CGE Training Materials for Vulnerability and Adaptation Assessment

Chapter 3
Baseline Socioeconomic Scenarios

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2.1. Introduction

Understanding the range and character of possible futures is critical to furthering the assessment of climate change, including the assessment of the potential risks to physical, natural and human systems in the context of different development pathways, and the assessment of mitigation and adaptation options to avoid, prepare for and manage those risks. Concerns about climate change stretch from the current time to the far future, so the field has a long history of using scenarios to explore and evaluate the extensive uncertainties associated with future climate change and development pathways. Projecting possible impacts under different futures and identifying the trade-offs and synergies of adaptation and mitigation policies require scenarios that include:

1. The drivers of greenhouse gas (GHG) emissions;
2. The resulting emissions;
3. Assumptions about other drivers of socioeconomic development that will affect the magnitude and pattern of impacts, and/or the ability to avoid, prepare for, cope with and recover from climate change;
4. The adaptation and mitigation policy environment.

As discussed in more detail later in this chapter, it may be tempting to examine the impacts of projected future changes in climate based only on current society and nature; that is, expecting current vulnerability to stay the same. However, doing so may under or overestimate future risks, because socioeconomic and natural conditions will change in future decades. Changes in population, demographics, where people live, income, technology and other factors will change the human and natural systems that are exposed to climate change, how sensitive the exposed systems are and the capacity of affected systems to adapt to the changes. Such changes in baseline socioeconomic conditions could have important implications for how vulnerable systems are to climate change.

That said, it is important to recognize that, as with climate change (discussed in chapter 4), *scenarios* of change are not predictions (see box 3-1). No one knows exactly how socioeconomic conditions will change in the future, particularly decades from now. The point of developing the scenario types discussed in this chapter is not to predict future changes and impacts of climate change, but to further our understanding of how vulnerability to climate change may change as a result of changes in socioeconomic conditions.

Box 3-1
Definition

Socioeconomic baseline scenario: a comprehensive and plausible description of the future of the human-environment system, including a narrative with qualitative trends and quantitative projections about development patterns. (See chapter 4: Climate Change Scenarios, for a discussion of climate change scenarios.)

The new scenario process [described in Section 3.1.1] builds on previous processes of global scenario development; specifically those directed specifically at climate change and particularly the Intergovernmental Panel on Climate Change (IPCC) *Special Report on Emissions Scenarios* (SRES) (Nakićenovic et al., 2000). The SRES scenarios were developed to represent the range of driving forces and emissions in the scenario literature, including underlying uncertainties. By design, the scenarios assumed no specific mitigation or adaptation policies and measures, and therefore they describe how future greenhouse gas (GHG) emissions could develop in the absence of specific climate policies.

The SRES scenarios developed four main storylines (A1, A2, B1 and B2) using a forward-looking logic that started by describing possible internally consistent future development pathways, including demographic, social, economic, technological and environmental dimensions. Quantification of the storylines yielded estimated emissions of GHGs over the course of the century, and these have been used by Earth system models to project changes in temperature, precipitation, other weather variables and sea level rise to 2100. Several scenarios were developed for each storyline (40 in total) to examine the range of possible future emissions pathways associated with similar assumptions about driving forces.

Climatic changes projected under the SRES scenarios have been used since their publication in 2000 to provide critical insights into the possible consequences for human and natural systems, and on the effectiveness of policy options to manage risks. However, advances in scientific understanding and in models mean that the SRES scenarios are becoming dated. For example: Earth system models now need a wider set of input data as well as GHGs, such as detailed data on air pollutants and land use; demographic projections for mid- to late-century differ from the projections used in the SRES scenarios; and there is better understanding of the potential for a range of technology options to reduce GHG emissions. Further, policymakers and decision makers are asking questions not just about the magnitude and pattern of climate change, but also how development pathways could ameliorate or exacerbate the risks of climate change and the options for managing these risks.

Answering these types of questions requires new variables that are not included in the SRES scenarios, such as how inequality and governance could evolve over the coming decades. Further, new scenarios are needed to cover a wider range of GHG concentrations (e.g. not only scenarios 'without climate policy', but also covering concentration levels that can be reached by implementing mitigation measures) and to facilitate the improved integration of mitigation, adaptation and impact analyses.

After completion of the SRES process, the IPCC and the scientific community decided that it would be the scientific community, not the IPCC, that would lead further scenario development, because of the greater scientific credibility of scenarios that would result, because of the potential for broader participation of researchers across a range of disciplines and geographic regions, and because of the growing ability of the climate research communities to self-organize (Ebi et al., 2014).

The next generation of scenarios for use by the climate change science community are designed to represent the wide range of uncertainty in mitigation efforts that is necessary to achieve particular radiative forcing pathways, and the wide range of uncertainty in adaptation efforts that could be undertaken to prepare for and respond to the climate changes and impacts associated with those pathways. Scenario development is facilitated by several organizations, including the Integrated

Assessment Modeling Consortium (IAMC) and the International Committee on New Integrated Climate Change Assessment Scenarios (ICONICS).[1] The development of the new scenarios, both the emissions and the development pathways, informed the analyses undertaken by Working Group III (Mitigation) of the IPCC (as discussed in, among others, Blanco et al., 2014).

2.1.1. The new scenario process

The new scenario process follows a different logic to that which was used in the SRES. SRES scenarios were developed using a forward-looking logic that started by first describing driving forces, and then modelling the resulting emissions and atmospheric concentrations of GHGs. Climate models used these concentrations to project the magnitude and pattern of climate change under different scenarios. In contrast, in the new scenario process, the scientific community agreed to first establish a small number of pathways of atmospheric concentrations (and their associated radiative forcing) over the twenty-first century, and then to simultaneously develop climate change projections and socioeconomic pathways consistent with the concentration pathways (Hibbard et al., 2007; Meehl and Hibbard, 2007).

The new scenario process involves three phases (Moss et al., 2010):

1. The **preparatory phase** is designed to serve the needs of the Earth system modelling community. In this phase, four representative concentration pathways (RCPs) were chosen and the integrated assessment modelling[2] community identified the emissions that could produce these pathways, taking into consideration the full suite of GHGs and short-lived species specific to a grid of 0.5° latitude x 0.5° longitude, land use and land cover change, and other factors. RCPs incorporate carbon dioxide (CO_2) and other GHGs, so RCPs are described in terms of their 'radiative forcing' in 2100, measured in watts per square metre (W/m^2) and their trajectory of change. Thus the four RCPs are 2.6, 4.5, 6.0 and 8.5 W/m^2 in 2100, corresponding to CO_2 equivalent (CO_2 eq)[3] concentrations in parts per million (ppm) of approximately 490 ppm, 650 ppm, 850 ppm and 1,370 ppm, respectively. The development of the four RCPs is documented in a special issue of *Climatic Change* (van Vuuren et al., 2011).
2. In the **parallel phase,** Earth system models use RCPs to project climate change, and the various communities involved in modelling of impacts, adaptation and vulnerability (IAV) and of integrated assessment, develop the socioeconomic backstories which describe the worlds that induce and simultaneously have to respond to climate change. RCPs were used in simulations run by Earth system models as part of the Coupled Model

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1 See <http://www.globalchange.umd.edu/iamc/> and <https://www2.cgd.ucar.edu/research/iconics>, respectively.

