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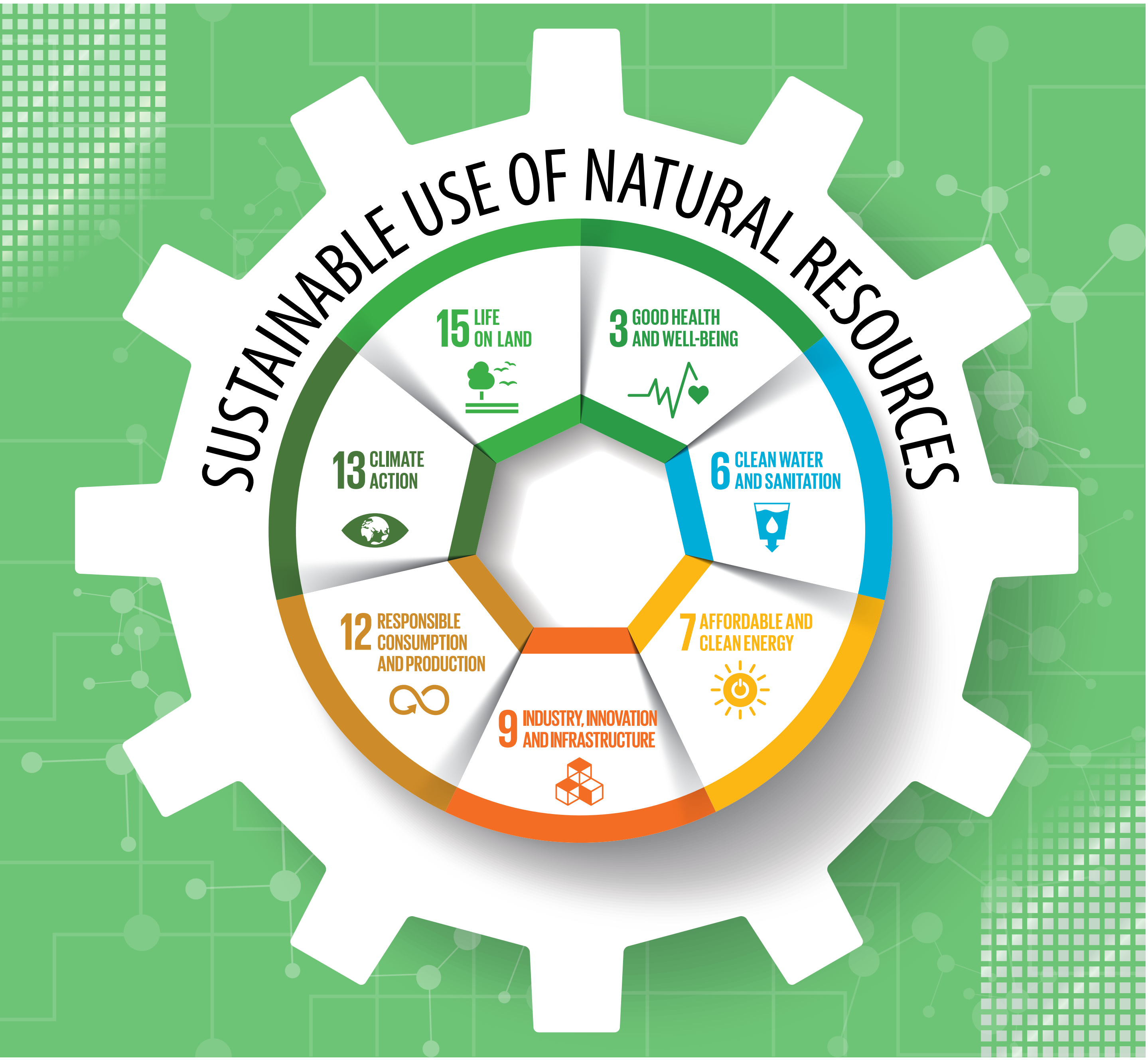
Natural Resource Nexuses in the ECE region



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Natural Resource Nexuses in the ECE region

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FOREWORD

The 2030 Agenda for Sustainable Development provides an ambitious and comprehensive framework that opens new perspectives for policymaking and international cooperation. While there has been progress in implementation, current efforts are far below the scale needed to deliver on the sustainable development goals (SDGs) within the next ten years. Ambitious, forward-looking action on the goals has become even more important in the context of the response to the COVID-19 pandemic: recovery that leads to greener, more inclusive economies and stronger, more resilient societies is essential.

ECE supports our member States in implementation of the 2030 Agenda through concrete and results-oriented activities in our eight sub-programmes: environment, transport, statistics, economic cooperation and integration, sustainable energy, trade, timber and forestry, and housing, land management and population. ECE's multi-sectoral structure has allowed us to support SDG implementation in an integrated manner, in line with the interlinked character of the SDGs, and to adopt a new way of working that cuts across sectoral boundaries. Four nexus areas have been defined where multiple SDGs converge:

- Sustainable use of natural resources
- Sustainable and smart cities
- Sustainable mobility and smart connectivity
- Measuring and monitoring progress towards the SDGs

In each of these areas, a cross-sectoral, inter-divisional team of ECE experts has undertaken an in-depth substantive analysis of current and future challenges and needs of ECE member States and has identified ways and means to address them, thus assisting member States to design and implement integrated policies in these areas. The findings of these analyses and corresponding policy recommendations are set out in a series of four flagship publications.

This report on the *Natural Resource Nexuses in the ECE region* describes the complex interactions and feedback loops between human and natural systems affecting the natural resource base such as energy, food, land, materials, and water. Two other sectors that are relevant to the nexuses, namely, transport and trade, also are considered here. A nexus approach ensures integrated and sustainable approaches to natural resource management that can be applied at all scales and that extend beyond the traditional sectoral "silos". This report identifies and analyses seven nexus hotspots that showcase specific challenges and opportunities for a nexus approach, considering core ECE expertise and products within a broader analytical framework that embraces regional megatrends and the SDGs.

The current patterns of linear, unlimited use of natural resources are starting to breach the carrying capacity of the planet. The seven key hotspots highlighted in this report are by no means exhaustive but demonstrate how total transformation of use and reuse of resources can be achieved through a holistic, systems approach. I invite member States to test and adapt the ideas put forward herein and to strengthen national capacities to tackle sustainable resource management through comprehensive approaches, especially given the challenge of building back better from the COVID-19 pandemic.

Olga Algayerova

Under-Secretary-General of the United Nations
Executive Secretary of the United Nations Economic Commission for Europe

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LIST OF ACRONYMS

CBD . . . . Convention on Biological Diversity
CES. . . . . Conference of European Statisticians
CLRTAP . . . . Convention on Long-range Transboundary Air Pollution
CO_2. . . . . Carbon Dioxide
ECE. . . . . United Nations Economic Commission for Europe
EEA. . . . . European Environment Agency
ELV . . . . End-of-life vehicles
EU . . . . European Union
EUTR. . . . . EU Timber Trade Regulation
FAO. . . . . Food and Agriculture Organisation of the United Nations
GEO . . . . Global Environment Outlook
GHG . . . . Greenhouse Gas
ha. . . . . Hectares
IISD. . . . . International Institute for Sustainable Development
IUCN . . . . International Union for Conservation of Nature
IPCC . . . . Intergovernmental Panel on Climate Change
km . . . . Kilometre
km^2. . . . . Square kilometre
m^3 . . . . Cubic metre
MEA . . . . Multilateral Environment Agreement
OECD . . . . Organisation for Economic Co-operation and Development
PM . . . . Particulate Matter
SDG . . . . Sustainable Development Goal
SEEA . . . . System of Environmental-Economic Accounting
SEIS . . . . Shared Environmental Information System
SNA . . . . System of National Accounts
UN . . . . United Nations
UNICEF . . . . United Nations Children's Fund
UNEP . . . . United Nations Environment Programme
WHO. . . . . World Health Organisation

NATURAL RESOURCE NEXUSES IN THE ECE REGION

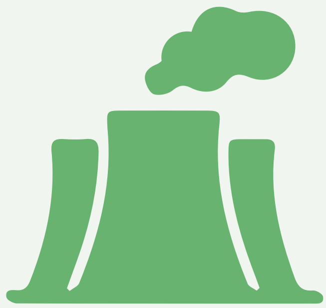
Key Messages

1 *Pressure on natural resources continues to increase*

Increasing demand, changing climates and technologies, urbanisation, growing populations, societal demand and inequalities, globalisation and other megatrends are putting enormous pressure on natural resources, most of which are not renewable.

World population has more than doubled since 1970

Annual global extraction of materials has increased from 27 to 92 billion tons since 1970



Since 1970, global CO_2 emissions have increased by about 90 per cent

2 *Megatrends shaping the sustainable use of natural resources*

- *Population growth and urbanisation*: **9 billion people** are expected by 2050 and 2/3 of the global population is projected to be living in urban areas.
- *Natural resources*: Use of material resources has increased more than **10 times since 1900** and is set to double again by 2030.
- *Economic growth*: Economic output is expected to **triple by 2050**.
- *Climate*: Natural ecosystems and biodiversity, economic growth and global food security and human health are threatened by **rapidly increasing climate change**.
- *Environmental pollution*: **Atmospheric, aquatic and soil pollution** will continue to increase.
- *Future pandemics*: May have significant impacts on **socio-economic and environmental activities**.

3 *Calling for integrated and sustainable natural resource use*

Taking a nexus approach provides opportunities to identify and promote integrated planning, management, and governance of natural resources. The nexus approach can generate relevant information about critical interlinkages that enable decision-makers to plan for robust governance and management, across resources and spatial scales.

The nexus approach should be part of the solution, ensuring more integrated and sustainable perspectives of natural resource use beyond the traditional sectoral silos, at all scales.

4 *Natural Resource Nexus Hotspots showcase major challenges and opportunities in the ECE region*

Seven nexus hotspots demonstrate the added value of taking a nexus approach, considering core ECE expertise and products, megatrends, and the SDGs:

The Food Loss and Waste Challenge

Life Cycle of Vehicles

Land Value Capture

Natural Resource Use in Transboundary Basins

Measuring the use of natural resources with the System of Environmental-Economic Accounting

Forest Landscape Restoration

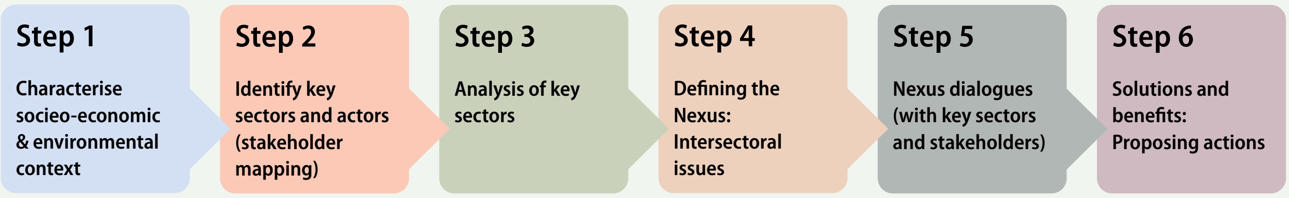
Integrated Management of Energy Resources

The study provides a set of recommendations for each nexus hotspot.

5 *Innovative nexus methodologies pioneered by the ECE*

Benefiting from experience within the ECE, a process that can identify nexus pathways has been developed, based largely on experiences with water and energy-related nexus activities that have been carried out in the ECE region.

The nexus approach has been left intentionally broad as it can be applied at many levels.

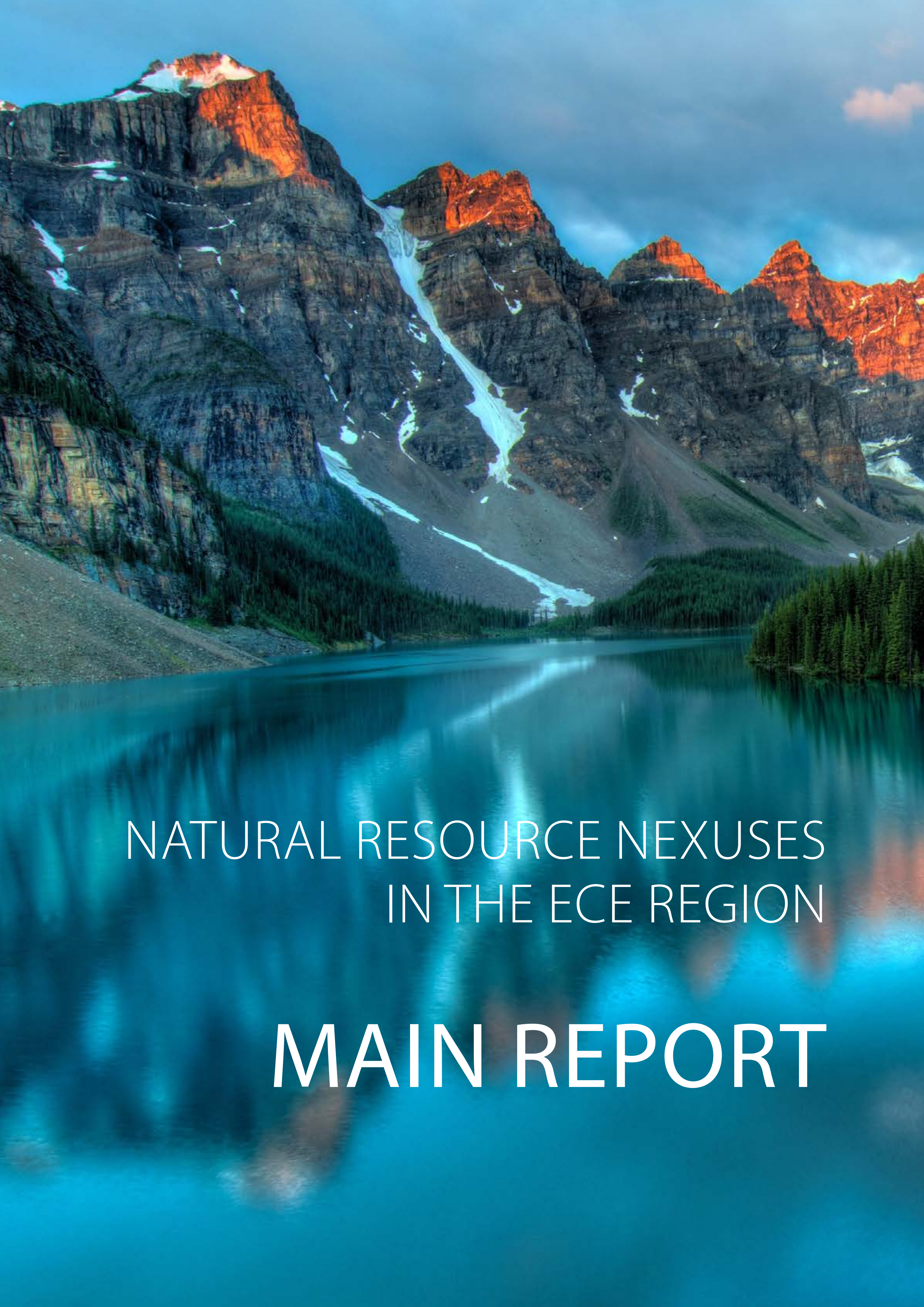


6 *ECE nexus-relevant tools can help leverage the sustainable management of natural resources in the region*

The ECE has developed nexus-relevant tools that share common features as part of its effort to address nexus issues throughout its various subprogrammes:

- Ensuring in-depth analysis of complex interactions, using the best available data.
- Taking a holistic and long-term approach, considering not only intersectoral impacts but also environmental, social, institutional and economic dimensions.
- Engaging stakeholders as part of finding solutions.
- Contributing to implementing the SDGs and targets of Agenda 2030, in conformity with the principles of the United Nations.
- Promoting "bottom-up" processes, whereby subprogrammes or intergovernmental bodies realise that a nexus approach is necessary to address the complex issues in their sector.

The study delivers a list of ECE tools available, across the respective nexus hotspots.



NATURAL RESOURCE NEXUSES IN THE ECE REGION

MAIN REPORT

PART 1

INTRODUCTION

1 CHALLENGING THE UNSUSTAINABLE USE OF NATURAL RESOURCES IN THE ECE REGION

1.1 Why do we need a nexus approach?

The United Nations Economic Commission for Europe (ECE) region is a significant source, transformer and consumer of natural resources. The area hosts some of the most abundant natural resources of materials, energy, fresh water, fertile land, forests, food and transport. The region leads the world in producing, adding value to and processing its natural resources and those of other regions for consumption, both in the region and outside. The region furthermore leads in innovation, technology provisioning and trade facilitation for the production and consumption of natural resources.

However, natural resource production, value-addition and consumption also have their downsides. The resources are often finite, requiring enormous energy and other resource inputs to transform them for productive use and leaving behind a large volume of waste and related externalities. The production and consumption of natural resources have an impact on land, water, soil, biota and the atmosphere. For example, land degradation, topsoil and biodiversity loss, carbon emissions, contamination of freshwater sources and air pollution are some of the negative impacts. Taken together, resource exhaustion, environmental and health externalities may significantly affect business-as-usual even in the short-term future. Notably, the COVID-19 pandemic illustrates how a global health event may affect and change natural resource and energy use.

The ECE region is also one of the most urbanized areas in the world. The negative impacts of unsustainable resource use are even more severe for urban populations. This may ultimately cause increasing levels of water scarcity, air pollution and declining general standards of living. These effects are further exacerbated by climate change. Even more, the Global Resources Outlook 2019 (UNEP, 2019a) highlights some worrying trends in natural resource use and consumption patterns on the global scale:

1. The extraction and processing of materials, fuels and food contribute half of total global greenhouse gas emissions and over 90 per cent of biodiversity loss and water stress.
2. Resource extraction has more than tripled since 1970, including a fivefold increase in the use of non-metallic minerals and a 45 per cent increase in fossil fuel use.
3. By 2060, global material use could double to 190 billion tonnes (from 92 billion), while greenhouse gas emissions could increase by 43 per cent.

Echoing these global messages, the Sixth Global Environment Outlook Assessment for the pan-European region (UNEP, 2016c) further highlighted that:

1. Air quality is the largest health risk to the pan-Europe population. More than 95 per cent of urban dwellers are exposed to air pollution in exceedance of European standards and WHO Air Quality Guidelines.
2. More than 62 million people in the ECE region still lack access to adequate sanitation facilities, making them vulnerable to water-related diseases.
3. Biodiversity loss and ecosystem degradation are continuing in the ECE region. They are mainly caused by increased land-use change (e.g. agricultural intensification, urbanization and habitat fragmentation).

4 Waste from electrical goods and electronic equipment is one of the fastest-growing waste streams in Europe with more than 12 million tonnes expected to be generated by 2020.

5 More than 20 per cent of protected areas, 32 per cent of wetlands and 45 per cent of agriculture land have already been lost to soil sealing and land take.

These trends serve to highlight the need for an intersectoral approach to address the interconnected and complex natural resource challenges facing society today. Unless the knowledge and expertise of different disciplines are brought to address these challenges, important opportunities may be overlooked. Working across sectoral silos may help to improve our understanding of the issues and challenges that we face and to find holistic pathways that may contribute towards long-term sustainable natural resources use. Moreover, resource richness and higher levels of prosperity need not be a threat to itself. The generally inventive, resourceful and knowledge-based communities of the ECE region could chart a course that will be sustainable and resilient, not only for the region but also the globe as a whole.

1.2 Background and objectives

Increasing demand, changing climates and technologies, urbanisation, growing populations, societal demand and inequalities, globalisation and other megatrends are putting enormous pressure on natural resources, in the United Nations Economic Commission for Europe (ECE) region and elsewhere. There are many complex policy choices to be made regarding their conservation and use. These choices necessitate a comprehensive nexus approach that can address the many interactions and trade-offs involved.

These challenges are recognised at the international level where, amongst other things, the integrative character of the 2030 Agenda for Sustainable Development calls for an assessment of the linkages and complementarities but also of the possible conflicts that exist between different Sustainable Development Goals (SDGs) and targets. Many other policy instruments and commitments recognise the interlinkages between individual sectors.

The ECE has a specific contribution to make on these questions, as its subprogrammes work on many aspects of natural resources that can be brought together through a nexus approach.

The study on natural resource nexuses in the ECE region aims to:

- Identify and briefly describe some of the current and future trends and challenges concerning the sustainable use and management of natural resources in the ECE region,
- Consider the potential for further strengthening the nexus approach to deliver social, environmental, and economic benefits,
- Suggest a direction of work and next steps for the ECE to address a more sustainable natural resource use and the management challenges facing the region.

1.3 Establishing an interdisciplinary team using the nexus approach

Considering natural resource use outside sectoral silos, based on a paradigm that is integrative and cross-sectoral, will contribute towards tackling the multidisciplinary dimension of the 2030 Agenda and its 17 SDGs. It is of utmost importance that the ECE identify and help its member States to address complex natural resources challenges while being aware of system-level trade-offs. In a nutshell, the business-as-usual approach for natural resources management will not be enough to address current (or future) natural resources challenges that are both complex and highly interconnected in nature. This is also why the ECE has initiated an interdisciplinary work using the nexus approach, focusing on natural resources use in the ECE region.

Analysing the Natural Resource Nexus will facilitate an integrated and holistic approach to respond to natural resource challenges that are specific to the ECE region, strengthen the bonds across ECE subprogrammes, as well as contribute towards the joint/coordinated implementation of existing work plan activities. Horizon-scanning and a continued commitment to innovation will further strengthen the position of the ECE as a forward-looking organization that can address the current and anticipated needs of its member States.

1.4 What is Natural Resource Nexus?

The Food and Agriculture Organisation of the United Nations (FAO) defines a nexus as a set of "**complex interactions** and **feedback** between **human** and **natural systems**" affecting the natural resource base (FAO, 2014c). In this case, the **resource base** refers to both natural and socio-economic resources as it relates to a given environment (e.g. interactions between water, food and energy). **Nexus interactions** are in turn how the natural resource system is being managed and used in terms of **interdependencies** (e.g. co-dependence on a resource), **constraints** (e.g. trade-offs and barriers) and **synergies** (e.g. shared benefits).

The **Natural Resource Nexus** for this report is one that integrates natural resources management and governance and recognises the interdependencies and feedback loops between:

- supply and demand of five resources: energy, food, land, materials and water.
- megatrends that drive natural resources use.
- risks and opportunities generated by these megatrends.
- broader nexus variables (e.g. technology, governance, social and political factors).

The Natural Resource Nexus emphasises the need to not view water, energy, food, land, and materials as separate entities (see Figure 1), but rather as complex and inter-related. For example, direct inputs of water are needed in the production of food and energy, while energy is required for the storage and distribution of food as well as in water extraction, conveyance, and treatment. Natural resources and ecosystems services also underlie water, food, and energy security. Any limitation in one of the inputs would disturb the availability of one of the others. Applying a nexus approach may thus help to improve understanding of these interdependencies.

The nexus approach is a way of ensuring more integrated and sustainable perspectives of natural resource use beyond the traditional sectoral "silos" which can be applied at all scales. Underlying the thinking of this report is the belief that the nexus approach can generate relevant information about critical interlinkages that will enable decision-makers to plan for robust governance and management across resources and spatial scales. The nexus approach also provides opportunities to identify and promote integrated planning, management, and governance of natural resources.

1.5 Structure of the report

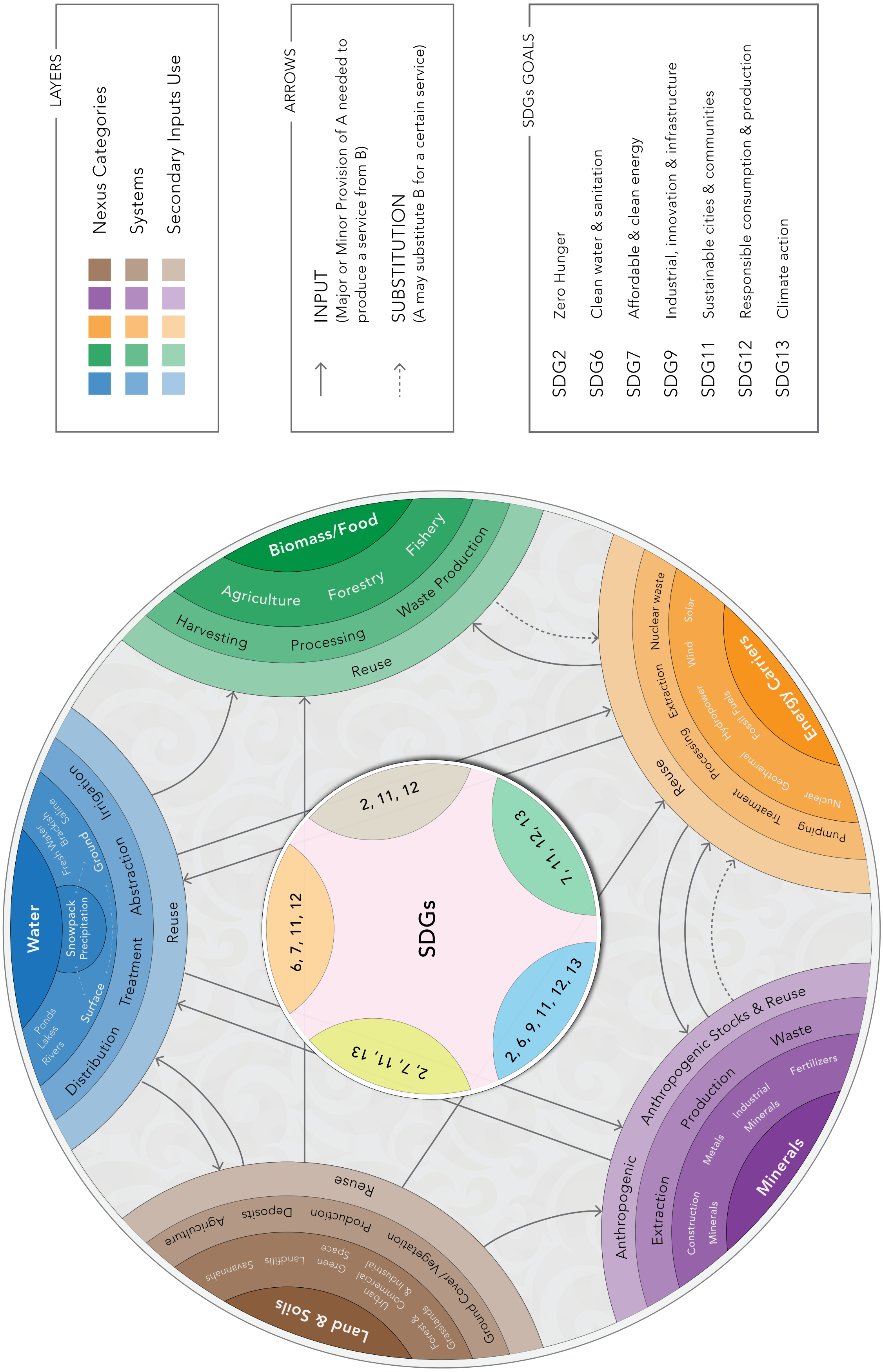
As outlined above, **part 1** sets out the background and objectives of this study, and perhaps more importantly, it defines what we mean by a natural resource nexus, as applied for this report. Given the many definitions and applications associated with a nexus perspective or approach, it is relevant to have a shared understanding of the nexus.

Part 2 presents the status and trends of natural resource use, globally and in the ECE Region. The text is structured around the five resources (water, energy, food, land and materials) and provides a brief historical overview of natural resource use and what may be expected for the future, including some of the megatrends in the region. It also covers some additional cross-sectoral issues, such as transport and trade, that relate directly to work being carried out by the ECE.

Part 3 identifies and analyses seven nexus hotspots which showcase specific major challenges and opportunities appropriate for a nexus approach, considering core ECE expertise and products within this broader analytical framework, as well as regional megatrends and the SDGs. Focusing on nexus hotspots serves to demonstrate solutions as well as knowledge demands, resources constraints and governance challenges that are unique to each hotspot. The nexus hotspots furthermore serve to present lessons learnt from the interdisciplinary nexus team while acting as case examples from a natural resource use perspective.

Part 4 offers suggestions for possible next steps by the ECE. It aims to describe an ambitious but realistic pathway for the ECE to incorporate the nexus approach wherever it is appropriate and thereby increase the effectiveness of policy instruments to address complex natural resource issues. Expanding nexus frameworks that consider interactions between sectors, across scales, between regions, and linkages with the SDGs could help ensure sustainable natural resource management and use as well as integrated SDG implementation.

Figure 1: **The Nexus: interlinkages across resources and the SDGs**



Source: Bleischwitz et al. (2018).

PART 2

STATUS AND TRENDS OF NATURAL RESOURCE USE IN THE ECE REGION

2 STATUS AND TRENDS OF NATURAL RESOURCE USE IN THE ECE REGION

The global economy is presently using the equivalent of 1.7 planets to produce the resources used by society and to absorb the waste that is generated in the process.[1] It has been projected that the global ecological footprint will exceed what nature can regenerate by 75 per cent in 2020 (WWF, 2018). Furthermore, there are high rates of biodiversity loss, deforestation and land degradation affecting natural environments throughout the ECE region. If these developments continue, the damage may be irreversible. For instance, recent estimates suggest that global efforts to mitigate climate change need to be tripled in order to achieve the 2°C scenario of the Intergovernmental Panel on Climate Change (IPCC), which is widely seen as the global community's accepted limitation of temperature growth to avoid significant and potentially catastrophic changes to the planet and increased fivefold to accomplish the 1.5°C scenario, which is the pathway to the target which countries have committed their best efforts to reach (UNEP, 2018). All-in-all, these are worrying signs, highlighting the urgent need for the sustainable management of natural resources.

2.1 Natural resource management

Natural resource management typically deals with conflicting interests of different stakeholders that use the same natural resources for various purposes. However, in order to have a healthy environment, all individuals must have a common understanding of what is being discussed.

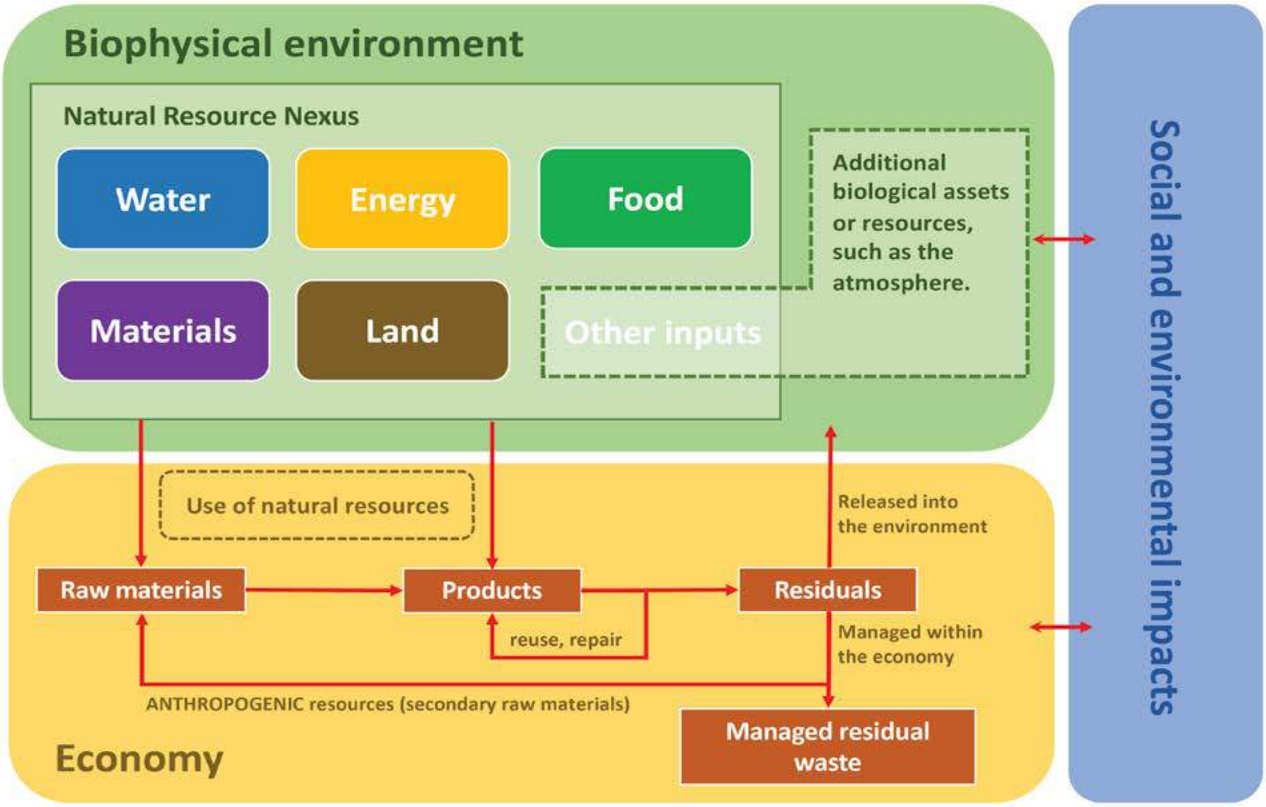
2.1.1 Definition of natural resources and sustainable management

Natural resources include water, energy, materials, food and land, and are part of the natural world that can be used in economic activities to produce goods and services (see Figure 2). Material resources are biomass (e.g. crops for food, forest products, energy and bio-based materials), fossil fuels (e.g. coal, gas and oil), metallic minerals (e.g. iron, aluminium and copper used in construction and manufacturing) and non-metallic minerals (e.g. sand, gravel and limestone used mostly for construction).

