Developing integrated pathways to prove the feasibility of achieving the SDGs and a long-term sustainability transformation: The World in 2050 Framework

Caroline Zimm (corresponding author), Phd. Candidate, Vienna University of Technology (TU Wien) and International Institute for Applied Systems Analysis (IIASA), zimmc@iiasa.ac.at, +43 650 942 13 20, Schlossplatz 1, 2361 Laxenburg, Austria
Sebastian Busch, International Institute for Applied Systems Analysis (IIASA)
Frank Sperling, International Institute for Applied Systems Analysis (IIASA) and School of Geography and Environment, University of Oxford, UK

1 Introduction

In 2015, the United Nations General Assembly adopted the Sustainable Development Goals (SDGs)[1], which define an ambitious development agenda to be achieved by 2030. Comprised of 17 goals and 169 associated targets, the SDGs provide quantitative and qualitative specifications of the economic, social and environmental dimensions of sustainable development. While the SDGs should be pursued in a comprehensive and integrative manner, there exist currently no integrated development pathways that achieve the 17 SDG. The potential for diverse trade-offs and synergies across SDGs has been recognized.[2,3] Proving the feasibility of sustainable pathways that meet all SDGS can provide helpful guidance to the global community during the SDG implementation process. The key question is: How can all 17 SDGs be achieved together?

The World in 2050 (TWI2050) is a global research initiative launched by the International Institute for Applied Systems Analysis (IIASA), the Sustainable Development Solutions Network (SDSN), and the Stockholm Resilience Center (SRC)[4] that aims to answer this question. The initiative brings together a network of leading modeling and analytical teams, policymakers, and organizations from around the world to collaborate in demonstrating the feasibility of the transformational change needed to achieve the SDGs. TWI2050 aims to do so by developing sustainable development pathways that fulfill the SDGs and sustainable socio-economic development within a stable earth system in the long-run. With the Shared Socio-economic pathways (SSPs)[5,6] the climate science, mitigation, impact, adaptation and integrated assessment research communities have developed pathways used for example by the Intergovernmental Panel on Climate Change (IPCC), which already cover several of the SDG targets (e.g. SDG13). A wide range of SSP indicators is lacking for achieving all SDG targets, which emphasizes the need for the development of novel integrated pathways.

In this paper, we provide insights into the sustainability and knowledge gaps of the most

---

[1] UN GA, "Transforming Our World: The 2030 Agenda for Sustainable Development " in *A/RES/70/1* ed. UN (New York: United Nations General Assembly (UN GA), 2015.)
[2] Måns, Nilsson, Dave Griggs, and Martin Visbeck. "Policy: Map the interactions between Sustainable Development Goals," *Nature* 534, (2016): 320–322.
[3] ICSU and ISSC, "Review of the Sustainable Development Goals: The Science Perspective" (Paris: International Council for Science (ICSU), 2015.)
[4] Nebojsa Nakicenovic and et al., "The World in 2050: Towards Pathways for Global Sustainability," (forthcoming).
[5] Keywan Riahi et al., "The Shared Socioeconomic Pathways and Their Energy, Land Use, and Greenhouse Gas Emissions Implications: An Overview," *Global Environmental Change* 42(2017).
[6] Brian C. O'Neill et al., "The Roads Ahead: Narratives for Shared Socioeconomic Pathways Describing World Futures in the 21st Century," ibid.

ambitious SSP, which the TWI2050 initiative has chosen as a starting point for its work. We show that even the most optimistic pathway currently used by scientific community falls short of several dimensions of sustainable development. To support the UN 2030 agenda scientifically and prove the SDG's feasibility, TWI2050 seeks to provide impetus for the research community to develop novel pathways to more comprehensively assess what is required to achieve the SDGs and sustainable development for all thereafter.

The paper is organized as follows: Section 2 provides some background on TWI2050, Section 3 introduces the concept of target spaces. Section 4 identifies the sustainability and knowledge gaps in existing pathways. Section 5 provides concluding remarks.

2 The World in 2050 initiative and framework

This paper relates to the methodological framework of the TWI2050 initiative.[7] The initiative differs from traditional ways of first developing a "reference" pathway that describes "business-as-usual" trends and then look at policy scenarios and how they perform vis-á-vis the reference case. In TWI2050, a normative, goal-based approach will be taken to develop pathways that achieve two target spaces. The first target space for 2030 is directly informed by the SDGs via representative indicators, which can be covered by Integrated Assessment Models (IAMs). The second target space focuses on long-term sustainability by 2050 and beyond to take account of longer-term earth system processes and advances in human development. Both target spaces are currently under development.

By 'back-casting' from desired development outcomes, TWI2050 aims to identify alternative sustainability development pathways that meet both target spaces, seeking insights on how these pathways differ in their implementation attributes, such as affordability or public acceptance. In addition, these sustainable development pathways will shed light on bifurcation points, which are key for development trajectories to meet both target spaces successfully. This will help in understanding the differences between policy choices (e.g. demand-side vs supply side policy measures in the energy sector). The approach is not intended to be policy-prescriptive.

TWI2050 will use a hybrid approach of linking quantitative modeling approaches, such as IAMs, with other analytical approaches that are more holistic. This makes a qualitative treatment of all SDGs possible. The quantitative analyses will be supported by qualitative narratives providing guidance on governance, cooperation within and across societies and behavioral change, for example. The initiative will connect modeling groups with social scientists to bridge that divide in a novel and constructive manner. It will facilitate community building and advance IAMs and research on the SDGs. The TWI2050 framework will facilitate intercomparison of results of addressing multiple SDGs at the same time. It has been shown that through tackling multiple goals, such as climate mitigation, air pollution control and energy access, at the same time, overall costs can be lowered substantially.[8]

---

[7] Nebojsa Nakicenovic and al., "The World in 2050: Towards Pathways for Global Sustainability."
[8] David L. McCollum, Volker Krey, and Keywan Riahi, "An Integrated Approach to Energy Sustainability," *Nature Clim. Change* 1, no. 9 (2011).