2 Integrated assessment models (IAMs) integrate knowledge from two or more domains into a single framework. In the context of climate change, these models integrate at least energy, environment, and economics.

3 CO_2 equivalency is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential (GWP), when measured over a specified timescale (generally 100 years). CO_2 equivalency thus reflects the time-integrated radiative forcing of a quantity of emissions.

Intercomparison Project phase 5 (CMIP5), producing projections of the magnitude and pattern of climate change over the twenty-first century and, in some cases, to 2300. These projections became the basis of some of the climate projections assessed in the Working Group I contribution to the IPCC Fifth Assessment Report (IPCC, 2013), 'Climate Change 2013: The Physical Science Basis'. At the same time, the integrated assessment modelling and IAV communities developed new descriptions of future socioeconomic conditions, the **shared socioeconomic pathways** (SSPs).

3. In the **integration phase**, scenarios for use in climate change science research and assessment are developed. These scenarios integrate socioeconomic development pathways with climate change projections and with assumptions about climate mitigation and adaptation policies.

An early question that had to be faced in this process was whether the approach of beginning with a set of pre-defined forcing pathways – the RCPs – and their climate change outcomes would constrain the range of future socioeconomic conditions that could be considered. An insight gained from the SRES (Nakićenovic et al., 2000) and confirmed by van Vuuren et al. (2012) is that the magnitude and extent of GHG emissions does not have a one-to-one relationship with demographic and socioeconomic development; that is, multiple 'reference' socioeconomic pathways (i.e. those that do not account for climate policy) could lead to the same RCP. For example, a development pathway with a large population and low emissions per capita can lead to the same emissions or radiative forcing pathway as a development pathway with a smaller population but higher emissions per capita. Similarly, a particular socioeconomic pathway could be consistent with a wide range of emissions or radiative forcing pathways, depending on the stringency and extent of mitigation efforts.

Therefore, a range of demographic and socioeconomic development pathways can be considered when creating scenarios by combining future socioeconomic conditions, as described in the SSPs, with possible mitigation and adaptation policies to reach radiative forcing pathways over the twenty-first century, as defined by the range of the RCPs.

The conceptual framework described in Kriegler et al. (2014), O'Neill et al. (2014), and van Vuuren et al. (2014) provides a flexible toolkit from which researchers can create scenarios to address specific research and policy-relevant questions.

2.1.2. Scenario matrix architecture

Instead of providing scenarios similar to those developed for the SRES, this process, which is based on a matrix approach, is producing a toolkit that the scientific community can use to develop scenarios. Using a 'matrix architecture' provides significant flexibility to develop scenarios to address a wide range of policy- and decision-relevant questions. For example, researchers and analysts can tailor-make scenarios to address specific decisions and policies (van Vuuren et al., 2014). In addition, **marker scenarios** are being developed to facilitate integration across disciplines and comparison within and across research communities.

Three building blocks of the matrix provide qualitative and quantitative elements for the new scenarios:

- Radiative forcing as described in the RCPs, and resulting climate change;
- Socioeconomic development pathways;
- Climate (mitigation and adaptation) policies.

O'Neill et al (2014) explain that the rows of the matrix are the level of forcing (as represented by the RCPs) and the columns are the SSPs (see section 3.1.3). The SSPs are shared community storylines that can be combined with several RCPs when developing a scenario. Scenarios will be developed within the cells of the matrix – although not all cells will be populated. When creating a scenario, additional assumptions may be needed about adaptation and mitigation policies to derive a scenario consistent with a given combination of a RCP and SSP; these are the **shared climate policy assumptions** (SPAs) (Kriegler et al., 2014).

2.1.3. Shared socioeconomic pathways

SSPs define plausible alternative states of human and natural societies at a macro scale. They include a narrative and quantified measures that define the state of societies and ecosystems as they evolve over the twenty-first century. The basic SSPs assume no new climate policies and no significant climate feedbacks on development (O'Neill et al., 2014). While these are unlikely to be plausible assumptions, they are necessary within the scenario matrix architecture because climate change projections, impacts and climate policy responses are all objects of study and so cannot be built into the pathways describing radiative forcing or socioeconomic development. (Note this is similar to the original goal of vulnerability assessments, as described in chapter 2, to understand consequences of unconstrained GHG emissions.) The SSP assumptions and quantifications may need to be modified when crafting scenarios.

SSPs are defined along axes describing increasing socioeconomic and environmental challenges to adaptation and to mitigation, to encompass a wide range of possible development pathways of relevance for climate change research (O'Neill et al., 2014, 2015). Socioeconomic factors considered in the SSPs include aspects of socioeconomic systems, such as demographic, political, social, cultural, institutional, lifestyle, economic and technological variables and trends. Also included are the human impacts on ecosystems and ecosystem services, such as air and water quality and biodiversity.

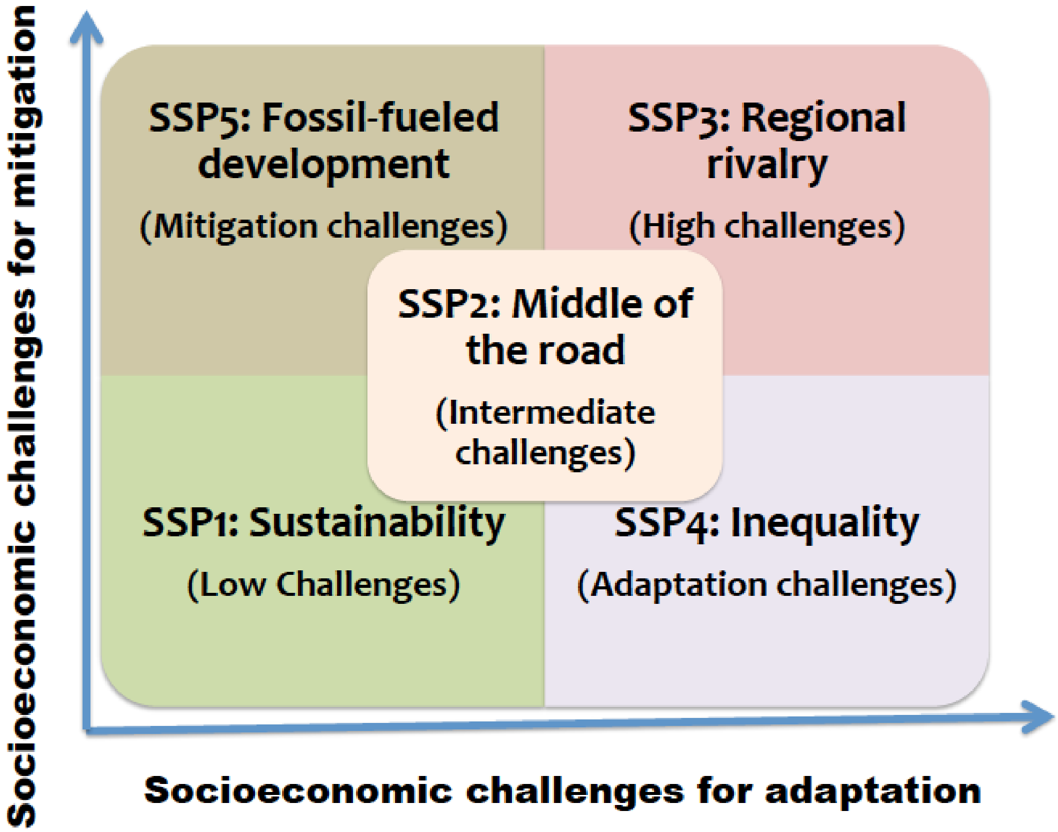
Challenges to mitigation include factors and trends that generate high GHG emissions in the absence of climate policy and that reduce the social capacity to mitigate those emissions. These include insufficient technologies, inadequate national and international policy-making institutions, and lack of financial and other resources to support mitigation policies, such as political will, and human and social capital. High reference emissions could result from various combinations of high population growth rates, rapid (conventionally defined) economic growth, energy-intensive economic systems, carbon-intensive energy supplies and the like. *Not all factors need to operate in the same direction to result in high (or low) emissions.*