Sustainable management is described in a multitude of ways but principally comprises the successful integration of ecological, social and economic aspects of natural resource use in a long-term time perspective. Unsustainable use of natural resources can cause the loss of ecosystem productivity decline of resilience over time and even destruction of the resource. For example, in some regions biodiversity loss, desertification and extreme events, such as floods and droughts, increase, due to the unsustainable use of natural resources.

1 See: https://www.footprintnetwork.org/.

Figure 2: A conceptual framework for the use of natural resources



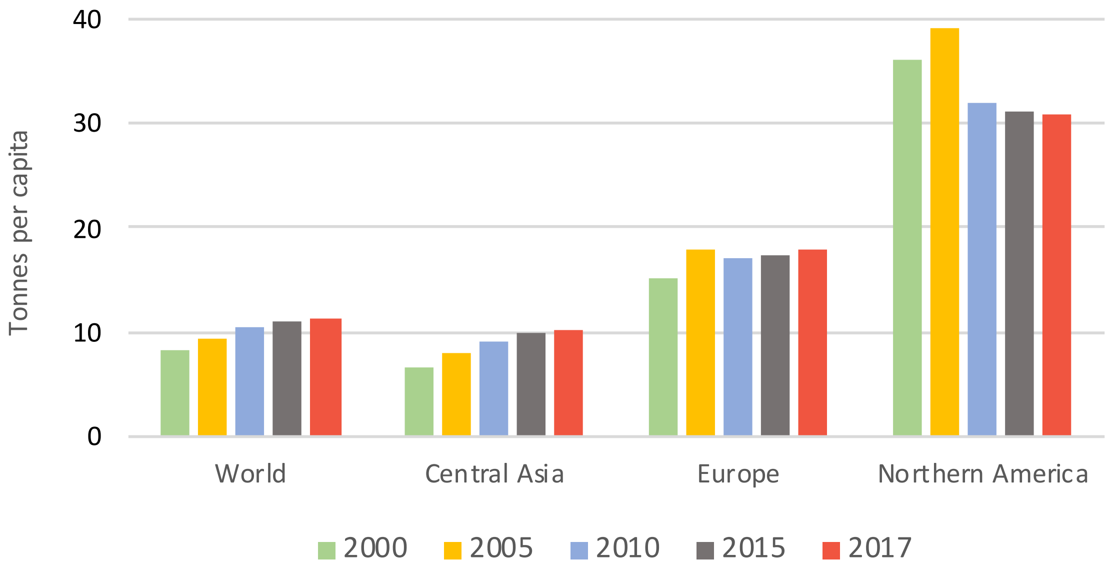
Source: own figure.

2.2 Management, production and use of natural resources in the ECE region

The global use of materials (here defined as metal ores, non-metallic minerals, fossil fuels and biomass) has almost tripled since 1970 and has been accelerating. For the ECE region, material production has increased from around 13 billion tonnes in 1970 to approximately 20 billion tonnes from 1998 and onwards. The total material footprint generated by the ECE region has been about 25 billion tonnes from 2010 (see figure 3). This material footprint includes imported materials, which presently equates to around 5 billion tonnes (ECE, 2019d). In the European Union (EU), it can also be noted that 12.4 tonnes of materials per capita were extracted, 3.2 tonnes of materials were imported, and 1.3 tonnes of materials were exported from the EU in 2015 (EEA, 2015d). There are, however, significant sub-regional differences, as can be seen in Figure 3.

Material use contributes significantly to climate change, while the extraction and production of materials have significant effects in terms of land use, eutrophication, and acidification, as well as freshwater and terrestrial ecotoxicity. The most substantial growth in materials use is projected to be in emerging and developing economies. In contrast, while there are no specific estimates on material use available for the ECE region, recent estimates for the OECD region demonstrate a rather stable trend, where decoupling has resulted in material use not increasing as rapidly as in other regions.

Figure 3: Material footprint per capita, tonnes, 2000, 2005, 2010 and 2017



Source: ECE (2019d).

2.2.1 A regional perspective of the Natural Resource Nexus

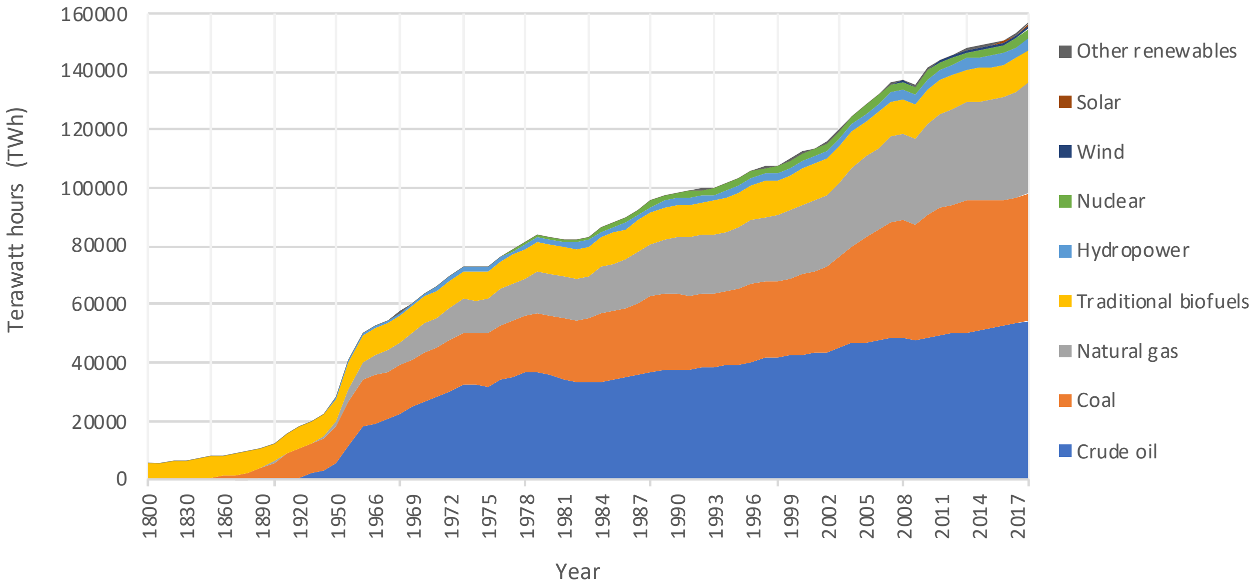
The Natural Resource Nexus (see Figure 1) breaks down the interdependencies between five natural resources (water, energy, materials, food and land). This framework is complex but highlights that we need to move away from a silo perspective, as well as the difficulty of doing so. For instance, our conceptual framework for natural resource use (see Figure 2) emphasises interlinkages and interdependencies, but conceptually and institutionally, the analysis of natural resource use still tends to operate within specific domains, rarely crossing sectoral barriers. Sectoral barriers are also visible in the ECE. It is for this reason relevant to consider where the ECE region stands with regards to the use and management of the five natural resources: water, energy, materials, food and land. Two sectors which are very relevant to the Natural Resource Nexus, namely, transport and trade, both of which are addressed by major ECE subprogrammes, are also considered.

2.2.2 Energy

Energy is one common denominator shared in the provisioning and management of water, food, materials and land, across sectors and scales. These natural resources all use energy in one form or another, whether as part of a system extracting critical minerals to storing and transporting food up the value chain to the provisions of heating or cooling in housing or industries. Notably, most of the energy produced today still rely on fossil fuels. Coal was still being used to generate approximately 38 per cent of the total global electricity, followed by natural gas, with a 23 per cent share, in 2018 (see Figure 4). Even more, according to recent estimates, global energy demand is expected to increase by 1 per cent per year until 2040, due mainly to rising standards of living and population growth in the developing world (IEA, 2019c).

In terms of natural resource use, oil remains the most consumed primary energy source in the world, with 4.6 billion tons of oil equivalent consumed in 2018, and fossil fuels are expected to continue to supply nearly 80 per cent of the global energy use up until 2040. Much of this increase is attributed to consumption expected in developing economies that currently depend primarily on fossil-based energy sources. In general, fossil fuels (e.g. coal, petroleum, natural gas, oil shale and tar sands) have grown in absolute terms from 6.2 billion tons to 15 billion tons. To this can be added that global primary energy consumption grew by 2.9 per cent in 2018, the most rapid growth since 2010, while carbon emissions grew by 2.0 per cent, the fastest growth for seven years, and natural gas consumption rose by 195 billion cubic metres or 5.3 per cent. (BP, 2018). These developments emphasise that a transition to sustainable energy systems is urgent. However, the impact of Covid-19 on the energy sector has been substantial; for example, there has been a 25 per cent decline in energy demand per week in countries that have been in lockdown.[2] While the implications of Covid-19 for a transition to sustainable energy systems are still unclear, it is likely to have a significant impact in the coming years.

Figure 4: Global primary energy consumption



Source: ourworldindata.org.

The key to decarbonising societies lies in the transition from an energy system dominated by fossil fuels to a renewable, low-carbon and sustainable energy mix, which is the long-term objective most countries have set as part of the Paris Agreement,[3] adopted in 2015. However, when looking at current trends and developments in energy use and production globally, the current outlook does not seem to be in line with this objective. The reason could be that energy transition is a slow process, taking several decades to show visible progress and most scenarios still show fossil fuel use and natural gas dominating energy production in 2030 and even 2050.

Energy use in the ECE region

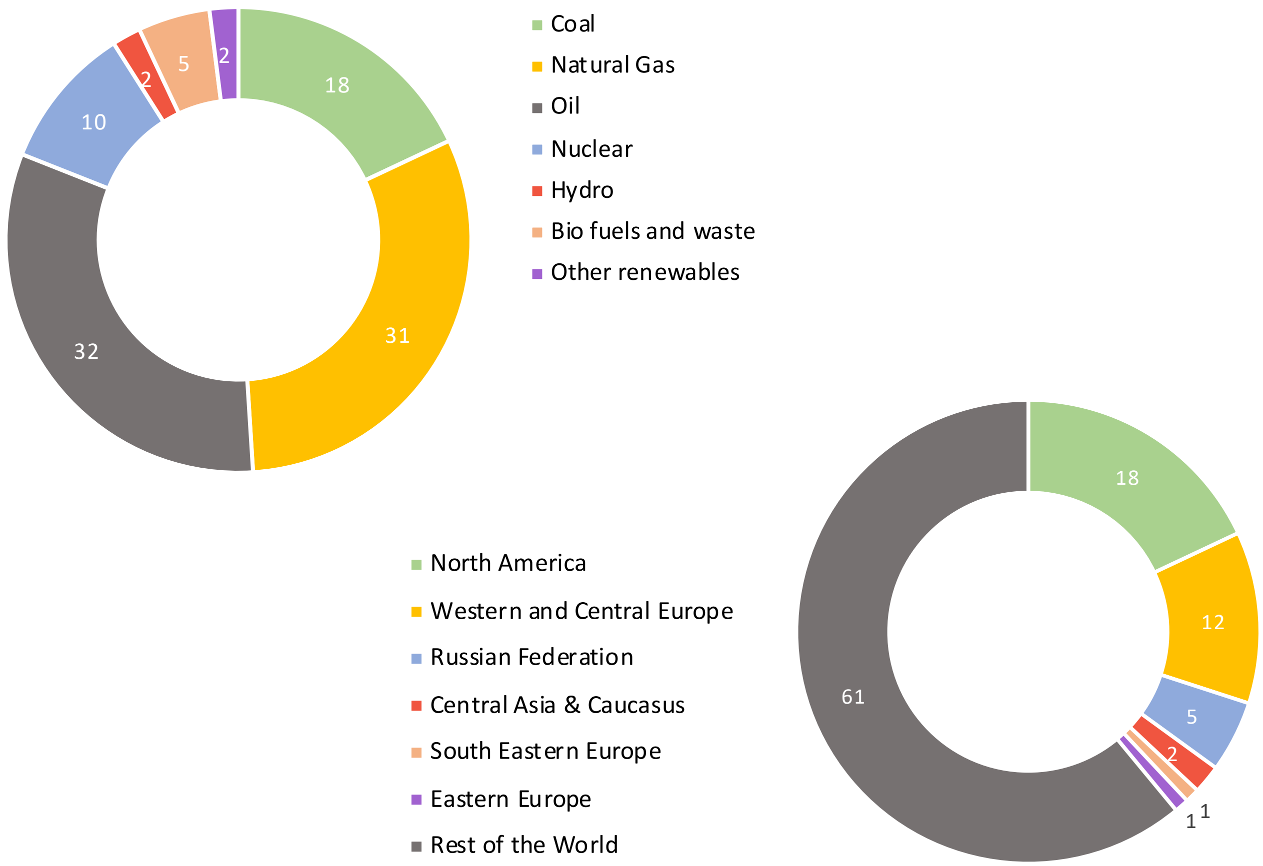
The region is comprised of high- and low-income countries, primarily countries that are energy-rich and energy-poor and countries that are in economic transition. The ECE region accounts for 39 per cent of the global primary energy consumption and has significantly higher primary energy supply per capita than the global average, although there are significant variations within the region. The region furthermore emitted 36 per cent of the global carbon dioxide (CO_2) emissions from fossil fuel combustion. The ECE region uses significantly higher primary energy supply per capita than world levels as a whole, but there are significant variations within the region.

Fossil fuels dominate the energy mix at 81 per cent (see Figure 5). Similarly, in the ECE region, about 80 per cent of the energy mix is fossil-based (ECE, 2020). When evaluated across the subregions, the least share is in Western Europe at 71 per cent, and the greatest is in Central Asia at 94 per cent. The electricity generation mix in the ECE region today is also predominantly fossil fuel-based (coal and natural gas), followed by nuclear energy and hydro. The traditional electricity supply system is defined by large scale plants that generate single-directional, predominantly fossil-fuel-based, power and heat to end-users.

2 See: https://www.iea.org/topics/covid-19.

3 See: https://treaties.un.org/doc/Treaties/2016/02/20160215%2006-03%20PM/Ch_XXVII-7-d.pdf.

Figure 5: ECE region energy mix (%) and regional share of global TPES (%), 2014



Source: ECE (2017b).

Although the region has tremendous potential for renewable energy, so far, sources from wind, solar, and geothermal accounted for only 1.6 per cent in total primary energy supply (TPES) compared to a global share of 1.4 per cent in 2014. Including hydropower, biofuels and waste renewable energy sources account for 9 per cent compared to a worldwide share of 14 per cent. However, renewable energy share in total primary energy supply nearly doubled from 1990 to 2014 across the ECE region from 5.9 per cent to 11.5 per cent in 2014. Nevertheless, even under a climate change scenario that meets a 2° target, fossil energy will still represent 40 per cent of the energy mix in 2050 (ECE, 2017b, ECE, 2018f)

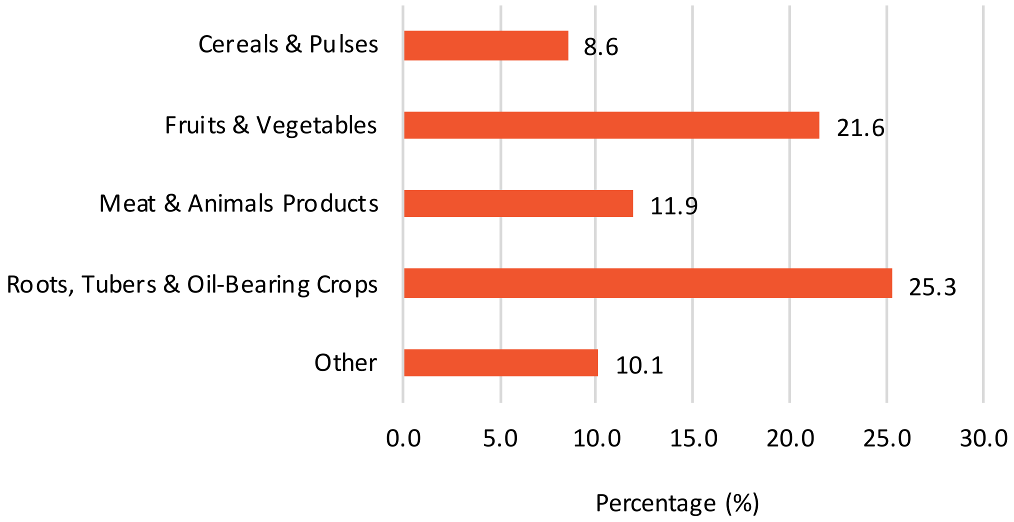
The ECE region has achieved 100 per cent access to electrical power networks and 98 per cent access to clean cooking fuels. Still, there remain significant quality and affordability challenges, and access to distributed generation sources or alternative energy networks is being considered. The rate of progress in improving energy efficiency and productivity is insufficient to meet Goal 7 (affordable and clean energy) of the SDGs (ECE, 2019d, ECE, 2019f). There is evidence in the ECE region of challenges in energy efficiency, energy access, heating service affordability, reliability of ageing systems and future resilience needs.

2.2.3 Food

Current estimates suggest that there will be more than 9 billion people living on this planet by 2050. Out of these, more than two-thirds are expected to live in urban areas. To be able to feed all these people, food production must increase by more than 50 per cent, and food loss and waste have to be reduced by 20 to 40 per cent by 2050 (FAO, 2019b, WB/FAO, 2017). However, it is not possible to simply increase food production using the same approaches as applied today. For instance, in addition to increasing food production, the environmental impact of the agricultural sector needs to be reduced. At present, agriculture contributes 26 per cent of all GHG emissions, takes up 37 per cent of all the landmass (or 50 per cent of the habitable land), accounts for 70 per cent of all freshwater withdrawals, and 78 per cent of the global ocean and freshwater pollution (FAO, 2017b). This is without factoring in the impact of climate change on crop yields, possible depletion of fertilizers, such as phosphorus, and competition from bioenergy for land which would otherwise be used for food production.

To this can be added that the total biomass demand increased from 9.1 to 24.1 billion tons between 1970 and 2017 (UNEP, 2019a). This demand increases, on average, 2.1 per cent per year, which is considerably higher than the growth rate of the global population of 1.6 per cent per year. Crop harvests have grown at an annual rate of 2.2 per cent over the last five decades and were the most crucial component of biomass extraction in 2017, accounting for 40 per cent of the total (or 9.5 billion tons). For example, global production of cereals (the world's most crucial source of food) increased by as much as 280 per cent between 1961 and 2014. Grazed biomass for livestock animals has grown at a similar average rate. This growth further reflects the growing importance of an animal and dairy-based diet on a global scale.

Figure 6: Global food loss and waste from post-harvest to distribution, by commodity group



Source: FAO (2019b).

The numerous value chains that make up the agricultural sector – from the field to the fork – demonstrate that it will not be possible to sustainably increase food production using a production-focused paradigm. Unlike many other sectors, increasing food production while reducing food loss and waste (see Figure 6) as well as decarbonising the sector, will require integrative and intersectoral solutions. This further emphasises the potential benefits in taking a nexus approach which allows for all interdependencies to be considered as part of the bigger picture.

There are many other nexus interactions between food supply and other natural resources, including the energy demand from intensive agriculture (greenhouses, but also fertilisers), energy supply from agriculture (biofuels from agricultural crops, biogas from agricultural residues), water demand from agriculture (agriculture is the largest single user of water) and water pollution by agriculture, notably by phosphates, leading in some cases to algal blooms.

Food production, consumption and waste in the ECE region

The ECE region has some of the largest agricultural producers and exporters in the world. The agricultural sector is one of the primary land users in the pan-European region, shaping landscapes throughout the region. For example, EU farms used 173 million hectares (ha) of land for agricultural production in 2016, which equates to 39 per cent of the total land area in Europe. To this can be added that water erodes 970 million tonnes of soil every year in the EU. Around 11.4 per cent of the EU's territory is also affected by a moderate to high-level soil erosion (Panagos et al., 2015; Panagos and Borrelli, 2017). There are however significant sub-regional variations: for example, while agriculture used 66 per cent of the total water used in Europe, around 80 per cent of total water abstraction for agriculture occurred in the Mediterranean region in 2014. These issues are exacerbated by the fact that 88 million tonnes of food is wasted annually in the EU (the majority from households and processing). However, from an economic perspective, the EU's agricultural sector created gross value added of 188.5 billion EUR in 2017. In 2018, exports and imports of agricultural products between the EU and non-member countries accounted for 7.0 per cent of the total EU international trade. And in terms of employment, agriculture employed 9.7 million people within the EU in 2016. This highlights the overall importance of the agricultural sector in environmental and socio-economic terms.

While food security in the ECE region has improved substantially over the past two decades, recent estimates suggest 1.8 per cent of the total population in the ECE region (or 16.5 million people) are exposed to a severe form of food insecurity, while up to 11 per cent (more than 100 million people) may be exposed to moderate food insecurity (FAO, 2019a). What can also be noted, in general, is that the composition of the total value of agricultural production in the ECE region is gradually changing. For example, specific subregions, such as Central Asia, have successfully implemented a policy of crop diversification, demonstrating declines in cotton production, smaller shares of cereals and meat, while increased shares of milk production and increases of fruits and vegetables (FAO, 2019a). While the picture is heterogeneous, these trends suggest that the region is reorienting policies and practices towards more diverse and sustainable food systems.

2.2.4 Land

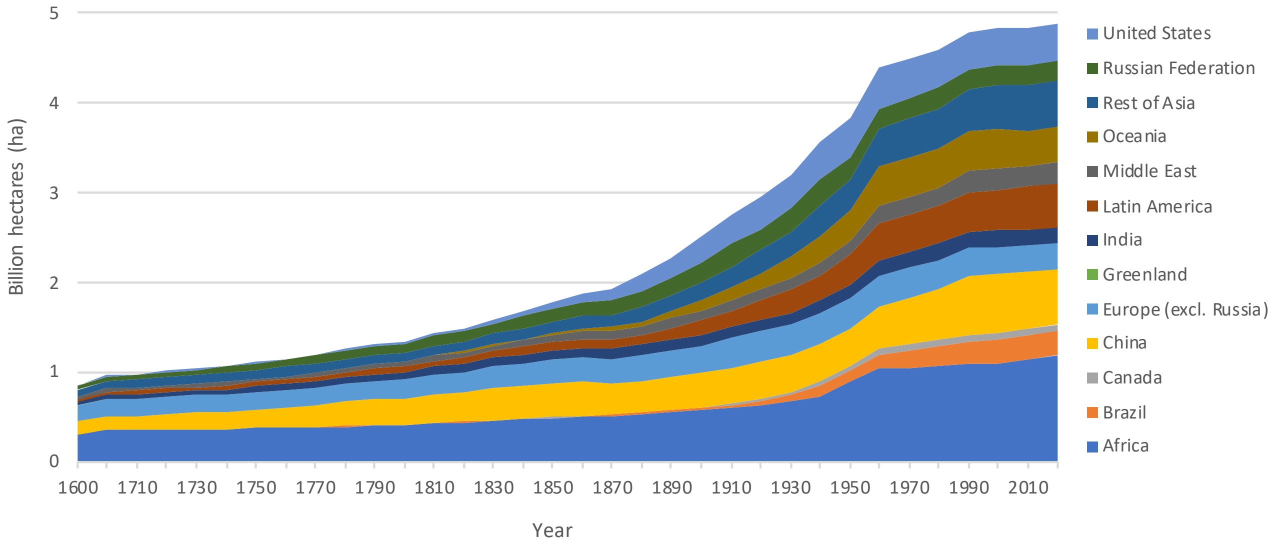
Land and land use are inherently integrated with the other nexus nodes, in particular, when considering food and water. However, the land is also distinct in that it encompasses many additional functions, such as the provision of habitats for plants and animals. Land policies and planning are thus crucial not only when considering sustainable water use and food production but also with regard to forest management and biodiversity conservation. For instance, land degradation, desertification, and drought have widespread impacts on livelihoods and promote large-scale migration. Looking at global land use, the total land area presently amounts to 149 million km^2, of which 104 million km^2 (or 71 per cent) is habitable.

Approximately 50 per cent of all the habitable land area is used for agriculture while 37 per cent is forest and 11 per cent is natural grassland, shrubland and savannah. Food production is thus the most crucial anthropogenic use of land (for most countries, the majority of agricultural land is used for livestock rearing in the form of pastureland, The rapid increase in the global agricultural area can be seen in Figure 7. Urban and built-up areas covered by settlements and infrastructure account for 1 per cent of the total area; however, their impacts on the environment and natural resource use extend well beyond these built areas.

Land as a nexus node helps to demonstrate the significant interactions between socio-economic and environmental factors on different scales, from the regional to the global level. For instance, the historical expansion of agriculture has had a significant impact on the natural environment, having transformed habitats (often radically) and putting pressure on biodiversity. It can, for example, be noted that of the 28,000 species considered as "threatened with extinction" on the IUCN Red List,[4] agriculture is listed as a threat for 24,000. Another example is desertification triggered mainly by the overuse of land and unsustainable agricultural practices, including areas in the Southwest United States and Central Asia that face the prospect of desertification. For instance, more than 30 per cent of North America is comprised of arid or semi-arid lands, with about 40 per cent of the continental United States at risk for desertification. Overgrazing and poor irrigation are one of the leading causes of desertification. These examples show some of the underlying complexity land-use and highlight the many trade-offs and interdependencies across sectors and natural systems.

4 See: https://www.iucnredlist.org/.

Figure 7: The agricultural area over the long term



Source: History Database of the Global Environment (HYDE) and ourworldindata.org.

Land use in the ECE region

The ECE region covers 4507 million ha. Even though croplands and pastures dominate land use in the region, there are significant sub-regional variations (see Figure 8). For instance, forests and other natural ecosystems prevail in the northern parts of the region. The expansion of the agricultural area in the ECE has also been slowed or stopped (the total cropland area has declined in Europe and North America) by increasing productivity, which suggests that the increase in agricultural productivity is contributing towards decoupling land use from food production.

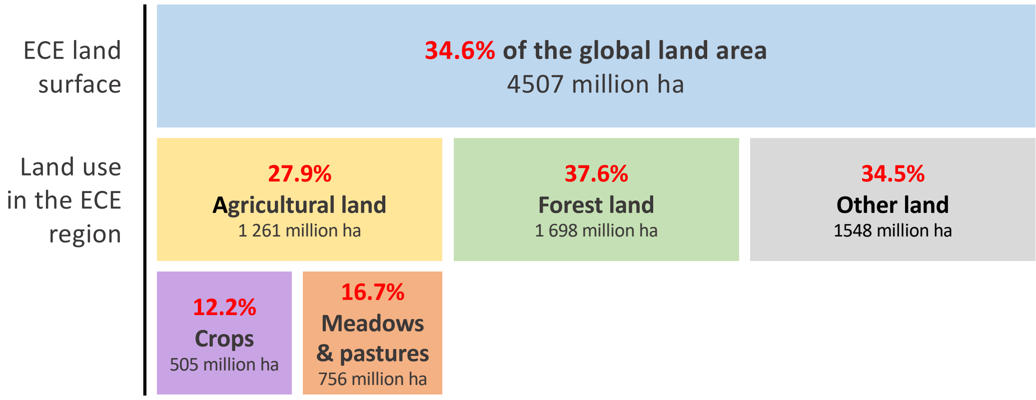
The forest area in the ECE region has been increasing and had expanded to 1698 million ha (37.6 per cent of land area) in 2016 (FAO, 2016). In contrast, the global forest coverage is, at present, a bit less than 31 per cent, showing a downwards trend.[5] Forests are also an interesting natural resource from a nexus perspective, as they are exposed to a wide range of conflicting demands from industries, including energy, construction and paper and pulp, as well as societal demands, notably for recreation and nature conservation. For instance, in Europe, more than 30 million ha of forests have been protected to conserve biodiversity or landscapes, but this also varies on the sub-regional level.

From a nexus perspective, trade-offs between all functions of forest ecosystems need to be taken into consideration in the forest-based sector to achieve sustainability. This can, for example, relate to finding a balance between conserving forests and extracting biomass (e.g. a certain proportion of forest biomass may serve the environment better by being left in the forest) while another example would be closing the loop from waste to natural resource (e.g. life cycle thinking). There are many win-win solutions, and the principles of sustainable forest management are widely applied in the ECE region. These examples demonstrate the need to step out of a silo-based framework when considering sustainable natural resource use.

Land use interacts with all other natural resources: watershed management is a major objective of land use planning, land use policy determines the availability of energy and material sources, whether from renewable or non-renewable sources for instance by regulating key energy and material infrastructure (e.g. mines, dams and wind power), or assigning land to energy production, or food production. Biodiversity is also strongly influenced by land-use decisions.

5 See: https://data.worldbank.org/indicator/AG.LND.FRST.ZS.

Figure 8: Land use in the ECE region



Source: FAOSTAT.

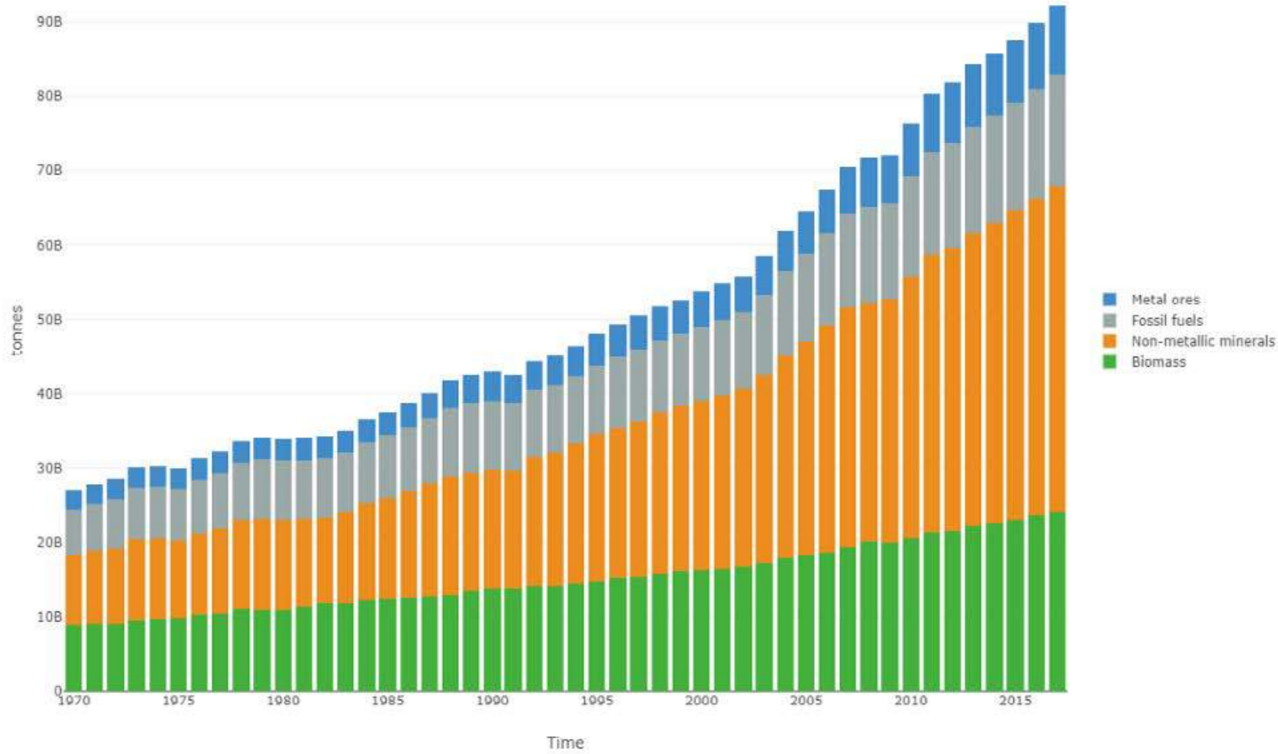
2.2.5 Materials

The sustainable use of natural resources is one of the most significant challenges that societies are facing today, especially in light of a rapidly growing global demand for finite natural resources. Materials are fundamentally important in this equation as they account for 50 per cent of natural resource use in most industrialized countries (e.g. non-metallic minerals, such as sand, gravel and limestone, represent more than half of total materials use, by weight) (OECD, 2019b). It can be noted that the global use of materials (defined here as fossil fuels, ores, non-metallic minerals and biomass) has almost tripled since 1970, from 26.7 billion to 92.1 billion tonnes in 2017 (see Figure 9). Material use has not only been increasing; it has been accelerating. Current forecasts estimate that material use will grow to between 170 and 184 billion tonnes in 2050 (CGRI, 2019). This means that a business-as-usual scenario will see material use double every 30 to 40 years, even more, if the rate of use of materials is not decoupled from economic growth, total materials would surpass 350 billion tonnes in 2060 (OECD, 2019b)

It can also be noted that material use contributes significantly to climate change. A large share of GHG emissions is directly linked to materials management, such as the combustion of fossil fuels for energy, agriculture, manufacturing and construction. For example, concrete is responsible for 9 per cent of total GHG emissions and metals (e.g. iron, aluminium, copper, zinc, lead, nickel and manganese) are responsible for 7 per cent. All-in-all, the increased extraction and use of materials contribute to a global increase in GHG emissions. Even more, the extraction and production of materials have significant effects in terms of land use (e.g. land surface used to produce the resource), eutrophication and acidification (e.g. impacts of nutrients on soil and water), freshwater and terrestrial ecotoxicity (e.g. impacts of toxic substances on terrestrial and freshwater ecosystems). This emphasises the linkages between economic activity, material use and environmental effects as a basic premise for any nexus. It is of interest to note that CO_2 emissions are expected to fall by 8 per cent in 2020 as the Covid-19 pandemic shuts down much of the global economy (IEA, 2020). The implications in terms of material use are nevertheless still unclear.

As noted above, material flows are inherently interlinked to the economic flows at the sectoral level. This demonstrates the importance of the natural resources nexus in that it conceptually links different forms of interdependent resource use. In other words, the study of material flows enables the integration of sectors that are typically managed separately (Bleischwitz et al., 2018).

