Frequently Asked Questions

FAQ

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These Frequently Asked Questions have been extracted from the chapters of the underlying report and are compiled here. When referencing specific FAQs, please reference the corresponding chapter in the report from where the FAQ originated (e.g., FAQ 3.1 is part of Chapter 3).

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FAQ 1.1 | What are the approaches to study the interactions between land and climate?

Climate change shapes the way land is able to support supply of food and water for humans. At the same time the land surface interacts with the overlying atmosphere, thus human modifications of land use, land cover and urbanisation affect global, regional and local climate. The complexity of the land–climate interactions requires multiple study approaches embracing different spatial and temporal scales. Observations of land atmospheric exchanges, such as of carbon, water, nutrients and energy can be carried out at leaf level and soil with gas exchange systems, or at canopy scale by means of micrometeorological techniques (i.e. eddy covariance). At regional scale, atmospheric measurements by tall towers, aircraft and satellites can be combined with atmospheric transport models to obtain spatial explicit maps of relevant greenhouse gases fluxes. At longer temporal scale (>10 years) other approaches are more effective, such as tree-ring chronologies, satellite records, population and vegetation dynamics and isotopic studies. Models are important to bring information from measurement together and to extend the knowledge in space and time, including the exploration of scenarios of future climate–land interactions.

FAQ 1.2 | How region-specific are the impacts of different land-based adaptation and mitigation options?

Land-based adaptation and mitigation options are closely related to region-specific features for several reasons. Climate change has a definite regional pattern with some regions already suffering from enhanced climate extremes and others being impacted little, or even benefiting. From this point of view increasing confidence in regional climate change scenarios is becoming a critical step forward towards the implementation of adaptation and mitigation options. Biophysical and socio-economic impacts of climate change depend on the exposures of natural ecosystems and economic sectors, which are again specific to a region, reflecting regional sensitivities due to governance. The overall responses in terms of adaptation or mitigation capacities to avoid and reduce vulnerabilities and enhance adaptive capacity, depend on institutional arrangements, socio-economic conditions, and implementation of policies, many of them having definite regional features. However global drivers, such as agricultural demand, food prices, changing dietary habits associated with rapid social transformations (i.e. urban vs rural, meat-eating vs vegetarian) may interfere with region-specific policies for mitigation and adaptation options and need to be addressed at the global level.

FAQ 1.3 | What is the difference between desertification and land degradation? And where are they happening?

The difference between land degradation and desertification is geographic. Land degradation is a general term used to describe a negative trend in land condition caused by direct or indirect human-induced processes (including anthropogenic climate change). Degradation can be identified by the long-term reduction or loss in biological productivity, ecological integrity or value to humans. Desertification is land degradation when it occurs in arid, semi-arid, and dry sub-humid areas, which are also called drylands. Contrary to some perceptions, desertification is not the same as the expansion of deserts. Desertification is also not limited to irreversible forms of land degradation.

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FAQ 2.1 | How does climate change affect land use and land cover?

Contemporary land cover and land use is adapted to current climate variability within particular temperature and/ or rainfall ranges (referred to as climate envelopes). Anthropogenic GHG emissions impact land through changes in the weather and climate and also through modifications in atmospheric composition through increased GHGs, especially CO_2. A warming climate alters the current regional climate variability and results in a shift of regional climate envelopes poleward and to higher elevations. The shift of warmer climate envelopes into high latitude areas has potential benefits for agriculture here through extended growing seasons, warmer seasonal temperatures and increased atmospheric CO_2 concentrations which enhance photosynthetic activity. However, this warming will also lead to enhanced snowmelt and reduced albedo, permafrost melting and the further release of CH_4 and CO_2 into the atmosphere as the permafrost begins to decompose.

Concurrent with these climate envelope shifts will be the emergence of new, hot climates in the tropics and increases in the frequency, intensity and duration of extreme events (e.g., heatwaves, very heavy rainfall, drought). These emergent hot climates will negatively affect land use (through changes in crop productivity, irrigation needs and management practices) and land cover through loss of vegetation productivity in many parts of the world, and would overwhelm any benefits to land use and land cover derived from increased atmospheric CO_2 concentrations.

FAQ 2.2 | How do the land and land use contribute to climate change?

