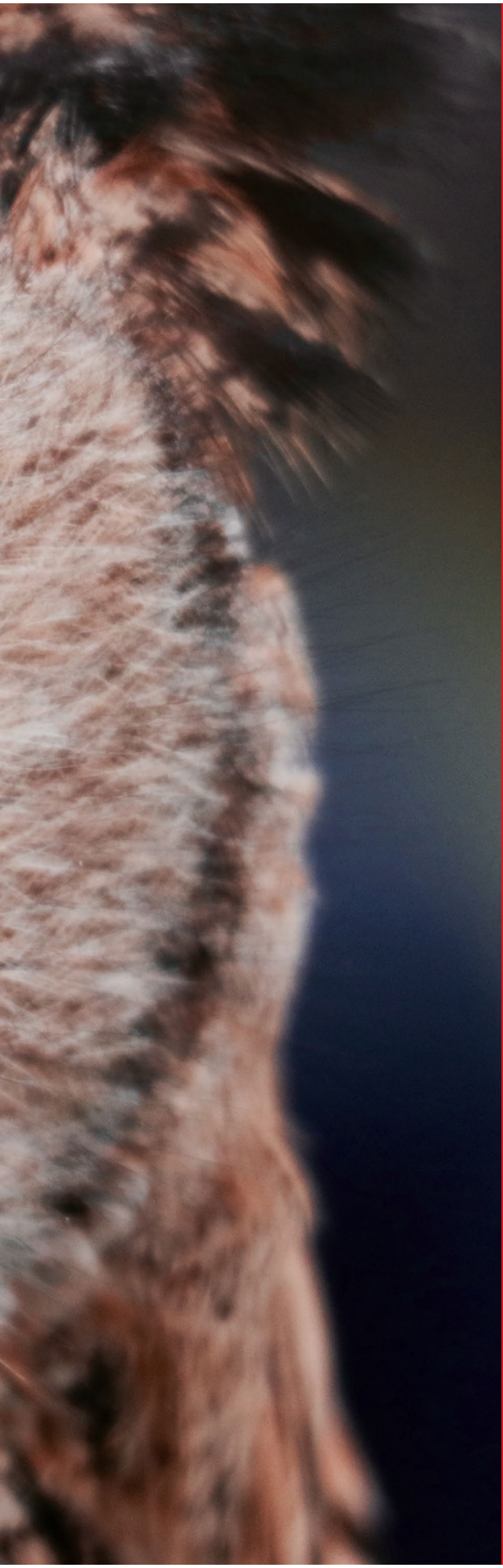


Part Two
THE OUTLOOK

An outlook is a vantage point, a platform, a perspective; it broadens our vistas and allows us to examine our prospects, both present and future. It is within this broader frame of thinking that the *Global Land Outlook* aims to present a unique perspective on one of the Earth's most precious assets: land. As we grapple with the current state of our land resources – a sober reminder of past misuse and mismanagement – Part Two presents both grounds for concern and opportunities for action. It provides a brief overview of how land resources are used today and assesses likely scenarios for how we can sustainably meet the demand for land, and its goods and services, in the future. It focuses on broader policy and practice, the cardinal issues long requiring attention, as well as the emerging concerns that need to be considered in the global public policy agenda.

Part Two

CHAPTER 6

SCENARIOS OF CHANGE

Given growing demands on land and emerging challenges from land degradation and climate change, policymakers require information on the possible consequences. This chapter explores trends up to 2050, through the Shared Socio-economic Pathways scenarios, based on the report '*Exploring the impact of changes in land-use and land condition on food, water, climate change mitigation and biodiversity: Scenarios for the UNCCD Global Land Outlook*'.[1]

Different scenarios point to large differences in future land-use, but Sub-Saharan Africa, the Middle East and North Africa, South Asia and, to a lesser extent, Southeast Asia are the regions that will bear the brunt of growth in population and overall consumption, and rapidly increasing pressure on the remaining land resources. Under all scenarios, the strongest regional land-use change is expected in Sub-Saharan Africa; however, the best land is already in use and expansion will increasingly take place on less productive lands, resulting in lower yields. Several regions have little land left for agricultural expansion or only more marginal land, such as in South Asia.

Future changes in the condition of land resources are also projected to be extensive as a result of continued land-use change and the deterioration of soils, land cover, and biodiversity. Biodiversity loss, in terms of mean species abundance, is projected to continue by 4 to 12 per cent point up to 2050, depending on the scenario, and will continue well into the second half of the 21st century. Changes in land cover and soil quality affect the probability of flooding and drought. The effects are amplified in drylands, which also face above-average population growth. Almost 20 per cent of the Sub-Saharan African land area shows declining productivity when corrected for climate effects, in most other regions this is between 5 and 10 per cent. On a global level, by 2050, there may be an additional 5 per cent expansion in cropland to compensate for these productivity losses.

To date, global soil organic carbon has been reduced by 176 Gt compared to the natural, undisturbed state. If current trends continue, anthropogenic land-based carbon emissions from soil and vegetation will roughly add another 80 Gt of carbon to the atmosphere over the 2010–2050 period, equivalent to about 8 years of current global carbon emissions from fossil fuels. Abating these projected land-based emissions would leave more of the available global carbon budget of 170–320 Gt C intact (i.e., the amount in CO_2 emissions that can still be emitted without jeopardizing the target of keeping average global temperature increase below 2°C). The global potential to store carbon in soils is considerable but requires the development of agricultural systems that combine high yields with close-to-natural soil organic carbon levels.

INTRODUCTION

Global scenarios on land-use change and land degradation represent potential storylines, descriptions, and evaluations of how the future may unfold, e.g., the possible future state of land resource use, demand, and condition. The scenarios presented here are a tool to explore uncertainties associated with possible future development pathways focused on the relevant human and environmental dimensions.[2] The increasing demand for food, water, energy, housing, and other land-based goods and services, and the resulting impacts on the quality and productivity of the land, is at the heart of these scenarios.

The primary aim of a scenario in this context is to help decision-makers to explore and shape the future and realize a long-term vision of sustainable development for all. In Part Three of this *Outlook*, scenarios that reduce pressure on our land resources are translated into broadly understood principles and response pathways. By analyzing the various pressures and forces that drive land-use change and land degradation, scenarios also allow a range of stakeholders at various scales to test how well the expected demand for and management of land resources will help achieve the Sustainable Development Goals (SDGs) and their targets, specifically SDG target 15.3 on land degradation neutrality.

Shared Socio-Economic Pathways

Global modelling requires an agreed methodology, which relies on the development of consistent storylines, followed by transparent modelling.[3] Most recently, the Shared Socio-Economic Pathways (SSPs) have been developed to provide a framework for scenario analysis, considering multiple driving forces of economic development, population, technological development, land-use, and international cooperation.

The SSPs represent alternative characterizations of possible societal futures for use by different research communities, including narrative descriptions of future trends and quantitative information for some of the key elements. This chapter is based on the scenario analysis[4] being undertaken by the PBL Netherlands Environmental Assessment Agency, in cooperation with Wageningen University, University of Utrecht, and the Joint Research Centre of the European Commission, and with the support of many experts from different fields and organizations. It shows the results of three explorative scenarios (SSP1–3) and one variant on the SSP2 scenario (the SSP2 productivity decline scenario) to estimate the order of magnitude of global changes in land-use, and condition up to the year 2050 under different societal development paths.

Table 6.1: Assumptions embedded in the three SSP scenarios.

	SSP1 Sustainability	SSP2 Middle of the Road	SSP3 Fragmentation
Globalization of trade	High	Medium	Low
Meat consumption	Low	Medium	High
Land-use change regulation	Strict	Moderate	Little
Crop yield improvement	High	Medium	Low
Livestock system efficiency	High	Medium	Low

These quantitative scenarios embed a set of internally consistent assumptions within a coherent storyline. The 'Middle of the Road' scenario (SSP2) is characterized by the continuation of current trends (business as usual); the 'Sustainability' scenario (SSP1) depicts a more equitable and prosperous world striving for sustainable development; and the 'Fragmentation' scenario (SSP3) portrays a divided world with low economic development, high population growth, and limited environmental concern.

In order to explore the impact of changes in land condition, a variant of the SSP2 scenario was created. The scenario 'SSP2 productivity decline' includes, in addition to SPP2, the impact of a decline in productivity, land cover and/or soil quality from poor land management. It assumes the continuation of the net primary productivity decline between 1982-2010, as observed by remote sensing techniques and corrected for climate effects, up to 2050. In order to discern the magnitude of changes in land condition from poor land management rather than that of climate change, the data have been corrected for climate change effects over the same period.