Figure 9: Global extraction of materials 1970-2017, by material group

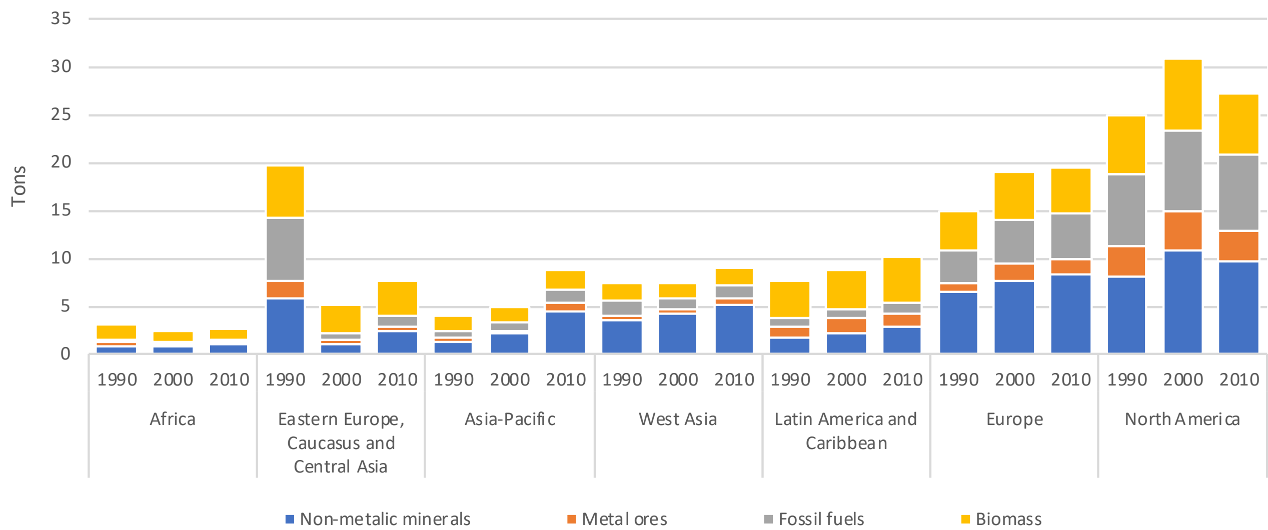


Source: UN IRP Global Material Flows Database.

Material use in the ECE region

The projected growth in material use varies across regions (see Figure 10). For instance, the most substantial increase in materials use is expected to be in emerging and developing economies. In contrast, while there are no specific estimates on material use available for the ECE region, recent estimates for the OECD region demonstrate a rather stable trend in material use (OECD, 2019b), where a pattern of decoupling has resulted in material use not increasing as rapidly as in other regions.

Figure 10: Regional average per capita resource footprints



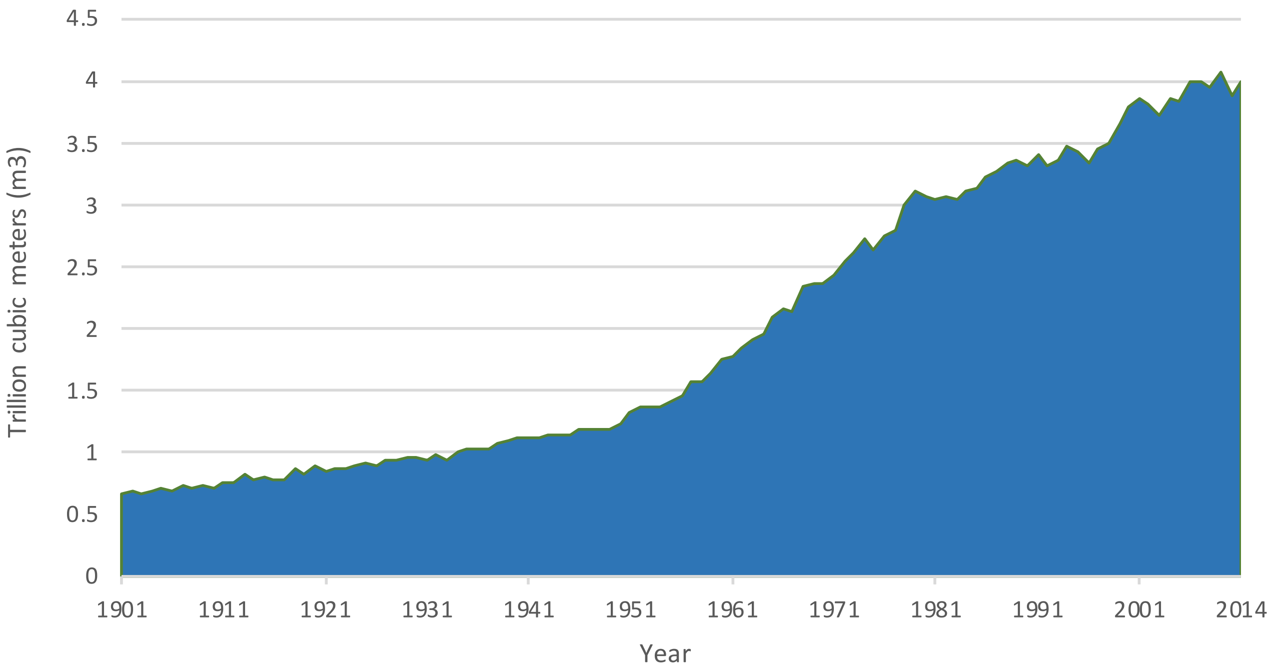
Source: resourcetrade.earth.

Material intensity is expected to decrease in the coming decades, with the rising importance of services. However, having said this, upper-middle-income economies, especially in North America, Europe and CIS, dominate the extraction and use of mineral resources, accounting for 56 per cent of the global total. In terms of material footprint per capita, high-income countries maintain the highest consumption of approximately 27 metric tons per person. This material footprint is 60 per cent higher than upper-middle-income countries.

2.2.6 Water

All living things require water and people depend on this natural resource for, amongst other things, drinking, cooking, irrigation, sanitation and power generation. Ninety-seven per cent of the global water resources is saltwater Only 3 per cent is freshwater, and approximately two-thirds of the freshwater is locked into glaciers and the polar ice caps. However, even though fresh water is a limited natural resource, there is presently enough water to meet the growing global demand, although this is not possible without changing the way water is used and managed. It has been noted that the worldwide water crisis is one of governance and not about resource availability (UNESCO, 2015).

Figure 11: Annual global freshwater withdrawals for agriculture, industry and domestic uses in m^3



Source: Global International Geosphere-Biosphere Programme.

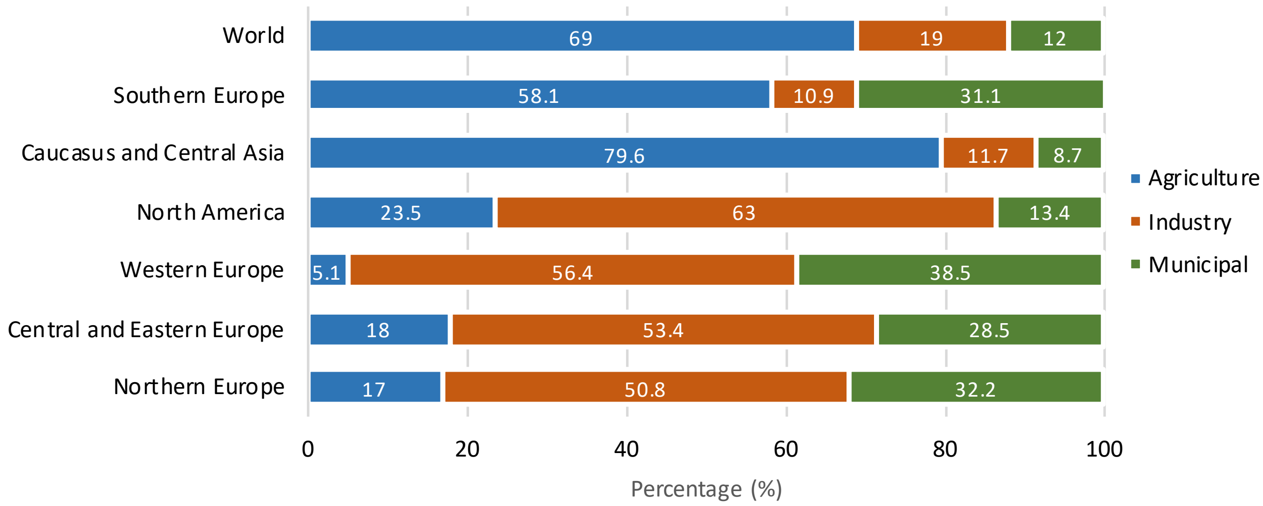
Freshwater is input to critical economic sectors such as agriculture, energy and industry, and it is an essential component for preserving biodiversity and maintaining other ecosystem services (e.g. regulation and maintenance of river flow). Globally, over 70 per cent of all the freshwater being withdrawn is used for agricultural purposes. Industry withdrawal accounts for 19 per cent, with municipalities responsible for 11 per cent. However, this varies considerably across regions. For example, agricultural withdrawals in Europe and Central Asia account for 35.7 per cent, whereas industry withdrawal is at 30.7 per cent and domestic withdrawals are at 33.5 per cent. These numbers diverge significantly from the world averages. It can further be noted that groundwater provides drinking water to at least 50 per cent of the global population and accounts for 43 per cent of all the water used for irrigation. 2.5 billion people depend on groundwater resources to satisfy their basic daily water needs (UNESCO, 2015). At present, estimates suggest that about 20 per cent of the world's aquifers are being used unsustainably (Gleeson et al., 2012), which can lead to land subsidence and saltwater intrusion, as well as water shortages when the aquifers are exhausted.

Water withdrawal and use are generally characterised by competing demands by many sectors, such as agriculture and energy, setting up an environment defined by trade-offs. With food production estimated to increase by at least 60 per cent by 2050, predicting water withdrawal and consumption is vitally important for identifying areas that are at risk of water scarcity and where water use is unsustainable (WHO/UNICEF, 2017b).

Water use in the ECE region

On average, freshwater is relatively abundant in the ECE region. However, the limits of water available for sustainable abstraction varies significantly. For example, while water from rivers, groundwater aquifers, and glaciers make the region rich in freshwater, there are areas of high-water stress, such as Central Asia, the Mediterranean area and the Western United States. This is coupled with significant variations in how freshwater is being used (see Figure 12), for instance, agriculture is the primary pressure on water resources in Southern Europe while water abstraction for electricity cooling is the leading pressure in Western Europe (EEA, 2018d).

Figure 12: Water withdrawals by sub-region and type, 2015



Source: FAO AQUASTAT.

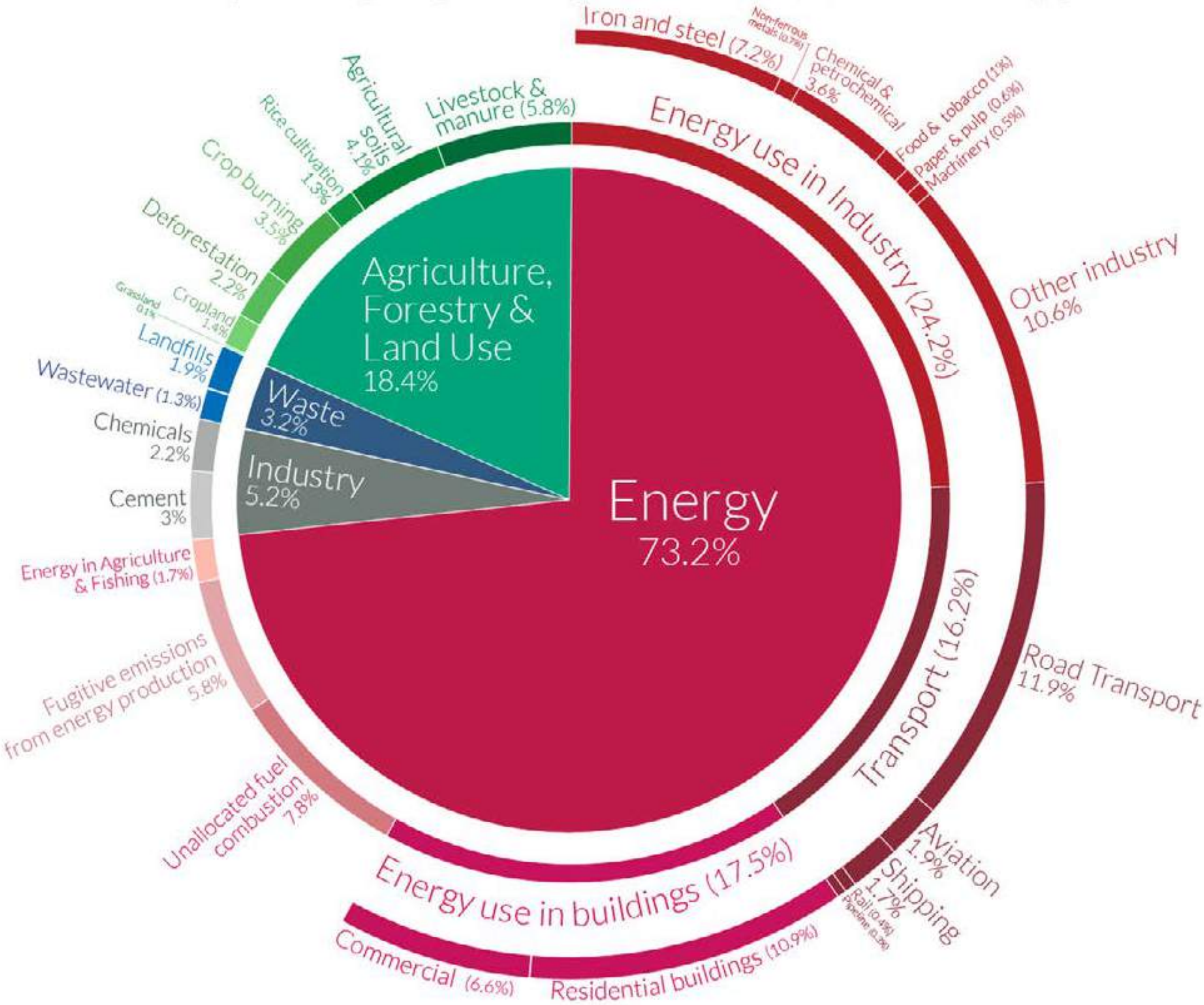
During the 2004 to 2012 period, fresh surface water use in the ECE region stabilized roughly around 300 billion m^3 per year. Since 2011, surface water withdrawal in the ECE region shows a downward trend. Careful water use by agriculture in some areas and integrated water resource management have contributed to this downward trend. Groundwater comprises a much larger freshwater volume than surface water. It is increasingly essential for water security in many countries (UNEP, 2016c). During the 1995 to 2009 period, groundwater withdrawal in the ECE region stabilized around 6 billion m^3 per year. From 2012, a declining trend is seen for the region. It can also be noted that diffuse agricultural pollution poses significant pressure on 38 per cent of the water bodies in the ECE region (FAO/IWMI, 2017).

The variations in water use across sub-regions and sectors (see Figure 12) imply that reconciling different water uses at the basin level and improving policy coherence nationally and across borders will remain a priority in the ECE region (ECE, 2016a). Transboundary collaboration is crucial for water management in the ECE region and requires coordination over different political, legal and institutional settings as well as over different information management approaches and financial arrangements (ECE, 2018e, ECE/UNESCO, 2018).

2.3 Interlinkages across the nexus nodes: Transport and Trade

Natural resource nexuses are the focus of this study, but it should be pointed out that there are many other nexus approaches, some of which are also being analysed by ECE, in parallel to the present study. For instance, nexuses on sustainable transport, smart and sustainable cities and on monitoring the SDGs are being analysed. This section will briefly consider two interlinkages which are very relevant to the Natural Resource Nexus, namely, transport and trade, both of which are addressed by ECE subprogrammes.

Figure 13: Global GHG emission by sector, 2016



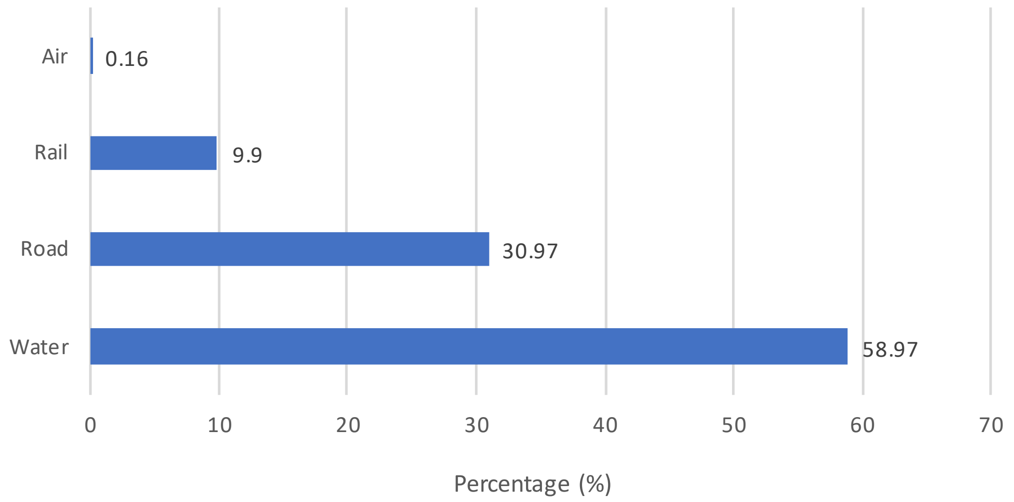
Source: ourworldindata.org, figure licensed under CC-BY.

As with the other nexus nodes, transport and international trade are usually analysed separately. Even more, the Natural Resource Nexus, as it has been articulated for this report, does not highlight transport and trade as separate nexuses. However, transport and trade are an inherent aspect of the Natural Resource Nexus as they have a significant impact on natural resource use. More importantly, they act as the glue between the natural resource nodes. For instance, globalisation has resulted in a global economy that is inherently interlinked, where integrative supply chains cross-national and regional boundaries, making up a complex web of sectoral interactions at the global scale. Transport and trade have made this possible and are critical drivers of economic development, globally and regionally. This also means that the ECE region cannot be considered in isolation from the rest of the world, in particular, when considering natural resource use and the impact of the trade and the associated transportation thereof.

From a nexus perspective, there are also other significant reasons for considering transport and trade. For example, transportation is the single largest source of air pollution and GHG emissions in the ECE region. Transport accounts for about 25 per cent of total emissions, including unallocated fuel combustion (see Figure 13). For every 2,000 litres of gasoline consumed, the average car produces 4,720 kg of carbon dioxide, 186.6 kilograms of carbon monoxide, 28 kg of volatile organic compounds (VOCs) and 25.6 kg of nitrogen oxides (NOs). UNEP has estimated that 2.4 million premature deaths from outdoor air pollution could be avoided each year. The links between GHG emissions and particulate matter make low carbon transport increasingly important, both to reduce emission levels and to improve public health through better air quality. Moreover, these interconnections are also apparent between the respective nexus nodes; for example, transport is an inherent component of food production and GHG emissions

Moreover, the concrete links between trade and transport are immediately apparent when considering that more than 80 per cent of the worlds merchandise trade by volume is transported by sea, making maritime transport a critical enabler of globalization. For example, with regards to the transportation of food, nearly 60 per cent is transported via water (see Figure 14). It can also be noted that international marine freight increased by an estimated 3.7 per cent globally in 2017 and projected growth will test the capacity of existing maritime transport infrastructure to support increased freight volumes. While these developments may be positive from a social and economic perspective, it highlights increasing concerns about natural resources exhaustion driven by an increase in both the value and volume of resource trade.

Figure 14: Share of global food miles (tonne-kilometres) by transport method

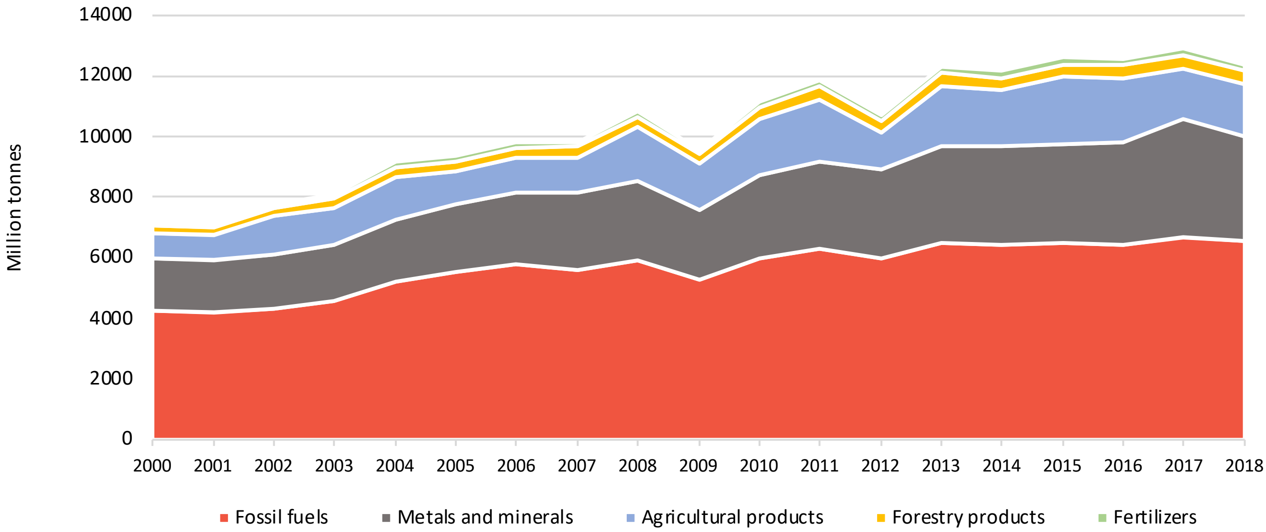


Source: Poore and Nemecek (2018).

In terms of global trade in natural resources, trade increased 2.5 times between 1980 and 2010, compared with a 1.8 increase in resource production and use over the same 30 years (see Figure 15). Resource trade has, therefore, become more significant not only in absolute terms but relative to domestic use too. As new centres of demand emerge, trade increasingly facilitates access to, and the redistribution of geographically concentrated natural resources. The share of the ECE region in the global total of resource imports was about 46 per cent (or 2.24 trillion USD) in 2015. In the same year, the ECE region also exported about 2.24 trillion USD worth of resources, which also accounts for 46 per cent of the global export share. Approximately 70 per cent of this trade is within the ECE region itself, and only 30 per cent of the resource imports and exports involve other regions.

Most importantly, the increase in natural resources traded generally means resource production also has to increase. An estimated 15 per cent of the globally extracted resources are directly traded (UNEP, 2016b). For fossil fuels and metals, around half of all production of these commodities were traded. But directly traded resources are dependent on even higher volumes of resource production. The output of 10 billion tonnes of directly traded goods in 2010 required 30 billion tonnes of total resource production (UNEP, 2016a). This stress how relevant transportation and trade are as enablers of natural resource use.

Figure 15: Growth in the volume of natural resource trade, 2000-2015



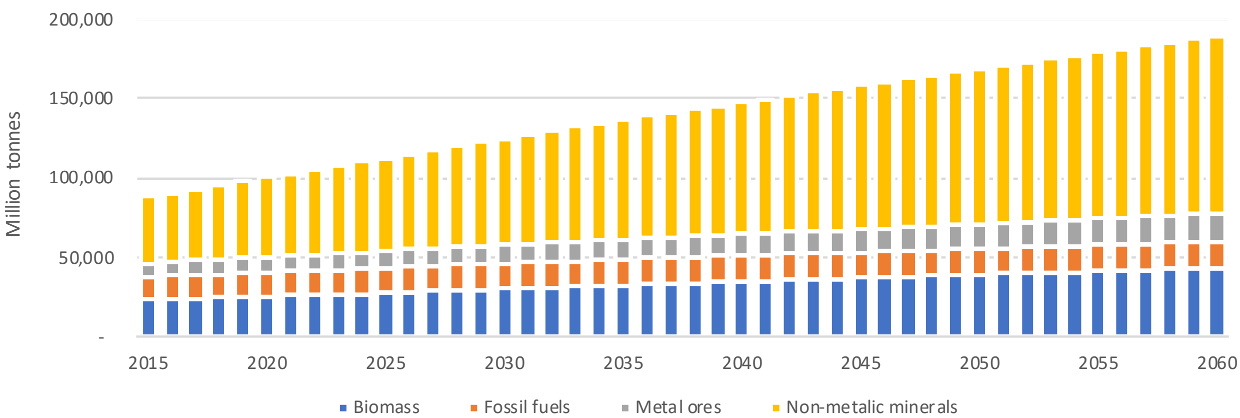
Source: resourcetrade.earth.

2.4 Looking ahead: Global and regional trends

The preceding chapters on the nexus nodes – water, land, materials, food and energy – have made it abundantly clear that the patterns for natural resource use in the ECE region are unsustainable, principally owing to the overuse of finite natural resources and trading patterns with other regions,[6] as well as the failure, so far, to develop the full potential of the circular economy. Even more, if current patterns of production and consumption continue, global natural resource use is set to increase dramatically in the coming decades (see Figure 16). Significant and tangible steps thus need to be taken towards improving resource efficiency, decoupling economic growth from environmental degradation and promoting sustainable production and consumption, if this trend is to be changed.

The analysis of natural resource use, globally and in the ECE region, underscores the importance of considering some of the megatrends and related impacts that may affect natural resources use in the ECE region. For example, demographic, economic or geopolitical developments will influence the availability and price of natural resources and energy in the ECE region, while increasing pollution may contribute to environmental and human harm. Thus, uncertainties notwithstanding, it is relevant to briefly consider what the future may hold.

Figure 16: Global material extraction, 2015-2060.



Source: UNEP (2019a).

6 Natural resource trade includes mainly commodities such as fossil fuels, minerals and biomass.

The megatrends listed below are only a small selection of issues that are commonly discussed and considered in relation to natural resource use. It is not an exhaustive list and principally serves the purpose of highlighting the fact that nearly all trends and forecasts point in the same direction, namely, that the world and the ECE region will probably continue to utilise finite natural resources at unsustainable levels in the decades to come. However, the megatrends also serve to demonstrate some of the more complex interdependencies underlying natural resource use. These megatrends suggest that radical steps are needed to change the current trajectories. More detailed information on these and other megatrends can also be found in EEA (2015b) and UNEP (2016c).

Continued population growth and urbanisation

A growing global population principally drives global urbanisation. Today there are 7 billion people on the planet, but around 9 billion are expected by 2050, and about two-thirds of the global population is in turn projected to be living in urban areas at that point. This trend is likely to have a significant impact on the ECE region in terms of land use (e.g. the share of peri-urban areas in land use is growing faster than that of any other type of land use in Europe) and the demand for natural resources (e.g. changing food demand may drive countries in the ECE region to seek resources elsewhere to a greater extent than now).

Increased urbanisation and changing consumption patterns may also have a significant impact on the quantity and quality of water resources as well as on energy use[7] (e.g. 60 to 80 per cent of all natural resource consumption and energy use and around 50 per cent of all $C0^{2}$ emissions can be attributed to cities). The interdependencies between natural systems, urban activities and population growth highlight that this megatrend that will continue to significantly affect natural resource use.

Increasing competition for natural resources

Even though the share of the total resource extraction has been reduced for the ECE region as compared to the global level, advanced economies remain resource-intensive – even if the resources originate, and are processed, in other regions. Thus, setting aside environmental implications, natural resource use will be determined by increased global resource demand and increased uncertainty about resource supplies, although the potential for substitution and increased efficiency should not be underestimated. For a region that is relatively resources poor, increased competition for natural resources may thus have significant implications, in the form of price rises and sectoral shortages. For example, the EU economy is structurally dependent on imported resources (e.g. metals and fossil fuels), which implies that growing resource scarcity could influence the speed and direction of economic growth.

Continued economic growth

The inherent interlinkages between the economy and natural resource use is apparent in that future economic growth may be hampered by increased resource scarcity. However, economic growth generally also implies increased resource use and environmental degradation. This underscores that developments in any domain, whether economic, social or environmental, will have knock-on effects on the other. Economic growth is a particularly important topic in this instance as economic output is expected to triple by 2050 (UNEP, 2019a). This stresses the need for resource decoupling or rather decoupling natural resource use and environmental impacts from economic growth. The interdependence of economic systems means that individual countries and regions, including the ECE region, are increasingly affected by global economic activity. Thus, although resource efficiency is increasing, it is expected that economic growth will drive resource use and emissions to higher absolute levels.

Increasingly severe effects of climate change

World leaders are committed to keeping the average global temperature rise compared to pre-industrial levels below two degrees Celsius, a threshold at which significant and irreversible environmental changes are likely to occur, although it is considered doubtful that this objective will be achieved. At the same time, the demand for natural resources is also expected to increase dramatically. For example, the demand for food is expected to increase by

7 These interactions will also be addressed in the ECE Nexus study on cities

35 per cent by 2030. Increasing demand for food will, in turn, have a significant knock-on effect on energy and water demand (e.g. demand for water would increase by 40 per cent and for energy by 50 per cent) whereas climate change may, in turn, reduce agricultural productivity by up to a third (FAO, 2017b). Possible action to prevent this, in addition to GHG emission reduction, including from agriculture, could include increased agricultural productivity (including more efficient use of inputs like water and energy) and increased agricultural area, reduction of food loss and waste, and changed consumption patterns. In a nutshell, in the absence of decisive action, climate change is expected to increasingly affect natural ecosystems and biodiversity, economic growth and global food security as well as threaten human health. It can further be noted that while many of the climate-related challenges in the ECE region are the same as those found elsewhere in the world, the sub-regions have varied capacities to adapt to and/or mitigate climate change. This is coupled with the fact that key risks may vary across the region, such as desertification versus flooding.

Growing pressures on ecosystems

Global and regional assessments indicate that biodiversity loss and ecosystem degradation will continue in the coming decades. For example, population growth, demand for food and climate change are expected to create significant threats to freshwater availability (e.g. growing competition for productive land and freshwater resources has resulted in a rapid increase in large-scale transnational land acquisitions, mostly in developing countries). The demand for land has also resulted in alarming tropical deforestation in recent decades (e.g. primary forests are still decreasing, although at a slower rate than before, and governments are committed to halting deforestation by 2030). Likewise, drylands and wetlands are threatened by depletion and loss of biodiversity, and their transformation into cropland continues at alarming rates, resulting in water stress and soil degradation. All-in-all, these drivers of biodiversity loss are likely to greatly outweigh the effects of any biodiversity protection measures. Continued ecosystem degradation will, in turn also affect those ecosystems services that provide for our food, water and other natural resources, creating a negative feedback loop that may generate regional instability and increasing risks of conflict. Having this in mind, crossing critical ecological tipping points could cause unparalleled environmental, social and economic problems throughout the ECE region.

Increasing environmental pollution

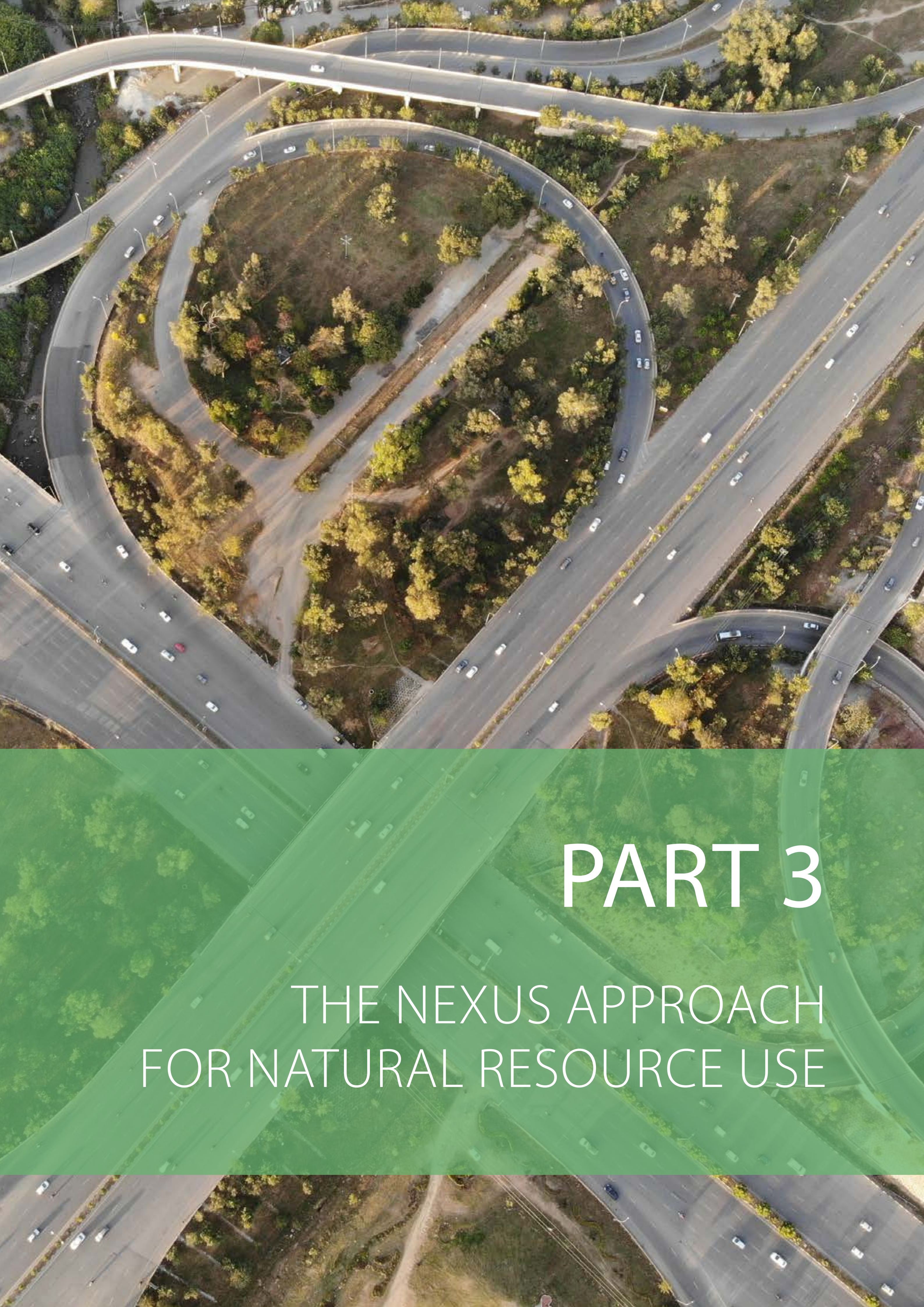
The significant increase in global production and consumption of natural resources, together with an increasing demand for food and energy, has had a massive impact on the environment. The main sources of environmental pollution are three activities, fossil-fuel combustion, fertilisers and pesticides in agriculture, as well as growing manufacture and use of chemicals. For example, more than 100,000 substances are at present commercially available in Europe alone, which are now being systematically evaluated by the REACH project. Environmental pollution is a transboundary problem, significantly affecting water, soil and air quality on the global level. This has long been addressed in the context of ECE, since the pioneering Convention on Long-Range Transboundary Air Pollution, signed in 1979. Air pollution, unsafe water supply, poor sanitation and hazardous chemicals exert considerable pressures on human health and well-being. While there are some sub-regional variations, projections under business-as-usual suggest that atmospheric pollution (e.g. nitrogen, sulphur, ozone and particulate matter) will continue to increase (OECD, 2012b). Also, the release of pollutants to aquatic systems and soils (e.g. agricultural fertiliser run-off into rivers) as well as the eutrophication of aquatic ecosystems is expected to continue.