Any changes to the land and how it is used can effect exchanges of water, energy, GHGs (e.g., CO_2, CH_4, N_2O), non-GHGs (e.g., BVOCs) and aerosols (mineral, e.g., dust, or carbonaceous, e.g., BC) between the land and the atmosphere. Land and land use change therefore alter the state (e.g., chemical composition and air quality, temperature and humidity) and the dynamics (e.g., strength of horizontal and vertical winds) of the atmosphere, which, in turn, can dampen or amplify local climate change. Land-induced changes in energy, moisture and wind can affect neighbouring, and sometimes more distant, areas. For example, deforestation in Brazil warms the surface, in addition to global warming, and enhances convection which increases the relative temperature difference between the land and the ocean, boosting moisture advection from the ocean and thus rainfall further inland. Vegetation absorbs CO_2 to use for growth and maintenance. Forests contain more carbon in their biomass and soils than croplands and so a conversion of forest to cropland, for example, results in emissions of CO_2 to the atmosphere, thereby enhancing the GHG-induced global warming.

Terrestrial ecosystems are both sources and sinks of chemical compounds such as nitrogen and ozone. BVOCs contribute to forming tropospheric ozone and secondary aerosols, which respectively effect surface warming and cloud formation. Semi-arid and arid regions release dust, as do cropland areas after harvest. Increasing the amount of aerosols in the atmosphere impacts temperature in both positive and negative ways depending on the particle size, altitude and nature (carbonaceous or mineral, for example). Although global warming will impact the functioning and state of the land (FAQ 2.1), this is not a one-way interaction as changes in land and land use can also affect climate and thus modulate climate change. Understanding this two-way interaction can help improve adaptation and mitigation strategies, as well as manage landscapes.

FAQ 2.3 | How does climate change affect water resources?

Renewable freshwater resources are essential for the survival of terrestrial and aquatic ecosystems and for human use in agriculture, industry and in domestic contexts. As increased water vapour concentrations are expected in a warmer atmosphere, climate change will alter the hydrological cycle and therefore regional freshwater resources. In general, wet regions are projected to get wetter and dry regions drier, although there are regional exceptions to this. The consequent impacts vary regionally; where rainfall is projected to be lower in the future (many arid subtropical regions and those with a Mediterranean climate), a reduction of water resources is expected. Here increased temperatures and decreased rainfall will reduce surface and groundwater resources, increase plant evapotranspiration and increase evaporation rates from open water (rivers, lakes, wetlands) and water supply infrastructure (canals, reservoirs). In regions where rainfall is projected to be higher in the future (many high latitude regions and the wet tropics), an increase in water resources can be expected to benefit terrestrial and freshwater ecosystems, agriculture and domestic use, however, these benefits may be limited due to increased temperatures.

An increase in extreme rainfall events is also expected which will lead to increases in surface runoff, regional flooding and nutrient removal as well as a reduction in soil water and groundwater recharge in many places. Anthropogenic land use change may amplify or moderate the climate change effect on water resources, therefore informed land management strategies need to be developed. A warming climate will exacerbate the existing pressures on renewable freshwater resources in water-stressed regions of the Earth and result in increased competition for water between human and natural systems.

FAQ 3.1 | How does climate change affect desertification?

Desertification is land degradation in drylands. Climate change and desertification have strong interactions. Desertification affects climate change through loss of fertile soil and vegetation. Soils contain large amounts of carbon, some of which could be released to the atmosphere due to desertification, with important repercussions for the global climate system. The impacts of climate change on desertification are complex and knowledge on the subject is still insufficient. On the one hand, some dryland regions will receive less rainfall and increases in temperatures can reduce soil moisture, harming plant growth. On the other hand, the increase of CO_2 in the atmosphere can enhance plant growth if there are enough water and soil nutrients available.

FAQ 3.2 | How can climate change induced desertification be avoided, reduced or reversed?

Managing land sustainably can help avoid, reduce or reverse desertification, and contribute to climate change mitigation and adaptation. Such sustainable land management practices include reducing soil tillage and maintaining plant residues to keep soils covered, planting trees on degraded lands, growing a wider variety of crops, applying efficient irrigation methods, improving rangeland grazing by livestock and many others.

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FAQ 3.3 | How do sustainable land management practices affect ecosystem services and biodiversity?