3 Applying the SDGs in the long-run

TWI2050 seeks to provide scientific guidance to help policy makers implement the SDGs successfully. To this end, the SDGs provide the basis. However, the majority of the SDGs have 2030 as their running period, some even 2025 or 2020. Sustainability calls for a longer time horizon, especially when looking at earth-system processes where changes might only materialize in decades (or even centuries). Climate change is such an example, where a long-term challenge of stabilizing temperature increase has implications for near term decisions concerning for example energy and transportation systems and the fulfilment of several SDGs.[9] Hence, the approach of back-casting from a normative goal.

To reflect this notion, TWI2050 has classified the numeric SDG targets (Annex A) according to how they could evolve beyond 2030 (Table 1).[10] This is a preliminary assessment of how the targets relate to long-term sustainability, displaying the need to go beyond the time horizon of the SDGs. Several SDG targets to do not come with absolute target values but provide only an indication whether the indicator value should increase or decrease, thereby requiring further interpretation. Many SDG targets cover multiple issues which poses a challenge when classifying them. In some cases the below categorization thus only relates to a part of the target. We identify three categories of SDG targets:

> A) SDG targets where the level of progress reached by 2030 should be sustained indefinitely thereafter (e.g. universal access to services meeting basic human needs such as food, water, energy, education, and health services).

> B) SDG targets that constitute not a complete achievement by 2030, requiring further increases in ambition thereafter, as they are (B1) not ambitious enough considering current best practices (e.g. homicides), (B2) do not consider possible future improvements (e.g. maternal mortality levels), or (B3) do not consider planetary boundaries (e.g. environmental targets).

> C) SDG targets, which will have to be re-visited post 2030 as they may not be applicable anymore.

We can see that the SDGs, their targets and suggested indicators and values are not always suitable and need to be interpreted in many cases to make them operational for research. Furthermore, the SDGs are very comprehensive. Research groups need to arrive at a concise set of indicators for the target spaces representing sustainable development in 2030 and 2050 and beyond in their work. This will require reducing the complexity of the full set of SDG targets, while minimizing information loss so that the assessment can be considered representative of all SDGs. This will facilitate intercomparison of results and communication thereof with policymakers. The identification of suitable indicators should follow an internally consistent framework. TWI2050 is involving domain experts and stakeholders of the relevant fields to identify crucial indicators that can reflect as much information as possible, ideally across several SDGs. The target spaces should reflect what models need and can do. To make them usable for a wide array of models, different sets of indicators are likely needed.

---

[9] Sperling et al, "Bridging the Gap – The Sustainable Development Goals and Climate Change Mitigation." In *The Emissions Gap Report 2016: A UNEP Synthesis Report*. (UNEP DTU Partnership, 2016), 40-47.
[10] Nebojsa Nakicenovic and al., "The World in 2050: Towards Pathways for Global Sustainability."

Table 1 Sustaining and strengthening SDG targets after 2030 to 2050 and beyond
(Source: Nakicenovic et al. forthcoming)

SDG Target Classification beyond 2030	Rationale	SDG Targets
A. Sustain 2030 SDG target levels	A. Future efforts have to focus on sustaining the SDG target levels. Most of these targets relate to universal access to services (e.g., health) or eradicating adverse conditions (e.g., illnesses).	**1.1, 2.1, 2.2, 3.3, 3.8, 4.1, 5.1, 6.1, 6.2, 7.1, 8.7, 9.1, 10.3, 11.1, 11.2, 12.2, 14.4, 15.2, 16.2, 17.1** (Exemplary list: All targets that are not listed in categories B and C fall within A)
B. Increase ambition to close sustainability gap	B1. Further effort required to close remaining gap (e.g., protect cultural heritage).	**1.2, 4.4 , 8.6, 9.3, 10.2, 10.3, 11.3, 11.4, 15.6, 16.1, 16.4**
	B2. Dynamic update required to ensure progress along target dimensions (e.g., maternal mortality, efficiencies).	**1.5, 2.3, 3.1, 3.2, 3.4, 3.5, 3.6, 3.9, 7.3, 10.6, 11.5, 13.1, 13.2, 13.3, 16.5, 16.8**
	B3. Further effort required to stay within Planetary Boundaries (environmental & earth systems) (e.g., pollution).	**6.3, 6.4, 7.2 , 8.4, 9.4, 11.4, 11.6, 12.3, 12.4, 12.5, 12.6, 12.7, 14.1, 14.2, 14.3, 14.5**
C. 2030 SDG targets might not apply	C. Reevaluation required to decide on ambition level beyond 2030.	**8.1, 8.2, 9.2, 10.1,**

4 The need for integrated sustainable development pathways

Scenarios and pathways provide alternative futures and can be used to evaluate different policy options.[11,12] One example of such pathways are the SSPs[13], developed by the climate research community for the IPCC to guide climate research. The SSP framework is a suitable basis as it has undergone rigorous review, it has been developed by a diverse community, is known to policy makers and has been applied by modeling teams globally. The SSP framework provides five different broad development trajectories that describe alternatives futures. They differ in population development, economic growth, grades of cooperation, environmental awareness and several other characteristics.

If we take *SSP1: Sustainability – taking the green road*[14] as a starting point, we chose a transition to a low-emissions future as basis with a narrative that comes close to the intention of the SDGs:

> *"The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Increasing evidence of and accounting for the social, cultural, and economic costs of environmental degradation and inequality drive this shift.[…]"* (full narrative in Annex B).

---

[11] Nebojsa Nakicenovic et al., *Special Report on Emissions Scenarios: A Special Report of Working Group Iii of the Intergovernmental Panel on Climate Change* (Cambrige, UK: Cambridge University Press, 2000).

[12] GEA, *Global Energy Assessment - toward a Sustainable Future* (Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, 2012).

[13] Riahi et al., "The Shared Socioeconomic Pathways and Their Energy, Land Use, and Greenhouse Gas Emissions Implications: An Overview."