Public health and natural resource use

The health challenges of COVID-19 for the ECE region and worldwide are daunting, with a serious potential loss of life, but also with significant short- and long-term impacts on socio-economic and environmental activities. Current demand and resource use trajectories are changing almost every day, and it is still too early to make any conclusive remarks with regard to how the future may look. It is however certain that things will change, at least in the short-term, and that these changes will have significant effects on natural resource use, globally. We have for instance seen global air traffic dropping by 60 per cent, significant improvements in air quality (e.g. falling nitrogen dioxide emissions) due to a reduction in road traffic, and a 25 per cent decline in energy demand in countries that have been in lockdown. Some products face shortages, others have exhibited high levels of food wastage due to falling demand. The structure of value chains, even of whole economies, may change in the post-COVID-19 recovery process and experiences gained during the pandemic period. While we may return to previous levels of economic activity as restrictions ease, serious questions concerning the recovery and future socio-economic models are now being discussed across the region. Discussions include the future of tourism and travel in general, the structure of supply chains, and increasing national self-sufficiency in certain goods, all of which could influence supply and demand of natural resources.

2.5 Setting the stage for the ECE region

The megatrends listed above are only a small selection of issues that are commonly discussed and considered in relation to natural resource use. It is not an exhaustive list and principally serves the purpose of highlighting that nearly all trends and forecasts point in the same direction, namely, the world and the ECE region will likely continue to utilise finite natural resources at unsustainable levels in the decades to come. However, the megatrends also serve to demonstrate some of the more complex interdependencies underlying natural resource use. For example, raising the living standards for the global population may carry with it a high environmental cost, such as in terms of water and air quality, biodiversity loss, and land degradation. These are some of the trade-offs that come to the heart of the resource challenge and emphasise that the pathway towards sustainable natural resource use is complex and multifaceted. Nevertheless, most importantly, what these megatrends clearly outline is that radical steps are needed to change the current trajectories.



PART 3

THE NEXUS APPROACH FOR NATURAL RESOURCE USE

3 THE NEXUS APPROACH FOR NATURAL RESOURCE USE

Part 1 and 2 have briefly outlined the main characteristics of the natural resources nexuses in the ECE region, and of the necessity for a nexus approach, abandoning the silo approach which still prevails in many organisations including, until now, the ECE, which is still largely structured along traditional and linear sectoral divisions (e.g. environment, energy, transport, trade, forest, housing and land). This section focuses on seven nexus "hotspots", where it appears that the ECE can make a useful contribution based on its existing strengths.

Underlying the thinking of this section, and the study as a whole is the belief that the nexus approach is able to generate relevant information about critical interlinkages that will enable decision-makers to plan for robust governance and management across resources and spatial scales. The outcomes should be consistent with planning frameworks such as national development plans, sustainable development strategies, energy or agricultural transitions, or national forest programmes, all of which by their nature take a holistic approach. This part identifies seven nexus "hotspots".

3.1 Seven Nexus Hotspots

This chapter highlights nexus hotspots which showcase specific major challenges and opportunities appropriate for a nexus approach, considering core ECE expertise and products within this broader analytical framework, as well as regional megatrends and the SDGs. Focusing on nexus hotspots (see Box 1) serves to demonstrate solutions as well as knowledge demands, resources constraints and governance challenges that are unique to each hotspot. The nexus hotspots furthermore serve to present lessons learnt from the interdisciplinary nexus team while acting as case examples from a natural resource use perspective. Having this in mind, the hotspots in this publication showcase both ongoing work by the ECE as well as other areas of work seen as relevant from a nexus perspective. It should also be noted that the nexus hotspots presented below are by no means an exhaustive list. Within the ECE, many more linkages and nexus areas related to natural resource use can be identified. Moreover, the hotspots below also cover interlinkages across the nexus nodes, thus going beyond the Natural Resources Nexus to cover trade and transport.

Box 1: The Nexus Hotspots in a nutshell

Food Loss and Waste (page 29)

There are significant loss and waste of food at all stages of the value chain, increasing the strain on natural resources and land, and increasing pollution and emissions unnecessarily. Understanding the scope of the food loss challenge can help guide actions to reduce food loss and waste as well as contribute to improved food access and security.

The food loss challenge is a nexus hotspot as it highlights the interdependencies and connections across different sectors at different levels of a supply chain, and there is the potential for significant savings, at an acceptable cost.

Life Cycle of Vehicles (page 37)

Vehicles use large volumes of natural resources, at every stage of their life cycle. This can be reduced if technical and policy choices are based on objective and comprehensive information through life cycle analysis.

Focusing on the life cycle of a product – as a nexus hotspot – is based on life cycle assessments being able to minimise natural resource use and environmental/climate impacts by accounting for the entire value chain, from production and trade of materials through manufacture and use of the vehicles, to recycling and re-use of the many components.

Box 1: The Nexus Hotspots in a nutshell (continued)

Land Value Capture (page 46)

The value that is attached to land reflects how the public utilises natural resources (principally land) to generate social and economic benefits, as well as social priorities, and resolve competing demands.

Land value capture is a useful nexus hotspot to influence competing land demands and in effect also natural resource use. It is included as an example of a financing tool for land-use planning that can reduce natural resource use.

Natural resource use in transboundary basins (page 53)

Many river basins are shared by several countries. For that reason, in many cases, it is not possible to promote sustainable and integrated natural resources management effectively without transboundary cooperation, in addition to intersectoral coordination.

Assessing natural resource use in a transboundary basin – as a nexus hotspot – highlights the complex intersectoral dynamics opportunities for more coherent policy and technical measures.

Measuring the use of natural resources with the System of Environmental-Economic Accounting (SEEA) (page 61)

This hotspot is about the role of data in natural resource management and the need for integrated monitoring, based on comprehensive and integrated data systems.

The System of Environmental-Economic Accounting is a useful nexus hotspot to demonstrate the added value of integrating data, which would be a necessary step for considering any nexus topic.

Forest Landscape Restoration (page 69)

There are millions of hectares of degraded landscapes in the world, including the ECE region. Significant efforts are needed to restore this land to a sustainable state. Forest landscape restoration is a promising system approach in that it may help to reconcile fundamental trade-offs at a landscape level.

As a nexus hotspot, forest landscape restoration is interesting as it focuses on entire landscapes, representing a mosaic of interacting land uses and sectors under different governance systems.

Integrated Management of Energy and Mineral Resources (page 78)

The concept of an integrated sustainable energy system can be described as a system that allows infrastructure and energy generation capacity to be used more efficiently.

One key reason for choosing integrated management of energy resources as nexus hotspot is due to the application of a systems approach as a relevant nexus perspective on natural resources use.

3.2 Food Loss and Waste

Increasing attention has in recent years been given to how trade and the environment interact with each other. However, trade is not only related to the environment but to many significant nexuses at a global, regional or national level, affecting several sectors. International trade in food, for instance, can have a negative impact on environmental quality through the production, transportation and consumption of food while having a positive impact on food security, income and economic growth. This serves to demonstrate that global food value chains are complex, and there are significant food losses, which can be reduced by addressing issues at each stage. There is an added value to adopting a nexus approach whereby an intersectoral perspective can be taken to consider interactions and trade-offs between sectors.

The ECE work in this area relates to the development of trade-related norms and standards, procedures and best practices to increase the efficiency, predictability and transparency of trade regulations and procedures. This covers, amongst other things, the traceability of sustainable value chains of textiles, leather, animals and fish as well as quality standards for the safe and transparent trade of food and agricultural produce. The trade-in and availability of, good quality food is of utmost importance for sustaining a growing global population and facing the climate and environmental challenges. The complexities underlying land-use systems, the need to adapt to meet water and food demands for humans and the upkeep of ecosystems in the face of global and regional change highlight an important nexus hotspot that warrants our attention.

3.2.1 Defining the Nexus Hotspot on food loss and waste

All the food produced, globally, is ultimately intended for consumption. Therefore, every single food item should ideally make its way through the food supply chain and meet consumption demands. However, owing to complexities, system failures, and inefficiencies in the food system, the current level of food loss and waste is exceedingly high and unsustainable. Understanding the scope of the food loss challenge can help guide actions to reduce food loss and waste as well as contribute to improved food access and security, avoid foregone income possibilities, improve the economic viability of food producers and lessen the negative impact on the environment.

What Constitutes Food Loss and Waste?

According to the FAO, food loss and waste is generally considered as a "*decrease in quantity or quality of food along the food supply chain*". In this case, **food loss** encompasses the supply chain from harvest up to the retail level, while **food waste** occurs at the retail and consumption level (FAO, 2019b). However, the lack of systematically collected data according to commonly agreed definition makes the collection and comparison of relevant data and information on food loss and waste within a country or across regions and countries more complicated.

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The ECE's work on reducing food loss and waste contribute directly to creating a **Zero Hunger** world and halving per capita global food waste at the retail and consumer levels and reducing food losses along production and supply chains, including post-harvest losses. This is done to reach the Sustainable Development Goals (SDGs), especially SDG 2 (Zero Hunger) and SDG 12 (Ensure sustainable consumption and production patterns).

How much food is lost and wasted, and what is the impact?

Food loss and waste represent a misuse of the water, energy, land and other natural resources (e.g. fertilizers) that go into the food's production and trade. Reducing food loss and waste would thus lead to more efficient land use, better water resource management, with positive impacts in terms of carbon emissions, waste generation, economic efficiency and livelihoods – without reducing and even increasing the availability of food.

Global Food Loss and Waste

- Approximately **1/3** of the food produced globally for human consumption is lost or wasted. This equates to about **1.3 billion tonnes per year** (FAO, 2011a). Producing these food accounts for 6 to 10 per cent of greenhouse gas emissions (Vermeulen et al., 2012).*

- People in Europe waste between **95 and 115 kg of food per person** each year. This can be compared with only **6 to 11 kg a year** for people in Sub-Saharan Africa and South Asia (FAO, 2011a).

- Global quantitative food losses and waste per year are roughly 30 per cent for **cereals**, 40 to 50 per cent for **root crops**, **fruits and vegetables**, 20 per cent for **oilseeds**, **meat and dairy** plus 35 per cent for **fish**.

- **1.4 billion ha** (28 per cent of the global agricultural area) is used annually to produce food that is lost or wasted (FAO, 2013b). For comparison, it can be noted that 5 to 10 million ha of forests are lost annually due to deforestation. This implies 150 to 200 years of deforestation as related to food loss.

- The carbon footprint of food loss and waste (e.g. the unnecessary carbon emissions to produce and trade food which is lost or wasted) was on average around **500 kg of CO_2** per person and year around 2012. Europe, North America, Oceania and industrial Asia have the highest per capita carbon footprint of food waste (around 700 to 900 kg of CO_2) (FAO, 2013b).

- If current production and consumption behaviour remains unchanged, it is estimated that food production would have to increase by as much as **70 per cent to feed 9 billion people by 2050** (Parfitt et al., 2010).

- Food loss and waste have been estimated to continue to rise by **1.9 per cent annually** from 2015 to 2030. This means that annual food loss and waste will hit **2.1 billion tons (worth $1.5 trillion) by 2030** (BCG, 2018).

* Estimates on annual food waste and loss is from 2011 and 2013. These figures are in the process of being replaced with two separate SDG indicators, the Food Loss Index and the Food Waste Index, by the Food and Agriculture Organization of the United Nations (FAO). More precise figures will be available in the near future (FAO, 2019b).

In a world that needs to double food production in order to meet the demand of a population expected to increase from seven billion today to nine billion in 2050, the current rate of food loss and waste, from farm to fork, cannot continue.

Food Loss and Waste in the ECE region

The ECE region encompasses some of the largest trade flows of food in the world. Food loss and waste occur along the entire supply chain, from production to consumption. The food loss/waste hotspots differ significantly across regions. For instance, consumers cause more food waste in higher-income countries than in lesser developed countries which have higher losses at the post-harvest and processing stages because of spoilage.[8] (FAO, 2011a, 2013b, 2019b). However, measured per capita, more food is going to waste in the developed world. To this can be added that the total amount of food wasted by consumers in developed countries is nearly as high as the total net food production in sub-Saharan Africa (FAO, 2013b).

8 Spoilage is high because of lack of modern transport and storage infrastructure, and financial, managerial and technical limitations in difficult climatic conditions.

- Food is lost or wasted throughout the entire supply chain, from post-harvest to distribution, ranging from **16 per cent** (in North America and Europe) to **21 per cent** (in Central and Southern Asia) (FAO, 2019b).
- Around **88 million tonnes of food waste** is generated annually in the EU, with an associated cost estimated at **143 billion Euros** (FUSIONS, 2016).
- Current estimations of food loss and waste generation range from **158 to 298 kg per person per year** in Europe (Corrado and Sala, 2018). The average is 173 kg per person per year (EU, 2017).
- High-income countries of the EU and EFTA waste more at the **household level** (e.g. nearly 25 per cent waste of bread and other cereal products by consumers), while in low and middle-income countries, losses dominate during **primary production** (e.g. ranging from 12 to 15 per cent losses in the field and during harvest) (FAO, 2014a).
- **170 million tonnes of CO_2** has been estimated to be emitted due to food production and waste in the EU every year (EU, 2017).

What causes food waste and where in the supply chain does food loss and waste occur?

Food loss and waste remain a multidimensional and complex challenge. The exact causes of food loss are highly dependent on specific conditions and local situations. However, three interrelated factors have been identified by Parfitt et al. as having contributed towards current rates of food loss and waste:

Large-scale urbanisation that has accelerated food demand and an **expansion of the agricultural sector**.

Dietary transitions to more **diversified** and **resource-intensive foods**.

Global trade and **globalisation** that drive an **increasing demand** for processed goods, supermarkets and international competition.

Source: Parfitt et al. (2010).

Other factors include the relative abundance and cheapness of food in richer countries, and the highly effective global supply chains which have been developed. Food loss and waste furthermore differ across food supply chains, depending, amongst other things, on crop types, economic development, and social and cultural practices. It occurs at the farm, in storage, in transit, in distribution centres, in the shop, and at home (FAO, 2019b, FAO, 2017a). The reasons are manifold and can include logistics issues (e.g. local transportation and storage), shortage of access to data (e.g. on production and prices), order cancellations, improper planning production and distribution, stringent buyer requirements, "natural overproduction" due to favourable growing conditions and climate and climate change. Box 2 provides an example of food loss and waste as related to fish.

Box 2: Snapshot case: Food Loss and Waste in Fish Value Chains

Fish is a difficult commodity in that it can spoil easily, becoming unfit for consumption and dangerous to health. Food loss in fish includes fisheries and aquaculture products that are not consumed or have incurred a reduction in quality.

- Losses in primary fish and seafood production are significant due to discarding rates of between 9 to 15 per cent of marine catches.
- Value of food lost or wasted annually at the global level is estimated at 1 trillion US$.

Reasons for the losses include inefficient fishing gear; bad handling practices; poor storage; lack of enforcement of regulations; social and gender equality issues such unbalanced access to services and market-related causes such as consumer habits.

The ECE supports improved traceability and transparency to improve the sustainability of complex global fishery value chains through its UN/FLUX fisheries data management standard,[9] the first communication tool to collect and disseminate fishery catch data through a harmonized message standard.

3.2.2 Why a nexus focus on the food loss and waste challenge?

The food supply chain is inextricably linked to **water**, **energy** and **land** used in the production and manufacture of food, while the **trade** of food and agricultural produce is driven by the demand in countries and regions (OECD, 2015). This highlights the interdependencies and connections across these sectors and the use of natural resources at different levels of the supply chain. For instance, energy is needed to extract, clean and distribute water from the source to supply, while also being used in the processing, transport, storage, cooking and manufacture of food. Another example is the land used to produce food, including the use of fertilizers (e.g. nitrates), pesticides and associated environmental impacts (e.g. biodiversity loss). Moreover, food waste is increasingly being used to produce energy, where water is also an important resource for energy production. To this can be added stressors, such as population growth and climate change, which may have significant effects on the global food supply chain. All these interrelated connections and impacts highlight the need for integrated solutions.

3.2.3 Intersectoral areas of work affecting food waste and loss

Emissions from Food Loss and Waste

Since food production involves the use of energy, water, land and other factors of production derived from natural resources (e.g. fertilizers), all these contribute to environmental degradation, in particular, if additional units need to be produced because of food loss and waste. The additional production of food means the extra use of freshwater and energy, which can in turn, be classified as water and energy waste.

If no changes are made to reduce food loss and waste, estimates suggest that global emissions from food loss and waste could reach between **5.7 and 7.9 Gt CO_2 per year by 2050**, an increase from 2011 of 2.5 times at the lower bound and 3.5 times at the upper bound (FAO, 2019b). The growing trend in emissions related to food loss and waste shows no signs of changing.

The typical measure of environmental costs is the emission of GHG caused by food loss and waste. This is measured either as the impact from the decomposition of food loss and waste at landfills or elsewhere, or, in terms of the emissions associated with the life cycle of food waste (e.g. food production, transport, retail and waste management). All food production consequently comes with an emissions profile, and understanding this can help to find solutions for reducing food waste and GHG emissions.

9 See http://www.unece.org/cefact.html for more information.

Food packaging

It is also very important to consider the packaging materials in which the food is stored, transported, displayed and sold. This material is often necessary and unavoidable for several reasons including food safety and transport as well as shelf life extension (which in turn may reduce food waste) While it has been argued that the environmental impact of packaging materials is less severe than the impact of food loss and waste, the increased global attention to the plastic pollution crisis highlights a pervasive problem associated with the food supply chain. For instance, out of the 78 million metric tons of plastic packaging produced each year globally, only 14 per cent is at present recycled. It has further been estimated that 11.4 billion US$ of recyclable packaging is wasted every year.

During the decade between 2004 and 2014, food waste per person doubled, and the amount of **plastic packaging in food products rose by up to 50 per cent**.

Setting aside plastic pollution, the waste flows generated by the food supply chain affect energy consumption and waste treatment as well as GHG emissions, highlighting once again the intersectoral nature of the challenges and inefficiencies facing the food industry. In short, although appropriate packaging may help to reduce food loss and waste, in many cases excessive or badly designed packaging creates significant environmental issues and GHG emissions

Energy from food

Every time food is lost or wasted, all the energy that went into producing that food is wasted. The problem is consequently not only related to the loss of the food itself (e.g. calories and nutrients) but also wasted energy. Maximizing the energy recapture of food waste is thus one way to improve efficiency (e.g. energy from organic waste captured through anaerobic digestion, aerobic composting, bioethanol fermentation and feed fermentation can be used to produce electricity and heat). By reducing food waste, it is not only possible to reduce demands on natural resources used to produce energy but also to provide viable economic opportunities (Ma and Liu, 2019).

Decomposition of an average ton of food generates approximately **376m^3 of biogas**. This is more than three times the biogas produced from the same quantity of biosolids through wastewater systems. Food waste is as such a better energy source than biosolids.

Water for food

As mentioned above, agriculture is the biggest user of freshwater. Considering water scarcity constraints, it is essential that water use is considered when discussing food production and consumption. The increase in the water needed to meet the demand for food is a major concern given the growing water scarcity and related environmental problems.

The 1.3 billion tons of food wasted annually corresponds to approximately 170 billion m^3 of water being wasted as well. This **equates to 24 per cent of all water used** for agriculture. Depending on how food is produced, and assumptions on population and diet, future water requirements to meet food demand by 2050 have been estimated at between 10,000 to 13,500 km^3/year (Lundqvist et al., 2008).

Reducing food loss and waste means reduced water needs in agriculture as well as freed up land and other natural resources that can be directed to purposes other than food production. This will require integrated and innovative strategies that account for intersectoral interactions and trade-offs.

Fertilizers and food production

Both water and fertilizers play a critical role as natural resources in agricultural production. For instance, the influence of fertilizers on yield depends on water availability; in turn, the yield also depends on nutrient availability. However, a challenge associated with managing soils to produce food is the management of nitrogenous fertilizers. There are, on the one hand, risks in terms of increased GHG emissions, biodiversity loss, groundwater pollution and eutrophication of ecosystems, open waters and coastal areas, due to the use of nitrogen, on the other hand, low yields are also associated with not using fertilizers. Europe is a nitrogen hotspot with high nitrogen export through rivers to the coast, representing 10 per cent of global N2O emissions.

By 2050, the world will need to increase food production by **70 per cent to feed the growing global population**. However, it has been estimated that the average per capita availability of cropland will not be enough to produce food for affluent diets with present production systems (Ibarrola-Rivas and Nonhebel, 2016). It is expected that up to **77 per cent of this future growth** in crop production comes from increased yields due to fertilizer, not accounting for other solutions, such as moving away from meat-based diets.

The need for increasing crop yields in the future highlight trade-offs between land and nitrogen use. In essence, the challenge will be to implement the more efficient use of nitrogen to increase food production while minimizing potential environmental problems.

Gender and food loss

Addressing food loss and waste requires that underlying social-cultural and economic factors are considered as an inherent component of the food supply chain. Having this in mind, gender dynamics are one primary component of the social-cultural and economic context of food production and consumption, shaping food value chains at all levels. Gender considerations influence the division of labour, roles and responsibilities along the food production and trade value chain (FAO, 2018).

Women comprise approximately **43 per cent of the global agricultural workforce**. In many regions, they play a primary role in food production and post-harvest activities. Gender relations and associated priorities, preferences and bargaining power of women and men in the food value chain need to be taken into account in relation to food loss and waste.

Gender concerns are relevant in determining the responses when considering food loss and waste policies in a specific food value chain and in determining their effectiveness and impact. If gender is overlooked, any strategy to reduce food loss and waste may ultimately be less effective than it could be, or even exacerbate gender inequalities along the food value chain.

Data availability and definitions

While FAO has brought more clarity into the harmonized definitions of food loss and waste, there is yet to be consensus and uniform use of the new definitions (FAO, 2019b). SDG target 12.3 has, in fact, two components (Losses and Waste), that should be measured by two separate indicators. In addition, target 12.3 speaks of halving food waste and only "reducing" food loss. Specifically, sub-indicator 12.3.1. a Food Loss Index (FLI) focuses on food losses that occur from production up to (and not including) the retail level. It measures the changes in percentage losses for a basket of 10 main commodities by country in comparison with a base period. The FLI will contribute to measuring progress towards SDG Target 12.3. However, information gaps and uncertainties highlight that there is no consensus on how much of the global food production is actually lost, and access to primary data sets is limited.

The terminology for food loss and waste is confusing, and there are subtle differences between food loss and food waste. These processes occur at different stages in the food supply chain, which includes agricultural production, harvesting, post-harvest storage and handling, processing, packaging or distribution, retail and consumption. Food lost at the post-harvest storage and handling stage is generally referred to as 'food losses' and 'spoilage', while at the later stages of the food supply chain it is termed 'food waste' and generally applies to food lost due to behavioural issues (e.g. consumer behaviour). FAO defines food loss as the "decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers" while food waste is referred to as "the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers" (FAO, 2019b). None of the definitions covers food lost pre-harvest, i.e. food which for various reasons including pricing or overproduction is not even picked from the tree or harvested.

Moreover, despite the development of indicators to measure food loss and waste (e.g. global food loss index indicator)[10] and associated food loss measurement methodologies (e.g. ECE food loss and waste measuring methodology (ECE, 2019c) and the IFPRI Food Losses methodology(IFRPI, 2017)), there is at present still no systematically measured data on food loss and waste. In other words, the identification of solutions is dependent on a systematic understanding of food loss and waste which, in turn, is not possible without relevant data.

Food waste as an opportunity

There are many opportunities to reduce waste and losses in the supply chain. In fact, food loss and waste provide an actionable pathway for corporate social responsibility at all levels, like efforts in recycling and energy efficiency as well as an excellent return for investment through efficiency and forgone income gains. In addition to GHG management through reduced methane emissions, acting on food loss and waste can translate into reduced GHG emissions in relation to the production, transportation, storage and disposal of food.

Aside from efforts to offset climate change impacts, opportunities in addressing food loss and waste are numerous, ranging from technological innovations (e.g. smart consumer appliances), channelling food waste into other productive economic activities, as well as recycling, renewable energy and waste management initiatives.

Taking the whole food supply chain into account may further help identify solutions for the transition to a Circular Economy, in particular, as the circular economy aims to reduce waste streams by reusing waste as a resource at different stages of the supply chain. This can create value across many sectors within the food industry and beyond. Realising a Circular Economy will require that policies for food waste are integrated into the broader contexts of sustainable food systems.

3.2.4 What is the ECE doing to address the food loss and waste challenge?

Preventing, reducing and re-using the amounts of food lost or wasted along the entire food value chain is a key priority to improve food security, the sustainability of food systems and addressing environmental challenges. This has been clearly recognized by the 2030 Agenda. However, for food loss and waste challenge hotspot, no single innovation will likely lead to a step-change in improved sustainability. The treatment of food loss and waste is rather a cross-cutting nexus issue which spans across the globe and therefore requires to be addressed in multi-sectorial approach

The ECE contributes to addressing the food challenges through its many efforts to develop impactful solutions with all stakeholders to keep as much food as possible in the human consumption chain to prevent, redistribute and revalue food loss along the value chain. This is done through constantly adapted quality standards for the safe and transparent trade of food and agricultural produce as well as a dedicated ECE food loss measurement methodology and the international Code of Good practice to avoid food loss, a handling guide for entire supply chains. In addition, ECE, together with other UN agencies and the private sector, has developed a new interactive trade and data measurement food loss management system (FeedUP@UN), supported by a blockchain, as part of a broader effort

10 See: http://www.fao.org/sustainable-development-goals/indicators/1231/en/.

to prevent and reduce food loss and revalue food which would otherwise have been lost. Other examples include the UN/FLUX fisheries data management standard, developed by UN/CEFACT. In addition, ECE is working on policy recommendations to assist governments in their transition to meaningful food loss and waste policies and circular economy approaches.

3.2.5 ECE tools and approaches relevant in the area of food loss and waste

	Type of Tool(s)	Description	Sub-programme(s)
Inter-governmental bodies	**Programme of Work**	Steering Committee on Trade Capacity and Standards • Working Party on Agricultural Quality Standards • Working Party on Regulatory Cooperation and Standardization Policies United Nations Centre for Trade Facilitation and Electronic Business • Team of Specialists on Sustainable Fisheries	
Publications	**Methodologies and guidelines**	• ECE food loss and waste measuring methodology for fresh produce supply chains • ECE Code of Good Practice: Reducing food loss in handling fruit and vegetables.	
	Policy brief	• Key role of transparency and traceability of value chains to advance responsible production and consumption patterns.	
	Management tool	• ECE's smart food loss management system • Traceability for Sustainable Trade: A Framework to design Traceability Systems for Cross Border Trade	
Data, standards and guidelines	**Standards**	• ECE quality standards for the safe and transparent trade of food and agricultural produce • UN/FLUX fisheries data management standard • Implementing UN/CEFACT e-Business standards in agricultural trade • Standards for the Sustainable Development Goals	
	Platform	• Multi-stakeholder policy platform to accelerate action for sustainable and circular value chains for the garments and footwear industry.	

3.3 Life Cycle of Vehicles

The 2030 Agenda for Sustainable Development makes a direct reference to sustainable transport systems, universal access to affordable, reliable, sustainable and modern energy services, and quality and resilient infrastructure, as a basis for building a strong economic foundation (UN, 2015, para. 27). This example from the 2030 Agenda serves to highlight some of the intersectoral linkages between transport, land use, economic development and energy. It is for example not possible to build transport infrastructure without the loss of soil resources (e.g. due to soil sealing), and rendering land unusable by other uses, notably agriculture and forestry. Another example is that nearly the entire energy consumption of the transport sector still consists of fossil fuels, which emit carbon dioxide (CO_2) and other pollutants, affecting air quality and public health. For instance, air emissions by the transportation sector account for approximately 24 per cent of total CO_2 emissions on a global scale (ECE, 2015a, IEA, 2019a). Moreover, there are many indirect cause and effect relationships (e.g. respiratory problems due to air pollution). Transport infrastructure also makes possible the extraction of materials found in remote places. Transport cannot be analysed in isolation from other sectors: this emphasises the need for the nexus approach and integrative solutions when tackling transport-related challenges.

The ECE's work in the area of transport relates to the promotion of sustainable transport through its framework for intergovernmental cooperation, focusing in part on efforts to improve safety and environmental performance in transport. This covers, amongst other things, a legally-binding framework for the sustainable development of national and international road, rail, inland water and intermodal transport, including the transport of dangerous goods, as well as the construction and inspection of road motor vehicles.[11] However, as the global population continues to increase, the provision of sustainable transport is becoming more and more necessary to improve air quality, public health and accessibility, and minimise stress and damage to natural resources in general. It is consequently important to review some of the nexus hotspots underlying the provision of clean and sustainable transportation.

3.3.1 Defining the Nexus Hotspot on the life cycle of vehicles

Transport is inherently related to how we design our living environment, reflecting numerous value chains related to land use, energy, raw materials and the environment in general. This can range from the extraction of minerals and metals needed to build a vehicle to standards applied in road safety and associated infrastructure to the digitalisation of transports and the sharing of information concerning logistics and the movement of products. There is an increasing need to understand vehicle production and use from a systems perspective. In this particular instance, this will involve considering the environmental impact of vehicles throughout their life cycles as well as considering a broader circular economy perspective, through a life cycle assessment. Reviewing the life cycle of a vehicle implies assessing the environmental impacts associated with all stages of the vehicle's life, from the cradle to the grave, while the circular economy relates more to impacts and possible systemic solutions.

What is a life cycle assessment?

As characterised by UNEP-SETAC,[12] **a life cycle approach** relates both to opportunities and risks associated with a product, ranging from the raw materials used to produce, recycle and re-use (UNEP, 2005, 2011). One way to do this is to use a life cycle assessment (LCA). An LCA is basically an environmental accounting methodology that allows for the identification, quantification and assessment of impacts that a product may have with regard to all relevant material flows. For example, with references to a vehicle, this can relate to natural resources, energy, waste and emissions used or produced throughout its entire life cycle (Egede et al., 2015, Pero et al., 2018, Qiao et al., 2019). Analysing the life cycle of a vehicle can help to reveal **inefficiencies along the value chains** involved in the automobile industry, as well as to provide the evidence base for complex policy choices. For this report, the added value of considering the life cycle of vehicles is that it allows for a perspective whereby all the sectors involved in producing, using and recycling vehicles and their many components can be considered.

11 See: https://www.unece.org/trans/trans/conventn/latest.html.

12 See: https://www.lifecycleinitiative.org/.

Transport contributes directly to five Sustainable Development Goals (SDGs) targets as related to **road safety** (3.6), **energy efficiency** (7.3), **sustainable infrastructure** (9.1), **urban access** (11.2), and **fossil fuel subsidies** (12.c). Sustainable transport is therefore essential to achieve a wide range of SDGs.

What impact does a vehicle have on the environment?

Vehicles, referring principally to automobiles, have a huge environmental footprint, from the emission of air pollutants and greenhouse gases (GHG) to road infrastructure. The automobile industry consumes a lot of natural resources even before the vehicle makes it to the road, principally as car production means the use of materials such as steel, rubber, glass, paints and rare metals. In addition, the automobile industry relies on oil and petroleum products for the synthesis of plastics and other synthetic materials. This is even before factoring in the impact from fuel consumption as well as the end of a vehicle's life, implying the recycling of plastics, batteries and other products that may be harmful to the environment. In fact, the emissions associated with producing a car typically rival the exhaust pipe emissions over its entire lifetime.