Sustainable land management practices help improve ecosystems services and protect biodiversity. For example, conservation agriculture and better rangeland management can increase the production of food and fibres. Planting trees on degraded lands can improve soil fertility and fix carbon in soils. Sustainable land management practices also support biodiversity through habitat protection. Biodiversity protection allows for the safeguarding of precious genetic resources, thus contributing to human well-being.

FAQ 4.1 | How do climate change and land degradation interact with land use?

Climate change, land degradation and land use are linked in a complex web of causality. One important impact of climate change on land degradation is that increasing global temperatures intensify the hydrological cycle, resulting in more intense rainfall, which is an important driver of soil erosion. This means that sustainable land management (SLM) becomes even more important with climate change. Land-use change in the form of clearing of forest for rangeland and cropland (e.g., for provision of bio-fuels), and cultivation of peat soils, is a major source of greenhouse gas (GHG) emission from both biomass and soils. Many SLM practices (e.g., agroforestry, perennial crops, organic amendments, etc.) increase carbon content of soil and vegetation cover and hence provide both local and immediate adaptation benefits, combined with global mitigation benefits in the long term, while providing many social and economic co-benefits. Avoiding, reducing and reversing land degradation has a large potential to mitigate climate change and help communities to adapt to climate change.

FAQ 4.2 | How does climate change affect land-related ecosystem services and biodiversity?

Climate change will affect land-related ecosystem services (e.g., pollination, resilience to extreme climate events, water yield, soil conservation, carbon storage, etc.) and biodiversity, both directly and indirectly. The direct impacts range from subtle reductions or enhancements of specific services, such as biological productivity, resulting from changes in temperature, temperature variability or rainfall, to complete disruption and elimination of services. Disruptions of ecosystem services can occur where climate change causes transitions from one biome to another, for example, forest to grassland as a result of changes in water balance or natural disturbance regimes.

Climate change will result in range shifts and, in some cases, extinction of species. Climate change can also alter the mix of land-related ecosystem services, such as groundwater recharge, purification of water, and flood protection. While the net impacts are specific to time as well as ecosystem types and services, there is an asymmetry of risk such that overall impacts of climate change are expected to reduce ecosystem services. Indirect impacts of climate change on land-related ecosystem services include those that result from changes in human behaviour, including potential large-scale human migrations or the implementation of afforestation, reforestation or other changes in land management, which can have positive or negative outcomes on ecosystem services.

FAQ 5.1 | How does climate change affect food security?

Climate change negatively affects all four pillars of food security: availability, access, utilisation and stability. Food availability may be reduced by negative climate change impacts on productivity of crops, livestock and fish, due, for instance, to increases in temperature and changes in rainfall patterns. Productivity is also negatively affected by increased pests and diseases, as well as changing distributions of pollinators under climate change. Food access and its stability may be affected through disruption of markets, prices, infrastructure, transport, manufacture, and retail, as well as direct and indirect changes in income and food purchasing power of low-income consumers. Food utilisation may be directly affected by climate change due to increases in mycotoxins in food and feed with rising temperatures and increased frequencies of extreme events, and indirectly through effects on health. Elevated atmospheric CO_2 concentrations can increase yields at lower temperature increases, but tend to decrease protein content in many crops, reducing their nutritional values. Extreme events, for example, flooding, will affect the stability of food supply directly through disruption of transport and markets.

FAQ 5.2 | How can changing diets help address climate change?

Agricultural activities emit substantial amounts of greenhouse gases (GHGs). Food supply chain activities past the farm gate (e.g., transportation, storage, packaging) also emit GHGs, for instance due to energy use. GHG emissions from food production vary across food types. Producing animal-sourced food (e.g., meat and dairy) emits larger amount of GHGs than growing crops, especially in intensive, industrial livestock systems. This is mainly true for commodities produced by ruminant livestock such as cattle, due to enteric fermentation processes that are large emitters of methane. Changing diets towards a lower share of animal-sourced food, once implemented at scale, reduces the need to raise livestock and changes crop production from animal feed to human food. This reduces the need for agricultural land compared to present and thus generates changes in the current food system. From field to consumer this would reduce overall GHG emissions. Changes in consumer behaviour beyond dietary changes, such as reduction of food waste, can also have, at scale, effects on overall GHG emissions from food systems. Consuming regional and seasonal food can reduce GHG emissions, if they are grown efficiently.