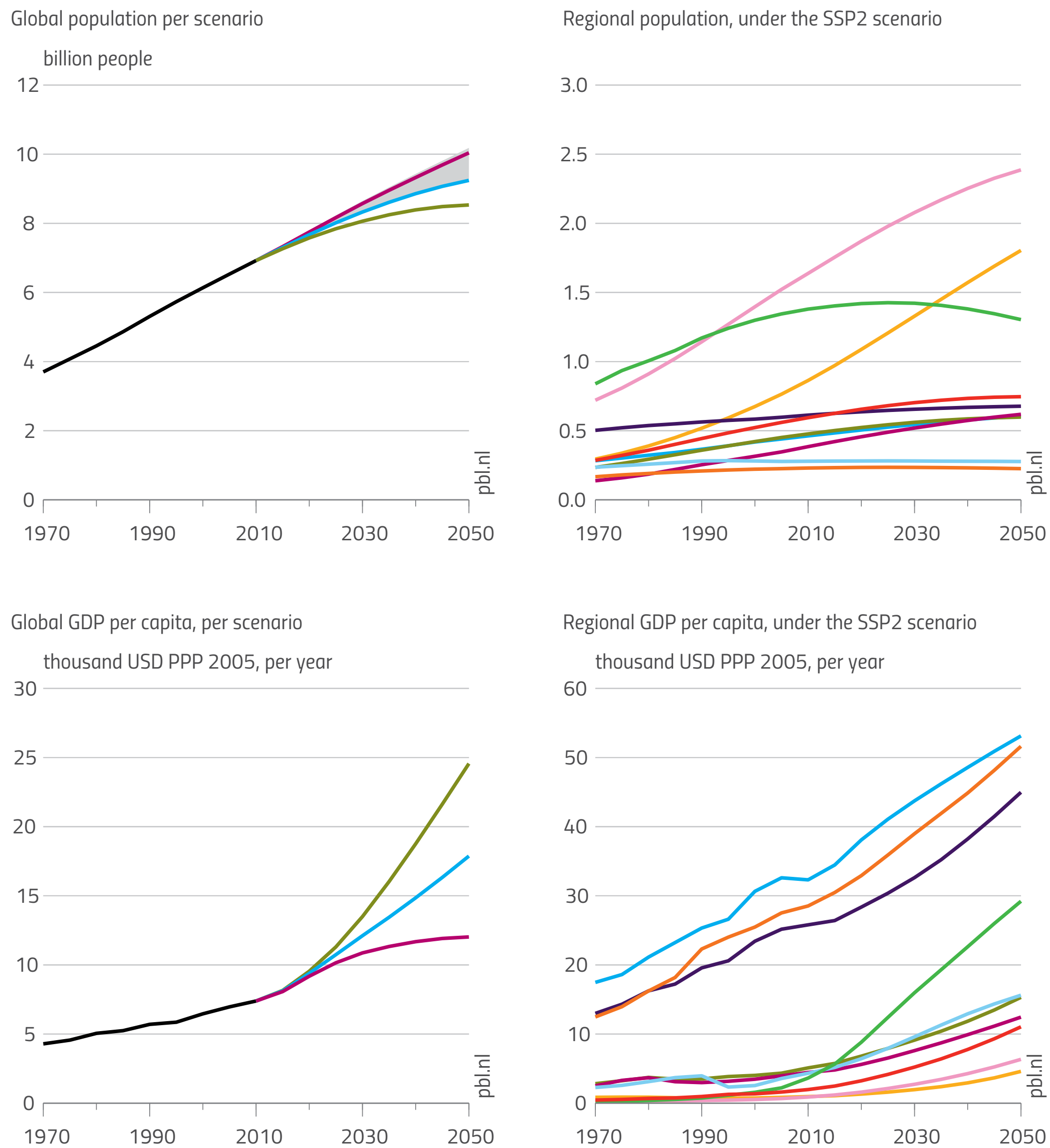
While all scenarios are potential futures, their storylines differ widely. This helps to explore the potential range of future developments in land-use, demand, and condition. These ranges then give decision-makers sufficient bandwidth within which they can expect changes to take place and challenges to materialize. Table 6.1 lays out the major differences in assumptions made for each of the three SSP storylines. These scenarios are elaborated with the IMAGE model,[5] by applying quantitative projections for populations,[6] urbanization,[7] and economic development,[8] and by quantifying model parameters to reflect the storylines as described above. The scenario results span the energy system, food production, land-use, GHG emissions, climate change, biodiversity, and impacts on water and soil properties. In assessing the trends in biodiversity, soil properties, and hydrological systems, both land-use change and climate change are important drivers that are accounted for in the modelling. For land-use patterns and the agro-economic system, however, climate change impacts are not included due to the large uncertainties and the experimental design.[9] The change in soil properties, biodiversity, and hydrological systems are elaborated with the S-World model,[10,11] GLOBIO model,[12] and PCR GLOB WB model[13,14] respectively.

The Shared Socio-Economic Pathways describe plausible alternative trends in the evolution of society and natural systems over the 21st century at the level of the world and large world regions. They consist of two elements: a narrative storyline and a set of quantified measures of development.

Figure 6.1: Socio-economic drivers (GDP and population) quantified for the SSP scenarios (PPP is purchasing power parity).
Source: PBL/IMAGE

Key

- History
- SSP1 scenario
- SSP2 scenario
- SSP3 scenario
- UN population projections (95% range)
- North America
- Central and South America
- Middle East and Northern Africa
- Sub-Saharan Africa
- Western and Central Europe
- Russia and Central Asia
- South Asia
- China region
- Southeast Asia
- Japan and Oceania



Population and Economic Growth

In all three scenarios, past population growth patterns will continue to 2050, yet at different rates (Figure 6.1). Global population growth is assumed to start levelling off in SSP2. The world population reaches about 9 billion people in 2050 but continues to grow rapidly in Sub-Saharan Africa with population doubling within 40 years; high growth rates are also projected for North Africa, the Middle East, and South Asia. Other regions show clear signs of levelling off or even declines in population. In SSP1, population growth is slower, peaking at about 8 billion in 2050, primarily due to lower growth rates in Sub-Saharan Africa, South and Southeast Asia.

In SSP3, population growth continues at its current rate and reaches more than 10 billion in 2050, primarily due to higher growth rates in all regions but especially in Sub-Saharan Africa and South and Southeast Asia.

Economic growth follows historical trends in SSP2, is assumed higher than historical trends in SSP1, and lower than historical trends in SSP3, especially in less developed regions. As a result, trends in population and economic growth partly compensate for each other in SSP3 with respect to food demand due to a larger but less affluent population. In SSP1, despite higher incomes, lower population numbers and attention to environmental concerns keep food demand below SSP2 levels.

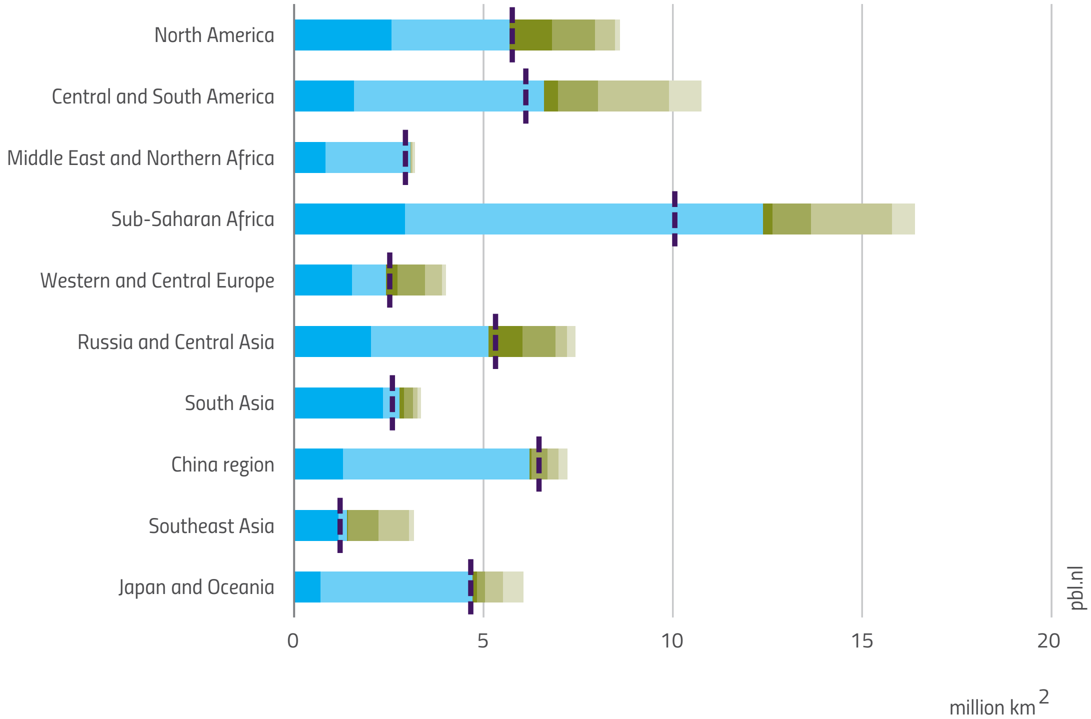


Figure 6.2: Land currently in use (dashed line), in 2050 and the potential of remaining suitable land for agriculture under the SSP2 scenario.
Source: PBL/IMAGE