[14] Brian C. O'Neill et al., "The Roads Ahead: Narratives for Shared Socioeconomic Pathways Describing World Futures in the 21st Century," ibid.

SSP1 describes a world that is quite different from the past development trajectory and political trends the world is currently experiencing. In SSP1 the global community works together to fulfill development targets.

In more detail, scenario runs of SSP1 that meet the Paris Climate Agreement goal of holding warming to approximately 2°Celsius (above pre-industrial levels) through limiting anthropogenic forcing of the climate system to 2.6 W/m^2 by 2100 are followed.[15,16] We will refer to these runs as SSP1-2.6. SSP1-2.6 was chosen as it already meets the challenge of mitigating climate change and as it is the most ambitious and sustainable possible future within the framework.

Table 2[17] shows how SSP1-2.6 aligns with the SDGs and their targets. It shows the sustainability (e.g., education or hunger) and knowledge gaps in the SSP framework, which does not quantitatively cover the majority of SDG targets (e.g., access to water or gender equality) or which only implies them within its narratives. This provides an indication of where future work is needed for research groups in developing their pathways and tools, going beyond climate-only, to capture all SDG dimensions. In many cases, this will not be possible via quantitative indicators but narratives can be used to cover qualitative elements such as governance, cooperation, or behaviors.

Again, classifying the SDG targets poses several challenges. The classification provided below has to be viewed as an approximation. Many SDG targets cover several topics that need more than one indicator or dimension to be represented. In some cases, SDG targets are indicators themselves, in other cases suitable indicators are used to represent them, either those that are directly available within the SSPs or as proposed by the Inter-Agency and Expert Group (IAEG) on Sustainable Development Indicators[18]. Where target values are missing often, it is a judgement call if a target has been achieved (e.g. *4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship).*

Here we provide more detail on the assessment of the sustainability and knowledge gaps within SSP1 and SSP1-2.6 vis-á-vis the SDGs and their targets. We will indicate which representative indicator we are referring to for each target and which assumptions we base our assessment on. We will present background on each target that is met (Category I) and where sustainability gaps persist (Category II). The SSP Public Database (Version 1.1.)[19] and the Wittgenstein Centre Data Explorer[20] provide the data for this assessment. As the number of targets where a knowledge gaps exists (Category III) would go beyond the scope of this paper, we will only provide some examples. This will inform the formulation of sustainable development pathways within the TWI2050 initiative which need to be more ambitious than SSP1-2.6 to meet the SDGs.

---

[15] Detlef P. van Vuuren et al., "The Representative Concentration Pathways: An Overview," *Climatic Change* 109, no. 1 (2011).
[16] Detlef P. van Vuuren et al., "Energy, Land-Use and Greenhouse Gas Emissions Trajectories under a Green Growth Paradigm," *Global Environmental Change* (2016).
[17] Nebojsa Nakicenovic and al., "The World in 2050: Towards Pathways for Global Sustainability."
[18] United Nations Economic and Social Council, "Report of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators," ed. Statistical Commission (New York: UN, 2017).
[19] IIASA, "SSP Database (Shared Socioeconomic Pathways) - Version 1.1,"(2016).
[20] Wolfgang Lutz, William P. Butz, and Samir KC, *World Population and Human Capital in the Twenty-First Century* (UK: Oxford University Press, 2014).
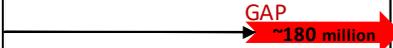
Table 2: Overview of coverage of SDG targets in SSP1-2.6. *(Source: Nakicenovic et al. forthcoming)*
Classification distinguishing between SDG targets
I) with which SSP1-2.6 is in line by 2030,
II) where sustainability gaps persists in SSP1-2.6 in 2030 and partly beyond and
III) that are quantitatively not sufficiently covered by SSPs to assess the sustainability gap, representing knowledge gaps

	SDG	Target/ Indicator			
I. SSP1-2.6 in line with SDG targets		In 2030, SSP1-2.6 runs **provide indicators** for and are **fully in line** with several SDG targets (3.1-3.7, 7.2, 7.3, 8.1, 8.2, 8.5). They are also **inline with parts** of other SDG targets (3.9, 9.4, 10.1, 11.6, 15.2., and SDG 13 via Paris Agreement per definition).			For details see table description

II. Sustainability Gaps within SSP1-2.6

SSP1-2.6 runs do not meet these SDG targets in 2030*

Target/ Indicator	2015	GAP	SDG value 2030	Sources
1.1 Pop. living in extreme poverty[1]	~700 million	~550 million	0	based on Rao et al. (forthcoming)
1.2 Pop. living in relative poverty[2]	~1,500 million	~1,600 million	750 million	
2.1 Pop. living at the risk of hunger	795 million	~180 million	0	Hasegawa et al. 2015
4.1 Pop. (age 15-19, %) w. lower secondary education	66%	77%	100%	KC and Lutz 2011
4.3/ 4.5 Gender gap (pop 15+) mean years of schooling	0.78 years	0.5 years	0	

III. Knowledge Gaps within SSPs

The following SDG targets are not (sufficiently) covered quantiatively by the SSPs

A **knowledge gap** persists within SSPs to quantiatively provide information about the majority of SDG targets (3.8*, 5.1, 5.2, 5.3, 5.4, 5.5.; 6.1, 6.2, 6.3, 6.4*, 6.5, 6.6; 7.1; 8.3, 8.7, 8.8, 8.9, 8.10; 9.1, 9.3, 9.5 . 9.2; 10.2, 10.3, 10.4, 10.5, 10.6; 11.1, 11.2, 11.3, 11.4, 11.5, 11.6, 11.7; 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.7, 12.8, 13.1, 13.3; 14.1, 14.2, 14.3, 14.4, 14.5, 14.6, 14.7, 15.1, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8, 15.9, 16.1, 16.2, 16.3, 16.4, 16.5, 16.6, 16.7, 16.8, 16.9, 16.10, 17.1, 17.2, 17.3, 17.4, 17.5, 17.6, 17.7, 17.8, 17.9, 17.10, 17.11, 17.12, 17.13, 17.14, 17.15, 17.16, 17.17, 17.18, 17.19).