FAQ 6.1 | What types of land-based options can help mitigate and adapt to climate change?

Land-based options that help mitigate climate change are various and differ greatly in their potential. The options with moderate-to-large mitigation potential, and no adverse side effects, include options that decrease pressure on land (e.g., by reducing the land needed for food production) and those that help to maintain or increase carbon stores both above-ground (e.g., forest measures, agroforestry, fire management) and below-ground (e.g., increased soil organic matter or reduced losses, cropland and grazing land management, urban land management, reduced deforestation and forest degradation). These options also have co-benefits for adaptation by improving health, increasing yields, flood attenuation and reducing urban heat island effects. Another group of practices aim at reducing greenhouse gas (GHG) emission sources, such as livestock management or nitrogen fertilisation management. Land-based options delivering climate change adaptation may be structural (e.g., irrigation and drainage systems, flood and landslide control), technological (e.g., new adapted crop varieties, changing planting zones and dates, using climate forecasts), or socio-economic and institutional (e.g., regulation of land use, associativity between farmers). Some adaptation options (e.g., new planting zones, irrigation) may have adverse side effects for biodiversity and water. Adaptation options may be planned, such as those implemented at regional, national or municipal level (top-down approaches), or autonomous, such as many technological decisions taken by farmers and local inhabitants. In any case, their effectiveness depends greatly on the achievement of resilience against extreme events (e.g., floods, droughts, heat waves, etc.).

FAQ 6.2 | Which land-based mitigation measures could affect desertification, land degradation or food security?

Some options for mitigating climate change are based on increasing carbon stores, both above-ground and below-ground, so mitigation is usually related to increases in soil organic matter content and increased land cover by perennial vegetation. There is a direct relationship, with very few or no adverse side effects for prevention or reversal of desertification and land degradation and the achievement of food security. This is because desertification and land degradation are closely associated with soil organic matter losses and the presence of bare ground surfaces. Food security depends on the achievement of healthy crops and high and stable yields over time, which is difficult to achieve in poor soils that are low in organic matter.

FAQ 6.3 | What is the role of bioenergy in climate change mitigation, and what are its challenges?

Plants absorb carbon as they grow. If plant-based material (biomass) is used for energy, the carbon it absorbed from the atmosphere is released back. Traditional use of bioenergy for cooking and heating is still widespread throughout the world. Modern conversion to electricity, heat, gas and liquid fuels can reduce the need to burn fossil fuels and this can reduce GHG emissions, helping to mitigate climate change. However, the total amount of emissions avoided depends on the type of biomass, where it is grown, how it is converted to energy, and what type of energy source it displaces. Some types of bioenergy require dedicated land (e.g., canola for biodiesel, perennial grasses, short rotation woody crops), while others can be co-produced or use agricultural or industrial residues (e.g., residues from sugar and starch crops for ethanol, and manure for biogas). Depending on where, how, and the amount of bioenergy crops that are grown, the use of dedicated land for bioenergy could compete with food crops or other mitigation options. It could also result in land degradation, deforestation or biodiversity loss. In some circumstances, however, bioenergy can be beneficial for land, for example, by increasing soil organic carbon. The use of co-products and residues for bioenergy limits the competition for land with food but could result in land degradation if carbon and nutrient-rich material is removed that would otherwise be left on the land. On the other hand, the by-products of some bioenergy conversion processes can be returned to the land as a fertiliser and may have other co-benefits (e.g., reducing pollution associated with manure slurry).

FAQ 7.1 | How can indigenous knowledge and local knowledge inform land-based mitigation and adaptation options?

Indigenous knowledge (IK) refers to the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. Local knowledge (LK) refers to the understandings and skills developed by individuals and populations, specific to the place where they live. These forms of knowledge, jointly referred to as Indigenous and Local Knowledge or ILK, are often highly context specific and embedded in local institutions, providing biological and ecosystem knowledge with landscape information. For example, they can contribute to effective land management, predictions of natural disasters, and identification of longer-term climate changes, and ILK can be particularly useful where formal data collection on environmental conditions may be sparse. ILK is often dynamic, with knowledge holders often experimenting with mixes of local and scientific approaches. Water management, soil fertility practices, grazing systems, restoration and sustainable harvesting of forests, and ecosystem-based adaptation are many of the land management practices often informed by ILK. ILK can also be used as an entry point for climate adaptation by balancing past experiences with new ways to cope. To be effective, initiatives need to take into account the differences in power between the holders of different types of knowledge. For example, including indigenous and/or local people in programmes related to environmental conservation, formal education, land management planning and security tenure rights is key to facilitate climate change adaptation. Formal education is necessary to enhance adaptive capacity of ILK, since some researchers have suggested that these knowledge systems may become less relevant in certain areas where the rate of environmental change is rapid and the transmission of ILK between generations is becoming weaker.