Key

Land area used in 2050

Crops
Pasture

Potential of remaining land suitable for agriculture

Very high
High
Moderate
Low

Land area used in 2010

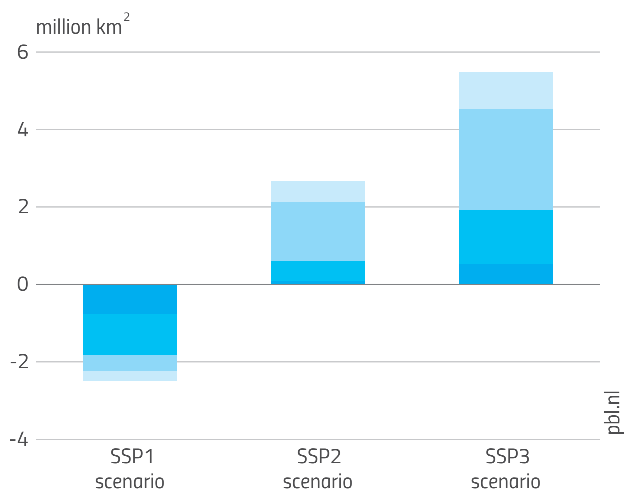


Figure 6.3: Land productivity potential of newly converted agricultural area.
Source: PBL/IMAGE

Key

Crop productivity class of converted land

Low
Moderate
High
Very high

Results from PBL's scenario analysis

In all three scenarios, the demand for land-based goods and services will continue to grow rapidly over the coming decades.[15] This includes agricultural products (e.g., food and fodder), fiber (e.g., cotton and timber for construction and paper), and fuel (e.g., fuelwood, biomass, liquid biofuels). In addition to the demand for land-based products, cities, villages, and infrastructure are built on land, and the conservation of forests and other natural areas for biodiversity, ecosystem services, and climate mitigation and adaptation all require land.

Overall, the scenario findings are robust as the overall linkages between food, fodder and their respective land-uses are well understood and rely on a broad empirical base. The key uncertainties in future land-use dynamics are the change in demand for agricultural products and trends in crop yields

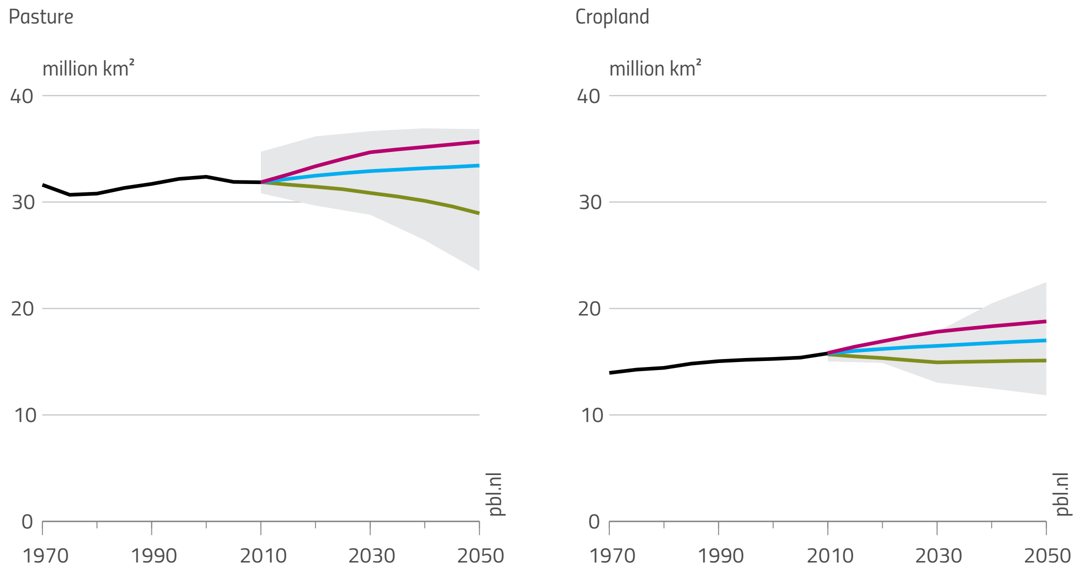


Figure 6.4: Global trends in land-use for the SSPs (colored lines) and the range in other models[16] (grey area) for 2010–2050.
Source: PBL/IMAGE

Key

- History
- SSP1 scenario
- SSP2 scenario
- SSP3 scenario
- IAM model range for scenarios SSP1, SSP2 and SSP3

and livestock production systems. All global models indicate for the Middle of the Road scenario SSP2, and even more so in SSP3, that the century-old trend to convert forested areas into agricultural land will continue at least until 2050. Not only will forests be affected by future land-use demands from agriculture but so will savannas and grasslands. As a consequence, we can expect continued habitat loss and the associated biodiversity impacts. The following sections reflect the following chapters in Part Two of the Outlook which present in more detail the evidence and potential future policy issues.

Agriculture

The remaining natural land suitable for agriculture is limited, with expansion increasingly taking place on more marginal lands. With much of the land potentially available for agriculture already in use, either for crops, livestock, or urban areas, additional land for agriculture has to expand to areas that are less productive (Figure 6.2). Using less productive land requires more area and/or inputs for the same output. Moreover, marginal lands are often more difficult to manage and more prone to degradation: they may be on slopes, have thin and less fertile soils, be more difficult to work, or restricted by water shortages or climate factors. Farmers thus require more effort and inputs, on top of having conditions that are less favorable than elsewhere. In various regions, smallholders are more likely to be pushed into marginal areas whereas larger producers maintain control over more fertile land.

Two out of the three scenarios project an increase in agricultural land-use: approximately 50 per cent (in SSP3) and 80 per cent (in SSP2) of that increase is estimated to take place on land of low or moderate productivity (Figure 6.3). In contrast, in the SSP1 scenario, the net global agricultural area will decrease as a result of the combination of low population growth, more attention to sustainable consumption and production (e.g., lower levels of meat consumption and food waste), and increased efficiencies in crop and livestock systems. In Europe and Russia, accounting for a large fraction of the world's most fertile lands, even highly productive land will face land-use change or abandonment. From the perspective of global efficiencies in land-use, more trade in land products would help allocate production to regions according to their comparative advantage. Still, there are many other concerns, such as domestic food self-sufficiency and the cost of transport, and CO_2 emissions due to long-distance transport.

Global land-use change is expected to continue in the SSP2 scenario, with the expansion of cropland from 15 million km^2 in 2010 by about 0.9 million km^2 in 2030 and 1.2 million km^2 in 2050, with an additional 1.4 million km^2 for energy crops in 2050. Pasture area (including grassland area for livestock) is projected to increase by about 1.6 million km^2 by 2050 (Figure 6.4).

Figure 6.5: Change in land-use and natural areas, globally (left) and regionally (right)
Source: PBL/IMAGE

Key
- Other natural land
- Forest
- Pasture
- Energy crops
- Food and feed crops
- Built-up area
- Range between scenarios SSP1 and SSP3

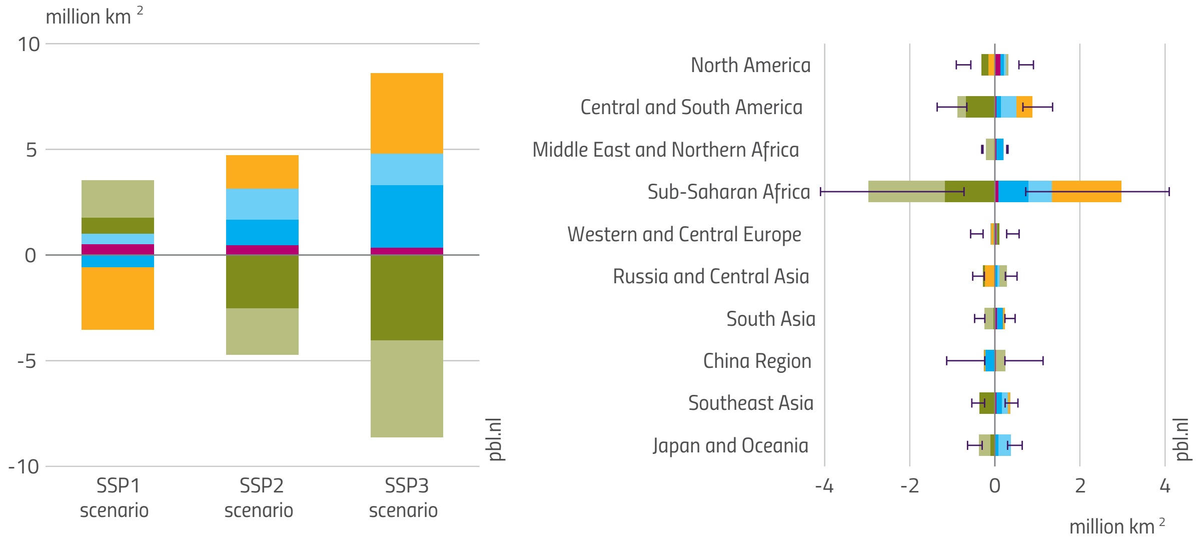


Figure 6.6: Land-use change over the 2010–2050 period: green indicates expansion of natural areas; purple indicates expansion of agricultural land/built up areas.
Source: PBL/IMAGE