Global impact of the transport sector

- 98.1 million motor vehicles were produced globally in 2018 (ACEA, 2019).
- Globally, transportation accounts for **24 per cent of GHG emissions** from fuel combustion, with road transportation accounting for approximately ¾ of this share (IEA, 2019c).
- After three years of stability, emissions from fuel combustion began increasing again, reaching **32.8 billion tons** in 2017 (IEA, 2019a).
- **3.7 million deaths** annually can be attributed to outdoor pollution. This is, however, not exclusively related to emissions from transport (UNEP, 2017).
- **90 of 193 countries** do not have vehicle emission standards (UNEP, 2017).
- Car buyers continue to purchase **larger, heavier vehicles**, in developed and developing markets (IEA, 2019c).
- Estimated emissions for manufacturing of vehicles with internal combustion engines are **10.5 tonnes** of CO_2 per car, compared to emissions for an electric car of 13 tonnes, including battery manufacturing (Qiao et al., 2019).*
- Estimated emissions for vehicle recycling, battery recycling and material recovery are **1.8 tonnes** of CO_2 for a fossil-fuelled car and **2.4 tonnes** for an electric car, including battery recycling (Qiao et al., 2019).*

* Estimates based on vehicles produced and recycled in China (see Qiao et al. (2019) for more information).

One core challenge for the transport sector, and in effect the transport-environment-land use-energy nexus, will thus be to meet the future demands for sustainable transport services while maintaining or improving the quality of the environment and reducing GHG emissions. This would entail addressing the trade-offs related to environmental impact and natural resource use.

Impacts from the transport sector in the ECE region

- Approximately **25 per cent** of all cars produced globally are being produced in the EU (ACEA, 2019). In 2018, around 58 million vehicles were produced in the ECE region, as a whole, while 18 million motor vehicles were produced in the EU (OICA).
- Transport continues to be a significant source of air pollution, especially of Particulate Matter (PM) and nitrogen dioxide (NO_2).
- In 2016, road transport was responsible for almost **86 per cent of total CO_2 emissions** from fuel combustion of the transport sector* in the ECE region, while **44.4 per cent of GHG** emissions from transport were from passenger cars in the EU (EEA, 2016).
- Emissions of GHGs from the transport* sector have increased by 18 per cent since 1990 for the ECE region. (EEA, 2015c).
- The use of diesel remains dominant in Europe, representing **67 per cent of total fuel used** for road transport in 2016 (EEA, 2018b). Diesel fuel consumption is also significant in the ECE region, where the proportion of diesel has increased from 28 per cent in 1990 to **39 per cent** in 2017.
- Total CO_2 emissions from vehicle production in Europe have fallen by nearly **24 per cent** since 2008. However, the number of cars produced have increased from 11.9 million in 2013 to **17 million in 2017** (ACEA, 2019).
- Up to **30 per cent** of Europeans living in cities are exposed to air pollution levels exceeding EU air quality standards (EEA, 2015a).
- Around **98 per cent** of Europeans living in cities are exposed to levels of air pollutants deemed damaging to health by the World Health Organization (EEA, 2015a).
- In 2016, the total reuse and recycling rates of end-of-life vehicles ranged from 78 per cent to 100 per cent in the EU (Eurostat).[13]

* Transport sector excludes international marine and aviation bunkers.

Where and how are vehicles produced?

Due to the differences and characteristics underlying individual transport sectors (e.g. aviation, road transport, rail and shipping), it is not possible to provide a comprehensive overview of all modes within the scope of this report. The emphasis in this section will be to introduce some of the interactions and trade-offs associated with the automobile industry (principally passenger cars), although the scope of the analysis could be widened at a later stage.

13 See: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_waselv&lang=en.

It can be noted that the automobile industry is highly concentrated, which means that the top 20 producing countries account for 90 per cent of global production. China is presently the biggest vehicle producer, accounting for approximately 25 per cent of global production. The United States and Japan are the second and third producers accounting for 13 per cent and 11 per cent, respectively, of the production of the global vehicles. Germany is the top automotive exporter. It accounts for 18 per cent of the global gross exports, followed by Japan and the United States.[14]

Several value chains are inherently involved in vehicle manufacturing. Neverthless, while distributed around the globe, the automobile industry still tends to be organized in clusters. This essentially means that while the supply chains are becoming more integrated on the global level, actual vehicle assembly remains close to the market. For instance, in the EU, approximately 85 per cent of all the cars sold are also produced in Europe (Bailey et al., 2010).

Box 3: Snapshot case: Climate impact of electric cars

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

Battery Electric Cars (BEVs), frequently also called EVs, are fully-electric vehicles that utilise rechargeable battery packs as compared to Internal Combustion Engine Vehicles (ICEVs) or hybrids. In 2018, the global EV fleet exceeded 5.1 million, up 2 million from 2017. Presently, EVs account for 1.7 per cent of the passenger vehicles sold in the EU. While this may appear small, as compared to ICEVs, it represents a 67 per cent increase from 2018.

EVs are being marketed as one way to decarbonise road transport and contribute to the transition towards a green economy, however, as demonstrated by recent research, the impacts of EVs are highly dependent on the vehicle's use, energy consumption and the electricity mix used for manufacturing, charging and decommissioning. In effect, EVs may lower the levels of air pollution (e.g. in urban areas), but the production of electricity for battery charging is energy-intensive and involves atmospheric emissions at the power plant. Other trade-offs are also foreseeable, such as high CO_2 emissions, eutrophication and human toxicity associated with EV manufacturing and recycling.

In effect, this implies that while EVs can be climate positive, this depends entirely on where the vehicle is located (e.g. carbon intensity of the electrical grid), when it is being recharged (e.g. CO_2 emissions are affected by the demands on the grid), and ultimately, how the materials used are being produced and recycled (e.g. carbon intensity of batteries).

ECE supports the work on EVs, amongst other things, through its adoption of an Electric Vehicle Regulatory Reference Guide[15] intended to serve as a point of reference for environmentally-related EV requirements. The guide focuses in part on standards that are available for voluntary compliance (e.g. energy efficiency standards and recycling/reuse). For instance, the EU end-of life-vehicles (ELV) Directive sets a reuse/recycling target of 85 per cent by weight of an ELV and reuse/recovery targets of 95 per cent (Directive, 2000/53/EC). A joint task force between groups of experts on EV and on energy efficiency is also being initiated to work on the energy life cycle emissions of EVs.

Sources: IEA (2019b), Egede et al. (2015), Pero et al. (2018) and Qiao et al. (2019).

As noted earlier, a wide range of natural resources is utilised during vehicle production. For instance, an average Internal Combustion Engine Vehicle (ICEV) is made up of approximately 70 per cent steel, 12 per cent synthetic materials and plastics, 5 per cent rubber, 4 per cent gas, oil and grease, 3 per cent glass, 2 per cent non-ferrous metals,

14 See: http://www.oica.net/wp-content/uploads/By-country.pdf.

15 See: https://www.unece.org/fileadmin/DAM/trans/doc/2014/wp29/ECE-TRANS-WP29-2014-81e.pdf.

2 per cent aluminium, 1 per cent lead and 1 per cent foam and cables (OFEFP, 2003).[16] These products come from a wide range of sectors, including mining industries that extract the raw materials to companies that process the raw materials so that the automobile industry can use them. In turn, the waste generated when manufacturing a vehicle corresponds to approximately 8,000kg raw material residues, 2,000kg rocks, 175kg copper, nickel and other types of residues from mining of the materials used (OFEFP, 2003). Aside from the automobile industry itself, this breakdown demonstrates not only the significant number of sectors involved in the value stream but also the significant material uses and waste generated when manufacturing a vehicle. It further helps to highlight the complexity inherent in tackling resource efficiency (e.g. every value chain associated with vehicle production has its own stakeholders and public/private interests).

3.3.2 Why focus on the life cycle of vehicles?

Transport is ultimately closely linked to economic, social and environmental development. For example, during economic growth, more goods are being exported and imported, and more people travel. In turn, increased transport has a significant impact on the environment, land-use, efforts to curb climate change and public health. On the other hand, the non-availability of transport and adequate vehicles impacts sectors such as the primary agricultural production and the food industry negatively, creating delays and food loss. The transport sector can thus not be reviewed in isolation from all the other sectors being affected. In a nutshell, progress towards sustainable transport requires a systems-based perspective that can account for intersectoral interrelationships and interdependence. Key to the understanding of the system is a common awareness of how environmental, economic and social systems interact, demonstrating the need for integrated solutions. It is also precisely because of this reason that a nexus approach can be advantageous. Moreover, placing emphasis on the life cycle of vehicles allows for a broader and longer terms perspective with regards to how vehicles are being produced and used. More importantly, it brings to the forefront many of the relationships described above. For example, it is not possible to produce the steel used in a car without also producing a lot of waste nor is it possible to fully understand the impact of new modes of transport (e.g. BEVs) without taking a life cycle perspective (see Box 3).

3.3.3 Intersectoral areas of work affecting transport

Energy use in the transport sector

Transport is responsible for around 29 per cent of the global energy demand (IEA, 2019c). For instance, the various types of transport (e.g. aviation and passenger cars) directly determine the amount and types of energy used. Factors that contribute to changes in energy consumption include the economy, oil prices and improved efficiency of vehicles. For instance, during the economic recession in 2008, there was a notable drop in energy consumption in the EU (EEA, 2015c). This highlights the strong interlinkage between the state of the economy and energy demand from the transport sector.

Energy consumption in the transport sector has grown significantly. Between 1990 and 2017, there was a net growth of total final consumption of energy of just 1 per cent in the ECE region. Diesel fuel consumption is significant in the ECE region, where the proportion of diesel has increased from 28 per cent in 1990 to 39 per cent in 2017. Similarly, the proportion of renewable energy used in transport in the ECE region has increased over time, reaching 4.7 per cent in 2017 (not including electricity). In the United States of America, petroleum products accounted for about 92 per cent of the total energy use by the transportation sector while biofuels, such as ethanol and biodiesel, contributed about 5 per cent in 2018.[17]

16 See: http://www.grida.no/resources/5697.

17 See: https://www.eia.gov/energyexplained/use-of-energy/transportation.php.

The issue of energy efficiency and the replacement of fossil fuels as a source of energy clearly connects the transport sector and energy systems on a technological and economic level. While the average fuel economy and energy efficiency of vehicles continue to improve, further and enhanced efforts to reduce energy consumption are needed. However, improved energy efficiency in transport is not possible without intersectoral action. This range from supporting technological innovation to changing how the public behaves to the policymaking processes that help to facilitate innovations and behavioural change.

Emissions and air quality

The production of fuels and vehicles, and the recycling/reuse of vehicles, account for approximately 40 per cent of emissions for a medium-sized ICEV, of which around 21 per cent is from vehicle production. The amount and type of energy used by different types of vehicles, in turn, determine the magnitude of GHG and air pollutant emissions. For instance, the introduction of fuel quality standards limiting sulphur in fuels, together with vehicle emission standards for cars and the steady renewal of the vehicle fleet in Europe, has played a significant role in reducing emissions of three important air pollutants, namely, sulphur oxides (SO_x), nitrogen oxides (NO_x) and PM. Emissions of lead and carbon monoxide (CO) have also decreased significantly. For instance, with the introduction of unleaded fuel, lead emissions have dropped to almost zero across Europe. The use of catalytic converters, coupled with the above-noted emission standards, has in turn reduced CO, hydrocarbon (HC) and NO_x emissions from gasoline engines by more than 70 per cent since its introduction (EEA, 2015c).

It has been estimated that air pollution, principally PM2.5, was responsible for **422,000 premature deaths** in the EU in 2015. It also has a considerable economic impact. The total health-related external costs of air pollution have been estimated at between **330 and 940 billion Euros** annually. In addition, air pollution affects agricultural productivity (e.g. affects vegetation and fauna directly, as well as the quality of water and soil) and causes biodiversity loss (EEA, 2018a).

Reaching levels of good air quality remains a challenge, especially in urban areas, where there are high volumes of traffic. For example, the annual limit value for nitrogen dioxide (NO_2), one of the pollutants typically associated with vehicle emissions, was exceeded across Europe in 2016 (EEA, 2018a). While progress has been made, tackling these challenges will require action in several sectors, ranging from improved urban planning to enforcing stricter emission standards.

Water and energy use

The automobile industry is a major consumer of water; in fact, water is the natural resource used the most in vehicle manufacturing. To this can be added that energy is the second most used natural resource, where 2.74 MWh of energy is used during vehicle manufacturing, on average, per vehicle (Babel et al., 2019, Semmens et al., 2014). Water conservation has thus become an increasingly important topic as related to sustainable vehicle production.

Estimates with regards to water consumption along the entire life cycles of a vehicle* in Europe range from **52 to 83m³ per vehicle**. From this, approximately **95 per cent is consumed in the production stage** (mainly due to the production of iron, steel, precious metals and polymers) (Berger et al., 2012).

* Range of water use relates to Volkswagen models Polo, Golf and Passat.

The water footprint of a vehicle demonstrates the many interlinkages between the mining industries, water and energy use associated with the different stage of a vehicles life cycle. In fact, water and energy use must be reduced substantially to achieve a reduction in CO_2 emissions with regards to vehicle manufacturing.

Transport and its effects on biodiversity

Transport infrastructure and the use of vehicles can affect ecosystems and biodiversity in different ways. For example, infrastructure can alter the connectivity of habitats and create physical barriers to the movement of plants and animals (e.g. habitat fragmentation). Increased pollution can, in turn, affect surrounding habitats negatively (e.g. reducing air, soil and water quality), which amongst other things has an impact on vegetation, plant-insect interactions and soil fauna in proximity to the road. Invasion of alien species is furthermore commonly associated with transport corridors. At the very least, transport infrastructure reduces the area of natural habitats. Animals can also be injured/killed by vehicles on the road or exhibit behavioural changes (e.g. changes in migratory behaviour). While environmental policies (e.g. stricter protection rules) have been introduced to establish procedures to minimise the impact from transport infrastructure (e.g. tunnels or nature bridges to increase connectivity), gaps concerning their implementation in practical terms remain. It also demonstrates the trade-offs between socio-economic benefits derived from increased connectivity to adverse environmental effects from transport.

Noise pollution in urban areas

While noise pollution is not directly associated with natural resources use, it is nevertheless an important environmental health problem that is linked to transport. In fact, road traffic is the most widespread source of environmental noise in Europe. Noise from road traffic has moreover been noted as the second most harmful environmental stressor in Europe, behind air pollution, according to WHO. The harmful effects of noise arise mainly from the stress reaction it causes in the human body, which can also occur during sleep. It can also be added that noiseless vehicles, such as EVs, are also increasing the risk of crashes with vulnerable road users (e.g. the ECE has adopted regulations to add artificial non-disturbing noise to EV driving to make it more noticeable to other road users).

> Noise pollution from transport affects more than **100 million people** in Europe, which implies that people are continuously exposed to average sound levels of 55 dB (or higher) due to noise from road traffic. The WHO Night Noise Guidelines for Europe recommend that exposure should not exceed 40 dB (EEA, 2014).

Tackling noise pollution could include measures to improve traffic flow, lowering speed limits, replacing road surfaces as well as improved urban planning. It could furthermore include measures to raise awareness on noise pollution. However, the main message is nevertheless the impact that the transport sector, and our use of vehicles, have on public health. It demonstrates one interrelation between transport demands and health, highlighting the need for integrative and innovative solutions.

3.3.4 What is the ECE doing to address sustainable transport?

The trade-offs between natural resource use and transport are somewhat paradoxical as transportation can produce substantial socio-economic benefits while having a negative impact on the environment. Transport is ultimately a sector that supports other sectors, such as trade and agriculture, but it also introduces barriers between natural habitats, emits pollutants and contributes to the introduction of invasive species. These examples highlight some of the many trade-offs associated with the production and use of vehicles as well as transport infrastructure. It further emphasises the added value of taking a nexus approach when considering these intersectoral interlinkages.

ECE contributes to the transport challenge in several ways. The Working Parties of the Inland Transport Committee (ITC) deal with intersectoral topics, such as pollution, energy and noise, amongst other things. The work being carried out through these intergovernmental decision-making bodies contributes towards improving the environmental performance and energy efficiency of the transport sector. Examples include globally harmonized UN regulations on the recyclability of motorized vehicles, developed at the ECE, which help to reduce the environmental footprint and life cycle impact of vehicle production and disposal, as well as ECE recommendations on fuel quality, which has just been revised to adjust to the latest vehicle emission standards. Another example is the Transport, Health and Environment Pan-European Programme (THE PEP), which deals with the interlinkages between transport, health and the environment.[18]

18 See: https://thepep.unece.org/.

3.3.5 ECE tools and approaches relevant in the area life cycle of vehicles

	Type of Tool(s)	Description	Sub-programme(s)
Inter-governmental bodies	**Programme of Work**	Inland Transport Committee World Forum for the harmonization of vehicle regulations: • Working Party on Noise and Tyres • Working Party on Pollution and Energy	
	Programme of Work	Convention on Long-range Transboundary Air Pollution: • Working Group on Effects • Working Group on Strategies and Review	
	Policy platform	Transport, Health and Environment Pan-European Programme (THE PEP)	

	Type of Tool(s)	Description	Sub-programme(s)
Regulations	**UN Regulations**	Uniform provisions concerning: • Emission of gaseous and particulate pollutants (UN Regulation No. 49) • Emission of pollutants according to engine fuel requirements (UN Regulation No. 83) • Approval of compression ignition (C.I.) (UN Regulation No. 96) • Emission of carbon dioxide and fuel consumption and of categories M1 and N1 vehicles equipped (UN Regulation No. 101) • Approval of motor vehicles with regard to their reusability, recyclability and recoverability (UN Regulation No. 133)	
	UN Global Technical Regulations	• Measurement procedure for the emission of gaseous pollutants, CO_2 emissions and fuel consumption (UN GTR No.2) • Test procedure with regard to the emissions of pollutants (UN GTR No.11) • Worldwide harmonized Light vehicles Test Procedure (UN GTR No.15)	
Data, standards and guidelines	**Statistical Repositories**	• ECE/ITF/Eurostat common questionnaire on transport statistics • Harmonized glossary for transport statistics	
	Guidelines	• ECE Code of Good Practice: Reducing food loss in handling fruit and vegetables	

3.4 Land Value Capture

A fundamental driver of future land use is population growth. Nowadays, more people live in urban areas as compared to those living in rural areas. While increased urbanization is associated with increased economic growth, as well as other socio-economic benefits, it is also having a profound impact on the environment, especially with regard to land and water use. Urbanisation is for this reason considered to be one of the most significant anthropogenic factors affecting our natural environment. For instance, due to urbanization (e.g. impacts resulting from new buildings, roads and infrastructure), available agricultural land is decreasing, in turn, this has significant implications in terms of food security. Aside from land-use change, the expansion of urban areas has also resulted in marked changes to natural resource use (e.g. provision of resources for growing cities), such as increased water use and deteriorating water quality (Patra et al., 2018). This highlights that it is not possible to expand a city (e.g. for housing or new infrastructures, such as transport), without also converting arable land, grasslands, forests and other types of landscapes. It further demonstrates the inherent interlinkages between land use, urban development, food security and natural resource use. It is thus not possible to consider the rapidly increasing number of people living in cities without the effects this is having on our environment, nor is it possible to tackle the associated intersectoral challenges and opportunities without also taking an integrated perspective.

The ECE's work in this area relates directly to urban development, housing and land management covering such topics as energy-efficient and adequate housing, sustainable cities, efficient land use and land administration.[19] These efforts are essentially based on key UN policy documents related to housing and urban development, including the Geneva UN Charter on Sustainable Housing and the Strategy for Sustainable Housing and Land Management 2014-2020, which address fundamental aspects of efficient natural resource use for growing cities. This work demonstrates not only the pressing need for sustainable urban development but also the importance of addressing urbanization and associated land-cover change and natural resource use outside their given silos. Against this background, an integrated perspective is needed, particularly as regards the relationship between cities and the provision of natural resources.

3.4.1 Defining the Nexus Hotspot on land value capture

Land management can be found at the nexus of urbanization, water, food, energy and sustainability; however, land use is generally not governed in an integrated way. There are, at present, no policy frameworks that can effectively deal with complex land use issues, urbanisation is one of these. In fact, from an international, regional or national perspective, there is a fragmented and incoherent landscape of policies and institutions that govern different aspects of land use, operating from a silo perspective (Aggestam and Vogelpohl, 2009). In an urban-rural context, this can range from sectors dealing with agriculture and forestry to energy, water as well as transport and trade, to name but a few. However, one often overlooked issue in this bigger picture concerns the value that is being attached to the land. In fact, land value often has less to do with land quality than with the value attached to specific land uses, which is often driven by socio-economic factors. For instance, environmental considerations (e.g. ecosystem services provided by land) are often undervalued, which can relate to the failure of the market to capture the environmental costs and benefits of natural resource use. Land value, therefore, represents a useful nexus perspective on competing land demands and in effect, also natural resource use.

What is land value capture?

Land value capture (also known as value sharing) is a land-based tool or policy approach, that can be used to **increase the value of urbanisation** to support public investments, such as transport infrastructure. In a nutshell, land value capture is basically a process by which increasing land prices (e.g. due to population growth and economic development), generated through the provision of urban infrastructure and/or services, is used to finance these developments (OECD, 2017, FAO, 2017c). For instance, by transforming rural to urban land, or by providing relevant infrastructure, it is possible to stimulate higher land prices. These increments in land value can then be used to generate a profit that goes towards

19 See: https://www.unece.org/housing.html.

public goods, such as the costs of the public infrastructure that makes possible projects, such as social and affordable housing. It is essentially based on the idea that public action should also generate public benefit.

Urban development, housing and land management contribute directly to two Sustainable Development Goals (SDGs) as related to **life on land** (SDG 15) and **sustainable cities and communities** (SDG 11). Land use and management can play an inherently important part of the achievement of several SDGs.

Why is land value capture relevant for the environment?

The reason for considering land value capture in this report is twofold. First, land value capture illustrates some of the intersectoral interactions that are associated with urbanisation and land management, including effects these interactions may have on natural resource use. More specifically, it is a useful medium to illustrate some of the trade-offs related to generating economic and social value for the public as compared to the effects this can have on the environment. Second, land value capture essentially represents a useful governance tool that can integrate different sectors in the pursuit of a common objective, such as enhancing urban climate resilience. Ultimately, the integration of land use and value-based policies would be a necessary step in the pursuit of practical and innovative solutions for a range of issues related to housing, employment, development and urbanisation.

Global impact of urbanisation

- Cities account for **75 per cent of global resource consumption**.[20]
- **100 million ha of land** is estimated to be required for residential, industrial and infrastructure developments by 2050. More than 90 per cent of this is in developing countries (FAO, 2011b).
- Cultivated land per person has declined to **less than 0.25 ha per capita** over the last 50 years. In contrast, global agricultural production has grown 2.5 times, while cultivated land has increased by only 12 per cent (FAOSTAT, 2015). The main drivers of change in this ratio are population growth, urbanisation and a major increase in productivity of agricultural land.
- The density of bird and plant species (no. species per km^2) has declined significantly in urban areas. Globally, only **8 per cent of native bird** and **25 per cent of native plant species** are currently present in urban as compared with non-urban areas (Aronson et al., 2014).
- Future urbanization may have severe impacts on **global biodiversity hotspots**. Globally, urban areas located within biodiversity hotspots have already disturbed regions that contain **10 per cent of all terrestrial vertebrates**. Forecasts suggest this to increase by four times until 2030 (CBD, 2012).
- Globally, **400 million people** living in urban areas currently face water shortage while **141 million** do not have access to improved drinking-water and 794 million live without access to improved sanitation facilities (WHO/UNICEF, 2017a).
- Water stress is a major concern in many urban areas. Urban water demand is expected to increase by **80 per cent** by 2050. Moreover, **36 per cent of all cities** may face a water crisis in the same time period (Flörke et al., 2018).

20 See: https://www.un.org/sustainabledevelopment/cities/.

Impacts from urbanisation in the ECE region

- **80 per cent** of people in the EU live in cities.
- Annual land take[21] in European countries (EEA-39)22 was approximately 107 6 km2 per year during the 2006 to 2012 period (EEA, 2017c), but fell to 827 km²/year in 2012-2018.
- **46.2 per cent of all land areas** that changed to an artificial surface in the EEA-39 was from agricultural land. Urban developments were in effect responsible for more agricultural land take than any other type of land (EEA, 2017c)
- In 2015, approximately **30 per cent of the total European population** was exposed to water scarcity conditions, most of which lived in urban areas (EEA, 2018d).
- Urban populations account for **69 per cent of European energy** use and thus, most greenhouse gas (GHG) emissions.
- Biodiversity is in strong decline. **42 per cent of all terrestrial animal and plant species** have declined in population size in the last decade. Land-use change, leading to habitat loss, is in turn, a major driver causing the loss of biodiversity in Europe and Central Asia (IPBES, 2018).

Where and how is land value capture being applied?

Rapid urbanisation, climate change and deteriorating infrastructure are some of the underlying drivers behind the application of land value capture. However, building resilient infrastructure is a major challenge, and financing these investments makes it even more challenging. This is one reason why land value capture has seen numerous applications all over the world, ranging from the development of new cities to urban highways and airports (WB, 2009). In the ECE region, the demand for infrastructure has mainly been driven by the housing and transport sectors (e.g. for roads, metros and rail). Examples, where countries have applied land value capture approaches, include mega projects (e.g. Nine Elms) and housing projects (e.g. Cirencester Chesterton Development) in the United Kingdom as well as efforts to address regional fragmentation in France (Huston and Lahbash, 2018). However, while land value capture approaches are innovative, integrative, and increasingly an accepted way to fund public infrastructure developments, their practical application remains somewhat limited due to technical, legal and administrative challenges (Huston and Lahbash, 2018, OECD, 2013). Progress on these issues has been made in some countries.

There are several tools available for capturing the value generated by public investments that affect the land price. Land value capture tools include:

- Taxes, such as property tax rates or Tax Increment Financing (TIF). Examples include a financing scheme in New York City to extend its subway or the use of business rights for the partial financing of the Canary Wharf in London.
- Fees, such as betterment levies. Examples include development charges, commonly used by municipalities, to finance new infrastructure development.
- Developer land sales. One example is the extension of the Copenhagen Metro, which was entirely financed through developer land sales, user fares and tax revenues.
- Regulations, such as the sale of building rights. Examples include transferable development rights, whereby landowners can exchange the land needed to build new infrastructure for an area elsewhere.

21 Conversion of agricultural, forest and semi-natural land to urban uses, developer land sales.
22 See: https://www.eionet.europa.eu/countries.

It is further possible for actors (e.g. municipalities) to engage directly in property development (e.g. public-private partnerships to share costs) as well as real estate development (e.g. as joint ventures with private real estate developers) to finance infrastructure developments (OECD, 2013).

Land value capture (in its various forms) is ultimately a form of public financing that is applied to harness the value that public infrastructure can generate. However, while having this in mind, this raises questions as to why it is not being applied more regularly. For instance, the increased land value could be used to finance green infrastructure, such as to reduce flood risk, restore natural floodplains, enhance climate resilience and ecosystem services, while also generate social and economic benefits to the public. Yet, despite green growth opportunities, practical applications up to this moment remain limited. The reasons for this may be due to the fact that greening urban systems is expensive and requires shifting of investments. Moreover, the benefits may be more long term (IDB, 2017, OECD, 2012a).

Box 4: Snapshot case: Green Finance

The latest Global Green Finance Index named Amsterdam as one of the leading centres for green finance. Green finance can be defined as any financial instrument or service, which has a positive impact on the environment and society, over the long term. This includes but is not limited to different value capture approaches.

One example is the Sustainable Finance Lab,23 an initiative of the City of Amsterdam and the Dutch bank ABN AMRO, which works towards identifying new financing mechanisms for realising the transition towards sustainable cities (e.g. ecosystem services, energy, water, raw materials and transportation) and a circular economy. The Lab is basically a forum for stakeholders from different sectors (e.g. public, private, NGO and research) aiming to develop new financial solutions for sustainability challenges. It has, amongst other things, tackled financing of green areas around Amsterdam, where land value capture is an inherent aspect of implementation.

The ECE principally supports the work on land value capture as a factor of housing affordability. This is an effort to address the negative effects of the increase in land value. Moreover, in terms of transport, ECE has put value capture forwards as an approach for financing transport infrastructure.

Sources: Wardle et al. (2019) and ECE (2017c)

3.4.2 Why focus on land value capture?

There is added value in considering land value capture, particularly, as land value capture effectively reflects how the public utilise natural resources (principally land) to generate social and economic benefits. As noted earlier, it also reflects inherent trade-offs in land management. For instance, the soil is a limited and non-renewable natural resource, which is utilised to develop most types of public infrastructure. This is often an irreversible process. Infrastructure developments consequently imply trading one resource for another. Moreover, while economic agents can capture the value of public investments, they are most often unable to capture other types of values, such as biodiversity value.

Another reason why land value capture and other similar approaches are important to consider is the fact that cities and urban areas are responsible for consuming most of our natural resources. For example, recent estimates suggest that cities are responsible for 55 per cent of spending and 64 per cent of investments in sectors that have a direct impact on climate change (OECD, 2019a). This implies that public and private investment choices in cities can (and do) have a significant impact not only on natural resource use but also on GHG emissions. So, while the link between natural resource use and land value capture may be indirect, capturing the full set of values from natural capital is an approach that can stimulate resource efficiency, contribute towards lowering emissions and ultimately decrease the use of natural resources (see Box 4). It could further be used to explicitly to fund green infrastructure as related to climate adaptation measures and biodiversity conservation.

23 See: https://sustainablefinancelab.nl/en/.

3.4.3 Intersectoral areas of work affecting cities and urban areas

Water and urbanisation

It is common knowledge that water demand across Europe has steadily increased over the past 50 years (e.g. due to agriculture). This has, amongst other things, resulted in an overall decrease in renewable water resources by 24 per cent per capita in Europe. Water demand from urban areas is a significant contributor to this decrease in renewable water resources. For example, in Europe, every person in a household uses about 144 litres of water, on average, per day. In turn, household water use represents approximately 18 per cent of total water use (Kristensen et al., 2004, EEA, 2018e). Water demand in urban areas is also expected to further increase in the future, which means that there is a high potential for conflicts between sectors (e.g. urban and agricultural sectors). This is especially the case if neither will be able to satisfy its demand.

The potential for conflicts over water, as well as the inherent limits to water supply, highlights the importance of improving water use efficiency, both in the agricultural sector and in urban areas (e.g. improving infrastructure). One key challenge will, however, be to finance the investments needed to improve water use efficiency. This is an area of work where land value capture approaches could play an important role in terms of either helping to directly finance investments or creating the necessary incentives needed to invest in water use efficiency (e.g. through taxation). This is consequently an example where land value capture approaches can have a direct impact on natural resource use.

Biodiversity, green infrastructure and cities

Cities are having a huge impact on biodiversity (e.g. due to habitat loss, pollution and over-exploitation of natural resources). In contrast, biodiversity provides a multitude of ecosystem services to urban areas, ranging from reducing noise to cleaning water to improving air quality. This also relates to green areas that for example, provide opportunities for recreation and education. These examples illustrate, on the one hand, how urban areas are negatively affecting biodiversity. While, on the other hand, biodiversity and green infrastructures clearly generate benefits for the general public.

During the 1992 to 2000 period, urban growth worldwide was responsible for the loss of **190,000 km^2 of natural habitat**. Leading up to 2030, it has been estimated that urban growth may threaten an additional **290,000 km^2 of natural habitat**. Urban growth has moreover been projected to destroy natural habitats that store an estimated **4.35 billion metric tons of $C0_2$** by 2030. To this can be added that **29 per cent** of all strictly protected areas are within 50km of an urban area, projected to be **40 per cent** by 2030 (McDonald et al., 2019).

Cities can play an important role in hosting rare and endangered species and habitat types. Green infrastructure could, for instance, be key to not only further strengthening sustainable urban development but also to support biodiversity conservation and ecosystem services. Land value capture could, in turn, be one of the instruments that enable cities to invest in relevant green infrastructure which can provide socio-economic as well as environmental opportunities.

Energy consumption and urban areas

Urban areas account for 60 to 80 per cent of global energy consumption and approximately the same percentage in terms of CO_2 emissions. Population growth and urbanization rates are, in fact, tied directly to energy production and use. The energy industry effectively imposes limits on urbanisation, for example, through the availability, cost and efficiency of energy. This co-dependency is also a bottleneck, where the energy sector affects land use and infrastructure developments associated with urbanisation.

The economic activity, transport costs, geographic factors, and urban form explain **37 per cent of urban direct energy use and 88 per cent of urban transport energy use** (Creutzig et al., 2015). Another example is the fact that buildings consume approximately **40 per cent of final energy use** in the EU. These issues highlight the need for intersectoral action as well as the overall potential to reduce urban energy use.

It is within the complex nexus of energy, urbanisation and populations where land value capture approaches could be one instrument that facilitates improvements in energy efficiency and a shift to renewable energy resources. This can, for example, relate to financing of energy infrastructure developments that target different stages of the energy life cycle, such as the location of use or production of natural resources to energy uses (e.g. transportation in the supply chain and energy-efficient buildings). Supporting energy efficiency in public infrastructure and the housing sector could in turn, have a major impact on natural resource use.

3.4.4 What is the ECE doing on land value capture?

While the land is a limited natural resource, there is no "one-size-fits-all" approach with regards to land management nor to mobilise public or private investment into green and sustainable infrastructure. The use of "land value" in this report principally showcases the complexity underlying competing land demands and interlinkages in terms of natural resource use and urbanisation; however, any financing solution needs to be tailored to specific national contexts. With this in mind, land value capture provides a useful nexus perspective, but it should be recognised that any application would need to be adapted to national and sub-national policy and regulatory frameworks. Another key message is the fact that the financing of green infrastructure as well as environmental and climate-related investments, are lagging behind. Action is thus needed to remedy this situation.