Socioeconomic challenges to adaptation increase the risks associated with any given level of climate change by making adaptation more difficult. Challenges to adaptation include factors such as: poverty and how wealth is distributed; ineffective national and international organizations, institutions, and governance; limited water and food security; low levels of educational attainment; and high levels of unplanned urbanization.

The challenges space can be divided into five domains (figure 3-1). Along the diagonal axis are: (1) sustainability with low challenges to adaptation and mitigation; (2) middle-of-the-road with intermediate challenges; and (3) regional rivalry with high challenges. Off-axis are: (4) inequality with low challenges to mitigation and high challenges to adaptation, and fossil-fueled development with high challenges to mitigation and low challenges to adaptation. Multiple socioeconomic pathways can lead to each domain.

The pathways evolve, describing challenges that change over time rather than referencing a particular time period. The adaptation and mitigation challenges are relative to the middle-of-the-road development pathway described in the second domain, which itself evolves.

Figure 3-1
Five shared socioeconomic pathways



Source: O'Neill et al., 2015.

Defining the SSPs by challenges to adaptation and mitigation is very different from earlier scenarios, such as the SRES scenarios and the Millennium Ecosystem Assessment scenarios (O'Neill et al., 2014). Those scenarios defined their axes by key socioeconomic driving forces which were assumed to be the principal uncertainties determining the outcomes of interest (e.g. global versus regional focus, economic versus environmental focus). Instead, the SSPs use the outcomes of interest to define the axes. These outcomes are not intended to indicate which combination of socioeconomic elements would produce a given set of challenges, nor which elements are the key uncertainties in those outcomes. Taking this approach makes it possible for the uncertainty in the implications of mitigating climate change to be characterized at a certain level of radiative forcing and of adapting to that level.

Key characteristics of the SSPs include (O'Neill et al., 2015):

- A focus on socioeconomic and environmental trends globally and in large world regions over the twenty-first century, sufficient to distinguish the SSPs;
- Qualitative narratives and quantifications;
- Quantifications typically used as input for integrated assessment models (IAMs) of the global energy-economy-land use system or for global-scale impact models, such as assumptions about future demographics, economic development and degree of global integration;
- They do not include assumptions about new climate adaptation and mitigation policies and they do not include decisions on how to most effectively manage the risks associated with climate change;
- Sufficient information for the global narratives to be extended in regional and sectoral scenarios. The SSPs create the boundary conditions within which such extensions can be created.

Based on these characteristics, elements that have either already been included in SSPs or will be included at a later stage include (O'Neill et al., 2015):

- Demographics, including population total and age structure, and urban versus rural populations;
- Economic development, including global and regional gross domestic product (GDP), trends in productivity and proportion of population in extreme poverty;
- Human development, educational attainment and health;
- Environmental and ecological factors, including air, water and soil quality;
- Resources, including fossil fuels and renewable energy potentials;
- Institutions and governance, including existence, type and effectiveness of national/regional/global institutions;
- Technological development, including type and rate of technological progress and diffusion of innovation;
- Broader societal factors, including attitudes to the environment and sustainability and lifestyles;
- Non-climate policies, such as policies on development, technology, urban planning, transportation, energy and the environment.

The following short summaries of the SSPs (O'Neill et al., 2015) are based on their placement within the challenges domain. O'Neill et al. (2015) provides full narratives for each of the SSPs.

SSP1: Sustainability – Taking the green road

The world shifts gradually, but pervasively, towards 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 (HICs), the emphasis on economic growth shifts towards 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 towards low material growth and lower resource and energy intensity. The combination of directed development of environmentally friendly technologies, a favourable 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, improvements in human well-being, along with strong and flexible global, regional and national institutions imply low challenges to adaptation.

SSP2: Middle-of-the-road

The world follows a path in which social, economic and technological trends do not shift markedly from historical patterns. Development and income growth proceed unevenly, with some countries making relatively good progress while others fall short of expectations. Most economies are politically stable. Globally connected markets function imperfectly. Global and national institutions work towards, but make slow progress in, achieving sustainable development goals, including improved living conditions and access to education, safe water and health care. Technological development proceeds apace, but without fundamental breakthroughs. Environmental systems experience degradation, although there are some improvements, and overall the intensity of resource and energy use declines. Even though fossil-fuel dependency decreases slowly, there is no reluctance to use unconventional fossil resources. Global population growth is moderate and levels off in the second half of the century as a consequence of completion of the demographic transition. However, education investments are not high enough to accelerate the transition to low fertility rates in low-income countries (LICs) or to rapidly slow population growth. This growth (along with the income inequality that persists or improves only slowly and continuing societal stratification and limited social cohesion), maintains challenges to reducing vulnerability to societal and environmental changes and constrains significant advances in sustainable development. These moderate development trends leave the world, on average, facing moderate challenges to mitigation and adaptation, but with significant heterogeneities across and within countries.