Key

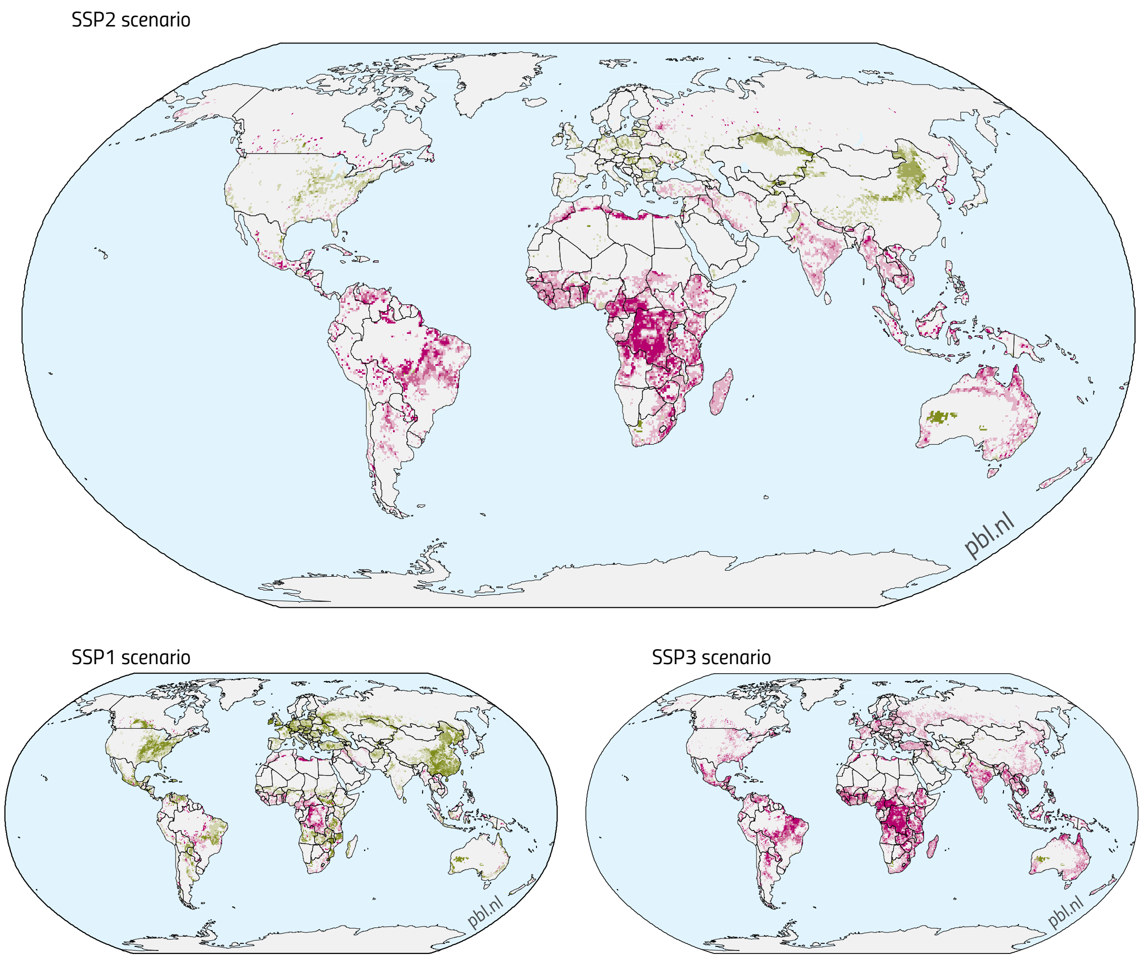
Deforestation and conversion of other natural land (% change per grid cell)

5 30 50 100

Reforestation and abandonment of agriculture to other natural land (% change per grid cell)

5 30 50 100

No or small change (less than 5%)



The SSP3 scenario shows larger expansions for cropland, bioenergy, and pasture than SSP2, mostly due to slow technological development. In the SSP1 scenario, a net decrease in agricultural area is projected globally due to small increases in population, more sustainable consumption and production, and increased efficiency in crop and livestock systems, thus requiring less land. The expansion of agricultural land is greatest in Sub-Saharan Africa due to high population growth and increasing demand for food and fodder, which cannot be met completely by increases in efficiency. Also in SSP1, despite a net decrease at the global level, agricultural land-use expands in Sub-Saharan Africa; in SSP3, expansion is about 40 per cent higher than in SSP2 due to slow improvements in crop yields and livestock system efficiency (Figure 6.5 and 6.6).

Land-use change is driven by the continued increase in the demand for food, fuel, and fiber. Global demand drives agricultural and timber production increases of 27 to 77 per cent until 2050, under the various scenarios and depending on population and income projections. This is in line with the range across the literature.[17] In the developing regions, the increase in production is moderate, as the growth in demand is levelling off, but large increases are expected especially in Sub-Saharan Africa (more than 150 per cent), South and Southeast Asia and Latin America (more than 70 per cent), driving agricultural land-use change. Part of the increasing regional demand is also met via production in other regions and trade.

In the SSP1 scenario, the increase in demand is much smaller in most regions or even constant. Changes in food demand in SSP3 are often similar to SSP2 at both global and regional levels as higher population and lower economic growth compensate each other: SSP3 has higher population, which would lead to more demand, but also less income, which would lead to less demand when compared to SSP2. In driving land-use change, agricultural intensity (crops and livestock) makes up the difference between these two scenarios. Timber production remains at high levels in developed regions in all scenarios and shows some increase in Latin America, Africa, and Southeast Asia, often via increased forest plantations.

Nitrogen and phosphorus fertilizer use is expected to increase rapidly in countries where use is currently low, improving land-use efficiency, but risking adverse environmental effects. Much of current market-oriented agricultural production has become reliant on artificial fertilizer, with naturally occurring soil nutrients not able to sustain current yield levels in many locations. In the SSP2 scenario, the rapid increase in food production will lead to increases in nitrogen and phosphorus fertilizer use, especially in regions where fertilizer use is currently low. Earlier comparable scenario projections estimate a 36 per cent increase in global nitrogen fertilizer use and 44 per cent in the use of phosphorus between 2005 and 2050, but with a quadrupling of phosphorus fertilizer use in Sub-Saharan Africa.[18]

All SSP scenarios show significant expansion of agriculture on tropical soils that are vulnerable to erosion. Soils under tropical forests are generally poor and weathered, with a long history of abundant rain and high temperatures having leached out most nutrients. The high productivity of natural vegetation is sustained via a near-closed cycle in which the majority of nutrients are found in the biomass and in the layer of dead and decomposing matter on the forest floor. The largest cropland expansion is projected in the Congo basin as a result of large increases in demand in Sub-Saharan Africa, even under the relatively optimistic assumption of around 200 per cent increase in agricultural productivity in that region under the SSP2 scenario. Without sustained and effective soil management systems, clearing these lands for agriculture could result in quickly declining agricultural production due to a lack of nutrients and exposure to water erosion.

Globally, continuing productivity loss in particular areas may require additional cropland expansion as compensation by 2050. Assuming local negative trends in net primary productivity as a proxy for land-based productivity declines in croplands allows for a first estimate of the additional cropland required to compensate for that loss. According to this SSP2 productivity decline scenario, this would result in a 5 per cent larger cropland area by 2050, on top of the 8 per cent expansion under the SSP2 scenario which was based on growth in food demand only. Regions that show the most additional expansion under these assumptions are North Africa, the Middle East and North Africa, Russia and Central Asia, Sub-Saharan Africa, and Japan and Oceania.

Water Resources

Future water security faces a multitude of risks from a scarcity perspective. These risks relate to the robust increase in water demand, uncertainties on non-renewable groundwater depletion, reductions in water quality, and changes in rainfall patterns as well as changes in soil depth, soil texture, and soil organic carbon. With the decline in soil condition, the ability of soils to hold water declines. Water holding capacity is especially relevant for rain-fed agricultural production in drylands, where rainfall can be erratic and the buffering function of soils to store water is used by plants to survive longer dry spells. Low yields in dryland systems are often ascribed to excessive water evaporation from soil surface, where higher amounts of organic mulching can – although not in all situations – improve water infiltration and storage, and therefore increase productivity.[19] When more water can be stored in the soil (e.g., due to mulching), the delayed release of moisture to groundwater systems can have a smoothing effect on river discharge.

Under the SSP2 scenario, the total global water demand increases from 2,056 km^3 to 2,445 km^3. Southeast Asia and Sub-Saharan Africa show the largest increase in water demand, due in large part to the demand by industry and households. Water scarcity refers to its limited availability given the total demand of different users. Water scarcity, now and in the future, is prevalent in densely populated regions such as India, Asia, the western United States, and Spain (Figure 6.7). These regions consist of large arid and semi-arid areas. Figure 6.7 also shows the regions that will experience an increase in water scarcity. Among others, in the east central coast of Africa, the Great Plains of the USA, around the Mediterranean Sea, and in parts of the Yangtze basin, water scarcity may slow down economic growth.