Legend:
→ 2030: Sustainability Gap: SDG not achieved
→ 2050: Sustainability Gap remains: SDG not achieved by 2050
→ 2100: Sustainability Gap remains: SDG not achieved by 2100

Category I where SSP1-2.6 runs are fully or partly in line with SDG targets

<u>3.1-3.7, 3.9 on decreasing mortality and access to reproductive services</u>
SDG 3 and its 13 targets focus on tackling child and maternal mortality, the major infectious diseases, non-communicable diseases, sexual and reproductive health, as well as providing universal health coverage. Possible future trajectories of these individual causes of death can be translated to aggregate mortality trends where achievement of the SDG targets can be well represented by a general low mortality trajectory[21].SSP1 represents an overall low-mortality pathway, which is seen through increases in life expectancy globally, covering close enough SDG targets related to decreasing mortality *(3.1-3.6, 3.9). Fertility is low in SSP1[22], which is connected to the targets on sexual and reproductive health-care service (3.7) and (5.6). SDG3 is closely linked to SDG 5 on gender equality and SDG4 on education. Lutz, Butz and KC (2014)[23] show that higher educational attainment of women leads to lower fertility rates.

<u>7.2 and 7.3 on renewable energy and energy efficiency</u>
SSP1-2.6 runs meet the energy efficiency target (7.3) and partly also the renewable energy target (7.2). The share of renewable energy in SSP1-2.6 runs varies between 16.9% and 36.8% in 2030[24], where the majority is substantially above the 2015 level of 18%[25]. Yet only some achieve the ambitious goal of doubling the renewable energy share as proposed by the Sustainable Energy for All (SE4ALL) initiative, which is based on the Global Energy Assessment[26]. Energy intensity falls from 5.7 MJ/yr/ US$2005/yr in 2015[27] to a range of 3 to 4 MJ/yr/ US$2005/yr in 2030 in SSP1-2.6.[28]

<u>8.1, 8.2, 8.5 on economic growth and unemployment</u>
SSP1 follows a contraction and convergence approach: income levels of less developed countries will increase faster than those of more developed economies[29]. The growth rate of per capita GDP in least developed countries in SSP1 is 7.3% in 2030[30], which meets the 7% limit of SDG target 8.1. The high overall growth rate of 3.9%[31] indicates higher levels of economic productivity (8.2). Unemployment is close to 2% in the long run in SSP1[32], which partly covers 8.5 on work for all, yet fails to cover the quality of work.

---

[21] Guy J. Abel et al., "Meeting the Sustainable Development Goals Leads to Lower World Population Growth," *Proceedings of the National Academy of Sciences* 113, no. 50 (2016).
[22] Samir Kc and Wolfgang Lutz, "The Human Core of the Shared Socioeconomic Pathways: Population Scenarios by Age, Sex and Level of Education for All Countries to 2100," *Global Environmental Change* 42 (2017).
[23] Lutz, Butz, and KC, *World Population and Human Capital in the Twenty-First Century*.
[24] IIASA, "SSP Database (Shared Socioeconomic Pathways) - Version 1.1."
[25] United Nations Economic and Social Council, "Progress Towards the Sustainable Development Goals. Report of the Secretary-General. Supplementary Information," ed. United Nations Economic and Social Council (New York 2016).
[26] GEA, *Global Energy Assessment - toward a Sustainable Future*.
[27] United Nations Economic and Social Council, "Progress Towards the Sustainable Development Goals. Report of the Secretary-General. Supplementary Information."
[28] IIASA, "SSP Database (Shared Socioeconomic Pathways) - Version 1.1."
[29] Rob Dellink et al., "Long-Term Economic Growth Projections in the Shared Socioeconomic Pathways," *Global Environmental Change* 42 (2017).
[30] IIASA, "SSP Database (Shared Socioeconomic Pathways) - Version 1.1."
[31] Ibid.
[32] Dellink et al., "Long-Term Economic Growth Projections in the Shared Socioeconomic Pathways."

<u>9.4 on CO$_2$ intensity</u>
SSP1-2.6 achieves the SDG target 9.4 on more sustainable industries in terms of a decrease in CO$_2$ intensities. From around 0.45 MtCO$_2$/yr/billion US$2005 in 2015[33] SSP1-2.6 runs reach 0.12-22 MtCO$_2$/yr/billion US$2005[34]. However, no indicator beyond CO$_2$ intensities, such as recycling rates or circular economy, that could characterize sustainable industries is available in the SSPs.

<u>10.1 on income inequality</u>
SSP1 provides information on income inequality across countries. The income Gini across countries falls from 0.66 in 2015 to 0.43 in 2030[35], as the income per capita of poorer economies grows stronger than that of more industrialized countries.

<u>11.6 on deaths from air pollution</u>
SSP1-2.6. also includes data on population living in areas affected by dangerous air pollution, partly covering target 3.9 on reducing the number of deaths and illnesses from pollution and contamination. SSP1 accounts for significant improvements of air quality based on *"faster rate of pollution control technology development, with greater effectiveness as compared to current technologies."[36]* In addition medium- and low income countries will quickly adapt best available technologies and experience strong enforcement of environmental laws. Despite large improvements in climate mitigation policy combined with energy access, in SSP1-2.6 still shares of population are exposed to levels of pollution above WHO recommended levels of PM 2.5 in 2030, especially in Asia (13% of population exposed to PM2.5 levels of above 35µg/m^3), the Middle East and Africa (8% above 35µg/m^3)[37]. Even though SSP1-2.6 does not provide estimates on deaths from air pollution, we conclude that the reduction in people affected by air pollution will result in decreases of deaths, meeting target 11.6.

