell-phone data to model malaria spread[258]	Real-time data; capture disease cases not officially recorded
Climate change	Satellite scan to monitor population and energy-related GHG emissions[243]	Separate emissions of urban populations from other sources; more regular updates
	Satellite images to measure net primary production[259]	Regular updates
Cities and housing, land management	Light emissions picked up by satellites to estimate urban extent[242]	Globally consistent way to map urban extent; more regular updates
Economy and macroeconomic stability	Light emissions picked up by satellites to estimate GDP growth[244]	Informal economy better reflected; information available at subnational level; improves estimates for countries with poor national accounts data
	Internet-based data to monitor inflation in real time[255]	Cheaper data available at higher frequencies
Disaster risk reduction	Satellite images to identify flood risk areas[260]	Data available frequently

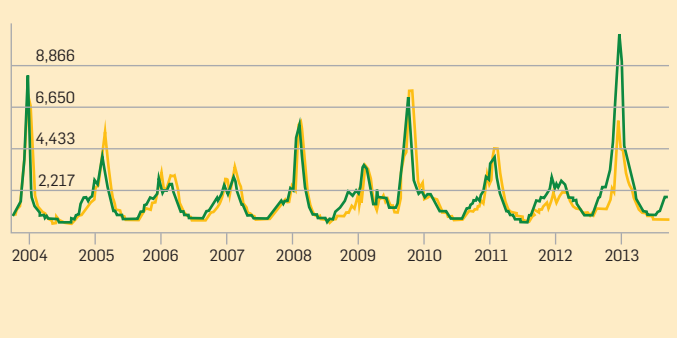
Source: Authors' elaboration.

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



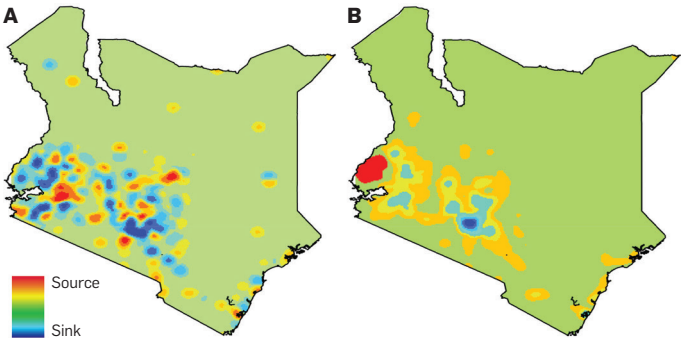
Note: Red denotes water. Source: Andersson et al.(2010)[254].

Figure 26. Google prediction (green) vs official data (orange) of percentage of medical visits for influenza like illness in the US



Source: Google Flu Trends(http://www.google.org/flutrends); methodology described in Ginsberg et al. (2009)[261].

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



Source: Wesolowski et al. (2012) Reprinted with permission from AAAS.
Note: Red areas are net emitters and blue areas are net receivers of people (A) and parasites (B).

5.4. The way forward

Since the 1990s, the number of initiatives aimed 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 recognized 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 United Nations Statistical Commission to launch a new process in this regard. Further, §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 adjusted savings, and human well-being.[263]

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 towards 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 policymakers. They can inform policy formulation on the basis of information that 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 the needs and tracking the progress of - sustainable development.

Also, inaccuracies in measurements introduce uncertainty. No measurement is fully accurate; the instruments used and the biases in people's responses to surveys 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 to measuring sustainable development that are presented in this chapter. [264]