The extent to which local water scarcity will become problematic also depends on local storage, the pumping of groundwater from aquifers, or measures upstream to prevent shortages downstream. The scenarios explored here only sketch the risks and do not include these potential mitigation and adaptation measures.

In the SSP2 scenario, many river basins with higher precipitation levels due to climatic changes show increases in runoff that are larger than expected based on the increases in precipitation alone; land cover change appears to reduce the ability of ecosystems to buffer water flows and thus leads to a higher runoff rate. The effects are amplified

Figure 6.7: Global projections of dynamic water scarcity, between 2010 and 2050, under the SSP2 scenario: the dynamic water scarcity index map is based on a monthly timescale and accounts for how often and how persistent water scarce conditions occur in a year. *Source: UU*

Key

- Low (0.1-0.2)
- Moderate (0.2-0.4)
- High (0.4 -0.8)
- Very high (0.8 or more)
- No water stress (less than 0.1)
- Projected increase in water stress, compared to 2010

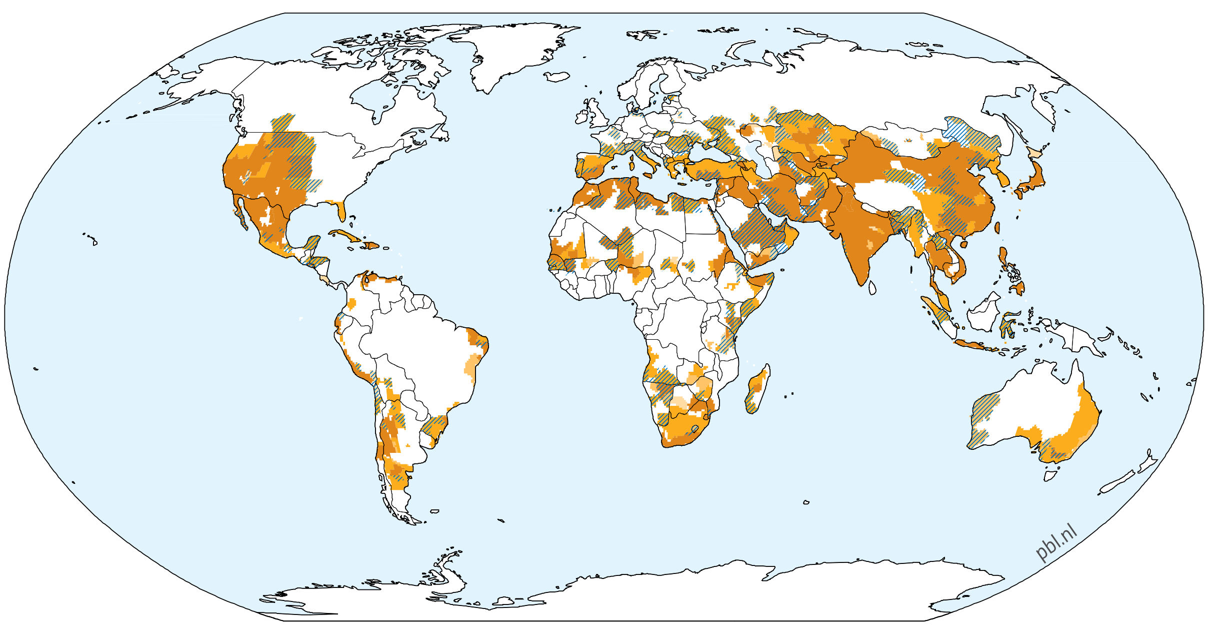
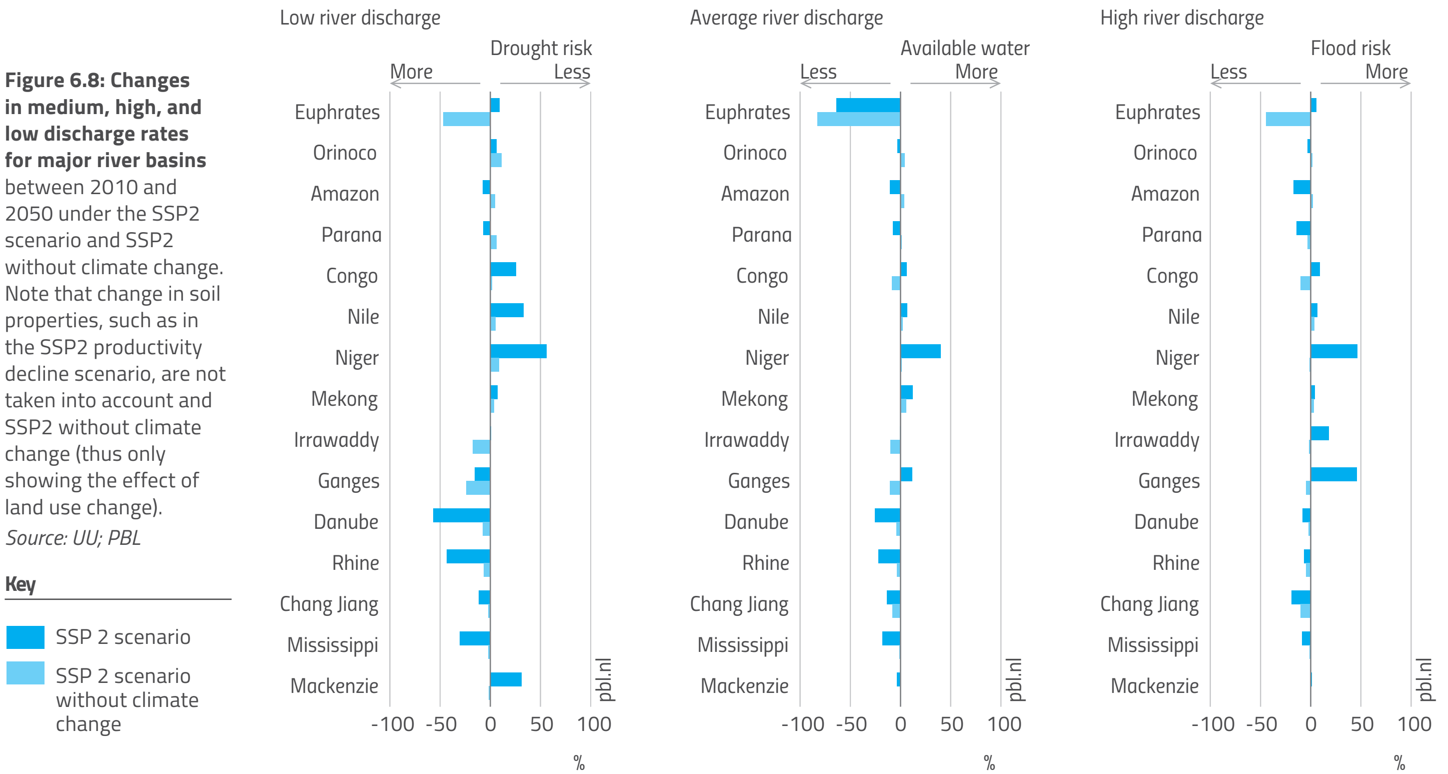


Figure 6.8: Changes in medium, high, and low discharge rates for major river basins between 2010 and 2050 under the SSP2 scenario and SSP2 without climate change. Note that change in soil properties, such as in the SSP2 productivity decline scenario, are not taken into account and SSP2 without climate change (thus only showing the effect of land use change).