FAQ 7.2 | What are the main barriers to and opportunities for land-based responses to climate change?

Land-based responses to climate change can be mitigation (e.g., renewable energy, vegetation or crops for biofuels, afforestation) or adaptation (e.g., change in cropping pattern, less water-intensive crops in response to moisture stress), or adaptation with mitigation co-benefits (e.g., dietary shifts, new uses for invasive tree species, siting solar farms on highly degraded land). Productive land is an increasingly scarce resource under climate change. In the absence of adequate deep mitigation in the less land-intensive energy sector, competition for land and water for mitigation and for other sectors such as food security, ecosystem services (ES) and biodiversity conservation could become a source of conflict and a barrier to land-based responses.

Barriers to land-based mitigation include opposition due to real and perceived trade-offs between land for mitigation and food security and ES. These can arise due to absence of or uncertain land and water rights. Significant upscaling of mitigation requires dedicated (normally land-based) sources in addition to use of wastes and residues. This requires high land-use intensity compared to other mitigation options that, in turn, place greater demands on governance. A key governance mechanism that has emerged in response to such concerns, especially during the past decade are standards and certification systems that include food security, and land and water rights, in addition to general criteria or indicators related to sustainable use of land and biomass, with an emphasis on participatory approaches. Other governance responses include linking land-based mitigation (e.g., forestry) to secure tenure and support for local livelihoods. A barrier to land-based mitigation is our choice of development pathway. Our window of opportunity – whether or not we face barriers or opportunities to land-based mitigation – depends on socio-economic decisions or pathways. If we have high population growth and resource intensive consumption (i.e., SSP3) we will have more barriers. High population and low land-use regulation results in less available space for land-based mitigation. But if we have the opposite trends (SSP1), we can have more opportunities.

Other barriers can arise when, in the short term, adaptation to a climate stress (e.g., increased dependence on groundwater during droughts) can become unsustainable in the longer term, and become a maladaptation. Policies and approaches that lead to land management that synergises multiple ES and reduce trade-offs could find greater acceptance and enjoy more success.

Opportunities to obtain benefits or synergies from land-based mitigation and adaptation arise from their relation to the land availability and the demand for such measures in rural areas that may otherwise lack incentives for investment in infrastructure, livelihoods and institutional capacity. After decades of urbanisation around the world, facilitated by significant investment in urban infrastructure and centralised energy and agricultural systems, rural areas have been somewhat neglected; this is even as farmers in these areas provide critical food and materials needed for urban areas. As land and biomass becomes more valuable, there will be benefits for farmers, forest owners and associated service providers as they diversify and feed into economic activities supporting bioenergy, value-added products, preservation of biodiversity and carbon sequestration (storage).

A related opportunity for benefits is the potentially positive transformation in rural and peri-urban landscapes that could be facilitated by investments that prioritise more effective management of ES and conservation of water, energy, nutrients and other resources that have been priced too low in relation to their environmental or ecological value. Multifunctional landscapes supplying food, feed, fibre and fuel to both local and urban communities, in combination with reduced waste and healthier diets, could restore the role of rural producers as stewards of resources rather than providing food at the lowest possible price. Some of these landscape transformations will function as both mitigation and adaptation responses by increasing resilience, even as they provide value-added bio-based products.

Governments can introduce a variety of regulations and economic instruments (taxes, incentives) to encourage citizens, communities and societies to adopt sustainable land management practices, with further benefits in addition to mitigation. Windows of opportunity for redesigning and implementing mitigation and adaptation can arise in the aftermath of a major disaster or extreme climate event. They can also arise when collective action and citizen science motivate voluntary shifts in lifestyles supported by supportive top-down policies.