The ECE contributes to the housing and urban development challenges of the ECE region in several ways. The ECE Committee on Urban Development, Housing and Land Management has, amongst other things, recently called attention towards the use of land value capture in the provision of affordable housing.[24] The Committee is furthermore active in the transition towards energy-efficient housing, has issued an action plan for energy-efficient housing in the ECE region in 2010. The work on energy-efficient housing, smart cities and land management address many of the intersectoral challenges and opportunities facing the housing sector, in particular the transition towards a carbon-neutral and circular economy, where new, innovative and integrative solutions are needed. Reducing the environmental footprint of urban areas and housing will, in the end, have a huge impact on natural resource use in the ECE region and globally. It can further be noted that the ECE has taken up land value capture as an innovative approach to finance transport infrastructure (ECE, 2017c).

24 See: https://www.unece.org/fileadmin/DAM/hlm/sessions/docs2019/Info_3_2019_Land_Value_Capture.pdf.

3.4.5 EC/E tools and approaches relevant in the area of urbanisation and land value capture

	Type of Tool(s)	Description	Sub-programme(s)
Inter-governmental bodies	**Programme of Work**	Committee on Urban Development, Housing and Land Management: • Working Party on Land Administration • Real Estate Market Advisory Group	
Publications	**Action Plan**	• Action Plan for Energy-Efficient Housing in the ECE Region	
	Strategy	• Strategy for Sustainable Housing and Land Management 2014-2020	
	Policy instrument	• Geneva UN Charter on Sustainable Housing	
	Regional studies	• Promoting sustainable building materials and the implications on the use of wood in buildings	
	Good practice guidance	• ECE Guidelines on Social Housing • Guidance for the implementation of the Geneva UN Charter on Sustainable Housing • Policy Framework for Sustainable Real Estate Markets • Survey on Land Administration Systems	
Data, standards and guidelines	**Standards**	• International Land Measurement Standard	
	Management tool	• ECE's smart food loss management system.	

3.5 Natural resource use in transboundary basins

Climate change is aggravating water scarcity, especially where water demand compared to availability is high. Access to freshwater has global and regional implications as it may disrupt food production (e.g. affecting food security), energy production (e.g. affecting hydropower) and the production of water-intensive goods (e.g. vehicles and clothing). For instance, while region-specific, estimates suggest that there may not be enough water available to meet the global demand for both drinking and energy production by 2040 (Aarhus University, 2014). Water scarcity may further affect the environment and biodiversity (e.g. reducing the water flow available to sustain ecosystems) and generate conflicts within and across countries (e.g. due to not being able to meet different sectors' water needs at all times). These examples not only highlight the intersectoral nature of water-related risks but also demonstrate some of the synergies and trade-offs between water, food, energy, materials and land. For instance, the Food and Agriculture Organisation of the United Nations (FAO) argues that water security, energy security and food security are very much linked to one another and that actions in one sector will have – both positive or negative – effects on the other sectors (FAO, 2014c). It is therefore important to view water issues in a broader frame where access to water, food, energy and ecosystem services are understood as being intrinsically interlinked.

The ECE's work in this area is principally carried out under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), which aims to ensure the sustainable use and protection of transboundary water resources.[25] The Water Convention effectively provides a legal and intergovernmental framework for promoting an integrated approach to water management, and the water-food-energy-ecosystems nexus has formed a devoted area of work in the Convention's consecutive programmes of work. The Protocol on Water and Health to the Water Convention further aims to protect human health by better water management and by reducing water-related diseases. Given the increasing impact from factors such as population growth, economic development, energy and food demand, it is relevant to review some of the intersectoral challenges facing water management. Understanding these intersectoral interactions (e.g. conflicting sectoral objectives) may contribute towards finding intersectoral solutions as well as reducing demands and impacts on water resources.

3.5.1 Defining the Nexus Hotspot on natural resource use in transboundary basins

Having this in mind, the review of natural resource use in a transboundary basin – as a nexus hotspot – is particularly interesting because it addresses not only complex intersectoral dynamics but also the inherent transboundary complexities underlying natural resource use. For instance, in the case of a river basin, it is not possible to promote sustainable and integrated natural resources management without also addressing transboundary coordination. Moreover, it introduces another crucial component for this report, namely, the importance of intersectoral cooperation and participation of stakeholders in natural resource use, both on the national and transboundary levels.

What is the transboundary basin nexus assessment methodology?

With the support of the ECE, a **methodology for assessing nexus issues in transboundary basins** has been developed, in an effort to discover intersectoral links, trade-offs and synergies as well as to promote transboundary cooperation (ECE, 2018c, 2018d). Water flows across borders, affecting water-food-energy security across countries. Water, energy, food and ecosystems are inevitably interlinked as part of the natural environment. This basically means that actions taken in one area or sector will have an impact on others. For instance, in simple terms, producing food requires natural resources such as land, water and energy, which in turn affect ecosystem function. Moreover, using a natural resource, such as land and energy, for producing food precludes its use by other sectors. While certain types of trade-offs are inevitable, improving our understanding of these sectoral interlinkages can contribute towards making natural resource use more efficient and sustainable, notably through better informed and more transparent and participatory decision-making.

25 See: https://www.unece.org/env/water/.

The ECE Water Convention contributes directly to Sustainable Development Goal (SDG) 6 related to **clean water and sanitation**, in particular, target 6.5 on the implementation of **integrated water resources management**, including through transboundary cooperation. It also supports goals such as **SGD2** (Zero Hunger), **SDG3** (Good health and well-being), **SDG7** (Affordable and Clean Energy), **SDG13** (Climate Action), **SDG15** (Life on Land), **SDG16** (Peace Justice and Strong Institutions) and **SDG17** (Partnerships for the Goals).

Why is it relevant to review natural resource use in transboundary basins?

The transboundary basin nexus assessment ultimately aims to identify intersectoral synergies that can be explored and used in different transboundary river basins. In effect considering the social, economic and environmental specificities that are inherent for each basin. The assessment includes the identification of policy measures and actions that can potentially reduce conflicts between different sectoral objectives, resolve trade-offs, and improve overall natural resource use and management. The nexus perspectives provided through these assessments demonstrate how all relevant sectors can achieve greater sustainability and propose concrete packages of solutions to that end. Moreover, the transboundary basin nexus assessment is fundamentally a participatory process, carried out in close cooperation with the key ministries of the riparian countries, and also involving utilities and the civil society. This highlights one dimension of the natural resource nexus that has not been considered much by this report, namely, the importance of civil society participation in natural resource use. For instance, pollution (whether by air, water or land) does not necessarily respect international boundaries, while extensive water use by one country (e.g. for energy or food production) may have significant knock-on effects on surrounding countries. These examples emphasize that any integrative solution with regards to natural resource use also requires buy-in from all relevant actors and sectors, in particular, if the interrelated demand for water, energy and food is to be satisfied, at a level acceptable to all.

Global impact of transboundary water use

- More than **2 billion people** presently live in countries experiencing high water stress. It has further been estimated that **1/4 of the world's children** under 18 will be living in areas of extremely high water stress by 2040 (UNICEF, 2017).
- There are approximately **275 international or transboundary river basins** as well as around **300 major transboundary underground aquifers**. These rivers and aquifers supply water to **1/3 of the global population** (FAO Aquastat)[26] and cover nearly **50 per cent** of the Earth's land surface.
- **145 countries** have territory within a transboundary lake and/or river basins, and **30 countries** lie entirely within them (ECE, 2018b). To this can be added that around **2/3 of the world's transboundary rivers** do not have a cooperative management framework (SIWI).[27]
- Nearly **800 million people** in **40 countries** receive most of their daily water supplies from sources outside of their own country (IISD, 2016).
- Agriculture presently uses **70 per cent of all freshwater supply**. It is further expected that the pressure on the water will only grow given that the demand for food and energy is estimated to increase by 50 and 35 per cent, respectively, by 2030 (Unilever, 2015).

26 See: http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en.
27 See: https://www.siwi.org/priority-area/transboundary-water-management/.

- **The global water crisis** has been consistently recognized as one of the main threats facing the world in the coming decades (World Economic Forum, 2018). Water demand is expected to **increase by around 1 per cent per year** due to pressures from population growth, economic development and changing consumption patterns (FAO Aquastat).

Transboundary water use in the ECE region

- Nearly **30 per cent of the European population** was exposed to water scarcity conditions in 2015, compared to 20 per cent in 2014. This water scarcity was linked to drought conditions in **34 out of 116 river basin districts**, which corresponds to around 20 per cent of the European territory (EEA, 2018c).
- Data and information exchange appears to take place in nearly all the pan-European transboundary waters. However, joint monitoring and assessment do not take place in at least **32 out of 72 transboundary basins** (ECE, 2018e).
- There is a general **lack of harmonized governance and water management systems** related to transboundary waters in the ECE region (e.g. differing norms for water pollution control and water quality classification) (ECE, 2018e).

How is the transboundary basin nexus assessment methodology applied?

The transboundary basin nexus assessment was basically built around the implementation of a participatory process that aims to collect, process and analyse inputs and views from different sectors and countries within a given transboundary basin (e.g. Sava River basin, which is shared mainly by Bosnia and Herzegovina, Croatia, Montenegro, Serbia and Slovenia).[28] The overarching objective of this process was to generate joint solutions and shared actions for pressing issues (as identified by relevant actors and sectors). This work was mainly carried out through workshops providing for intersectoral and transboundary dialogue. The workshops are thus explicitly designed to facilitate dialogue and consultation between relevant sectors whereby possible solutions can be discussed and analysed jointly (ECE, 2018c, 2018d).

The transboundary basin nexus assessment methodology is carried out in six steps as follows:

1. **Identify general socio-economic and environmental conditions of the basin** (e.g. current state of energy, food, water and environmental security, availability of natural resources, and relations between the countries);
2. **Identify key sectors** (e.g. energy & agriculture) and **actors** (e.g. competent authorities) to be analysed in the assessment;
3. **Analyse key sectors** (e.g. resource flows are identified) and **governance set-up** (e.g. strategies, policies, rules and regulations) concerning the management of the natural resources in the basin;
4. **Organise a workshop** to analyse the results from the desktop study (step 1 to 3) to **identify interlinkages**, discuss them from a sectoral perspective, and develop a list of basin-specific interlinkages and **pressing intersectoral issues** (e.g. water constraints for agriculture or threats to ecosystem services);

28 See: http://www.unece.org/env/water/nexus.

5. **Nexus dialogue**, as part of the workshop, to provide different sectoral and country perspectives as well as to prioritise the identified interlinkages and issues. This dialogue provides the basis for **nexus storylines** and the emergence of possible **solutions**.
6. **In-depth analysis of inputs** of the first workshop provides the basis for **identifying solutions** to increase synergies in the management of water and other natural resources (e.g. technical solutions and policy interventions). This provides the basis for a **second workshop**, where the proposed solutions are translated into **feasible actions**, linked to actual policies and/or projects.

The active exchange of information between the implementing organisation and relevant stakeholders involved in the process is ultimately meant to integrate the knowledge and values of the stakeholders and result in joint actions that can have a positive impact on natural resource use (ECE, 2017a, 2018c, 2018d). The transboundary basin nexus assessment methodology underlines the fundamental importance of social innovation when integrating multiple aspects of natural resource use into a system of sustainable natural resource management. In the end, it is not possible to meet the explicit goals of different natural resource users without having an intersectoral and transboundary dialogue where relevant trade-offs and conflicting objectives are addressed directly (see Box 5).

Box 5: Snapshot case: Transboundary cooperation in the Drina River Basin

The Drina River Basin is shared by Bosnia and Herzegovina, Montenegro and Serbia. The basin is characterized by high levels of biodiversity, hydropower generation capacity (including unexploited renewable energy potential) and water quality issues (e.g. wastewater discharges and solid waste). The nexus assessment demonstrates that the basin's natural resources are subject to various development plans and pressures (e.g. altered river flow due to uncoordinated hydropower operations).

The assessment highlights that power generation is at the heart of the nexus in the basin and that water flow regulation for power generation is sub-optimal, having an impact on flood and drought risks. Most importantly, the assessment demonstrates how transboundary cooperation can generate mutual benefits around nexus issues, which would not be possible without joint coordination. In a nutshell, it is argued that intensified intersectoral cooperation could generate economic and environmental benefits. The follow up to the Drina nexus assessment included multi-stakeholder "Hard Talks" to trouble-shoot obstacles to renewable energy investment, linking to the transition to sustainable energy systems.

The ECE supports the work on the natural resource nexus, amongst other things, through its Task Force on the Water-Food-Energy-Ecosystems Nexus.[29] Moreover, the ECE Water Convention has published a transboundary basin nexus assessment methodology as an approach to address nexus challenges in a transboundary context (ECE, 2018c) and, building on the Drina nexus assessment, a toolkit for renewable energy policy-makers has been developed as a joint effort of the ECE Sustainable Energy and Environment Divisions. The toolkit seeks to inform different action tracks from strategic planning and policy design through to project development to promote cross-sector synergies and help address trade-offs.

Source: ECE (2017a).

29 See: https://www.unece.org/env/water/task_force_nexus.html.

3.5.2 Why focus on the transboundary natural resource management and use?

Taking a transboundary perspective is important simply because natural resource flows and interactions transcend political and geographical divisions. The premise for this type of cooperation is the importance of the natural resource (e.g. clean water) and the need for collaborative actions to prevent further degradation or damage to the natural resource (e.g. water extraction upstream may have an impact on water availability downstream). While water is a classic transboundary natural resource, the concept is equally applicable to any natural resource, such as forests, biodiversity and protected areas, that cross national borders, making a case for coordination and cooperation. Regional coordination in planning development of the energy sector, as well as regional trading of electricity, are means to use infrastructure and capacities more effectively and to build on complementary resource bases. The proper and effective management of transboundary natural resources is essential for overcoming key challenges related to transboundary effects and the sustainable use of natural resources (e.g. principle 2 of the Rio Declaration refers to the issues of sharing in the use and management of resources that move across international borders). In turn, it can be noted that the water-food-energy-ecosystem nexus approach can improve how transboundary effects can be managed, overcoming the siloed management of natural resources, policy fragmentation, and the establishment of procedures and structures for working across political and sectoral boundaries.

3.5.3 Intersectoral areas of work affecting transboundary water management

Biodiversity and transboundary water management

Unsustainable water use is a particularly significant driver of biodiversity loss, especially as there are many competing demands placed on water (e.g. agriculture accounts for approximately 70 per cent of all water extracted from rivers). Drivers, such as land erosion, nutrient runoff and infrastructure developments (such as dams and levees) are causing significant habitat change, which ultimately compromises crucial water ecosystem services and cause the loss of biodiversity (CBD, 2008).

Biodiversity of freshwater ecosystems is declining faster than for any other biome. Freshwater species loss is presently occurring **two to three times more quickly** than terrestrial or marine biodiversity loss. For instance, the recently published Living Planet Index for 2018 demonstrate that populations in monitored freshwater systems have declined by **81 per cent** during the 1970 to 2012 period. The decline in the marine living planet index for the same period, was **36 per cent** (WWF, 2018).

Leading up to 2050, it is expected that land-use change will continue to be a major driver in the provision of ecosystem services (CBD, 2008; WWF, 2018). While the effects this will have on natural resource use are complex and not solely limited to water, biodiversity considerations add significant weight to the case for wider adoption and implementation of transboundary cooperation. Transboundary cooperation is one prerequisite to achieve conservation goals across international boundaries, to effectively implement measures such as protecting and restoring critical habitats, safeguarding and restoring river connectivity, improving water quality, environmental flows and reducing pressures. Cooperation on many different levels is essentially required to halt freshwater ecosystem degradation, and biodiversity loss and the ECE multilateral environmental agreements support cooperative environment protection efforts. The ECE Second Assessment of Transboundary Rivers, Lakes and Groundwaters (ECE, 2011) featured 25 Ramsar sites and other wetlands of transboundary significance located in transboundary basins where synergizing between local cross-border conservation cooperation, and inter-governmental transboundary water management cooperation would be mutually beneficial and help reconcile water needs for the ecosystems and economic activities.

Water and energy production

Energy and water security are significantly interconnected; in fact, all water services require an input of energy, and vice-versa. It can, for instance, be noted that 80 per cent of the global electricity is produced by thermal power, which emphasizes the interaction between water and energy as conventional fossil-fuel and nuclear power plants require water to cool the steam they generate to make electricity. Moreover, as noted in the nexus assessment of the Drina River Basin (see Box 5), power generation is in fact often at the heart of the nexus, directly affecting the water flow of a river that crosses national borders. Integrating water resource and environment early on into deploying renewable energy can significantly add to its sustainability.

Energy production accounts for 15 per cent of global water withdrawals and is expected to increase to 20 per cent by 2035 (UN Water).[30] Water use does, however, vary greatly depending on the energy type, for example, one unit of energy (MWh) from natural gas or coal can consume between 4.1 and 4.4 m^3 water, while for nuclear power it is up to 3.2 m^3 water. In contrast, photovoltaic energy production uses nearly no water (Macknick et al., 2012).

While there is a multitude of complex and intersectoral factors affecting water security, existing and planned energy production is one of the more prominent drivers behind water use, especially in a transboundary context, such as hydropower (ECE, 2016a). This highlights the need for transboundary cooperation and the added value of taking a nexus approach not only across sectors but also across national boundaries.

Climate change, water and transboundary cooperation

Consistently across most climate change scenarios, water is projected to become increasingly scarce, with associated socio-economic and environmental impacts ranging from changing precipitation patterns and snow cover to flooding and droughts. These effects will vary significantly across the ECE region depending on natural environmental conditions. Most future scenarios suggest increasing demands for water in order to supply human demands (e.g. food production) under changing conditions (e.g. impacts on the water cycle affecting freshwater ecosystems and the services they provide). Moreover, 90 per cent of all natural disasters exacerbated by climate change are linked to water-related risks (IPCC, 2018). However, more importantly for this report, it can be noted that impacts can be expressed in one part of a basin but felt in another part of the same basin, highlighting the need for taking a basin-wide perspective when considering climate change adaptation and mitigation (ECE, 2015b).

By 2050 it is expected that two-thirds of the global population will be affected by water scarcity. In Europe, there is a relative abundance of freshwater resources; however, water availability and socio-economic activities are not evenly distributed across the ECE region. There are consequently major variations in the levels of water stress and expected impacts from climate change across the region and over time (IPCC, 2018, EEA, 2018c).

At the end, where water is shared between countries, transboundary cooperation for enabling integrated water resources management has a fundamental role to play in addressing climate change. It can even be considered a necessary step to manage shared waters in an integrated and sustainable way, in particular, as the demand for water, energy and food is set to rise sharply in the coming decades.

Gender and water

Water resource management has historically been characterised by a gender imbalance (e.g. collecting water). Closing the gender gap is thus fundamentally important in order to improve the sustainable management of water resources. However, it can be noted that there is a general lack of sex-disaggregated data that can demonstrate gender inequalities as related to water. Gender analysis, as part of this effort, is consequently important for understanding the provision, management and conservation of water resources, even more in a transboundary context, where socio-economic conditions can vary significantly across countries (FAO, 2013a, ECE, 2018a).

30 See: https://www.unwater.org.

Women and men have different and generally **unequal access to water-related resources and assets**. For instance, in the agricultural sector, irrigation is principally managed by men in the Europe Union. In 2013, as much as **87.2 per cent** of all the land equipped for irrigation was managed by men, down by only 2 per cent since 2005 (FAO AQUASTAT).[31]

The gender-water nexus demonstrates that gender issues with regards to water access, use and management, need to be integrative. Even more, when considering transboundary water management, most institutions responsible for transboundary water governance are not gender-sensitive.

3.5.4 What is the ECE doing to address natural resource management and use in transboundary basins?

Many areas throughout the pan-European region are presently facing more extreme flooding and drought conditions. Glaciers are melting, snow and ice covers are shrinking, while precipitation patterns are changing throughout Europe (and globally). At the same time, climate-related extremes, such as heavy downpours and heatwaves, are increasing in frequency and intensity (EEA, 2017b, IPCC, 2018). All these factors are having wide-ranging effects on water, ecosystems, economic sectors and human health. Even more, to this already complex web of interactions can be added that population growth, economic development, increasing energy and food demands are all exerting increasing pressures on water, which will have to be met in a sustainable manner. In a transboundary setting, there are furthermore additional challenges, e.g. differing national interests and priorities in policy and development that affect the prospects for sustainably managing water. Having this in mind, the wide range of water-related nexuses support the assertion that the management of interlinked natural resources, such as energy and ecosystems, requires integrative and systemic solutions.

The ECE contributes to the water challenge in several ways. Amongst other things, one objective of the work under the ECE Water Convention has been to address the water-food-energy-ecosystems nexus, addressing the optimization of natural resource use and intersectoral impacts in a participatory fashion (ECE, 2016a, 2018c, 2018d, 2018b, 2018e). The transboundary basin nexus assessment methodology furthermore stresses the importance of integrating multiple aspects of natural resource use (not only water) into a system of sustainable natural resource management. This work has principally been done through the Task Force on the Water-Food-Energy-Ecosystems Nexus, which provides a platform extending beyond water management actors for exchange of experience about, e.g. assessment, tools and solutions. Subject to the issues at stake, the nexus assessments in specific basins have involved cooperation across sectors and divisions/units/bodies in ECE (e.g. Group of Experts on Renewable Energy), drawing upon diverse expertise, guidance, instruments (e.g. the Aarhus Convention, SEA Protocol) and resources. Further, ECE provides effective legal tools to promote transparency and effective and inclusive public participation in decision-making in this area. As a result of broad consultation with the riparian countries and key stakeholders, broad tailored packages of nexus solutions ranging from policy to investments were defined in each basin.

In line with the above-mentioned work, it can also be noted that the ECE Working Group on Integrated Water Resources Management and the ECE Working Group on Monitoring and Assessment (two subsidiary bodies established by the Water Convention)[32] focus explicitly on the integrated management of transboundary water resources and in establishing programmes for monitoring the conditions of transboundary waters. These bodies consequently address several of the intersectoral challenges outlined above.

31 See: http://www.fao.org/aquastat.

32 See: https://www.unece.org/env/water.html.

3.5.5 ECE tools and approaches relevant in the field of natural resource management and use in transboundary basins

	Type of Tool(s)	Description	Sub-programme(s)
Inter-governmental bodies	**Programme of Work**	Water Convention: • Working Group on Monitoring and Assessment • Working Group on Integrated Water Resources Management • Task Force on the Water-Food-Energy-Ecosystems Nexus	
Publications	**Methodology**	• Methodology for assessing the water-food-energy-ecosystems nexus in transboundary basins and experiences from its application: synthesis • Forests and Water: Valuation and payment for ecosystem services	
	Regional reports	• Towards sustainable renewable energy investment and deployment: Trade-offs and opportunities with water resources and the environment • A nexus approach to transboundary cooperation: The experience of the Water Convention • Assessment of the water-food-energy-ecosystem nexus and benefits of transboundary cooperation in the Drina River Basin, among others[33]	

33 For assessment reports or policy briefs on several river basins, see: http://www.unece.org/env/water/publications/pub.html.

3.6 Measuring the use of natural resources with the System of Environmental-Economic Accounting (SEEA)

Data are the central pillar for improving natural resource use. The sustainable use of natural resources requires access to high-quality, timely and comparable data and information to enable informed decision-making. This is irrespective of whether the decision is taken on a farm, in a factory, or as part of a national policy-making process. In other words, the planning and management of natural resources are inherently dependent on data, at all levels of governance (Bilotta et al., 2014, Capalbo et al., 2017, Soomai, 2017, Mollenhauer et al., 2018). In fact, the importance of environmental data is enshrined in many policy instruments at the international, regional national and subnational level. Examples include reporting obligations for Multilateral Environment Agreements (MEAs), such as the Convention on Long-range Transboundary Air Pollution (CLRTAP) Convention and the Convention on Biological Diversity (CBD), EU reporting and monitoring of environment legislation, such as the EU Timber Trade Regulation (EUTR) and the Habitats and Birds Directives, and regional (or nationally specific) reporting obligations, such as for the Alpine and Carpathian Conventions. These instruments represent data flows that provide the basis for monitoring and reporting on progress towards environmental targets and objectives. The point here is basically to stress the importance of data governance and data production as an intrinsic component of natural resource use. Even more, data value chains are ultimately framed by the political institutions, industries or people that are governing (or using) the data flows. This effectively means that the role of integrated data needs to be considered within the broader scope of taking a nexus approach as well as the overall implications for natural resource use.

The ECE's work in this area relates to the production of international and official statistics, as steered by the Conference of European Statisticians (CES),[34] and to efforts to improve environmental monitoring and assessments. The ECE basically focuses on the provision of methodological guidance, modernization of statistics and capacity development. This work is effectively being carried out through a number of Steering Groups and Task Forces, such as the Task Force on a Set of Core Climate Change-Related Statistics, the CES Steering Group on Statistics for Sustainable Development Goals and the Joint Task Force on Environmental Indicators and Statistics, addressing cross-cutting topics that are relevant to natural resource management. However, with regard to integrative natural resource management, the ECE also deals with the challenge of integrating information from different sources, such as social, environmental and economic data. The integration of data from different sources is a prerequisite for intersectoral communication for any given nexus area.

3.6.1 Defining the Nexus Hotspot on measuring the use of natural resources with the System of Environmental-Economic Accounting (SEEA)

Somewhat in contrast to the other nexus hotspots, this section does not focus on specific natural resources, but rather something more intangible, namely, the role of data in natural resource management. For example, there are serious data challenges in tracking the Sustainable Development Goals (SDGs), which require integrated monitoring. Also, large-scale problems, such as climate change, require data from different sources and sectors that may not be compatible (e.g. due to different sizes, formats and dimensionalities). This reflects, on the one hand, the integrative nature of key societal problems, while on the other hand, highlighting that different disciplines are essential to address these integrative challenges. There are, in effect not only sectoral silos, but there are also data silos, limiting the prospects for different sectors to cooperate. Having this in mind, the System of Environmental-Economic Accounting (SEEA)[35] is a useful case example to demonstrate the added value of integrating data. The SEEA is a framework that facilitates the integration of environmental and economic statistics, which would be a necessary step for considering any nexus.

34 See: http://www.unece.org/stats/ces.html.

35 See: https://seea.un.org/.

What is the System of Environmental-Economic Accounting?

The System of Environmental-Economic Accounting (SEEA) is an international statistical standard designed for multiple purposes, which include policy-making, research and the provision of information to the public (e.g. through indicators). SEEA integrates information from multiple sources, in particular, environmental and economic statistics, following the principles of the System of National Accounts (SNA)[36] Adopted by the United Nations Statistical Commission in 2012, it is an internationally agreed statistical framework to measure the environment and its interactions with the economy (e.g. how economic drivers affect the environment) (Vardon et al., 2018). The integration of environmental-economic information means several things. Amongst other things, the use of the same concepts (e.g. system boundaries, definitions, classifications and methods), the presentation of different information using a common format and classifications, and the presentation of descriptive statistics and indicators on pressure, state, response. It further means the construction of analytical models for environmental-economic analysis. For example, the SEEA is a statistical standard that can be used to monitor several environmental and economic SDG indicators in an integrated way.

Data is the backbone for measuring progress towards the SDGs goals and targets. Statistics consequently contributes directly to all Sustainable Development Goals (SDG), in particular those related to natural resource use. This includes targets related to **water-related ecosystems** (6.6.1), **protected areas** (14.5), **forests** (15.1.1) and **land degradation** (15.3.1), to just note a few examples.

Why is it relevant to consider the role of data in natural resources use?

Data on natural resource use serves as a premise for any (evidence-based) decision-making aiming to manage natural resources in a sustainable way. Practical examples relate to everything from a municipality that wishes to improve waste management to an enterprise that wishes to increase resource efficiency throughout its value chain. Data production is the engine behind these processes, allowing people or organisations (public or private) to make proper assessments and to take action. While it should be noted that people do not always rely on data to make decisions (Kleinschmit et al., 2018), the complex nature of the challenges facing society today makes it nearly impossible to make informed decisions without having supporting data. Nor is it possible to assess without data, whether interventions or actions have the intended effect. The importance of relevant data for natural resource use is consequently clear. However, looking at it from another perspective, it can also be noted that there is a general lack of data in many cases. For example, many countries still do not have the human resources and infrastructure necessary to monitor the environment, such as monitoring progress towards the SDGs (UNEP, 2019b, Aggestam, 2019). On the other end of the spectrum, there has also been an exponential growth in the volume of digital data over the recent year. For example, a total of 1,200 exabytes (10^{18} bytes) of digital data existed in 2010, up from some 160 exabytes four years earlier (e.g. the world's capacity for storing information has roughly doubled every 40 months since the 1980s) (ECLAC, 2014). The point here is basically to stress the importance of the entire data value chain for natural resources management and the fact that data production is not only limited by the data content but also by how it is being governed and available data infrastructure.

36 SNA is the internationally agreed standard set of recommendations on how to compile measures of economic activity (see: https://unstats.un.org/unsd/nationalaccount/sna.asp).

Global data issues affecting natural resource use

- **90 per cent** of the data in the world has been created in the last two years, and it is projected to increase by 40 per cent annually (ECLAC, 2014).
- The cost for 144 developing countries to produce data for Tier 1 and 2 SDG indicators has been estimated at **2.8 to 3.0 billion USD per year** up to 2030 (GPSDD, 2016).
- There is presently **no data available**, at the global level, to measure progress towards **68 per cent** of the environment-related **SDG indicators** (UNEP, 2019b).
- There are very little data that can be used to assess **biodiversity**, **ecosystem health**, the **concentration of pollution** and **waste** in the environment, and other environmental threats (UNEP, 2019b).
- More than **30 per cent** of the environment-related SDGs indicators still **do not have an agreed methodology** (UNEP, 2019b).
- Presently, more than **80 countries** have active environmental-economic accounting programmes.

Data issues affecting natural resource use in the ECE Region

- The **availability** and **accessibility** of environmental data vary depending on the natural resource (e.g. biodiversity, energy, waste and water) across the ECE region (ECE, 2016b).
- Out of **67 environment-related data sets**,[37] only **51 per cent were accessible and available** online across the ECE region in 2016. In addition, accessibility varies significantly across the ECE Member States (ECE, 2016b).
- Significant **limitations persist in the possibility to compare environmental data** across the ECE region, such as for protected areas (ECE, 2019b).
- Even though data is being produced, there is **limited use of indicators** for environmental policymaking, such as for tracking progress towards policy targets (ECE, 2019b).
- Monitoring progress towards a circular economy is hampered by a **general lack of data on product stocks and flows** throughout the economy as well as macro-economic data and **indicators on material input reductions** in the EU (EEA, 2017a).

37 See: https://www.unece.org/env/europe/monitoring/iandr_en.html.

How is the System of Environmental-Economic Accounting being applied?

The System of Environmental-Economic Accounting (SEEA) is an accounting system that provides a systematic way to measure and report on stocks and flows of natural capital.[38] The underlying idea is that the environment should be recognised as an asset that is maintained and managed, and its contributions should be integrated into commonly used frameworks, such as the SNAs. At present, the SEEA essentially consists of two parts:

(1) The **SEEA Central Framework**, which was adopted in 2012 by the UN Statistical Commission[39] as the first international standard for environmental-economic accounting. The framework looks at environmental assets, such as water and energy resources, and their use in the economy and returns back to the environment, such as waste, air and water emissions. The framework is basically an internationally agreed set of standard concepts, definitions, classifications, accounting rules and tables to produce internationally comparable statistics on the environment and economy.

(2) The **SEEA Experimental Ecosystem Accounting**, which is an international effort toward coherent ecosystem accounting. It takes an ecosystem perspective to analyse how different environmental assets interact within a given ecosystem.

SEEA presents information in physical and monetary terms regarding environmental stocks and flows between the environment and the economy as well as economic activity related to the environment. It provides frameworks for producing accounts in several areas, such as agriculture, forests, and fisheries accounts; air emission accounts, energy, environmental activity accounts, ecosystem accounts, land accounts, material flow accounts, and water.

From a nexus perspective, the SEEA is a promising approach in that it provides a framework that can systematically integrate environmental and economic information from different sources, ultimately, with the aim to enable better, evidence-based, decision making (see Box 6). The SEEA may, for example, help to address fundamental trade-offs affecting natural resource use, such as the trade-offs between nature conservation, and production of food, materials and energy. Since it can account for the flow of natural capital across sectoral domains (e.g. measuring the contribution of the environment to the economy and vice versa), it can bring a system-level understanding of natural resource use. This would be a prerequisite for managing any nexus. After all, it is not possible to consider a nexus without also considering how natural resource use affect other sectors.

Box 6: Snapshot case: Integrated monitoring for the SDGs

The 2030 Agenda represents an important move towards an integrated policy agenda. However, from a statistical perspective, this has (and will) require not only the integration of National Statistical Systems for an integrated information system but also global reporting mechanisms to reduce overlap and streamline international reporting. In a nutshell, integrated monitoring for the SDGs requires methodological consistency and coherence.

The SEEA has already provided the basis for the development of coherent environmental-economic SDG indicators. For example, recently, the SEEA was adopted as part of indicator 15.9.1 measures "Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020".[40]

38 Natural capital is another term for the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people (Natural Capital Coalition).

39 See: https://unstats.un.org/unsd/statcom/.

40 See: https://seea.un.org/news/seea-implementation-now-reflected-two-sdg-indicators.

Box 6: Snapshot case: Integrated monitoring for the SDGs (continued)

The ECE supports the implementation of SEEA throughout the ECE region.[41] This entails building capacity in support of environmental-economic accounting, providing a platform for the exchange of knowledge and experience (e.g. annual joint OECD/ECE seminar on the implementation of SEEA), assessing data availability and developing methods and sources for the needed data.