SSP3: Regional rivalry – A rocky road

A resurgent nationalism, concerns about competitiveness and security and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. This trend is reinforced by the limited number of comparatively weak global institutions, with uneven coordination and cooperation for addressing environmental and other global concerns. Policies shift over time to become increasingly oriented towards national and regional security issues, including barriers to trade, particularly in the energy resource and agricultural markets. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development, and in several regions move towards more authoritarian forms of government with highly regulated economies. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time, especially in developing countries. There are pockets of extreme poverty alongside pockets of moderate wealth, with many countries struggling to maintain living standards and provide access to safe water, improved sanitation and health care for disadvantaged populations. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions. The combination of impeded development and limited environmental concern results in poor progress towards sustainability. Population growth is low in industrialized countries and high in developing countries. Growing resource intensity and fossil-fuel dependency, along with difficulty in achieving international cooperation and slow technological change, imply high challenges to mitigation. The limited progress on human development, slow income growth and lack of effective institutions, especially those that can act across regions, implies high challenges to adaptation for many groups in all regions.

SSP4: Inequality – A road divided

Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally connected society that is well-educated and contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labour-intensive, low-tech economy. Power becomes more concentrated in a relatively small political and business elite, even in democratic societies, while vulnerable groups have little representation in national and global institutions. Economic growth is moderate in industrialized and middle-income countries, while LICs lag behind, in many cases struggling to provide adequate access to water, sanitation and health care for the poor. Social cohesion degrades, and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. Uncertainty in the fossil-fuel markets leads to underinvestment in new resources in many regions of the world. Energy companies hedge against price fluctuations partly through diversifying their energy sources, with investments in both carbon-intensive fuels such as coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle- and high-income areas. The combination of some development of low-carbon supply options and expertise, and a well-integrated international political and business class capable of acting quickly and decisively, implies low challenges to mitigation. Challenges to adaptation are high for the substantial proportions of populations at low levels of development and with limited access to effective institutions for coping with economic or environmental stresses.

SSP5: Fossil-fueled development – Taking the highway

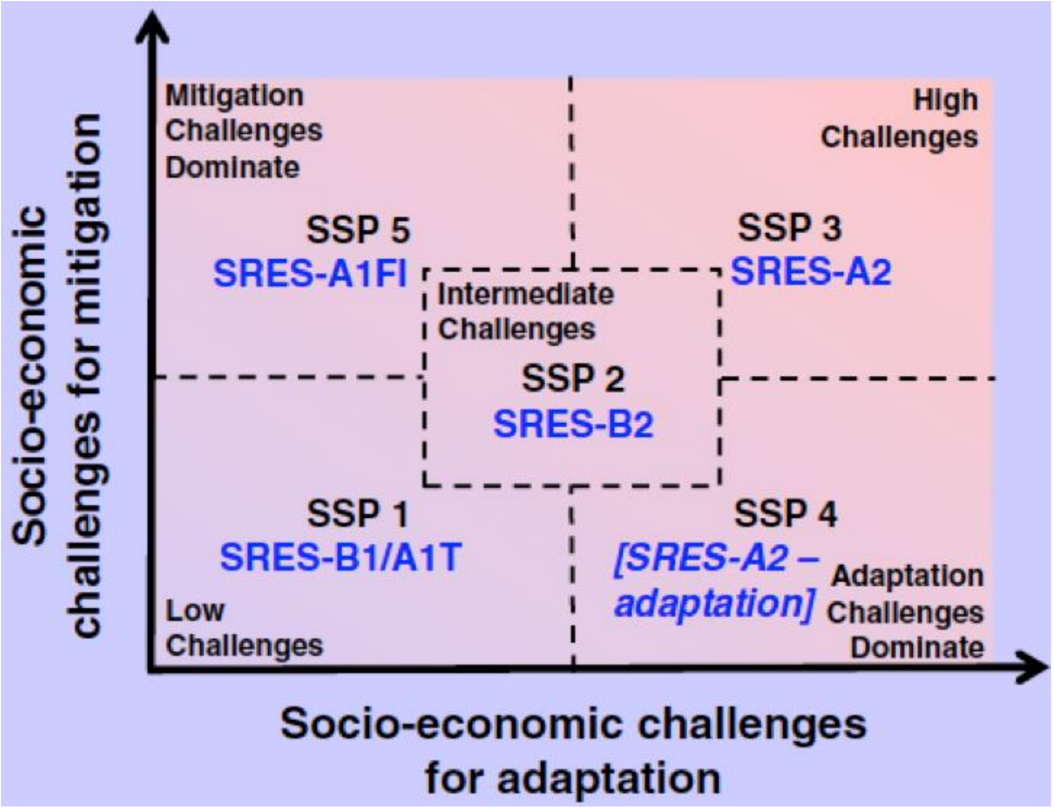
Driven by the economic success of industrialized and emerging economies, this world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated, with interventions focused on maintaining competition and removing institutional barriers to the participation of disadvantaged population groups. There are also strong investments in health, education and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil-fueled resources and the adoption of resource- and energy-intensive lifestyles worldwide. All these factors lead to rapid growth of the global economy. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary. While local environmental impacts are addressed effectively by technological solutions, there is relatively little effort made to avoid potential global environmental impacts due to a perceived trade-off with progress on economic development. Global population peaks and then declines in the twenty-first century. Though fertility declines rapidly in developing countries, fertility levels in HICs are relatively high (at or above replacement level) due to optimistic economic outlooks. International mobility is increased by gradually opening up labour markets as income disparities decrease. The strong reliance on fossil fuels and the lack of global environmental concern result in potentially high challenges to mitigation. The attainment of human development goals, robust economic growth and highly engineered infrastructure results in relatively low challenges to adaptation to any potential climate change for all but a few.

2.1.4. Comparing shared socioeconomic pathways with the SRES scenarios

In their article, 'Climate and socio-economic scenarios for climate change research and assessment: Reconciling the new with the old', van Vuuren and Carter (2014) mapped the SRES illustrative scenarios onto the framework of the SSPs by comparing storylines, projected atmospheric composition, radiative forcing and climate characteristics for SRES and RCPs. They identified four suggestions of suitable combinations (see figure 3-2):

- An A2 world onto RCP 8.5 and SSP3;
- A B2 (or A1B) world onto RCP 6.0 and SSP2;
- A B1 world onto RCP 4.5 and SSP1;
- An A1FI world onto RCP 8.5 and SSP5.