Source: UU; PBL



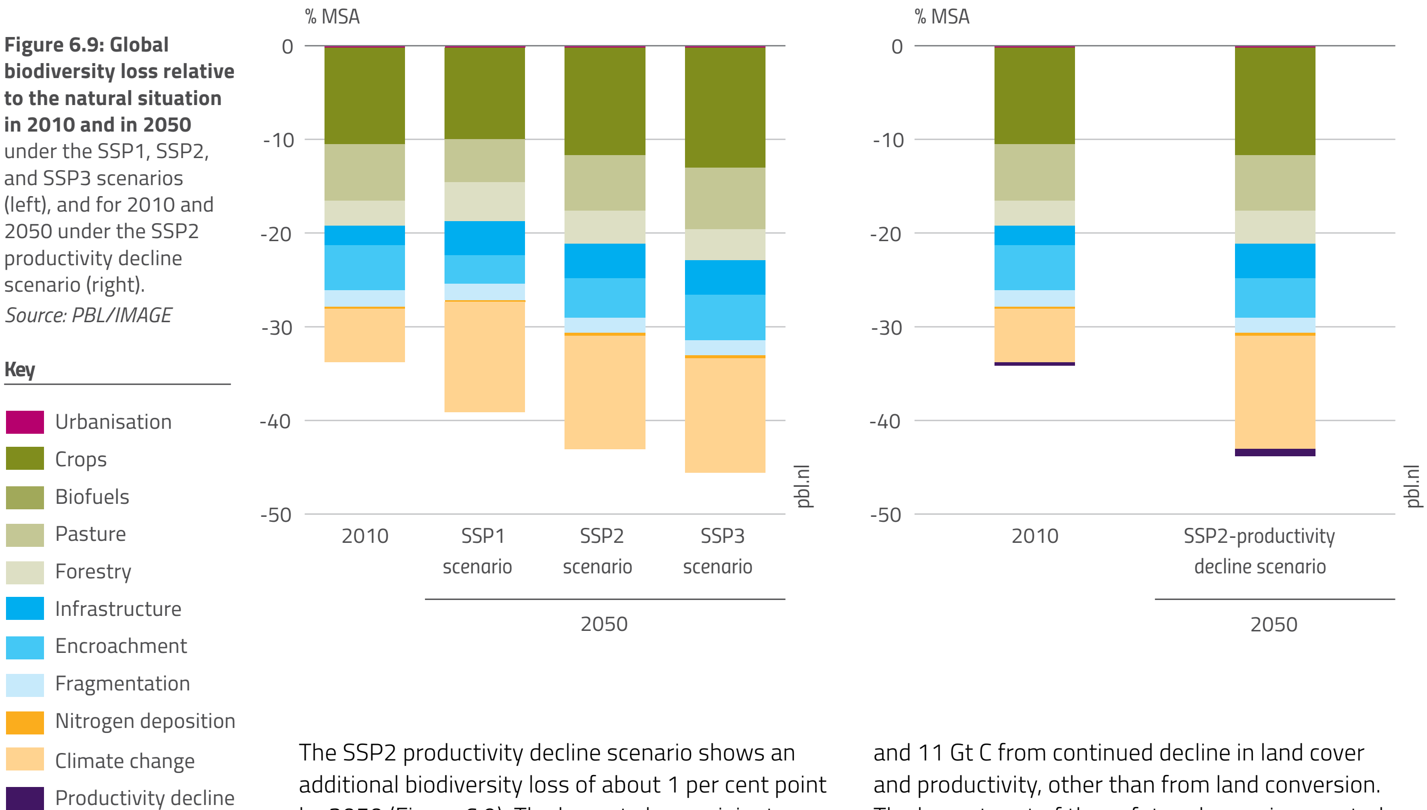
in dryland regions, where for many small basins just a little intensification in land-use can cause a significant change in runoff.

Climate change and land cover change result in changes in runoff which influence river flow volumes. Based on average discharge, river basins may get wetter or drier. But as river discharges generally show a high natural variability, high and low discharge volumes rather than average discharge levels provide more information about the hazards of flooding and drought. Figure 6.8 shows the relative change in low, average, and high discharge volumes for the SSP2 scenario, with and without climate change, for some of the larger river basins of the world. Several developments may amplify or moderate one another and the extent varies per river basin, depending on the local situation. A negative change in low discharge means that their volumes will become smaller, indicating that a river basin will be more susceptible to hydrological drought. For high discharges, it is the other way around.

Biodiversity

Biodiversity loss, as measured by mean species abundance (MSA), is projected to increase from 34 per cent in 2010 to 38, 43, and 46 per cent under SSP1, 2, and 3, respectively (Figure 6.9). In SSP1, the rate of loss is slowed down by halting the expansion of cropland although this leads to a higher impact from forestry. This is a typical example of trade-offs between different sector developments; the forestry area has to expand more than in SSP2 and SSP3 to compensate for the absence of timber production from forests cleared for cropland expansion. SSP2 and SSP3 show the biggest biodiversity losses as a cumulative effect of the increase in cropland, also including bio-energy crops, infrastructure, and encroachment from human settlements, forestry, and climate change. These scenarios would continue or even accelerate the rate of loss recorded in the 20th century. In all scenarios, the loss in biodiversity continues well beyond 2050 while the impacts from climate change accelerate in all scenarios.

Figure 6.9: Global biodiversity loss relative to the natural situation in 2010 and in 2050 under the SSP1, SSP2, and SSP3 scenarios (left), and for 2010 and 2050 under the SSP2 productivity decline scenario (right).
Source: PBL/IMAGE



The SSP2 productivity decline scenario shows an additional biodiversity loss of about 1 per cent point by 2050 (Figure 6.9). The largest share originates from the loss in the productivity in croplands that leads to additional cropland expansion in order to compensate for the loss. A smaller part comes from former land use, now abandoned, and informal, extensive land use, such as extensive grazing and fodder and wood collection. One per cent point may be perceived as relatively small but in absolute terms it is a considerable amount. As a reference, 1 per cent point in MSA loss is equivalent to complete biodiversity loss in a pristine area about 2.4 times the size of continental France.

Soil, Vegetation, and Carbon

The total historical anthropogenic loss of soil organic carbon (SOC), mostly from conversion of natural ecosystems to agriculture, has resulted in an estimated loss of 176 Gt of SOC, equivalent to 8 per cent of the total SOC pool of the total SOC pool of about 2,200 Gt under natural conditions.[19,20] This is in line with the estimates in the literature.[21,22,23] It is estimated that much of these losses have occurred in Europe, the Indian subcontinent, the Sahel, the south-eastern part of South America, and in large parts of China (Figure 6.10 middle).

Under the SSP2 productivity decline scenario, cumulative emissions from SOC are estimated at around 27 Gt C over the 2010–2050 period (Figure 6.11). Of this, 16 Gt C originates from the future conversion of natural land into agricultural land, and 11 Gt C from continued decline in land cover and productivity, other than from land conversion. The largest part of these future losses is expected in the southern hemisphere regions, especially Sub-Saharan Africa (Figure 6.10 bottom). Medium and low productive soils, often with low carbon content, may lose a relatively high share of their (already small) total carbon pool in a short timeframe when they are converted to cropland.

The continued drainage of peat soils and subsequent peat fires are estimated to contribute cumulatively about 9 Gt C (±2) emissions between 2010 and 2050. This amount is based on projections of emissions in Southeast Asia[24] and the extrapolation of current emissions from Europe, including European Russia.[25] Cumulative carbon emissions from vegetation loss are estimated at around 45 Gt C by 2050; this is biomass loss due to agricultural expansion, forest degradation, and forest management (Figure 6.11). This is the net balance of, in particular, afforestation in the Northern regions and continued deforestation in the southern regions.[26]

The above anthropogenic land-based emissions add up to around 80 Gt C by 2050, equivalent to about eight years of annual carbon emissions from fossil fuels of 9.9 Gt C/y[27] (Figure 6.11). These estimates do not include the feedbacks of climate change (temperature and precipitation) on SOC stocks nor the impacts from CO2 fertilization on carbon stocks in vegetation.

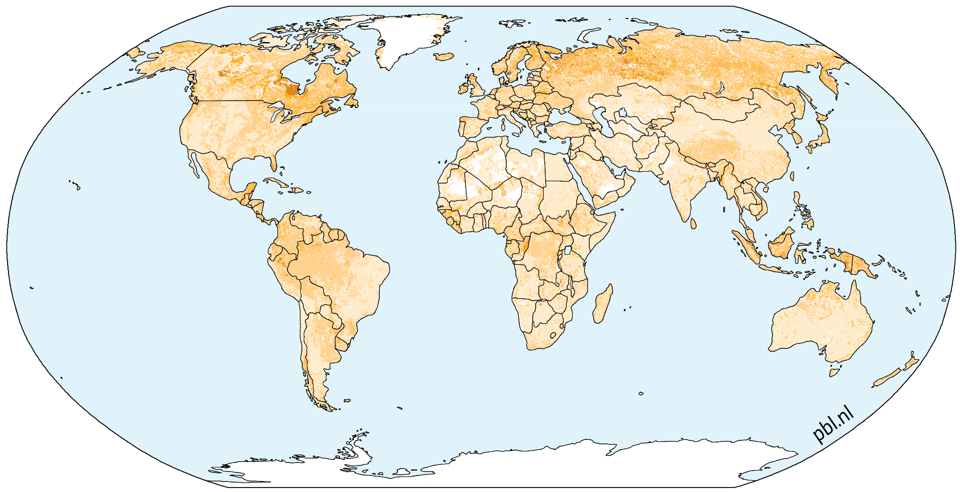
Figure 6.10: Current SOC content (top); historical loss of SOC as fraction of SOC in a natural state (middle); future loss of SOC as fraction of the current state under the SSP2 productivity decline scenario (bottom).