Source: UN Statistics Division.

3.6.2 Why focus on the System of Environmental-Economic Accounting?

The development of an information system is a core element of implementing any nexus approach. For that reason, this section focus on SEEA, namely, to highlight the relevance of integrating data from different sectoral and disciplinary domains for nexus planning and management. Data integration is of course, not the complete picture, but it provides a vital part of the puzzle for any nexus approach. Data basically offers a common language for different sectors to communicate with each other, thereby allowing for the possible identification of innovative and integrative solutions. For example, critical interactions within a "Water-Energy-Food" nexus would require an intersectoral monitoring process and a joint understanding of how different indicators and variables are characterised. This would not be possible without a system, such as SEEA, that can characterise the social, economic, and ecosystem interactions that make up the nexus. Moreover, frameworks like the SEEA can provide a commonly accepted lexicon and ontologies. As a systems approach, the SEEA consequently demonstrate how an integrated data and information system can contribute towards sustainable natural resource use.

3.6.3 Intersectoral areas of work affecting data integration and management

Big Data for Sustainable Development

Big data[42] has the potential to transform data use and official statistics over the coming years. For instance, from a natural resource use perspective, big data can provide information on the flows (e.g. energy, waste and air pollution), in real-time, and thus help to manage natural resources more efficiently. Advances in high-resolution remote sensing techniques, as well as smart information and communication technologies, have already had an impact on things like disaster management, smart water and energy management systems (Sun and Scanlon, 2019). Many National Statistics Offices have further acknowledged that the only way to meet the disaggregated data requirements of some SDGs will be to utilize innovative methods and data sources, such as big data.

There were approximately **4.5 billion people** connected to the internet in 2019. This equates to **58.8 per cent** of the global population, and in Europe, this number is as high as **87.7 per cent**.[43] In turn, there are, as of now, **2.7 Zettabytes**[44] of data online. With so much information available online, big data can supplement traditional data sources to help keep better track of natural resource use.

Insights from big data mining can, in effect complement official statistics and provide a more nuanced picture of natural resource use. Even more, the integration of new types of data, together with traditional data, can help to produce high-quality information that is more detailed, timely and relevant. Big data can as such bring opportunities in terms of new forms of information processing and analytics that can affect natural resource management and use.

41 See: https://www.unece.org/stats/seea.html.

42 See: https://unstats.un.org/bigdata/inventory.

43 See: https://www.internetworldstats.com/stats.htm.

44 1 Zettabyte is a billion Terabyte (or 115 Megabytes).

Missing data and the food loss and waste challenge

One of the preceding nexus hotspots (see chapter 3.2) considered the nexus surrounding food loss and waste, which has become a global concern. For example, SDG target 12.3 sets out to "*halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses*" by 2030. One aspect of achieving this objective will be the availability of global data on food loss and waste as a prerequisite for tracking progress, analysing environmental impacts and exploring mitigation strategies. However, data inconsistencies and a limited temporal, geographical and food supply chain coverage remains a significant challenge.

It was recently found that nearly **50 per cent of all publications** on food loss and waste are based only on **secondary data**. This highlights the high degree of uncertainty that exists with regards to any publication that tackles food loss and waste (Xue et al., 2017).

This highlights the need for more data on food loss and waste, both for the ECE region as well as on the global level. Ultimately, primary and high-quality data will be needed to allow for robust estimates on food loss and waste, and the development of measures to address food loss and waste. The lack of data on the causes, volumes and hotspots in the food value chain remains, but efforts are ongoing to better understand food waste and loss, such as the systematic recording of data through innovative IT solutions.

Data gaps and the Sustainable Development Goals

Access to environmental data varies greatly across the ECE region, highlighting sub-regional variations in countries' readiness to develop and use environmental information and data. This poses a unique challenge for the region as the use of relevant data in policy (e.g. through the state of the environment reporting) also varies substantially across countries. There are moreover fundamental challenges in comparing and contrasting data across the environmental, social and economic domain that would be a necessary prerequisite for sustainable development (ECE, 2016b, ECE, 2019b). With regards to the SDGs, there is, as noted earlier, not enough data to assess progress on 68 per cent of the environment-related SDGs. To this can also be added that the lack of data reflects low levels of investment toward achieving the SDGs (UNEP, 2019b).

The world is presently on track to only meet **22 per cent** of the environment-related SDGs. Progress has been made on all **11 environmental-related SDGs indicators** related to policy, financial and institutional processes with available data; however, there is mixed progress in improving access to environmental resources and reducing the impacts of environmental degradation on human health and food security. There is further either **no data or no progress towards all 12 of the SDGs targets related to the state-of-the-environment** (UNEP, 2019b).

The lack of data on the SDGs reflects the need to scale up environmental monitoring and analysis and to promote using data for action, whether on the SDGs or any other area of work affecting natural resource management. More data is needed to monitor the use of natural resources towards achieving sustainable consumption and production. Moreover, it is a prerequisite to understanding how terrestrial and marine ecosystems and biodiversity can be protected or how to prevent pollution, reduce climate change as well as manage natural resources effectively. SEEA is one possible source of information for SDG monitoring (especially for SDGs 6, 7, 8, 12, 13, 14 and 15).

3.6.4 What is the ECE doing to address the need for integrative data on natural resource use?

Effective policies on natural resource use and management require monitoring and assessment tools, in particular, indicators on the use of materials, energy, land and water. As this section has demonstrated, there remains a significant need for improving the knowledge base on natural resource use, both globally and regionally. Examples include – but are not limited to – the lack of data to monitor progress towards the SDGs (UNEP, 2019b) and the lack of data on how to implement the circular economy (EEA, 2017a). This data challenge is why this section has focused on the SEEA. Setting aside problems associated with the lack of data, integrated statistical production processes and services as SEEA provide the tools needed to compare and analyse data from different sectors and disciplines. This would be a natural step for a more unified monitoring framework, as related either to advancing the nexus approach or the sustainable management of natural resources. SEEA basically provide the linkages between economic and environmental accounts that in turn can be used to better understand the system conditions and characterise the requirements for integrated natural resources management. This includes data reporting requirements that arise from global agreements, such as the Paris Agreement, the Sendai Framework for Disaster Risk Reduction and the 2030 Agenda for Sustainable Development.

ECE contributes to the data challenge in several ways. One objective of the ECE has been to promote the SEEA. This is – amongst other things – achieved through an annual joint seminar with the OECD on the implementation of SEEA, as well as, under the auspices of the Joint Task Force on Environmental Indicators and Statistics, which assist countries in methodologies in producing and sharing specific environmental indicators, such as for the SEEA. ECE, through its Working Group on Environmental Monitoring and Assessment, is also regularly engaged in addressing the lack of environmental data throughout the ECE region. This is, for example, achieved through the implementation of the Shared Environmental Information System (SEIS)[45] in Central Asia and Europe (ECE, 2016b, ECE, 2019b). The CES Steering Group on Statistics for SDGs has furthermore been involved in issuing guidance to national statistical offices on producing statistics for SDG (ECE, 2017d), highlighting efforts to support the establishment of national mechanisms that can tackle an integrated policy agenda.

The Aarhus Convention[46] and the Protocol on Pollutant Release and Transfer Registers is another area of work which provide a solid framework for the governments to develop digital environmental information system aggregating data from different reliable sources, provide effective public access to environmental information in electronic form, harness benefits of Open Data and re-use of available information, ensure modern reporting on the state of the environment, streamline the reporting obligations from business to the government and to the public and apply new and emerging digital technologies for effective use of natural resources, sustainable consumption and production and etc. The tools support the development and use of eco-labelling, eco-auditing schemes and specific inventories to track the pollution, waste and the use of resources.

Finally, it can be noted that the Espoo Convention and the SEA Protocol provide the tools for strategic environmental assessments. These assessments allow for a cohesive, holistic and integrated approach that goes beyond the limits of the individual sectors, being a tool for coordinating between various sectoral planning decisions. Relevant in terms of data provision and integration, a strategic environmental assessment can provide decision-makers early warning of unsustainable options of sectoral planning and decision-making and contributes to the reduction and management of environmental and health risks, considering effects that are direct and indirect, secondary, cumulative, synergistic, short-, medium- and long-term, permanent and temporary, positive and negative.

45 See: http://www.unece.org/environmental-policy/environmental-monitoring-and-assessment/envema.html.

46 See: http://www.unece.org/env/pp/welcome.html.

3.6.5 ECE tools and approaches relevant in the field of System of Environmental-Economic Accounting

	Type of Tool(s)	Description	Sub-programme(s)
Inter-governmental bodies	**Programme of Work**	Conference of European Statisticians: • Joint Task Force on Environmental Indicators and Statistics • Joint OECD/ECE Seminar on the implementation of SEEA • Task Force on National Reporting Platforms • Task Force on Waste Statistics • Task Force on a Set of Core Climate Change-Related Statistics • High-level Group for the Modernisation of Statistical Production and Services Aarhus Convention • Task Force on Access to Information	
Publications	**Good practice guidance**	• Road Map on Statistics for Sustainable Development Goals • Guidelines on producing leading, composite and sentiment indicators • Guidance on Modernizing Statistical Legislation • Recommendations on Climate Change-Related Statistics • Forest products conversion factors for the ECE region • Measuring the Value of Forests in a Green Economy • Forests and Water: Valuation and payment for ecosystem services • Guidelines for the Development of a Criteria and Indicator Set for Sustainable Forest Management	
	Regional reports	• ECE Countries in Figures 2019	
Data, standards and guidelines	**Environmental-Economic Accounting**	• System of Environmental-Economic Accounting	
	Statistical Repositories	• Statistics for SDGs Public Wiki • ECE statistical database • Joint Forest Sector Questionnaire • Joint Pan-European Reporting on Forests and Sustainable Forest Management • Joint Wood Energy Enquiry • Shared Environmental Information System (SEIS)	

3.7 Forest Landscape Restoration

Forests are crucial for society, providing ecosystem services that are essential for our survival as well as being deeply rooted in cultural services. The multifaceted contributions of forests range from regulating the climate to water resources management and biodiversity conservation. Forests provide opportunities for recreation, public health but also food and resulting income generation. Even more, forest ecosystems provide wood, a strategic natural resource that can be used for the creation of advanced, reusable and recyclable products and biomaterials as well as for energy production. However, the many demands for forest goods and services demonstrate a fundamental challenge, namely, how to balance and satisfy to contrast and conflicting demands on the same natural resource, simultaneously protecting and maintaining that resource – the forest. The Sustainable Forest Management (SFM) has addressed this issue to some extent and helped pave the way for a more thorough consideration of multiple ecosystem services (Hoogstra-Klein et al., 2017, Sutherland and Huttunen, 2018). For instance, as a part of SFM, protected areas play a crucial role in preserving forest biodiversity, although strictly protected areas have usually excluded or seriously reduced provision of other services. In forest management, efforts are however ongoing in trying to resolve the trade-offs inherent in the demand for protection of biodiversity, the supply of timber and for other goods and services (e.g. recreation). SFM is not a fixed, rigid routine but an open concept that adapts to conditions and evolves in time with changing demands and circumstances. This has included the development of new and integrative approaches, such as retention forestry (Gustafsson et al., 2019) and multifunctional or multi-use forestry (Hoogstra-Klein et al., 2017). Forests and the interactions they have with other sectors are complex, making it even more important to consider forests (as a natural resource) and how they interact with water, biodiversity and food production, and related land uses. This also includes people, such as the landowners and other users. There is in effect great value in considering a forest-centred nexus.

ECE has been working on topics related to forests jointly with FAO since 1947. The work of the joint ECE/FAO Forestry and Timber Section relates to promoting SFM and sustainable production and use of forest-based products. It further assists countries in the ECE region in monitoring and managing forests.[47] Tools include a set of topical forest and forest products datasets, the knowledge-exchange platform through thematical teams of specialists, national policy dialogues and capacity building activities. These are complemented by analytical work resulting in studies, guidelines, outlooks (e.g. on sustainable use of biomass, on the promotion of green jobs in the forest sector) and national and international action plans and programmes. The Rovaniemi Action Plan for the Forest Sector in a Green Economy, developed by the ECE Committee on Forests and the Forest Industry (COFFI) and the FAO European Forestry Commission (EFC) on the basis of an open consultation with member States and stakeholders supports the sector's "greatest possible contribution to a green economy". These efforts are being carried out under the ECE Committee and the FAO Commission.[48] From a nexus perspective, the work being carried out by the ECE addresses multiple interactions and dimensions of ecosystem services management as well as potential sustainable solutions.

3.7.1 Defining the Nexus Hotspot on forest landscape restoration

Forests are, in one way, a nexus in and by themselves. Forests need to be managed in parallel or together with water, air, biodiversity and food production, most often representing a system that interacts with other sectors and competes for the same resources (e.g. water, energy and land are needed to grow food). They are also part of the landscapes, having complicated and sometimes competitive relations with other land use types (e.g. agriculture or infrastructure). Efforts to better understand these complex interactions and demands being placed on forests are thus particularly relevant, especially given the many integrative challenges facing forests, such as a growing global population, climate change, land degradation and scarcity as well as deforestation. Having this in mind, one aspect of the natural resources nexus concerns tools that allow for integrated natural resource management. One example of this is forest landscape restoration. Forest landscape restoration is a promising systemic approach which may help

47 See: http://www.unece.org/forests/welcome.html.
48 See: http://www.unece.org/forests/greeneconomy.html.

to reconcile fundamental trade-offs at a landscape level, such as those between biodiversity conservation, soil and water protection and production of timber and food. From a nexus perspective, it is also interesting as it focuses on entire landscapes, representing a mosaic of interacting land uses and sectors under different governance systems.

What is the forest landscape restoration approach?

Managing the interactions between forests, water, biodiversity and food is complex. However, a landscape perspective can reveal environmental, social and economic priorities on a macro level. Take, for example, the demand for biomass for energy production.[49] How can this demand be satisfied without affecting wood and food production or having a negative impact on water quality, soil and biodiversity conservation or the climate? The argument is that it is easier and more rational to consider these interactions and trade-offs at the landscape level. With this in mind, forest landscape restoration focusses on landscape resilience and the creation of options whereby the provision of ecosystem goods and services are optimised, based on current and future demands from society (ECE, 2019a, IUCN, 2019). The above is further complicated by land use and ownership structures that need to be respected, which often have been shaped through long historical processes.

Landscape restoration can be achieved via multiple ways, including new trees being planted outside of forests, managing forest regeneration, improved landscape patterns and land management to accommodate intersectoral interests (e.g. agriculture) or agroforestry. The focus is principally on land restoration; however, social, cultural and economic values are inherent to the approach. This approach recognizes that restoration is not possible without the acceptance of all relevant stakeholder groups, representing different sectoral interests and respecting land ownership.

The ECE/FAO Forestry and Timber Section contributes directly to Sustainable Development Goal (SDG) 15 related to **life on land**, which addresses forestry in a broad spectrum. This includes specific targets related to forests (e.g. Target 15.1 and 15.2) and contributions towards biodiversity (e.g. Target 15.4 and 15.5). Further, SFM has a positive impact on **SDG1** (No poverty), **SGD2** (Zero Hunger), **SDG3** (Good health and well-being), **SDG6** (clean water) **SDG7** (affordable and clean energy), **SDG12** (Responsible consumption and production) and **SDG13** (Climate Action).

Why is it relevant to review natural resource use from a landscape perspective?

From an SDG perspective, it can be noted that Target 15.3 calls for steps to "*combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world*" by 2030. Considering the overall objective of forest landscape restoration, this would imply that this approach could contribute directly towards achieving a land degradation-neutral world. From a nexus perspective, the integration of different sectors at the landscape level is indispensable for the full achievement of this target, because of the multilateral linkages between resources they manage and services they provide. In essence, the restoration of land and forests can help to address multiple challenges, such as water, wood and food security as well as being

49 It is recognized that energy is an inherently relevant sector when considering forests. Renewable energy targets and the management of biomass are fundamentally important when considering the trade-offs affecting forest use. However, as energy is the principal focus of another nexus hotspot (see chapter 3.8), it will not be considered extensively in this section.

a natural solution for climate change. For example, restoring forests and agroforestry systems can improve the food security and livelihood of small-scale landowners (e.g. by diversifying crops, avoiding soil erosion, increasing water availability and improving pollination) (IUCN, 2015). Yet another example is restoration (as a nature-based strategy) which can provide climate change solutions, including both mitigation and adaptation. Even more, ecosystem-based adaptation strategies tend to be not only more cost-effective but also more long-lasting as compared to other strategies (IUCN, 2010). These examples demonstrate how interdependent forests, other land-use, water, food and climate systems are and that landscape restoration can act as an integrative solution for sustainable natural resource use, in particular when considering the synergistic interactions between forest-water-biodiversity and food processes.

Global impact of forests

- Forests cover **one-third of land** (4 billion ha), and they are the second (after agriculture) biggest land use category (FAO, 2020).
- Forests are home to more than **80 per cent** of all terrestrial species of animals, plants and insects.[50]
- Human activities have destroyed **50 per cent** of the forests that once existed under modern climatic conditions (UN/WCMC, 1998).
- The rate of forest loss in 2015-2020 declined to an estimated **10 million ha**, **down from 12 million ha** in 2010-2015 (FAO, 2020).
- Almost **two-thirds of all forests** show clear signs of past human interventions (FAO, 2014b).
- At least **1 out of every 5 ha** of the vegetated surface shows declining trends in productivity (UNCCD, 2017).
- **40 per cent** of the world's 230 major watersheds have lost more than half of their original tree cover (IUFRO, 2018).
- Approximately **1.6 billion people** depend on forests for their livelihood, including **70 million indigenous people**.[50]
- Food production accounts for more than **a third of all arable land** while agricultural expansion accounts for **70 per cent** of tropical deforestation (mostly for beef, soy and palm oil) (FAO, 2019b).

Forest use in the ECE region

- The ECE region is rich in forest resources, accounting for **41.4 per cent of the global total** (or 1.89 billion ha). Forest cover has been expanding in all parts of the ECE region. The net increase was 28.1 million ha during the 2000 to 2015 period (ECE/FAO, 2015).
- The area of forests certified as sustainably managed in the ECE region **expanded by 45 per cent** during the 2006 to 2013 period (ECE/FAO, 2015).
- The area of forests protected for biodiversity was approximately **12 per cent** in the ECE region in 2015 (ECE/FAO, 2015).

50 See: https://www.un.org/sustainabledevelopment/biodiversity/.

- In Europe, soil erosion rates are higher by a **factor of 1.6** compared to soil formation rates. **970 Mt of soil** is lost, annually. This is equal to an area the size of Berlin at 1 metre deep every year (Panagos and Borrelli, 2017).
- There is **no harmonised definition of or approach to forest degradation** in the ECE region, which also implies there is no comparable data for the region (ECE/FAO, 2015).
- Desertification affects **8 per cent of the territory in the EU**, representing around 14 million ha in Southern, Eastern and Central Europe (Cherlet et al., 2018).
- 4 to 10 per cent of cropland, **27 to 68 per cent** of pastureland and 1 to 8 per cent of forests are degraded in Central Asia (Cherlet et al., 2018).
- **17 per cent of the total land area in Central Asia** is expected to be unsuitable for agriculture by 2080 due to unproductive soils (Mirzabaev et al., 2016).

How is forest landscape restoration applied?

Forests, biodiversity, water and agricultural land provide some of the primary resources that make up livelihoods and economies, providing key ecosystem services to society. Healthy and productive landscapes are thus essential. If a landscape is degraded, the application of a nature-based solution such as forest landscape restoration aims to restore multiple ecological, social and economic functions across deforested or degraded forest landscapes (IUCN, 2015, 2019).[51] It is adaptive in that it is tailored to the specific landscape using different approaches (e.g. accounting for local conditions, values and governance structures), emphasizing multiple benefits and land uses, over time.

The types of landscape components that are usually restored fall into four basic categories:

1. **Forest land**, including protected, productive and degraded forests.
2. **Agricultural land**, meaning land that is being managed for food production.
3. **Protective land and buffers**, which focus on land that is safeguarding against natural hazards and climate change.
4. **Inland waters which** include lakes, rivers, ponds, streams, groundwater, springs, floodplains, as well as bogs, marshes and swamps

The options that are available to restore these types of landscapes can range from planting trees on formerly forested land, allowing for natural regeneration, applying silvicultural measures to improve quality of the forest land, managing trees on active or fallow agricultural land to improve crop productivity as well as measures to protect watersheds and control for erosion. Further, landscape restoration may include the improvement of the structure and pattern, to increase its resilience, ability to maintain its biodiversity as well as to better serve its protective and aesthetic functions.

Considering restoration from a nexus perspective, it is of interest to note the guiding principles of forest landscape restoration (WRI, 2015). First and foremost, by focusing on the landscape, it is possible for the restoration approach to scale and balance environmental, social and economic priorities. This would be a prerequisite for any nexus approach that would like to understand how different environmental, social and economic factors and sectors interact, whether in a landscape or elsewhere. Perhaps more importantly, it provides insights into the trade-offs that prevail in managing and using available natural resources (in this case, forests). For instance, if a landscape is reviewed, it may provide for a better understanding of how deforestation and biodiversity loss have been driven by interacting land uses, such as the expansion of crop and pastureland, and to assess to which extent they are valid now. It is further

51 See: https://infoflr.org/.

interesting to note the emphasis on maintaining and enhancing natural ecosystem services and multifunctionality. These are fundamental for allowing the sustainable management of forests as well as the provision of multiple goods and services in any given system. In other words, the nexus approach highlights the need for an integrated landscape perspective. In turn, the forest landscape restoration provides one conceptual framework and tool not only to review trade-offs but also to govern the use of primary natural resources, such as forests and water.

Box 7: Snapshot case: The Bonn Challenge

RESTORE OUR FUTURE
BONN CHALLENGE

The Bonn Challenge[52] is a voluntary global effort to bring **150 million ha of deforested and degraded land into restoration by 2020, and 350 million ha by 2030**. It is linked to international commitments, such as the SDG Target 15, the Aichi Biodiversity Targets, the UNFCCC REDD+ goal, and the Rio+20 land degradation neutrality goal.

It has been estimated that achieving the 350 million ha goal may generate around **USD170 billion, annually, in net benefits** from watershed protection, improved crop yields and forest products. It could further **absorb up to 1.7 gigatonnes of carbon dioxide**, annually. Many countries have made ambitious pledges to the Bonn Challenge, which in turn is underpinned by the forest landscape restoration approach.

The ECE support both the work on forest landscape restoration and the Bonn Challenge. One example is its aid to countries in the preparation of restoration pledges in the Caucasus and Central Asia leading up to the Ministerial Roundtable on Forest Landscape Restoration and the Bonn Challenge in the Caucasus and Central Asia.[53] It can, for instance, be noted that these efforts have resulted in Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan committing to restore over 3 million ha of forest landscapes by 2030 (ECE, 2019a).

Sources: ECE (2019a).

3.7.2 Why focus on the forest landscape restoration approach?

Current landscapes and their use have rarely been shaped through a comprehensive process, but are rather the result of the competition among uses. These challenges cannot be fully solved by taking a silo-based approach that fails to recognise trade-offs and synergies between sectors. Another key aspect of the forest landscape restoration approach is the application of nature-based solutions as part of a governance model that allows for integrated natural resources management. Take, for instance water and forests, which are traditionally managed by separate government agencies and policy instruments, are nevertheless interlinked through multiple functions. This includes, amongst other things, the regulation of basin flow, reduction of flooding, water quality and climate regulation (e.g. through carbon sequestration). Despite these connections, the sectors interact very little with each other. For example, the EU's Water Framework Directive only mentions forests once, as a pressure on the water environment (Aggestam et al., 2017). Managing these primary resources (water-forests) consequently requires a governance model that can create a bridge between sectors and allow for the identification of cross-cutting solutions. This is ultimately the added value of taking a landscape approach.

3.7.3 Intersectoral areas of work affecting forests

Forests, energy and biodiversity

The forest-based sectors are particularly interesting from a nexus perspective as they provide renewable materials that are used by many other sectors (e.g. construction, furniture, packaging energy, etc.). Different sectoral policies affect distinct stages of the forest-based value chains (and their respective sub-sectors) in different ways.

52 See: https://www.bonnchallenge.org/.

53 See: http://www.unece.org/index.php?id=52389.

However, more importantly, these policy instruments often represent conflicting goals and objectives. One example is targets related to renewable material and biodiversity conservation, where both depend on one natural resource, namely, forests. However, governance frameworks do not fully address these different societal demands towards forest goods and services (Aggestam and Pülzl, 2018; Aggestam et al., 2017).

The EU's Natura 2000 network of protected areas (Habitats Directive and Birds Directives) is the core of biodiversity conservation in Europe. Natura 2000 facilitates an integrative conservation approach that combines conservation goals with other land uses. However, given trade-offs between biodiversity conservation and biomass production, these policies have been linked to implementation conflicts (European Commission, 2015).

The complex interactions between different sectors affecting the use of forests (as a natural resource) make it challenging to have a coordinated policy approach for the ECE region. This holds particularly true given the competition between different political paradigms, such as energy and biodiversity conservation. Furthermore, this interrelation highly depends on national and local conditions, and greatly vary among ECE countries. However, what these conflicts emphasise is the need for intersectoral communication and coordination.

Landscape fragmentation, transport and forests

Landscape heterogeneity is a general feature of natural environments. However, land-use change is fragmenting natural ecosystems, with the great extent of fragmentation resulting from natural resource use and exploitation (e.g. transport infrastructure). Fragmentation in turn, has major consequences for biodiversity (e.g. if natural resources are used so extensively as to affect large parts of the landscape) as well as other key ecosystem services, such as freshwater supply (Tidwell, 2016).

In Europe, 15 per cent of all woodlands are strongly fragmented by mainly intensive land uses such as agriculture. Moreover, 70 per cent of all landscapes with woodlands are poorly connected and more vulnerable to further fragmentation in the future (JRC, 2013). Transport is another sector with significant effects on the landscape; for example, Europe is highly fragmented by transport infrastructure, where half the region is within 1.5km of a paved road or railway line.

Landscape fragmentation not only reduces the amount of area available to plants and animals, but it changes the flow of resources and the distribution of suitable habitat, making it impossible to ignore the limitations in land availability and its links to other natural resources. Taking a landscape perspective, there is consequently an urgent need to address fragmentation in a coordinated manner which warrants intersectoral approaches for the forest-biodiversity and food nexus, having different landscape functions in mind.

Gender in landscape restoration

Forestry and agroforestry systems do not always provide equal opportunities for men and women. . Women face more legal and cultural barriers to land ownership as compared to men, which is even of greater importance in rural areas where land ownership (and its management) is one of the main sources of the livelihood. Furthermore, there tend to be significant differences between knowledge and restoration priorities between men and women (CIFOR, 2017). For these reasons, it is relevant to ensure that any restoration effort reflects the priorities, interests and knowledge of both women and men equally.

Women make up **43 per cent of the agricultural workforce**; however, women in forestry, fishing and agriculture receive only **7 per cent of total agricultural investments**. Women also receive fewer and smaller loans than men. Only **10 per cent of total international development assistance** for agriculture and forestry reaches women (FAO, 2006, FAO, 2018).

There is a need to better integrate gender in natural resources management. Mechanisms and measures for gender-responsive landscape restoration can range from the choice of stakeholders, restoration approaches, re-distribution of benefits, priority species and how to monitor progress. It is important to ensure that restoration efforts utilise the knowledge and experiences of both women and men.

3.7.4 What is the ECE doing to restore degraded landscapes?

The focus on forest landscape restoration helps to explain how a landscape perspective can address land-use trade-offs, not only for forests but for any land-use practice. It is thus a tool that can help tackle unsustainable practices and help restore ecosystem functions across a whole landscape, taking into account different natural resources, sectors and stakeholders. In a nutshell, while there are no simple solutions, forests and efforts to restore degraded landscapes can play an important role in creating a more integrated approach towards natural resource management, production and use. Moreover, considering the UNGA's Declaration for a Decade on Ecosystem Restoration (2021-2030),[54] the use of nature-based solutions feed into ongoing efforts to restore ecosystems for food and energy, water and biodiversity, while creating jobs and combating climate change.

ECE contributes to the land degradation challenge in several ways. For instance, the ECE has supported the launch of the ECCA30 initiative in 2019,[55] seeking to bring 30 million ha of degraded and deforested land in Europe, the Caucasus and Central Asia into restoration by 2030. The ECE has also carried out studies on the potential to restore forests in the Caucasus and Central Asia (see Box 7) and East and South-Eastern Europe, as well as the, providing the first overview of the state of forests in the Caucasus and Central Asia (ECE, 2019e). This work has been carried out through the ECE/FAO Integrated Programme of Work. In line with this work, the Joint Section has recently integrated the analysis of circularity concepts and how they relate to forest-based sectors in its work (e.g. through the organisation of discussion panels and preparation of stock-taking documents). The promotion of integrative management approaches and measures towards a circular economy demonstrate ongoing efforts to address the intersectoral challenges facing the forest-based sectors and the need for integrative solutions.

54 See: https://www.decadeonrestoration.org/.
55 See: https://infoflr.org/bonn-challenge/regional-initiatives/ecca30.

3.7.5 ECE tools and approaches relevant in the area of forest landscape restoration

	Type of Tool(s)	Description	Sub-programme(s)
Inter-governmental bodies	**ECE/FAO Integrated Programme of Work**	ECE Committee on Forests and the Forest Industry and FAO European Forestry Commission • Joint ECE/FAO Working Party on Forest Statistics, Economics and Management • EFC Working Party on the Management of Mountain Watersheds • Team of Specialists on Monitoring Sustainable Forest Management • Team of Specialists on Boreal Forests • Team of Specialists on Sustainable Forest Products • Team of Specialists on Forest Products Statistics • Team of Specialists on Wood Energy • Team of Specialists on Forest Sector Outlook • Team of Specialists on Green Jobs in the Forest Sector	
Publications	**Action Plan**	• Rovaniemi Action Plan for the Forest Sector in a Green Economy	
	Good practice guidance	• Guidelines for the Development of a Criteria and Indicator Set for Sustainable Forest Management • Good practice guidance on the sustainable mobilisation of wood in Europe • Promoting sustainable building materials and the implications on the use of wood in buildings • Forest products conversion factors for the ECE region • Measuring the Value of Forests in a Green Economy • Forests and Water: Valuation and payment for ecosystem services • Guidelines on the Promotion of Green Jobs in Forestry • Guidelines on using wood energy "More heat with less wood	

	Type of Tool(s)	Description	Sub-programme(s)
Publications	**Regional reports**	• State of Forests in the ECE Region • Forest Products Annual Market Review • Wood Energy in the ECE Region • Forest Landscape Restoration in the Caucasus and Central Asia • State of Forests of the Caucasus and Central Asia • Forest Sector Workforce in the ECE Region • Trends in Green Jobs in the Forest Sector in the ECE Region • Green Jobs in the Forest Sector	
Data, standards and guidelines	**Online tools**	• Forest Information Billboard	
	Data collection processes	• Joint Forest Sector Questionnaire • Joint Pan-European Reporting on Forests and Sustainable Forest Management • Joint Wood Energy Enquiry	
	Forecast	• Forest Sector Outlook Studies	

3.8 Integrated Management of Energy and Mineral Resources

Central to the overuse of natural resources is the question of energy supply, which relates directly to land use (including water) and climate change as areas with high uncertainty. In fact, it can be noted that global CO_2 emissions from fossil fuels rose to an all-time high in 2018. Energy use presently represents the largest source of greenhouse gas emissions, accounting for more than two-thirds of global greenhouse gas emissions(IEA, 2019a). Even more, increasing global demand due to, for example, population growth and economic development are expected to further increase energy supply by 100 per cent by 2050 (WEC, 2007). About 12 per cent of the world population do not have any access to electricity, and around 3 billion people do not have access to clean and modern cooking fuel, posing risks to their health, the environment and climate. Annually there are 4.3 million deaths from exposure to household air pollution (UN, 2018a). These actual and forecasted increases in energy supply and emissions stress the need for efficient use of natural resources, especially with regards to energy resources. Immediate action is needed to meet climate change objectives, and the energy sector is an integral component of these efforts (UNEP, 2018, 2019a).

Applying a system or nexus perspective, the energy sector has crucial intersectoral linkages to both water and land, principally as a consumer of these natural resources (e.g. water is used throughout the energy industry). It also relates to raw materials provided by extractive industries (e.g. coal-fired power generation) to more environmentally-friendly alternative sources of energy, such as biomass. Further adding to the energy challenges are, for example, the relationship between energy access and economic development, representing fundamental trade-offs between environmental, social and economic priorities. Energy conservation and reducing emissions are thus not straightforward, placing the sustainable development of energy resources at the core of several societal challenges.

3.8.1 Defining the Nexus Hotspot on the integrated management of energy and mineral resources

Energy is essential for nearly all the Sustainable Development Goals (SDGs), ranging from efforts to expand access to electricity to improving water supply to combating climate change. In particular, SDG7 relates directly to the provision of affordable, reliable and sustainable energy. However, the global energy system must undergo a profound transformation from one that is based on fossil fuels to one that is focused on efficiency and on renewable energy to achieve these goals. One aspect relates to the production of sustainable energy through system integration. The concept of an integrated sustainable energy system can be described as a system that allows infrastructure and the energy generation capacity to be used more efficiently. This can include making sure that policy instruments are flexible, addressing the role of the processing industries in the energy system, and introducing new technologies (e.g. energy storage in combination with solar and wind energy and carbon capture and storage). From a nexus perspective, energy is highly relevant for two reasons. First, energy production relates directly to natural resources use (e.g. coal and gas). Thus, any effort to transform the energy system would also require a shift in how these natural resources are being utilized. Second, achieving sustainable energy through system integration will require coordination across key sectors (e.g. transport and construction). Thus, it will require a system perspective.