Figure 3-2
Suggested mapping of the SRES scenarios (in blue) onto the five domains of the shared socioeconomic pathways



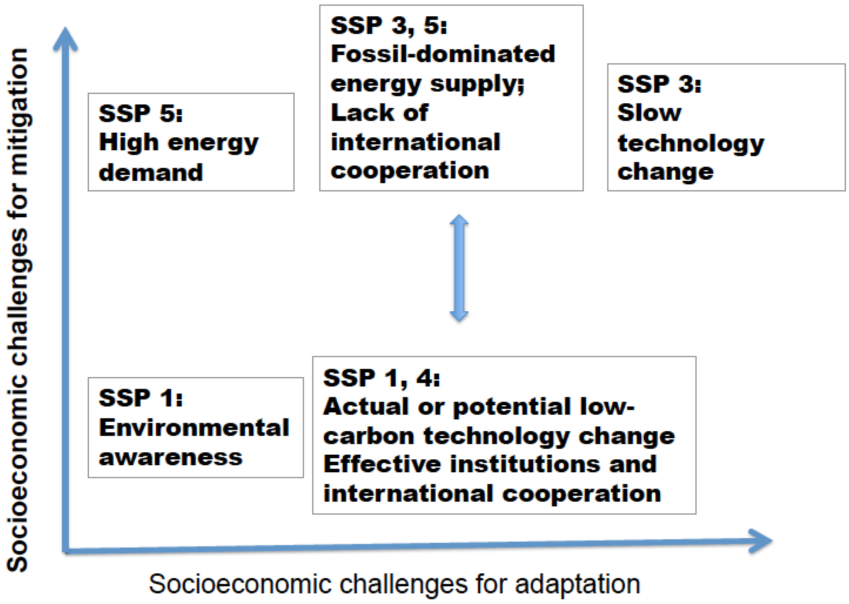
Source: van Vuuren and Carter, 2014.

2.1.5. Shared socioeconomic pathway elements

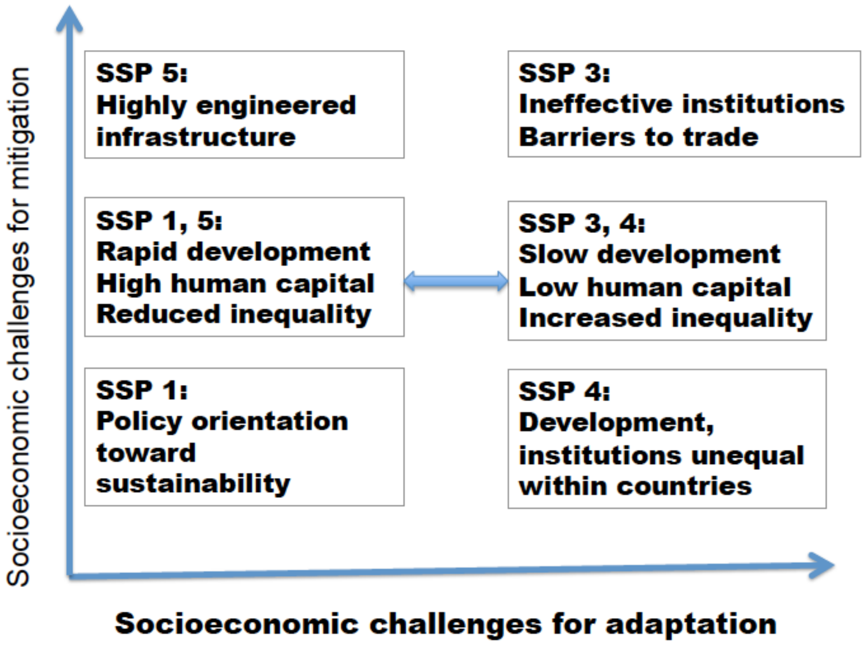
Figure 3-3 summarizes the SSP elements that contribute to high or low challenges to (a) mitigation and (b) adaptation. Elements listed towards the top or bottom of the challenges space in figure 3-3(a) apply to pathways with high or low challenges to mitigation, respectively; while elements listed towards the left or right side of the challenges space in figure 3-3(b) apply to pathways with low or high challenges to adaptation, respectively.

Figure 3-3
Shared socioeconomic pathway elements that contribute to high or low challenges to (a) mitigation and (b) adaptation

(a)



(b)



Source: O'Neill et al., 2015.

Table 3-1 summarizes assumptions regarding demographic and human development elements of the SSPs. (See Samir and Lutz (2014) for definitions of country fertility groupings. World Bank definitions are used for LIC, medium-income countries (MIC) and HIC.)

Table 3-1
Assumptions regarding demographic and human development elements of the shared socioeconomic pathways

SSP element	SSP1			SSP2			SSP3			SSP4			SSP5		
	Country fertility groupings for demographic elements														
	High fert.	Low fert.	Rich-OECD	High fert.	Low fert.	Rich-OECD	High fert.	Low fert.	Rich-OECD	High fert.	Low fert.	Rich-OECD	High fert.	Low fert.	Rich-OECD
Demographics															
Population															
Growth	Relatively low			Medium			High		Low	Relatively high		Low	Relatively low		
Fertility	Low	Low	Med	Medium			High	High	Low	High	Low	Low	Low	Low	High
Mortality	Low			Medium			High			High	Med	Med	Low		
Migration	Medium			Medium						Medium			High		
Urbanization															
Level	High			Medium			Low			High	High	Med	High		
Type	Well managed			Continuation of historical patterns			Poorly managed			Mixed across and within cities			Better mgmt. over time, some sprawl		
Human development															
Education	High			Medium			Low			V.low/uneq.	Low/uneq.	Med/uneq.	High		
Health investments	High			Medium			Low			Unequal within regions, lower in LICs, medium in HICs			High		
Access to health facilities, water, sanitation	High			Medium			Low			Unequal within regions, lower in LICs, medium in HICs			High		
Gender equality	High			Medium			Low			Unequal within regions, lower in LICs, medium in HICs			High		
Equity	High			Medium			Low			Medium			High		
Social cohesion	High			Medium			Low			Low, stratified			High		
Societal participation	High			Medium			Low			Low			High		

Source: O'Neill et al., 2015.

Table 3-2 summarizes assumptions regarding economy and lifestyle, and the policies and institutions elements of SSPs.

Table 3-2
Assumptions regarding economy and lifestyle, and the policies and institutions elements of shared socioeconomic pathways

SSP element	SSP1	SSP2	SSP3	SSP4	SSP5
Economy & lifestyle					
Growth (per capita)	High in LICs, MICs; medium in HICs	Medium, uneven	Slow	Low in LICs, medium in other countries	High
Inequality	Reduced across and within countries	Uneven moderate reductions across and within countries	High, especially across countries	High, especially within countries	Strongly reduced, especially across countries
International trade	Moderate	Moderate	Strongly constrained	Moderate	High, with regional specialization in production
Globalization	Connected markets, regional production	Semi-open globalized economy	De-globalizing, regional security	Globally connected elites	Strongly globalized, increasingly connected
Consumption & Diet	Low growth in material consumption, low-meat diets, first in HICs	Material-intensive consumption, medium meat consumption	Material-intensive consumption	Elites: high consumption lifestyles; Rest: low consumption, low mobility	Materialism, status consumption, tourism, mobility, meat-rich diets
Policies & institutions					
International Cooperation	Effective	Relatively weak	Weak, uneven	Effective for globally connected economy, not for vulnerable populations	Effective in pursuit of development goals, more limited for envt. goals
Environmental Policy	Improved management of local and global issues; tighter regulation of pollutants	Concern for local pollutants but only moderate success in implementation	Low priority for environmental issues	Focus on local environment in MICs, HICs; little attention to vulnerable areas or global issues	Focus on local environment with obvious benefits to well-being, little concern with global problems
Policy orientation	Toward sustainable development	Weak focus on sustainability	Oriented toward security	Toward the benefit of the political and business elite	Toward development, free markets, human capital
Institutions	Effective at national and international levels	Uneven, modest effectiveness	Weak global institutions/ natl. govts. dominate societal decision-making	Effective for political and business elite, not for rest of society	Increasingly effective, oriented toward fostering competitive markets

Source: O'Neill et al., 2015.