<u>15.2 on halting deforestation</u>
SSP1-2.6 performs well in terms of land-use change. In most runs deforestation comes to a halt, in some forest cover increases slightly (start value in 2015: 4,000 million ha. SSP1-2.6 range for 2030: 3,881-4,135 million ha)[38]. No information on the quality of the forests is available as only the area of forest cover is given. Qualitative indicators pose a challenge across all SDG dimensions. The Forests, Agriculture, Biodiversity, Land, and Energy Project: Pathways for Sustainable Land Use (FABLE)[39] initiative was recently launched to fill this gap.

<u>SDG 13 on climate change</u>
By selecting SSP1-2.6 runs we achieve the below 2°Celsius temperature goal of the Paris

---

[33] UN, "Progress Towards the Sustainable Development Goals. Report of the Secretary-General. Supplementary Information."
[34] IIASA, "SSP Database (Shared Socioeconomic Pathways) - Version 1.1."
[35] Dellink et al., "Long-Term Economic Growth Projections in the Shared Socioeconomic Pathways."
[36] Shilpa Rao et al., "Future Air Pollution in the Shared Socio-Economic Pathways," ibid.
[37] Ibid.
[38] IIASA, "SSP Database (Shared Socioeconomic Pathways) - Version 1.1."
[39] "The Forests, Agriculture, Biodiversity, Land, and Energy Project: Pathways for Sustainable Land Use"
http://www.iiasa.ac.at/web/home/research/researchPrograms/EcosystemsServicesandManagement/event/170403-fable.html.

Climate Agreement per definition. As SDG 13 refers to the United Nations Framework Convention on Climate Change (UNFCCC) we interpret this as sufficiently meeting this SDG. The concrete targets of SDG 13 on education, resilience and policies fall under category C of our assessment.

Category II where SSP1-2.6 runs do not meet SDG targets in 2030

1.1 and 1.2 on absolute and relative poverty
Assuming a log-normal distribution of income and its relation to poverty[40], national GDP and population projections of SSP1, household consumptions shares of GDP (which were held constant) together with national income inequality projections[41] were used to calculate the share of population living in absolute and relative poverty respectively. As a first approximation, the absolute poverty threshold was increased from 1.90 USD/person/day in 2015[42] to 3.10 USD/person/day in 2030 to account for economic growth.. The number of people living in absolute poverty then falls from close to 700 million (9.6% of global population)[43] in 2015 to around 550 million (7%) in 2030 in SSP1, missing the SDG target of ending absolute poverty.

For relative poverty, the widely used poverty measure of proportion of people earning less than 60% of their country's median income[44] was assumed. The population living in relative poverty according to this measure increases in SSP1 from 1.5 billion in 2015 to 1.6 billion in 2030, clearly missing the target of approximately 750 million by 2030 (half of 2015).

2.1 on undernourishment
SSP1-2.6 does reduce the people living at the risk of hunger by 2030, yet around 180 million people remain undernourished, failing the SDG target 2.1[45]. By 2050, hunger is eradicated in SSP1.2-6. With increasing economic prosperity within SSP1, malnourishment should also be regarded in terms of the risk of obesity. This is not been assessed within the context of the SSPs, neither is the quality of the food intake, beyond caloric value, such as micronutrients.

4.1 on universal secondary education
SDG4 focuses on "ensuring inclusive and equitable quality education and promote lifelong learning opportunities for all" and is split into ten targets. Target 4.1 on primary and secondary education for all by 2030 is the most prominent and specific one and also covers content of other targets (e.g. 4.5. on equal access, 4.6. on literacy). Higher educational attainment is linked with several benefits of human development, from higher

---

[40] Humberto Lopez and Luis Servén, "A Normal Relationship? Poverty, Growth, and Inequality " *World Bank Policy Research Working Paper*, no. No. 3814 (January 2006).
[41] Narasimha Rao et al., "Inequality Projections within the SSPs," (forthcoming).
[42] World Bank, "Faqs: Global Poverty Line Update," *Brief*(2015), http://www.worldbank.org/en/topic/poverty/brief/global-poverty-line-faq.
[43] World Bank, "PovcalNet: an online analysis tool for global poverty monitoring." Last modified March 23, 2016, iresearch.worldbank.org/PovcalNet/
[44] European Anti-Poverty Network (EAPN), "Poverty and Inequality in the European Union," http://www.poverty.org.uk/summary/eapn.shtml.
[45] Tomoko Hasegawa et al., "Scenarios for the Risk of Hunger in the Twenty-First Century Using Shared Socioeconomic Pathways," *Environmental Research Letters* 10, no. 1 (2015).

productivity, income and health to stronger political agency, environmental awareness, risk resilience and gender equality.[46]

The population projections of SSP1 rely on high levels of investments in education across all countries which accelerates the demographic transition[47]. In the rapid development case of SSP1, these investments result in in high advances in education rates which are based on a combination of the medium future trajectory for progression rates rooted in the experiences of the past four decades of all countries and the assumption that educational advances are accelerating in line with the experiences of the benchmark of South Korea which experienced the most rapid expansion recently.

In 2010, more than 1.1 billion adults (17% of the population) had no education at all or had not completed primary school.[48] With 57% of global population with primary, 44% with lower and 27% with upper secondary education in 2010[49], target 4.1 cannot be fulfilled anymore in time as too many cohorts have fallen out of the education system already to catch up in 15 years, independent of interpreting "secondary education" as completing lower or upper secondary education. Also, enrollment and graduation rates do not provide any insights on quality of education. The World Bank[50] estimates that about 250 million children in the world cannot read or write despite having attended primary school for three years or more.

According to SSP1[51], in 2030 71% of global population will finish primary education, 60 % lower secondary and 44% upper secondary education, leaving 10% with no or incomplete primary education and another 11% with primary only. By 2100, the SSP1 comes very close to achieving target 4.1 with 91% finishing primary education, 87% lower secondary and 81% upper secondary education, 52 % post-secondary, leaving only 1% without any education or incomplete primary (the remainder 8% are children and youth below 15 years).

SSP1 is more ambitious in terms of education than SDG4 as it represents high shares of tertiary education, including for women, which is not covered quantitatively by SDG4. It has been shown that higher educational attainment of women has a direct effect on fertility rates[52] , which is reflected in SSP1. This trickle-down effect via fertility and mortality on the underlying driver of population will impact several other SDGs, especially on basic human needs (access to food, water and energy) and human impacts on the Earth systems.