Source: Stoorvogel et al. 2017; Schut et al. 2015; PBL

Key

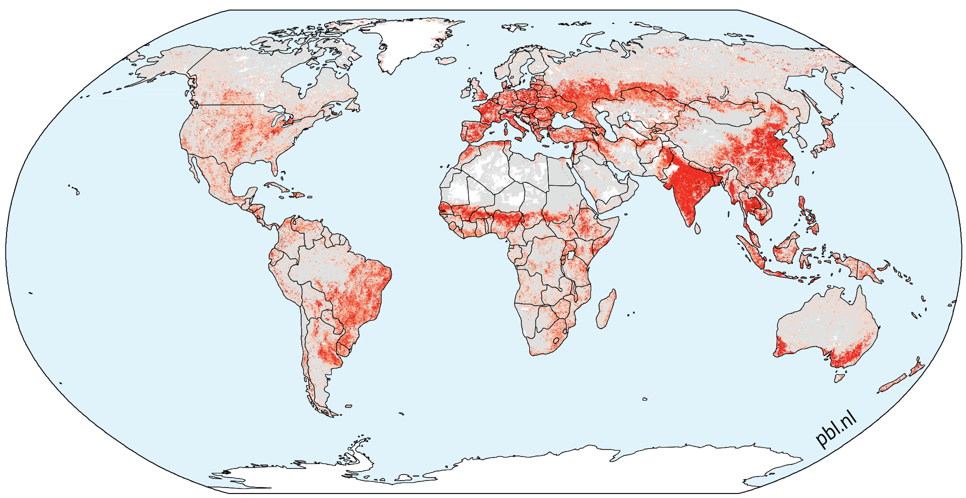
- Low (1.5% or less)
- Moderate (1.5-3.0%)
- High (3.0-5.0%)
- Humose (5.0-12.0%)
- Organo-mineral (12.0-35%)
- Organic (More than 35%)

2010



- 50 and more
- 30 - 50
- 20 - 30
- 10 - 20
- 2 - 10
- 2% loss - 2% growth
- More than 2% growth

Change compared to natural situation, 2010



- No data

Change under the SSP2-productivity decline scenario, 2010 – 2050

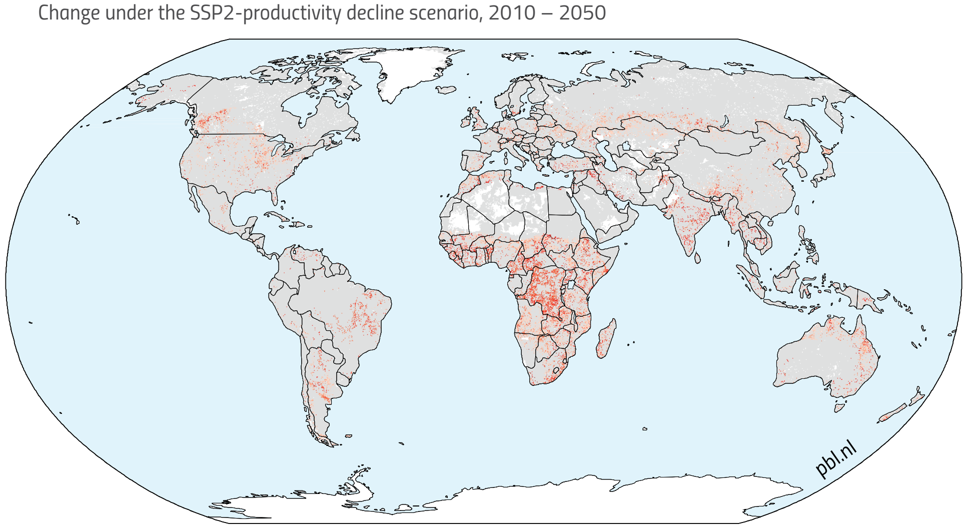
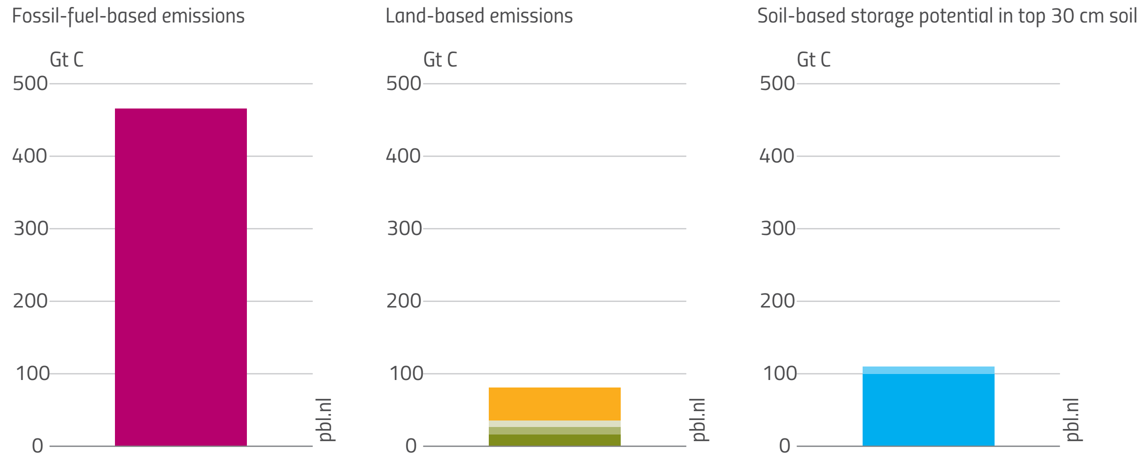


Figure 6.11: Cumulative carbon emissions from fossil fuels from the energy and industry sector (left); cumulative land-based emissions from vegetation (land-use change) and soils (middle); carbon sequestration potential in the top soil (< 30 cm) in agriculture and natural land (right).
Source: PBL



Since the greatest part of the historical loss in SOC originates from the top 30 cm soil in agricultural land, the greatest restoration potential is in current agricultural land. This global potential is considerable but requires the development of agricultural systems that combine high yields with close-to-natural SOC levels (Figure 6.11).

Future land-based carbon emissions are relatively small compared to the emissions from fossil fuels (Figure 6.11). Nevertheless, reducing future land-based emissions and utilizing the carbon sequestration potential in agricultural land would be significant from a climate change mitigation perspective. Scenarios with a likely probability of keeping global temperature increase below 1.5°C to 2°C require future cumulative CO_2 emissions to be limited to 170–320 Gt C.[28,29,30]

Climate Change

The impact of climate change on agriculture is likely to decrease yields and the availability of suitable agricultural land in some regions, while increasing yields in others for moderate levels of warming. This will likely lead to both altered trade patterns and the expansion of agricultural areas, but the uncertainty range of the climate change impacts on agricultural land-use is very large.[31] The impact differs widely between regions: while some temperate regions are likely to benefit from higher temperature and longer growing periods, regions like Sub-Saharan Africa and India are expected to see yield declines due to increased water limitation and – even more importantly – higher temperatures.[32]

Drylands are especially vulnerable. Figure 6.12 shows a global map of current aridity and future change under the SSP2 scenario. Higher productivity due to CO_2 fertilization may compensate for some of the adverse effects, but it is still unclear to what extent these benefits can be realized in practice. Globally, yields on existing cropland could decrease by 10-15 per cent while the area suitable for cropland may increase about 10 per cent, in particular in the northern hemisphere. This would result in a few per cent decline in global production by 2050 compared to a situation without climate change, but the picture is significantly more diverse at the regional scale and moderated through trade.

In addition to the impacts on the suitability of land for food production, climate change will also affect water availability and thus may create wider effects such as conflicts, especially in drylands where strong population increases are expected and water scarcity is already a contentious issue.[33,34,35,36] Finally, warming can also accelerate the decomposition of soil organic matter, putting pressure on the condition of land in already warm regions and further adding to carbon emissions[37] as well as the migration of pests and diseases.