Table 3-3 summarizes assumptions regarding technology and environment and natural resources elements of SSPs.

Table 3-3
Assumptions regarding technology and environment and natural resources elements of shared socioeconomic pathways

SSP element	SSP1	SSP2	SSP3	SSP4	SSP5
Technology					
Development	Rapid	Medium, uneven	Slow	Rapid in high-tech economies and sectors; slow in others	Rapid
Transfer	Rapid	Slow	Slow	Little transfer within countries to poorer populations	Rapid
Energy tech change	Directed away from fossil fuels, toward efficiency and renewables	Some investment in renewables but continued reliance on fossil fuels	Slow tech change, directed toward domestic energy sources	Diversified investments including efficiency and low-carbon sources	Directed toward fossil fuels; alternative sources not actively pursued
Carbon intensity	Low	Medium	High in regions with large domestic fossil fuel resources	Low/medium	High
Energy intensity	Low	Uneven, higher in LICs	High	Low/medium	High
Environment & natural resources					
Fossil constraints	Preferences shift away from fossil fuels	No reluctance to use unconventional resources	Unconventional resources for domestic supply	Anticipation of constraints drives up prices with high volatility	None
Environment	Improving conditions over time	Continued degradation	Serious degradation	Highly managed and improved near high/middle-income living areas, degraded otherwise	Highly engineered approaches, successful management of local issues
Land Use	Strong regulations to avoid environmental tradeoffs	Medium regulations lead to slow decline in the rate of deforestation	Hardly any regulation; continued deforestation due to competition over land and rapid expansion of agriculture	Highly regulated in MICs, HICs; largely unmanaged in LICs leading to tropical deforestation	Medium regulations lead to slow decline in the rate of deforestation
Agriculture	Improvements in ag productivity; rapid diffusion of best practices	Medium pace of tech change in ag sector; entry barriers to ag markets reduced slowly	Low technology development, restricted trade	Ag productivity high for large scale industrial farming, low for small-scale farming	Highly managed, resource-intensive; rapid increase in productivity

Source: O'Neill et al., 2015.

2.1.6. Shared climate policy assumptions

When combining a particular SSP with a level of radiative forcing to create a scenario, the analyst may need to specify the mitigation and adaptation policies required to reduce emissions to achieve the RCP and to cope with the resulting climate change (Kriegler et al., 2014). There are a wide variety of such policies, so **shared climate policy assumptions** (SPAs) are used as a means to deploy common assumptions across a wide variety of studies. SPAs capture key climate policy dimensions that are not specified in the SSPs, describing features of policy (e.g. global and sectoral coverage of GHG reduction regimes and/or adaptation effectiveness in different world regions). Note that because GDP and other elements within an SSP could be affected by climate policies and by climate change impacts, scenarios that include SPAs may need to modify some of the reference SSP assumptions.

2.1.7. Developing socioeconomic storylines

Failure to take into account socioeconomic changes when assessing future risks and opportunities of climate change equates to making the implicit assumption that current vulnerability will stay the same. That is not a very likely outcome. Therefore, it is important to develop a baseline of present-day social and economic vulnerabilities (see chapter 2) against which future risks under different socioeconomic and climate scenarios can be evaluated. Chapter 4 discusses scenarios of climate change (e.g. temperature, precipitation, sea level rise); whereas this chapter explores developing narratives and quantifications of future socioeconomic changes that are likely to affect the magnitude and pattern of risks associated with climate change.

In other words, the development of **socioeconomic storylines** helps to approximate some of the key elements of an ever-changing backdrop of technology, infrastructure, social conditions and natural environments, and helps to establish a consistent and structured base for comparing vulnerability to climate change. For example, increased population growth may place more people and property at risk from increased frequency or intensity of extreme climate events. On the other hand, economic growth and development may increase the wealth and the capacity of a community to withstand and adjust to future changes, thus reducing impacts compared with current circumstances.

The SSPs were designed to support developing these storylines by describing five possible development pathways that differ with respect to whether and how much key variables such as population, income, technology, wealth distribution, laws and the environment could change over coming decades. The narratives help to identify which socioeconomic variables are most likely to increase or decrease vulnerability to climate change. In addition, there can be surprises, such as the emergence of new diseases or new technologies, which can substantially affect socioeconomic conditions. Stakeholder involvement in scenario development for a V&A assessment – including civil society, government ministries and representatives of important economic, environmental and cultural sectors – is key in the development of storylines, because these stakeholders can also inform the choice of indicators and projections to use in the assessment (see chapter 10 for a discussion of stakeholders in V&A assessments).

Socioeconomic storylines also can help to support sectoral assessments. Box 3-2 provides an example of a narrative for the health sector for SSP2, comparing it with SSP1 to illustrate differences between the storylines (Ebi, 2014). V&A assessments undertaken in the sectors discussed in chapters 5–8 would benefit from a holistic assessment of future socioeconomic conditions affecting risks. In doing so, this would assist in taking an integrated view of climate change impacts (outlined in chapter 9) within broader socioeconomic contexts, to inform decision makers.

Box 3-2
An example of a health narrative for SSP2

SSP2 depicts a world where population health improves, although not as quickly as in SSP1. Progress in reducing the burden of climate-related health outcomes in LICs is slow and uneven, with not all LICs making progress. Public health and international health care institutions and non-governmental organizations (NGOs) have an inadequate and not well-coordinated focus on addressing the burden of climate-related health outcomes. Access to safe water, improved sanitation and medical care slowly improve. For many LICs, the burdens of infectious and chronic diseases increase (i.e. the double burden of disease), thus continuing the disproportional impacts of climate-relevant health outcomes on children. Multiple factors contribute to some countries making slower progress in reducing health burdens, including, in some LICs, high burdens of climate-related diseases combined with moderate to high population growth.

Box 3-2 (cont.)
An example of a health narrative for SSP2

Other contributing factors include constraints to adaptation because of limited human and financial resources and personnel; weak surveillance and control programmes; and insufficient access to new technologies and expertise. Funding for public health infrastructure and health care falls below requirements, with inadequate resources and international commitment for: (1) integrated monitoring and surveillance systems: (2) research on and modelling of the health risks of climate change; (3) iterative management approaches; (4) training health care and public health professionals and practitioners; and (5) technology development and deployment. Limited cooperation across sectors increases the probability of co-harms from adaptation and mitigation options implemented in other sectors. This lack of integration increases the health risks of food and water insecurity, and limits progress on managing the risks of extreme events and disasters. Adverse health outcomes associated with the burning of fossil fuels increase (with moderate progress on regulations on end-of-pipe measures to reduce air pollutants), particularly in rapidly industrializing economies, leading to increasing burdens of associated chronic diseases.