The pathway to achieve these ambitious advances in education is hampered by a substantial gap in investments. UNESCO[53] estimates a total annual financing gap of $39

---

[46] Lutz, Butz, and KC, *World Population and Human Capital in the Twenty-First Century*.
[47] Kc and Lutz, "The Human Core of the Shared Socioeconomic Pathways: Population Scenarios by Age, Sex and Level of Education for All Countries to 2100."
[48] Lutz, Butz, and KC, *World Population and Human Capital in the Twenty-First Century*.
[49] Ibid.
[50] World Bank, "Primary & Secondary Education,"
http://www.worldbank.org/en/topic/primarysecondaryeducation/overview#1.
[51] Lutz, Butz, and KC, *World Population and Human Capital in the Twenty-First Century*.
[52] Ibid.
[53] UNESCO, "Education for All Global Monitoring Report: The Cost of Reaching New Targets by 2030," in *UNESCO Policy Paper 18* (Paris: United Nations Educational, Scientific and Cultural Organization, 2015).

billion between 2015 and 2030, translating to a need for development aid to increase at least six fold. Yet, in recent years, development aid for education has decreased, with levels 8% lower in 2014 than at their peak in 2010.[54]

<u>4.3 and 4.5 on education and gender</u>
Education is the only area of the SSPs where implications on gender equality are included. Within SSP1, the gender gap in the number of mean years of schooling among the whole adult population is decreasing from 0.78 in 2015 to 0.5 years in 2030.[55]

Category III where not enough quantitative information is available within the SSPs

The SSP framework does not cover the majority of target quantitatively. Many qualitative SDG targets (Category III) are mentioned in the SSP-narrative (e.g. technological innovation, cooperation, environmental awareness, access to services, see Annex B). Some targets can be assumed to be implicitly included in the framework as they are closely related to other indicators. One example would be 3.8 on universal health coverage. The low mortality rates and increasing life expectancy within SSP1 provides an indication that health coverage and health services will improve. In the narrative increasing health investments are also mentioned. Yet no clear indicator is available within the SSPs to assess the degree of coverage of health services. In other cases, no information on an SDG at all is given in the SSPs. This is the case for gender issues or oceans, for example.

We have shown that despite SSP1 being a very optimistic scenario for the future global socio-economic development, the pathways does not meet several SDG targets and does not provide quantitative information on the large majority of SDG targets. The long list of SDG targets, which cannot be assessed by the SSPs provides us with a diverse research agenda. Research is needed to develop integrated sustainable development pathways to include as many SDG targets as possible. This calls for model development and, methodological advances such as better integration of modeling and other approaches, e.g. qualitative assessments in order to guide SDG implementation scientifically. At the same time, policy makers are urged to implement the 2030 Agenda as even within an optimistic case several dimensions are not achieved in time.

5 Conclusion

With the SDGS, the global community has set itself an ambitious development agenda. Current analytical and quantitative modeling capabilities fall short of being able to capture all 17 SDGs and their targets. TWI2050 is a multi-year community initiative that aims to guide the implementation of the SDGs and provides the scientific community with a coherent framework to do so.

For research and modeling purposes, the SDG targets can serve as a basis but need to be operationalized to reduce complexity. They also have to be looked at in a different light when accounting for long-term sustainability beyond 2030. TWI2050 is working on identifying a list of indicators to represent the target spaces for 2030 and 2050.

---

[54] Ibid.
[55] Lutz, Butz, and KC, *World Population and Human Capital in the Twenty-First Century*.

We have also introduced the need for integrated sustainable development pathways that highlight the feasibility of achieving the SDGs holistically, accounting for synergies and trade-offs. We have shown that even highly ambitious and optimistic pathways currently used in research, such as SSP1/SSP1-2.6, do not meet all SDGs and fail to provide information on some of them. We see this as call for action for science to work on filling the knowledge gaps. At the same time, this is also a call for policy makers and the global community to close the sustainability gaps that emerge from such analysis.

We anticipate that these analyses when integrated into TWI2050 will provide useful information for policy and investment decisions during implementation of the UN 2030 Agenda. While still at a very aggregate level, more refinement on regional and national level assessments will follow.

Bibliography

Abel, Guy J., Bilal Barakat, Samir KC, and Wolfgang Lutz. "Meeting the Sustainable Development Goals Leads to Lower World Population Growth." *Proceedings of the National Academy of Sciences* 113, no. 50 (December 13, 2016 2016): 14294-99.

Rao, Narasimha et. al., "Inequality Projections within the Ssps." (forthcoming).

Dellink, Rob, Jean Chateau, Elisa Lanzi, and Bertrand Magné. "Long-Term Economic Growth Projections in the Shared Socioeconomic Pathways." *Global Environmental Change* 42 (1// 2017): 200-14.

European Anti-Poverty Network (EAPN). "Poverty and Inequality in the European Union." http://www.poverty.org.uk/summary/eapn.shtml.

GEA. *Global Energy Assessment - toward a Sustainable Future*. Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria2012.

ICSU, and ISSC. "Review of the Sustainable Development Goals: The Science Perspective." Paris: International Council for Science (ICSU), 2015.

IIASA. "The Forests, Agriculture, Biodiversity, Land, and Energy Project: Pathways for Sustainable Land Use." http://www.iiasa.ac.at/web/home/research/researchPrograms/EcosystemsServicesandManagement/event/170403-fable.html.

———. "SSP Database (Shared Socioeconomic Pathways) - Version 1.1." 2016.

Kc, Samir, and Wolfgang Lutz. "The Human Core of the Shared Socioeconomic Pathways: Population Scenarios by Age, Sex and Level of Education for All Countries to 2100." *Global Environmental Change* 42 (1// 2017): 181-92.