Figure 6.12: The aridity index in 2010 and the change under the SSP2 scenario

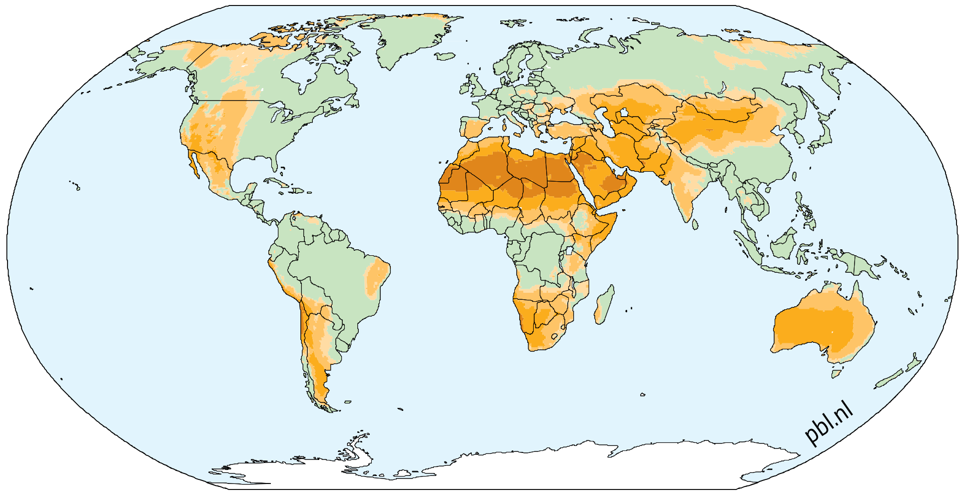
Source: PBL/IMAGE

Key

Aridity index

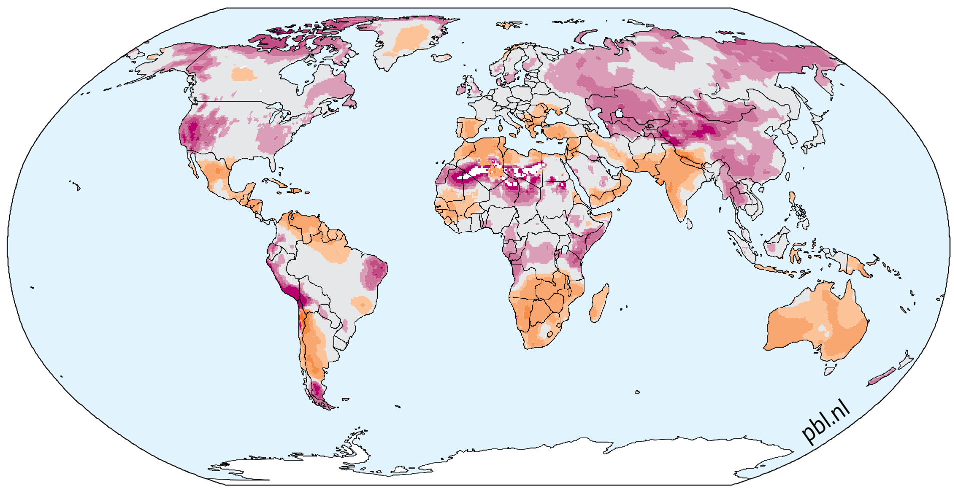
- Hyper arid (< 0.03)
- Arid (0.03 - 0.2)
- Semi-arid (0.2 - 0.5)
- Dry sub-humid (0.5 -0.65)
- Humid (> 0.65)

Aridity index, 2010



- More arid
- No change
- More Humid

Change in aridity under the SSP2 scenario, 2010 – 2050

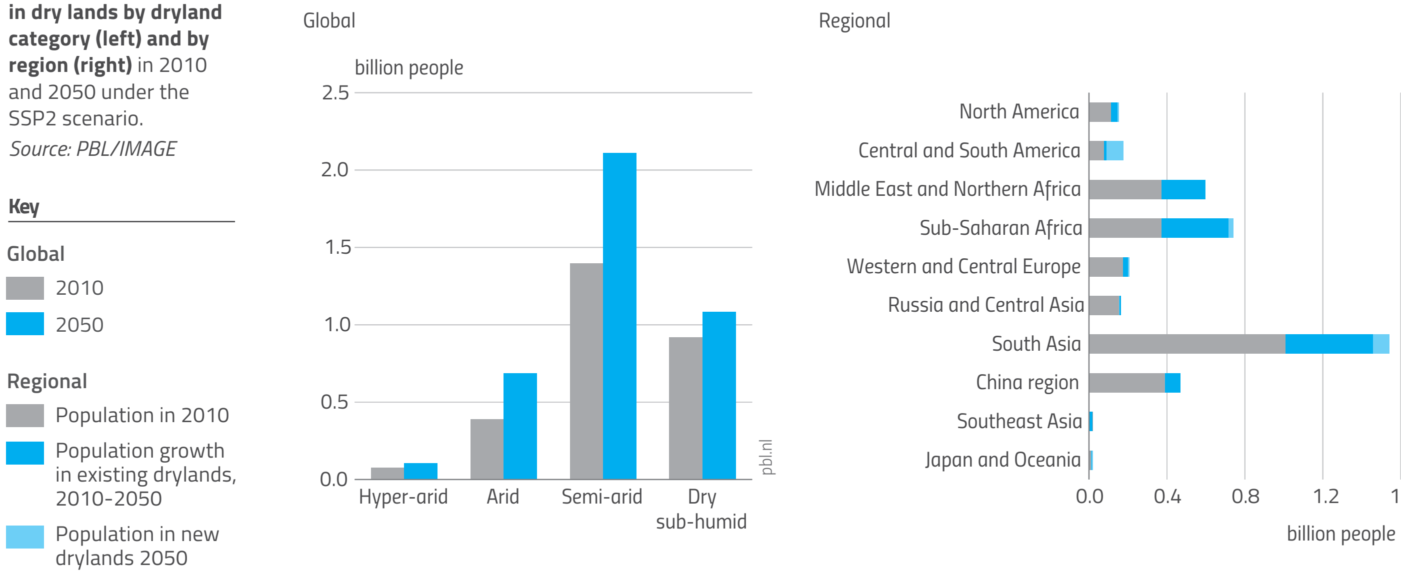


Urbanization

Expansion of urban areas and infrastructure, while small compared to land conversion for agriculture, increasingly displaces fertile agricultural land. The world is becoming increasingly urbanized, which directly and indirectly affects land-use. Human settlements have historically developed in the most fertile areas, and on accessible lands. Their growing size is beginning to significantly displace fertile agricultural land. In one region of China, more than 70 per cent of the increase in urban land took place on previously cultivated land.[38]

Urban expansion is mainly taking place in peri-urban areas, slowly fragmenting and occupying agricultural and natural landscapes. Agriculture is often then displaced to other, sometimes less productive locations. Urban populations are increasingly disconnected from rural areas and the ways in which food and other land-based goods are produced. The extent of built-up area is projected to increase by 0.4 million km^2 in the SSP2 scenario. Much of this increase occurs on highly productive agricultural areas (see Chapter 11), thereby triggering displacement of agriculture to less productive regions, and requiring more area to produce the same output. This finding is generally consistent with other literature though some project the largest expansion of urban area in other regions, such as China.[39]

Figure 6.13: Population in dry lands by dryland category (left) and by region (right) in 2010 and 2050 under the SSP2 scenario.
Source: PBL/IMAGE



Drylands

Population in drylands is projected to increase by 43 per cent by 2050 under the SSP2 scenario, a much larger increase than the global population growth rate of around 33 per cent. Overall, population in drylands is projected to increase from 2.7 billion in 2010 to 4.0 billion in 2050 (Figure 6.13).

In the drylands, water is generally the limiting factor for plant growth. With the population increases in the SSP2 scenario, water scarcity is bound to become an even more pressing issue in many of these regions. The largest increases in populations are projected to take place in the semi-arid and arid drylands. Regionally, South Asia is projected to see the largest increase in number of people in drylands, at over 500 million, and Sub-Saharan Africa is estimated to see a doubling of the number of people living in the drylands. Though smaller in absolute terms, such a doubling is also expected in Central and South America. Whereas in Sub-Saharan Africa the increase is mainly driven by population growth, in Central and South America the main cause is the expansion of drylands due to climatic changes. Therefore, while many regions do become somewhat dryer and some become wetter, the overall challenges in drylands will be aggravated by increased demands from larger populations more than by climate change. The effects of climate change however, such as increasingly erratic weather, especially droughts, will affect many more people in drylands in the future.

Regional Perspectives

Examining changes in land-use and ecosystem functions from a regional perspective, Sub-Saharan Africa, South Asia, and the Middle East and North Africa will face the greatest challenges. These regions are characterized by a combination of the following factors: high levels of population growth (especially in the drylands), low per capita GDP, high levels of undernourishment, strong increases in water stress, limited protein intake, lower self-sufficiency rates, expansion in agricultural area, rapid reductions in the remaining potentially available cropland, continued low crop yields, ongoing productivity loss, and high biodiversity losses. At the same time, the economic and institutional means to cope with these changes are currently limited, and although development may improve this in the future, in the meantime this may lead to unmanageable problems and risk of conflict and mass migration, inside and outside of the region.

Southeast Asia faces many similar challenges, but to a lesser degree. It is characterized by a relatively strong increase in water demand, low self-sufficiency, continued agricultural expansion, further declines in potentially available cropland, and high biodiversity losses. The remaining regions show relatively fewer yet still a diverse group of challenges while having better economic and institutional means to cope with these changes.

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CONCLUSION

This scenario analysis demonstrates, that in many regions, significant changes in land-use, demand, and condition can be expected in the coming decades, mainly as a result of the combination of increased population and wealth, leading to an increasing demand for food, shifts towards more meat and land-intensive foods, increased demand for fiber and energy, urbanization, accelerating climate change, and continued local declines in land cover, productivity, and soil organic carbon.

These drivers will influence high and low river discharges, water scarcity, aridity, crop yields, agricultural land expansion, land as carbon source and sink, and biodiversity. Sub-Saharan Africa, the Middle East and North Africa, South Asia and, to a lesser extent, Southeast Asia face an alarming combination of environmental and socio-economic challenges that will increase the pressures on land-based goods and services in the future. As a consequence, the multi-dimensional impacts on human security (see Chapter 5) may lead to unmanageable problems and risks.

Response pathways (see Part Three) need to help alleviate land pressures and achieve a more equitable balance between environmental and socio-economic trade-offs. It is the sum total of our individual decisions – as heads of households, consumers, producers, business owners, and policymakers – that is leading to a global failure in achieving food, water, and energy security for all while mitigating climate change and halting biodiversity loss. Like our response to climate change, a business-as-usual approach is insufficient to address the magnitude of this challenge. Such responses need to address population growth, consumption levels, diets, yield gaps for all commodities, the efficient use of space, water, materials, and energy, deforestation, food waste and post-harvest losses, climate change, and the conversion of natural areas. Land governance at the local, national and international scale coupled with enlightened land use planning and land management systems will be essential to navigate such a transition.

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