SSP1 differs from SSP2 in that, in SSP1, the world moves more quickly to improve population health, with increased emphasis on enhancing public health and health care functions which, in turn, increase the capacity to prepare for, respond to, cope with and recover from climate-related health risks. Coordinated, worldwide efforts through international institutions and NGOs to achieve sustainable development goals increase access to safe water, improved sanitation, medical care, education and other factors in underserved populations. Social capital increases, resulting in more effective community-based efforts to manage local health and environmental quality. These improvements reduce the burden of these health outcomes before considering any impacts of climate change. Life expectancies increase in LICs with decreasing burdens from the key causes of childhood mortality (e.g. under-nutrition, diarrhoeal diseases, malaria). However, as more children survive to adulthood, burdens of non-communicable diseases increase, although changes in dietary patterns; and reductions in air pollution from burning fewer fossil fuels lower the burden of some chronic diseases. Enhanced cooperation across sectors minimizes co-harms from adaptation options implemented in other sectors, such as agriculture and water. This cooperation and coordination leads to integrated effects to address food and water security and to enhance protection from extreme weather and climate events.

Source: Ebi, 2014.

There are a number of resources written to support the development of socioeconomic scenarios. These are summarized in table 3-4.

Table 3-4
Key resources supporting socioeconomic scenario development

Resource	**Year**	**Description**	**Link**
Intergovernmental Panel on Climate Change (IPCC) Socioeconomic Data and Scenarios	2014	The IPCC Data Distribution Centre (DDC) provides access to baseline and scenario data related to population, economic development, technology and natural resources for use in climate impact assessments. This information, along with environmental data and scenarios also held by the DDC, is important for characterizing the vulnerability and adaptive capacity of social and economic systems in relation to climate change in different regions.	<http://sedac.ipcc-data.org/ddc/>
Global Energy Assessment (GEA) Scenario Database	2013	The scenarios of the GEA explore the feasibility and costs of global and regional energy transformations towards normative objectives for energy access, environmental impacts of energy conversion and use and energy security. The GEA database includes detailed quantitative information for 41 pathways that fulfil these objectives.	<http://www.iiasa.ac.at/web/home/research/researchPrograms/Energy/Global-Energy-Assessment-Database.en.html>
SSP Database	2013	The SSP database aims at the documentation of quantitative projections of the SSPs and related integrated assessment scenarios.	<https://secure.iiasa.ac.at/web-apps/ene/SspDb/dsd?Action=htmlpage&page=about>
United Nations Department of Economic and Social Affairs – Sustainable Development Scenarios for Rio+20	2013	This document draws lessons from 40 years of global sustainable development scenarios based on 98 models, with a particular focus on scenarios created for the United Nations Conference for Sustainable Development. Scenarios are documented in terms of ultimate goals, visions, strategy (including goals and targets), pathway characteristics and policies and actions, as well as investment needs. Past trends towards sustainable development are compared with baseline scenarios for the future and contrasted against sustainable development scenarios.	<https://sustainabledevelopment.un.org/content/documents/793SD21%20scenario%20report.pdf>
IPCC General Guidelines on the Use of Scenario Data for Climate Impact and Adaptation Assessment	2007	This document advocates two approaches to incorporating socioeconomic information into adaptation assessment.	<http://www.ipcc-data.org/guidelines/TGICA_guidance_sdciaa_v2_final.pdf>

2.2. Steps to developing and applying baseline scenarios

Five steps are recommended for developing and applying baseline scenarios, although it is not necessary to conduct all steps. Analysts are encouraged to go as far as time and resources permit. The five steps are to:

1. Develop a baseline of current socioeconomic and other vulnerabilities to climate variability and change, and of the effectiveness of policies and programmes designed to manage those vulnerabilities;
2. Project how the outcomes of interest could change under different climate change scenarios, assuming current vulnerabilities remain the same;
3. Use the SSPs to develop several socioeconomic storylines (e.g. development pathways with low, medium and high growth), with narrative elements and quantifications, for future time periods, such as 2030 and 2080;
4. Project how the outcomes of interest could change between the future and the baseline period under different socioeconomic storylines, to estimate how development pathways could after risks;
5. Project how the outcomes of interest could change under different climate change scenarios and socioeconomic development pathways. The projected magnitude and pattern of risks would reflect the interactions of climate and development.

2.2.1. Step 1: Develop a baseline of current socioeconomic and other vulnerabilities to climate variability and change

The first step is to examine the current conditions with respect to the factors responsible for vulnerability to climate variability and change. Current conditions are used as a baseline for further storylines because today's conditions are known. Population demographics (how many and where people live), income levels, technology levels, economic status and natural conditions are known or can easily be determined. It can be easier to communicate how today's conditions could be affected by climate change than to communicate risks regarding a hypothetical future set of socioeconomic conditions. However, when doing so, it would be important to communicate that current socioeconomic conditions are unlikely to remain unchanged over time.

It also is important to identify **key indicators** for each sector being assessed (see box 3-3). In this context, an indicator is a socioeconomic variable, factor or condition that can determine or be closely related to vulnerability to climate variability and change. For example, population in coastal zones can be an indicator of vulnerability to sea level rise or increased coastal storms. The reason for selecting indicators is to make it easier to estimate how the vulnerability of a sector can change.

Box 3-3
Example indicators

For the agricultural sector, indicators may include: degree of food security (i.e. percentage of the population with access to sufficient quantities and qualities of food for health and nutrition); share of food imported; and production of key crops.

In the water sector, examples include: the extent of available water supplies that are diverted or consumed; share of the population with ready access to potable water; and per capita water use.

2.2.2. Step 2: Project how the outcomes of interest could change under different climate change scenarios, assuming current vulnerabilities remain the same

Using the qualitative or quantitative relationships identified during the V&A assessment between weather patterns and particular outcomes, project how these outcomes could change under different climate change scenarios; assuming current vulnerabilities remain the same into the future. Many studies projecting risk take this approach.

2.2.3. Step 3: Use the shared socioeconomic pathways to develop several socioeconomic storylines for future time periods

SSPs can be used to develop regional and sectoral socioeconomic storylines (e.g. development pathways with low, medium and high growth), with narrative elements and quantifications for future time periods, such as 2030 and 2080. The storylines can be developed using expert judgement of how the different elements in tables 3-1 to 3-3 could change in the region/sector of interest.

Quantifications of key variables, such as population and GDP, should be available from national or regional governments or other resources for at least the next 15–20 years. Because the consequences of GHG emission pathways do not diverge until about mid-century, projections of risks until then need not consider the RCPs, although use of multiple climate models would be important to better understand the range of uncertainties (see chapter 4 on climate change scenarios).