Lopez, Humberto, and Luis Servén. "A Normal Relationship? Poverty, Growth, and Inequality ". *World Bank Policy Research Working Paper*, no. No. 3814 (January 2006).

Lutz, Wolfgang , William P. Butz, and Samir KC. *World Population and Human Capital in the Twenty-First Century*. UK: Oxford University Press, 2014.

McCollum, David L., Volker Krey, and Keywan Riahi. "An Integrated Approach to Energy Sustainability." *Nature Clim. Change* 1, no. 9 (12//print 2011): 428-29.

Nakicenovic, Nebojsa, and et al. "The World in 2050: Towards Pathways for Global Sustainability." (forthcoming).

Nakicenovic, Nebojsa, Alcamo, Joseph, Davis, Gerald, Vries, Bert de, Fenhann, Joergen, Gaffin, Stuart, Gregory*, Kenneth et al. Special Report on Emissions Scenarios: A Special Report of Working Group Iii of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press, 2000.

Nilsson, Måns, Griggs, Dave and Visbeck, Martin. "Policy: Map the interactions between Sustainable Development Goals" Nature 534, 320–322 (2016)

O'Neill, Brian C., Elmar Kriegler, Kristie L. Ebi, Eric Kemp-Benedict, Keywan Riahi, Dale S. Rothman, Bas J. van Ruijven*, et al.* "The Roads Ahead: Narratives for Shared

Socioeconomic Pathways Describing World Futures in the 21st Century." *Global Environmental Change* 42 (2017/01/01/ 2017): 169-80.

———. "The Roads Ahead: Narratives for Shared Socioeconomic Pathways Describing World Futures in the 21st Century." *Global Environmental Change* (2016).

Rao, Shilpa, Zbigniew Klimont, Steven J. Smith, Rita Van Dingenen, Frank Dentener, Lex Bouwman, Keywan Riahi*, et al.* "Future Air Pollution in the Shared Socio-Economic Pathways." *Global Environmental Change* 42 (2017/01/01/ 2017): 346-58.

Riahi, Keywan, Detlef P. van Vuuren, Elmar Kriegler, Jae Edmonds, Brian C. O'Neill, Shinichiro Fujimori, Nico Bauer*, et al.* "The Shared Socioeconomic Pathways and Their Energy, Land Use, and Greenhouse Gas Emissions Implications: An Overview." *Global Environmental Change* 42 (1// 2017): 153-68.

Sperling, Frank. Granoff, Ilmi; Northrop, Eliza, Olhoff, Anne, Gale, Andrew Scott. "Bridging the gap – the Sustainable Development Goals and climate change mitigation."in *The Emissions Gap Report 2016: A Unep Synthesis Report*. UNEP DTU Partnership, 2016. p. 40-47.

Hasegawa, Tomoko, Fujimori, Shinichiro, Takahashi, Kiyoshi and Toshihiko Masui. "Scenarios for the Risk of Hunger in the Twenty-First Century Using Shared Socioeconomic Pathways." *Environmental Research Letters* 10, no. 1 (2015): 014010.

United Nations Economic and Social Council. "Progress Towards the Sustainable Development Goals. Report of the Secretary-General. Supplementary Information." edited by United Nations Economic and Social Council. New York 2016.

———. "Transforming Our World: The 2030 Agenda for Sustainable Development " In *A/RES/70/1* edited by UN. New York: United Nations General Assembly, 2015.

UN GA. "Transforming Our World: The 2030 Agenda for Sustainable Development " In *A/RES/70/1* edited by UN. New York: United Nations General Assembly (UN GA), 2015.

UNESCO. "Education for All Global Monitoring Report: The Cost of Reaching New Targets by 2030." In *UNESCO Policy Paper 18*. Paris: United Nations Educational, Scientific and Cultural Organization, 2015.

United Nations Economic and Social Council. "Report of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators." edited by Statistical Commission. New York: UN, 2017.

van Vuuren, Detlef P., Jae Edmonds, Mikiko Kainuma, Keywan Riahi, Allison Thomson, Kathy Hibbard, George C. Hurtt*, et al.* "The Representative Concentration Pathways: An Overview." *Climatic Change* 109, no. 1 (2011): 5.

van Vuuren, Detlef P., Elke Stehfest, David E. H. J. Gernaat, Jonathan C. Doelman, Maarten van den Berg, Mathijs Harmsen, Harmen Sytze de Boer*, et al.* "Energy, Land-Use and Greenhouse Gas Emissions Trajectories under a Green Growth Paradigm." *Global Environmental Change* (2016).

World Bank. "Faqs: Global Poverty Line Update." *Brief* (2015). Published electronically September 30, 2015. http://www.worldbank.org/en/topic/poverty/brief/global-poverty-line-faq.

———. "Primary & Secondary Education." Accessed July 23, 2017, http://www.worldbank.org/en/topic/primarysecondaryeducation/overview#1.

———. "PovcalNet: an online analysis tool for global poverty monitoring." Last modified March 23, 2016, iresearch.worldbank.org/PovcalNet/

Annex

A: SDG targets (numeric) (UN. "Transforming Our World: The 2030 Agenda for Sustainable Development " In *A/RES/70/1* edited by UN. New York: United Nations General Assembly, 2015)

SDG 1 END POVERTY IN ALL ITS FORMS EVERYWHERE

1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day

1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions

1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable

1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance

1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

SDG 2 END HUNGER, ACHIEVE FOOD SECURITY AND IMPROVED NUTRITION AND PROMOTE SUSTAINABLE AGRICULTURE

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed

SDG 3 ENSURE HEALTHY LIVES AND PROMOTE WELL-BEING FOR ALL AT ALL AGES

3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births

3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births

3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases

3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being

3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol

3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents

3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes

3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all

3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

SDG 4 ENSURE INCLUSIVE AND EQUITABLE QUALITY EDUCATION AND PROMOTE LIFELONG LEARNING OPPORTUNITIES FOR ALL

4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes

4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education

4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university

4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship

4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations

4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy

4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development

SDG 5 ACHIEVE GENDER EQUALITY AND EMPOWER ALL WOMEN AND GIRLS

5.1 End all forms of discrimination against all women and girls everywhere

5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation

5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation

5.4 Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate

5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life

5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences

SDG 6 ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

SDG 7 ENSURE ACCESS TO AFFORDABLE, RELIABLE, SUSTAINABLE AND MODERN ENERGY FOR ALL

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

7.3 By 2030, double the global rate of improvement in energy efficiency

SDG 8 PROMOTE SUSTAINED, INCLUSIVE AND SUSTAINABLE ECONOMIC GROWTH, FULL AND PRODUCTIVE EMPLOYMENT AND DECENT WORK FOR ALL