The storylines should be evaluated to determine their usefulness. In particular, it is necessary to determine whether the scenarios provide estimates of variables that can help when estimating how indicators could change. Using an estimate that has already been developed can save time and resources in preparing national communications.

A key element of developing socioeconomic scenarios is the development of **narrative storylines**. Storylines are a qualitative view of the general structure and values of society and consider national and regional development plans. The development of effective storylines requires close engagement with stakeholders, such as through participatory scenario development (PSD) approaches. This is a process that involves the participation of stakeholders to explore the future in a creative and policy-relevant way.

2.2.4. Step 4: Project how the outcomes of interest could change between the future and baseline period under different socioeconomic storylines

This step estimates how development pathways could alter risks over the time period of interest without consideration of climate change.

An example is a study conducted by Nelson et al. (2009) using a crop simulation model (Decision Support System for Agrotechnology Transfer, DSSAT) and the International

Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) to estimate crop production (with and without CO_2 enrichment), calorie availability, number of children underweight, and adaptation costs in 2050. The study concluded that improvements in socioeconomic conditions would significantly reduce the number of undernourished children in developing countries from 147.9 million in 2000 to 113.3 million in 2050, excluding the effects of climate change.

Under the A2 emissions scenario, the study found that yields of most important crops would decline in developing countries by 2050, that per capita calorie availability would drop below levels that applied in the year 2000, and that the number of children underweight would be approximately 20 per cent higher (in the absence of carbon-enrichment effects). That is, about 25 million children would be affected (see table 3-5). Of note, the underweight estimates do not account for possible improvements in socioeconomic conditions between 2000 and 2050. However, it was estimated that substantial improvements would be necessary to counteract the effects of climate change. These included a 60 per cent increase in yield growth (all crops) over baseline, a 30 per cent faster growth in animal numbers, and a 25 per cent increase in the rate of expansion of irrigated areas.

Table 3-5
Number of undernourished children younger than 5 years of age, in millions

Scenario	**South Asia**	**East Asia/ Pacific**	**Europe and Central Asia**	**Latin America and Caribbean**	**Middle East/North Africa**	**Sub-Saharan Africa**	**All developing countries**
2000	75.6	23.8	4.1	7.7	3.5	32.7	147.9
2050 without climate change	52.3	10.1	2.7	5.0	1.1	41.7	113.3
2050 with climate change	59.1	14.5	3.7	6.4	2.1	52.2	138.5

Source: Nelson et al., 2009.

2.2.5. Step 5: Project how the outcomes of interest could change under different climate change scenarios and socioeconomic development pathways

This step projects the magnitude and pattern of risks, reflecting the interactions of climate and development. These projections can be quantitative or qualitative. Box 3-4 gives an example of a stakeholder-driven process to develop climate change scenarios and socioeconomic development pathways for a Swedish municipality to prioritize different climate adaptation plans to protect a groundwater aquifer (Carlsen, Dreborg and Wikman-Svahn, 2012).

Box 3-4
An example of a stakeholder-driven process

Working with civil servants from different municipal sectors, the first phase of the study identified the most promising adaptation options for adapting freshwater resources to climate change in the Stockholm municipality of Botkyrka (Carlsen, Dreborg and Wikman-Svahn, 2012).

Two time perspectives were chosen for the analysis: 2030 and 2060. For 2030, one climate scenario and two socioeconomic scenarios were constructed; for 2060, two climate scenarios (one assuming medium climate change and one assuming a higher level of climate change) were constructed. To limit the complexity of the process, only one socioeconomic scenario was used for the longer time perspective.

The climate scenarios were based on climate projections from the Swedish Meteorological and Hydrological Institute. The foundations for the socioeconomic scenarios were laid out in a workshop with civil servants from different municipal sectors, primarily from the departments of social services, city planning, health and environment, as well as representatives from the secretariat to the council and the executive board. Key drivers for the scenarios were generated in structured brainstorming sessions. Narratives for each scenario were distributed to the participants before a second workshop. Participants assessed the adaptation options along social, ecological and environmental dimensions. The participants generally considered the approach to be useful and of high relevance. It was particularly helpful to have the same group of people developing and using the socioeconomic scenarios.

Almost all participants stressed the importance of establishing a clear link between the scenarios and the stakeholders' own concerns.

2.3. Data sources

Data useful to consider when developing indicators are available from a variety of sources, depending on the particular sector under consideration (see table 3-6). Many multinational organizations, such as the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), United Nations Development Programme (UNDP) and the World Bank have readily accessible data on many variables that might be appropriate for indicators (see relevant chapters in this publication). General data that may be particularly relevant for one or more indicators include the following:

- ***Economy***: GDP, important sectors, comparative advantages, technology, infrastructure and institutions;
- ***Demography***: population, age structure, education and health;
- ***Environment***: land, water, air, biota, principal and unique resources, quantity and quality.

Table 3-6
Summary of key information sources on demographic data

Data/tool	Source	Link/contact
Gridded maps of human population and of socioeconomic data	Socioeconomic Data and Applications Center, Center for International Earth Science Information Network	<http://sedac.ciesin.columbia.edu/data/collection/gpw-v3>
Projections of national populations to 2300	United Nations Population Division	<http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf>
Core national demographic statistics	National census and health statistics offices	Links and contacts will be country-specific

2.4. Final thoughts

In order to project the risks from climate change it is necessary to consider not just the magnitude and pattern of climate change over coming decades at relevant spatial and temporal scales, but – and equally important – considering how near-term development choices could affect future vulnerabilities. The rate of progress in meeting development goals will be an important determinant of the extent to which future societies will be resilient to climate change. Therefore, developing baseline socioeconomic scenarios for V&A assessments will be critical for helping to understand the possible separate and joint contributions of climate and development to future vulnerability, and for enabling the selection of adaptation options that are robust to a range of possible futures. Part of the analysis and selection of adaptation options may be the identification of development pathways that decrease vulnerability and increase resilience to climate change.

When selecting baseline socioeconomic scenarios, it is important to keep in mind that the following:

1. The future is unknowable, but failure to consider a range of possible futures equates to making the implicit assumption that future vulnerability will be similar to today's: a highly unlikely prospect. The level of future vulnerability will affect the magnitude and pattern of future risks through, for example, altering the timing and character of thresholds.
2. The primary purposes of socioeconomic scenarios are to facilitate the exploration of a range of possible futures, and to generate insights that can be useful to inform policy-making. Development choices could increase or decrease resilience to climate variability and change, depending on the sector of interest and the temporal and spatial scale considered. There can also be interactions across sectors, which could affect resilience.
3. At a minimum, it is preferable to develop at least three visions of the future: pessimistic, optimistic and a continuation of current trends that are deemed important for the assessment. Depending on the decisions to be taken, developing worst-case or best-case socioeconomic scenarios may be particularly relevant.

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