8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the LDCs

8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors

8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services

8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead

8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value

8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training

8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms

8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women, and those in precarious employment

8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products

8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all

SDG 9 BUILD RESILIENT INFRASTRUCTURE, PROMOTE INCLUSIVE AND SUSTAINABLE INDUSTRIALIZATION AND FOSTER INNOVATION

9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries

9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets

9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities

9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending

SDG 10 REDUCE INEQUALITY WITHIN AND AMONG COUNTRIES

10.1 By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average

10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status

10.3 Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard

10.4 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality

10.5 Improve regulation & monitoring of global financial markets and institutions and strengthen the implementation of such regulations

10.6 Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions

10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies

SDG 11 MAKE CITIES AND HUMAN SETTLEMENTS INCLUSIVE, SAFE, RESILIENT AND SUSTAINABLE

11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums

11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons

11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries

11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage

11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations

11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

SDG 12 ENSURE SUSTAINABLE CONSUMPTION AND PRODUCTION PATTERNS

12.1 Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries

12.2 By 2030, achieve the sustainable management and efficient use of natural resources

12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses

12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment

12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse

12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle

12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities

12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature

12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production

12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products

12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities

SDG 13 TAKE URGENT ACTION TO COMBAT CLIMATE CHANGE AND ITS IMPACTS[56]

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

13.2 Integrate climate change measures into national policies, strategies and planning

13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning

SDG 14 CONSERVE AND SUSTAINABLY USE THE OCEANS, SEAS AND MARINE RESOURCES FOR SUSTAINABLE DEVELOPMENT

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans

14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics

14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information

14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation

14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism

SDG 15 PROTECT, RESTORE AND PROMOTE SUSTAINABLE USE OF TERRESTRIAL ECOSYSTEMS, SUSTAINABLY MANAGE FORESTS, COMBAT DESERTIFICATION, AND HALT AND REVERSE LAND DEGRADATION AND HALT BIODIVERSITY LOSS

15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally

15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world

15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development

15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species

---

[56] Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed

15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products

15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species

15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts

SDG 16 PROMOTE PEACEFUL AND INCLUSIVE SOCIETIES FOR SUSTAINABLE DEVELOPMENT, PROVIDE ACCESS TO JUSTICE FOR ALL AND BUILD EFFECTIVE, ACCOUNTABLE AND INCLUSIVE INSTITUTIONS AT ALL LEVELS

16.1 Significantly reduce all forms of violence and related death rates everywhere

16.2 End abuse, exploitation, trafficking and all forms of violence against and torture of children

16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all

16.4 By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime

16.5 Substantially reduce corruption and bribery in all their forms

16.6 Develop effective, accountable and transparent institutions at all levels

16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels

16.8 Broaden and strengthen the participation of developing countries in the institutions of global governance

16.9 By 2030, provide legal identity for all, including birth registration

16.10 Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements

SDG 17 STRENGTHEN THE MEANS OF IMPLEMENTATION AND REVITALIZE THE GLOBAL PARTNERSHIP FOR SUSTAINABLE DEVELOPMENT TARGETS

Finance

17.1 Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection

17.2 Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of ODA/GNI to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed countries; ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries

17.3 Mobilize additional financial resources for developing countries from multiple sources

17.4 Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress

17.5 Adopt and implement investment promotion regimes for least developed countries

Technology

17.6 Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism

17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed

17.8 Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology

Capacity-Building

17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation

Trade

17.10 Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda

17.11 Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020

17.12 Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access

Systemic issues

Policy and Institutional coherence

17.13 Enhance global macroeconomic stability, including through policy coordination and policy coherence

17.14 Enhance policy coherence for sustainable development

17.15 Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development

Multi-stakeholder partnerships

17.16 Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries

17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships

Data, monitoring and accountability

17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts

17.19 By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries

B: SSP1 Narrative

O'Neill, B.C., Kriegler, E., Ebi, K.L., Kemp-Benedict, E., Riahi, K., Rothman, D.S., van Ruijven, B.J., van Vuuren, D.P., Birkmann, J., Kok, K., Levy, M., Solecki, W., The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. Global Environ. Change (2015), http://dx.doi.org/10.1016/j.gloenvcha.2015.01.004

SSP1 narrative: "The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Increasing evidence of and accounting for the social, cultural, and economic costs of environmental degradation and inequality drive this shift. Management of the global commons slowly improves, facilitated by increasingly effective and persistent cooperation and collaboration of local, national, and international organizations and institutions, the private sector, and civil society. Educational and health investments accelerate the demographic transition, leading to a relatively low population. Beginning with current high-income countries, the emphasis on economic growth shifts toward a broader emphasis on human well-being, even at the expense of somewhat slower economic growth over the longer term. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Investment in environmental technology and changes in tax structures lead to improved resource efficiency, reducing overall energy and resource use and improving environmental conditions over the longer term. Increased investment, financial incentives and changing perceptions make renewable energy more attractive. Consumption is oriented toward low material growth and lower resource and energy intensity. The combination of directed development of environmentally friendly technologies, a favorable outlook for renewable energy, institutions that can facilitate international cooperation, and relatively low energy demand results in relatively low challenges to mitigation. At the same time, the improvements in human well-being, along with strong and flexible global, regional, and national institutions imply low challenges to adaptation."