What is an integrated sustainable energy system?

The transition to a sustainable energy future will require integrating higher shares of renewable and clean energy technologies (e.g. wind and solar power, energy efficiency and carbon capture and storage) into current energy systems. This is essential for decarbonizing the energy sector while also meeting the growing demand for energy. Energy systems integration, as defined here, consequently relates to the removal of technological, physical, institutional and legislative barriers with regards to the uptake of renewable energy and clean energy technologies in energy systems. This integration can include changes in the design and implementation of energy supply infrastructure and regulatory frameworks that facilitate greater use of modern renewable energy sources and integration of clean energy technologies. For instance, a system with a high proportion of variable wind and solar energy, require different strategies and flexibility (e.g. in terms of energy production and demand) to maintain energy supply, over time, as compared to a traditionally linear energy system. When considering the energy-water and land nexus, the challenges of systems integration are of particular interest, namely, as it demonstrates how difficult it is to transform a sector and to move away from a traditionally linear approach. For example, energy can increasingly be seen as a service, where new industries are emerging, such as energy storage industries, that complement the implementation of new technologies and the diversification of renewable energy systems. These types of changes, aside from intersectoral cooperation, require a creative shift in industrial infrastructures as well as in policy and regulation. These are also all highly relevant issues, from a nexus perspective, as they reflect the systemic nature of natural resource use and management.

The ECE contributes directly to Sustainable Development Goal (SDG) 7 **Affordable and clean energy**. SDG7 addresses a broad range of energy-related issues; specific targets include increasing the share of renewable energy and improving energy efficiency (Target 7.2 and 7.3) and enhancing international cooperation to facilitate access to clean energy research and technology (Target 7.A). Further, efforts to implement sustainable energy systems relate to, amongst others, **SDG9** (industry, innovation and infrastructure), **SGD11** (sustainable cities and communities), **SDG12** (responsible consumption and production) and **SDG13** (Climate Action).

Why is it relevant to implement an integrated sustainable energy system?

Taking a step back, the energy system basically consists of a multitude of technologies and processes that convert natural resources into energy. On the one end of the system, there are the primary energy resources (e.g. coal, wind and water), and on the other end of the system, there are the energy services (e.g. electricity, heating and processing). Thus, if the objective is to reduce the use of depletable natural resources while providing a sustainable energy supply, the system needs to change radically. One way to facilitate this change is to integrate energy systems (e.g. across transportation and water), which essentially increases the flexibility of the energy system overall. The idea is that a flexible system makes it more resilient and help balance the fluctuations presently inherent in renewable energy systems (e.g. sun and wind energy), which in turn contribute towards a sustainable energy transition. The energy use in typically split between (i) electricity generation, (ii) the industry and (iii) transportation and buildings with approximately a third share each. In view of several competing uses, at various nexus points, this is highly relevant. Not only to address societal challenges, such as climate change, but also the interactions with other sectors to facilitate the sustainable management of the natural resource. For example, water is one key natural resource that is being used by the energy sector (e.g. for processing and hydropower), but it is also being used for food production (e.g. irrigation), for drinking, and by other industries (e.g. energy accounts for roughly 75 per cent of all industrial water withdrawals). This demonstrates that the management of energy resources in a systemic and integrative manner is consequently imperative.

Global impact of the energy sector

- Energy production and use amount to approximately **20 per cent of the global GDP**. This is around 20 trillion USD per year (IRENA, 2018).
- The global energy production came from **80 per cent fossil fuels**, **10 per cent biofuels**, **5 per cent nuclear** and **5 per cent renewable** (e.g. hydro, wind, solar and geothermal) in 2016 (Shell, 2017).
- Electricity generation has grown by more than **250 per cent** over the past 40 years. Electricity generation is forecast to grow by **70 per cent** by 2030 (IRENA, 2018).

- Coal-fired power generation capacity has grown by **nearly 900 gigawatts** (GW) since 2000 (IEA, 2019c).
- Energy accounts for about **15 per cent of total water withdrawals**. Global water withdrawals for energy are expected to increase by **20 per cent by 2035**, whereas water consumption for energy is expected to increase by **85 per cent** (WWAP, 2014).
- Food systems consume **30 per cent of the available energy globally**, out of which around 70 per cent is beyond the farm (FAO, 2012).

Energy use in the ECE region

- The ECE region accounted for **40 per cent** of the global total primary energy supply and 34 per cent of the global CO_2 emissions from fossil fuel combustion in 2014 (ECE, 2017b).
- Share of fossil fuels in total primary energy supply is on average **80 per cent**, with some sub-regional variations. This is about the same as for the global share of 81 per cent (ECE, 2017b).
- The ECE region was the only region to increase the share of renewable energy in total final consumption to **11.5 per cent** in 2014, up from 5.9 per cent in 1990 (ECE, 2017b).
- Share of renewable energy varies significantly across the region, ranging from **26 per cent** in South-Eastern Europe to **4.9 per cent** in Eastern Europe, Caucasus, Central Asia and the Russian Federation (DENA/ECE, 2017).
- Wood energy is a leading renewable energy source in the ECE region, accounting for around **45 per cent of primary energy** from renewable sources. Wood energy is principally used by households, the wood-processing industry and for power and heating (ECE, 2018f).
- The ECE region has achieved **100 per cent access to electricity and 98 per cent access to clean cooking fuels** (ECE, 2017b)

How is the system perspective on energy sustainability being applied?

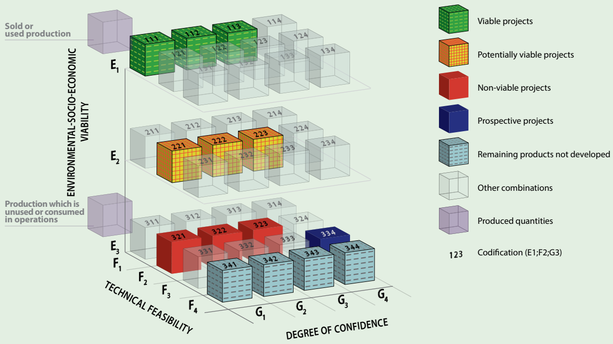
The implementation of integrated sustainable energy benefits from taking a systems approach to understanding the trade-offs in the management of energy resources, whether these are renewable or not, and understand the interactions between the stakeholders in an energy system (ECE, 2017b). As energy systems and related technologies are capital intensive, the transition of the energy system is often slow, requiring several decades and huge investments. Systems thinking can help manage complex environments where there are no simple solutions and where solutions need to account for the impact on the whole system (e.g. provide affordable energy services, achieve energy security and reduce greenhouse gas emissions).

One example of a system perspective on energy sustainability would entail reviewing:

1. **Required energy services** (e.g. food production, heating and transport).
2. **Energy resources sustainability** (e.g. hydroelectricity, biomass and solar energies).
3. **Energy generation** (e.g. power stations, photovoltaics and geothermal).
4. **Transmission and distribution** (e.g. transmission and distribution lines).
5. **End-use efficiency, productivity and recovery** (e.g. energy costs/savings and productivity in different sectors such as agriculture and manufacturing, co-generation).

The points above provide a simplified example of how an energy system could be analysed, however, the basic premise is that all intersectoral connections and dependencies are considered, covering the entire value chain (from demand to supply to use). This basically includes considering the range of sectors that may be involved in the energy system and the respective natural resources utilised. This is of interest from a nexus perspective as it can address the functioning, productivity, and management of complex systems, such as making apparent the relationships between food, water and energy systems. More importantly, understanding relevant interlinkages between resource systems can guide a transition to sustainability (e.g. by reducing negative impacts within the system).

Box 8: Snapshot case



The United Nations Framework Classification for Resources (UNFC)[56] is a global, principles-based and user-friendly system for classifying, managing and reporting on energy, mineral, and raw material resources. It is a unique system in which resource quantities are classified on the basis of three fundamental criteria that reflect technical, socio-economic and planning dimensions. Thus having a direct link to SDG7 on access to clean and affordable energy.

The UNFC is a highly relevant initiative as it has addressed a gap, at global, regional, national level, for coherent and consistent definitions and categorization of recoverable natural resources available. It essentially provides a common terminology and guiding principles for the sustainable management of all energy and mineral resources. UNFC has been adopted as the basis for national resource classification in many countries, including China, India, Mexico, Poland and Ukraine.

The ECE has developed the original UNFC (previously the United Nations Framework Classification for Reserves and Resources of Solid Fuels and Mineral Commodities) in 1997. This work led up to the recent revisions introduced by ECE Expert Group on Resource Management,[57] whereby the framework now includes renewable energy, injection projects for geological storage and anthropogenic resources. Most importantly, these efforts provide for a common and harmonised language on sustainable natural resource use, which has been missing up to now.

Source: Heiberg et al. (2018).

3.8.2 Why focus on integrated sustainable energy?

Current standards in energy resource management were basically developed in the 1970s to support a linear industry, fragmented into sectors such as petroleum, solid fuels and renewable energy supply, with limited focus on the demand side, including storage, and the social and environmental issues. Energy production and use were effectively silo-based. However, as natural resources are becoming increasingly scarce and hard to access and as emissions generated by extracted raw materials are rising (e.g. CO_2 emissions), including accelerated environmental degradation, it is obvious that a new system for sustainable management of energy resources is needed (see Box 8). It is further obvious that it is not possible to achieve a sustainable energy system without addressing the synergies and trade-offs across sectors in the planning of energy demand and supply. Hence, the need for integrated sustainable energy.

56 See: https://www.unece.org/energy/se/reserves.html.
57 See: https://www.unece.org/energy/se/egrc.html.

From the nexus perspective, the reason for tackling integrated sustainable energy is twofold. First, energy is at the core of many significant challenges facing society today, ranging from climate change to sustainable food production and water supply. The energy sector is thus inherently interlinked with natural resources use, across the ECE region. It is also fundamentally intersectoral, representing synergies and trade-offs between economic, social and environmental objectives. Second, the systems approach is central to nexus thinking, in particular, with regards to finding integrative solutions (such as integrated sustainable energy). It is instrumental in understanding relevant nexus interactions (e.g. interrelations and interdependencies of natural resources) to improve environmental governance or achieve sustainable natural resource use. In other words, the system approach explains the complex relations between the demand for natural resources, availability and use, as well as physical and financial constraints, which in turn set the boundaries for integrating energy systems, across sectors and scales.

3.8.3 Intersectoral areas of work affecting sustainable energy systems

Technological innovation, renewable energy and resource efficiency

Cleaner and more energy-efficient technologies are essential to further reduce natural resource use and emissions. For example, as production techniques have become more efficient, greenhouse gas emissions per dollar GDP have declined (IRENA, 2017). Also, a large part of the energy system in 2050 will still be depended on fossil fuels. A large share of energy beyond 2050 needs to come from Bioenergy and Carbon Capture and Storage (BECSS) systems. Industrial growth anticipated for the next few decades require the support of several clean energy technologies, including carbon capture. However, incremental improvements are presently not enough to limit climate change. New technologies and approaches are thus urgently needed to transform and decarbonise the energy sector.

Decarbonisation requires global carbon intensity to be reduced by **85 per cent over the next 35 years**. It has been estimated that the deployment of renewables and energy efficiency can achieve **90 per cent of the emissions reductions** needed to achieve Paris Agreement climate goals. However, for one-third of the global anticipated energy use in the coming 20-25 years, **no practical decarbonisation solutions** presently exist (IRENA, 2017).

Renewables are one major component of this transformation. For instance, two out of three units of primary energy supplied must come from renewables by 2050 (IRENA, 2018). The deployment of technological innovation can, aside from reducing costs and improving energy efficiency, enable the integration of renewable technologies into current energy systems. The decarbonisation of energy use is naturally interlinked with research and development. In a nutshell, innovations are needed to integrate new technologies.

Public health and energy

Energy is central to activities, such as preparing food, heating/cooling and travel; however, these activities also have significant health impacts. One significant impact is caused by the burning of solid fuels, coal and biomass, causing household and ambient air pollution as well as occupational health risks. For example, the lack of access to clean fuels and electricity remains a particularly serious health risk globally (Smith et al., 2013). Such risks are borne mainly by women and children. There are as such significant linkages between energy and public health.

Every year approximately 7 million people die prematurely due to the exposure from both outdoor and indoor pollution. Regional estimates suggest that around 500,000 premature deaths are due to air pollution in the EU (UNEP, 2016c).

The health-energy nexus demonstrates that trade-offs and synergies between energy production, air quality, economic development, climate change and health are not always clear-cut. Co-impacts commonly occur throughout any system where, for example, the development of energy systems can have positive social and economic impacts (e.g. increased options for livelihoods) while also generating public health impacts. These complexities require integrative solutions.

Environmental costs of renewable energy

Fossil fuels, principally coal, place a heavy burden on the environment, both during extraction and use. In contrast, most renewable energy projects have lower pollution-related impacts on ecosystems and public health. However, no energy source is without environmental impacts. One common example is hydropower, where dams can cause significant impacts ranging from habitat destruction to blocking the migration of aquatic species and reducing sediment flow and nutrient transport. Another example is waste treatment and recycling of photovoltaic cells; for instance, estimates suggest that there will be 60 million tons of photovoltaic waste in Europe by 2050 (Gibon et al., 2017). Wind energy production requires heavy-duty magnets that need a lot of rare-earth elements, the extraction of which have severe environmental impacts. Energy storage is very much depended on the supply of metals such as nickel, cobalt and lithium. Apart from environmental impacts, production of metals such as cobalt involves social issues like child and forced labour.

Excluding biomass for cooking and heat, estimates for bioenergy needed to mitigate climate change range from 80 to 200 EJ by 2050. For example, total global primary energy production was 572 EJ in 2015 (UN, 2018b). At the upper end of this range, approximately 200 million ha of land for bioenergy would be needed. Higher estimates range between 240 to 905 million ha, while most estimates exceed 500 million ha (Souza et al., 2017).

The global greenhouse gas reduction targets of 2°C will not be reached without bioenergy. In other words, bioenergy is indispensable to reduce carbon emissions. However, low-carbon energy sources clearly also harm the environment, emphasising the need to consider how and where these technologies should be implemented within a system so as to minimise adverse environmental, social or economic effects.

3.8.4 What is the ECE doing to support integrated and sustainable energy production?

The systems approach demonstrates the fundamental importance of understanding the interdependence of natural resources within a system, across space and time. In other words, it is not possible to make a system more efficient when you only review the productivity of individual components. Energy system interactions and impacts are intersectoral. However, while there is clear added value in the application of integrated solutions (e.g. to optimise trade-offs and maximise synergies across sectors), major challenges remain. Consider for instance the fact that a common and harmonized language on energy and mineral resources – as related to renewable energy – has been missing up until recently, as illustrated by the UNFC (see Box 8). Successful natural resources management requires relevant information on the resource base. Ultimately, if sectors are unable to communicate adequately, it is not possible to implement an integrated and sustainable energy system. One key message here, however, is that a system approach is of strategic value not only when considering the energy transition but for the nexus concept as it accounts for the interconnection between natural resources.

The ECE contributes to the sustainable energy challenge in several ways. For instance, the ECE has recently launched a project on finding pathways to sustainable energy,[58] supporting countries in the ECE region to reach sustainable energy objectives, including the development of an early-warning system to monitor progress. Other efforts to support the uptake of renewable energy and improve energy efficiency in the region is being carried out by the ECE Group of Experts on Renewable Energy (GERE) and the Group of Experts on Energy Efficiency, subsidiary bodies to the Committee on Sustainable Energy. In the framework or GERE, as a joint effort with the Water Convention and the Task Force on the Water-Food-Energy-Ecosystems Nexus, a toolkit for sustainable renewable energy investment and deployment was developed to help policymakers to address trade-offs and to seize cross-sectoral opportunities for synergy. The UNFC, developed by the Expert Group on Resource Management, is another example whereby the ECE provide guidelines and best practices for the energy and mineral sectors which fully integrates social and environmental considerations as part of achieving affordable and clean energy. For example, under UNFC, new standards for the assessment of solar and wind energy resources have recently been developed. From a nexus perspective, it is also

58 See: https://www.unece.org/energywelcome/areas-of-work/pathways-to-sustainable-energy/about-pathways-to-sustainable-energy.html.

interesting to note an ongoing project on integrated energy and water resource management project in South-East Europe and Central Asia,[59] highlighting an increased awareness about water-energy intersectoral links and impacts. To provide comprehensive support to integrated resource management, ECE is developing the United Nations Resource Management System (UNRMS).

3.8.5 ECE tools and approaches relevant in the field of integrated management of energy resources

	Type of Tool(s)	Description	Sub-programme(s)
Inter-governmental bodies	**Programme of Work**	Committee on Sustainable Energy • Group of Experts on Energy Efficiency • Group of Experts on Renewable Energy • Expert Group on Resource Management • Experts on Cleaner Electricity Systems	
	ECE/FAO Integrated Programme of Work	ECE Committee on Forests and the Forest Industry and FAO European Forestry Commission • Team of Specialists on Wood Energy	
Publications	**Good practice guidance**	• United Nations Framework Classification for Resources • Best Policy Practices for Promoting Energy Efficiency • Guidelines on using wood energy "More heat with less wood." • Towards sustainable renewable energy investment and deployment: Trade-offs and opportunities with water resources and the environment	
	Regional reports	• Global Tracking Framework: ECE Progress in Sustainable Energy • Pathways to Sustainable Energy • Energy for Sustainable Development in the ECE Region • Status and Perspectives for Renewable Energy Development in the ECE Region • Progress in the Areas of Energy Efficiency and Renewable Energy in Selected Countries of the ECE Region • Coordinated Operations of Flexible Coal and Renewable Energy Power Plants • Wood Energy in the ECE Region	
Data, standards and guidelines	**Energy accounts**	• System of Environmental-Economic Accounting (SEEA) Central Framework for Energy Accounts	
	Statistical Repositories	• Joint Wood Energy Enquiry	

59 See: https://www.unece.org/fr/energywelcome/areas-of-work/unfc-and-sustainable-resource-management/projects/integrated-energy-and-water-resource-management-project.html.

3.9 Nexus Thinking and the Circular Economy

The Circularity Gap Report presented at the 2019 World Economic Forum Annual Meeting in Davos estimates that only 9 per cent of the global economy is circular today. This emphasises the need for efficient and integrated management of natural resources (energy, food, land, materials, and water) to address some of the most significant societal challenges, such as climate change, economic, environmental and social security. Innovative approaches, such as a circular economy, may become key to encourage nexus thinking along value chains, providing opportunities for the development of cross-sectoral policies. Increasingly, integrated natural resource management includes, often in a central position, the core concepts of a circular economy. These are briefly described below

Reduction of food loss and waste through a circular approach

Most current food systems operate on a wasteful linear model, generating negative social and environmental impacts and using limited natural resources. Developed regions, such as Europe, waste more food than developing countries, with the loss happening at different levels in the supply chain. Reducing food waste and loss consequently has the potential to save natural resources, reduce pollution, increase food security and strengthen the sustainability of food systems. One possible food loss and waste reduction strategy relates to the implementation of the circular economy. In a circular economy, natural resources use is based on closed-loop systems to ensure resources are conserved with given product lifecycles. With regards to food waste management, the concept of the circular economy has the potential to place greater responsibility on retailers and food sellers to ensure that food waste and loss are minimised.

> Food waste occurs at production, retail and consumer levels and approximately 88 million tonnes of food waste are generated annually with associated costs estimated at 143 billion euros in the EU (FUSIONS, 2016), where 11 per cent of the total population is undernourished (UN, 2017). Food loss and waste reduction should be an integral part of the circular economy.

From a nexus perspective, the circular economy provides a more holistic approach, which could contribute towards tackling food waste and loss. By fighting food waste and loss through a circular economy model, it is possible to factor in socio-economic and environmental effects associated with any food loss and waste reduction strategy, considering different regional specificities as well as infrastructure, energy, markets, and education as part of a highly complex and interlinked food system.

Transportation in a circular economy

The actual CO_2 emissions per vehicle produced have fallen by nearly 24 per cent since 2008 (e.g. due to a shift to low-carbon or renewable energy sources). There has also been a reduction in water use by 31 per cent in the same period (e.g. due to the uptake of technologies that reuse water) also the amount of waste produced has fallen by nearly 14 per cent per vehicle produced. This is without factoring in improved fuel efficiency and recycling/reuse rates as well. However, while this demonstrates a drive towards more efficient vehicle manufacturing, the overall increase in the number of vehicles on the road has clearly offset these developments. In fact, CO_2 emissions generated by the transport sector has increased over time and remains one of the main emitters of GHG today (EEA, 2018a, IEA, 2019c, ECE, 2015a). There is consequently a considerable need to further reduce the environmental impact associated with the production and use of vehicles towards an inclusive circular economy

Taking a circular economy perspective might help pave the way for a sustainable transport sector. In the face of increased pollution, limited natural resources and degrading ecosystems, this would, on the one hand, need to ensure a reduction of GHG emissions as well as other pollutants that have an impact on health. On the other hand, it would need to ensure that natural resources are preserved, e.g. in terms of the recycling, reuse and optimised use of natural resources. This is particularly important as the production of a vehicle involves a significant generation of waste. For instance, according to the World Economic Forum, closed-loop recycling[60] could reduce energy consumption by up to 75 per cent. Although there are many strategies and approaches that can contribute to a circular economy, the automobile industry should adopt design principles that support the implementation of a circular economy (e.g. UN regulation No.133 on the reusability, recyclability and recoverability of vehicles).

Cities and urban areas in the circular economy

Urbanisation in the ECE region is ongoing, both in terms of land expansion and increasing population share. However, environmental challenges and opportunities associated with urbanisation are closely connected in both a rural and urban context. For instance, many urban areas struggle with high population densities (overcrowding) and air pollution, while cities also imply economic growth and opportunity that would otherwise not exist. From a natural resource use perspective, it can also be noted that an urban dweller generally consumes less energy and land per capita than do rural residents. Finding the appropriate balance (e.g. addressing trade-offs) between socio-economic and environmental factors (e.g. economic growth, population density and life quality) is consequently a major challenge for any urban area.

The transition towards low-emission and resilient urban areas depend on governments ability to address trade-offs while implementing a circular and green economy, both locally and nationally. In this bigger picture, the use and application of land value capture represent one tool available to policy-makers; it also illustrates the inherent difficulties in financing the transition towards a circular economy. For example, the financing of climate objectives in cities to deliver sustainable growth can be noted to have seen only a minimal increase in overall environmental and climate-related spending and investment, both in real terms and as a share of GDP, during the 2000 to 2016 period (OECD, 2018). This highlight the pressing need for tools, such as land value capture that can help to facilitate and showcase socio-economic and environmental opportunities associated with green growth, green infrastructure and the implementation of a circular economy.

Water use in the transition towards a circular economy

Water management covers the entire water cycle, ranging from surface water and groundwater management in order to meet different uses and functions to the production of drinking water as well as sewage and wastewater treatment. All these interlinked elements represent opportunities with regards to the transition towards a circular economy. The role of water is further apparent in maintaining biodiversity and ecosystem services as well as in providing numerous socio-economic services.

Water will play a prominent role in any effort to realise a circular economy. This can range from the recovery of resources and energy from water, improved water efficiency (which commonly results in higher energy efficiency also when less water is pumped and treated), water reuse, and a reduction in impacts from pollution and climate change. Efficiency in water use provides benefits in terms of economizing other resources: less energy is required to pump, heat, convey and treat water. Similarly, certain circular economy benefits can be achieved when water quality is adjusted to different uses' requirements: e.g. nutrients in water become resources upon water reuse for agricultural purposes. However, more importantly, for this report, the application of systems thinking (as inherent in the nexus approach) is critical for the identification of circular economy opportunities. This highlights that water management cannot be tackled in isolation from other sectors, in particular, if water systems are to be managed for long-term sustainability (ECE, 2016a, 2018b). Even more, as systems thinking is a core concept for the circular economy, efforts to better understand complex intersectoral dynamics affecting natural resource use in transboundary basins emphasise the important role of cooperation in managing natural resources. Closer coordination of sectoral and water management planning cycles as well as improving the exchange of information and coordination of investments between sectors and countries would help in the transition towards a circular economy.

60 See: https://www.weforum.org/agenda/2019/11/build-circular-economy-stop-recycling/.

Data demands for a Circular Economy

The circular economy is fundamentally promoted as an opportunity to reduce the dependency on fossil-based natural resources while also securing a sustainable supply of raw materials and energy while preserving the environment and the climate. It is also an emerging policy issue with links to several SEEA accounts. From a data perspective, this transformation is in part characterised by the need for a systems approach and the use of economic, environmental and social data. This process consequently requires, on the one hand, an integrative framework for data production and use, on all levels. On the other hand, it also needs to address the lack of data as a key barrier to achieving a circular economy. For instance, some of the missing data concern gaps relating to existing criteria sets (e.g. for certification), legislative frameworks (e.g. conflicting policy objectives), end-of-life processes as well as standardisation activities affecting natural resource use (Majer et al., 2018).

For the circular economy to be effective, it has, amongst other things, to address the **product life-cycle**. However, **data and indicators to track material input reductions on a macro-economic scale are mostly missing**. This includes information with regards to reuse, repair, redistribution, refurbishment, remanufacture and eco-design. Indicators and assessment tools will be needed to fill these data and knowledge gaps (EEA, 2017a).

The implementation and uptake of a systemic approach such as the circular economy are obviously not only dependent on access to relevant data and information; it is, however, a significant barrier. Integrative solutions, whether at the industry or governance level, cannot be identified without appropriate data on product stocks and flows throughout the economy (see also Section X.X). At present, most of the available data is about materials, which is insufficient to implement a circular economy. Even more, data are presently structured according to the logic of a linear economy, which is yet another barrier to different circular strategies.

Forests and the circular economy

A comprehensive approach to the circular economy considers various inputs and outputs in the product lifecycle, including energy supply from renewable sources, land use and management, and the conservation of soil, water and biodiversity. Circular concepts do not guarantee sustainability if they rely substantially on fossil-based materials with large environmental footprints or when the increased production of bio-based products competes with food production and has a negative impact on ecosystems, the climate, or the risk of natural disasters.

Therefore, while forest ecosystems provide the biodegradable raw material – a strategic resource for a number of advanced, reusable and recyclable bio-materials, it is important, in the transition to the circular economy, to ensure that they also continue to play their role in water resources management, climate regulation, biodiversity conservation, recreation as well as in providing livelihoods for local communities. Sustainable Forest Management helps conserve and enhance forest ecosystems and balance forest resources flows. For instance, as regards considering alternative uses of biomass which may serve ecosystems better by being left in the forest or extracted and used as an alternative to fossil-based products.

50 per cent of greenhouse gas emissions are related to extracting and processing materials, fuel and food (UNEP, 2019a). Global estimates suggest that forests could provide more than **one-third of the total CO_2 reductions** required to keep global warming below 2°C leading up to 2030 (Griscom et al., 2017), presently storing as much as **296 gigatonnes of carbon** in both above- and below-ground biomass. In Europe forests potential to sequester carbon can account for as much as **9 per cent of total greenhouse gas emissions**. Moreover, trees can serve as a great source of **renewable energy** as well as contribute to **reducing the use of carbon-intensive materials** by offering wood-based alternatives (e.g. in construction).

Forests are a source of bio-based products, which in the circular economy can substitute for non-renewable materials, and they have the capacity to naturally restore and recycle the quality of their resources. Different parts of a tree are used to manufacture various products, starting from the highest to the lowest quality grade. In a typical tree, harvested for sawmilling, less than two-thirds are taken from the forest for processing, and the remainder is either left, burnt, or collected as fuelwood. After sawmill processing, only 28 per cent of the original tree becomes lumber, and the remainder becomes residues, which are also used by the industry

The development of innovative, biodegradable, cellulose-based materials allows the closure of production-consumption loops with a smaller environmental footprint and creates economic growth in sectors supporting production, including research and development, design and product development, marketing, consulting, sales. Major wood components—cellulose, hemicellulose, lignin and extractives—serve as the basis for the production of various outputs such as construction materials, chemicals, biofuels, heat and electricity, bioplastics, packaging, food and feed ingredients, textiles, and pharmaceutical components, ensuring cross-sectoral transition to circular, more sustainable value chains across the entire economy.

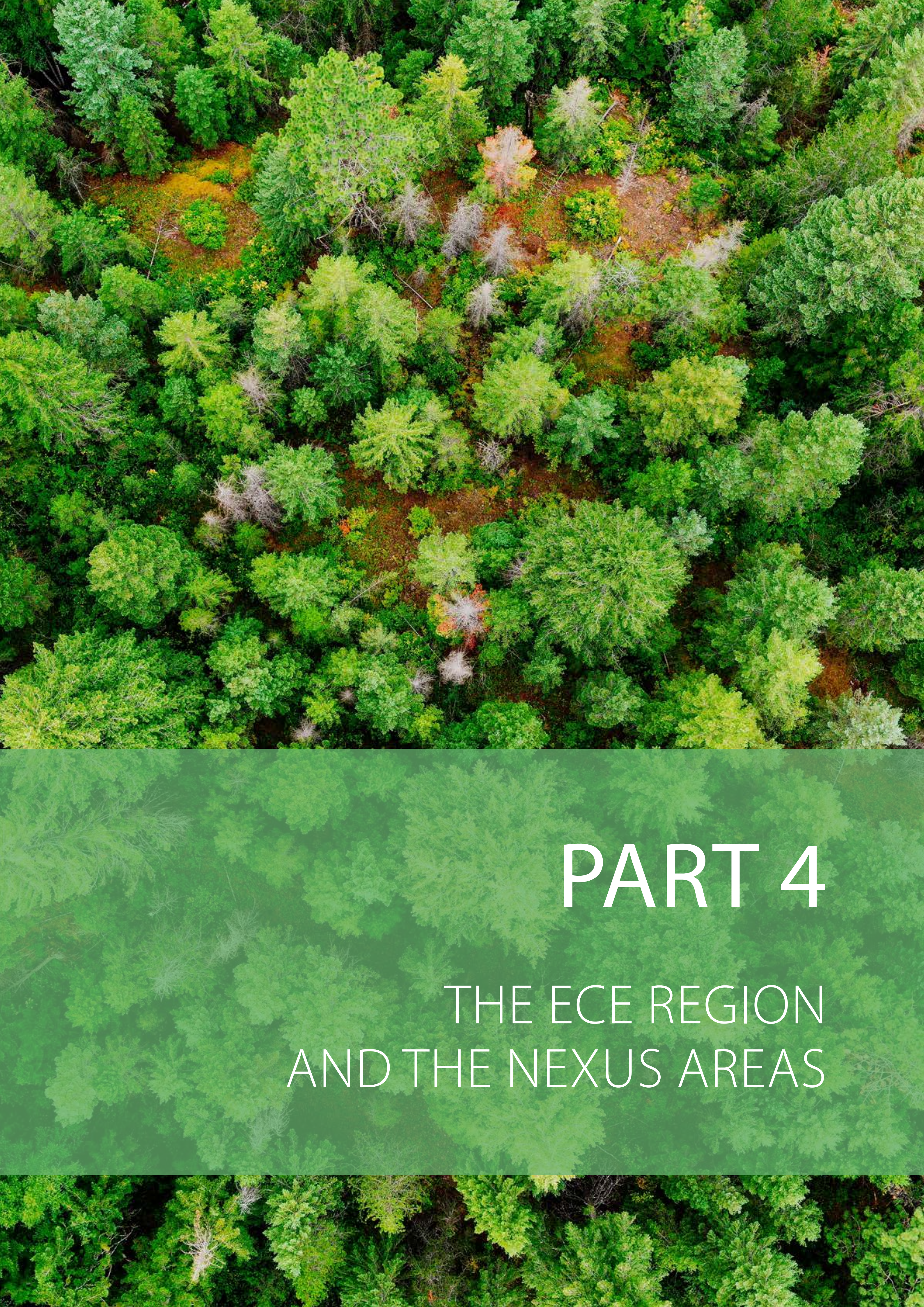
Circularity in an energy system

Even though there are numerous definitions of circularity, there are three cross-cutting principles of the circular economy, namely, to reduce, reuse and recycle. Having a regenerative circular model provides one pathway for an energy transition, underpinned by conversion to renewable energy sources, energy efficiency and clean technologies such as carbon capture and storage. It is basically a system where loops are closed, waste and pollution are designed out of the system, and negative externalities are eliminated. For instance, while not part of the recycling loop, turning renewable waste products into energy is one of the ways that circularity can be achieved in an energy system. The circular economy is essentially all about making better use of natural resources and to lower energy consumption and carbon dioxide emissions.

The share of renewable energy in final energy consumption reached **17.5 per cent in 2015**.[61] However, as the global material footprint is rapidly growing, it will be essential to further decouple energy production from finite natural resource consumption. For example, **22 per cent of the total CO_2** emissions in the EU could be mitigated by forest and the forest-based sector by 2050 (Nabuurs et al., 2017).

Energy systems are particularly problematic from a circular perspective, principally, as energy production often involve using natural resources (e.g. biomass and coal), whether they are renewable or not. The same applies to other energy sources, such as hydro, wind and solar power, which require large areas of land that may affect environmental conditions and compete with other land use (e.g. food production). Moreover, as indicated previously, energy systems are capital intensive and have lifetimes of forty years or more, with hydro-electric dams having more than 100 years of life. This emphasises some basic challenges underlying circularity. From a nexus perspective, it further showcases that balancing energy demand and supply will not only require increasing resource-efficiency and improved natural resources management but also taking a systems approach whereby all relevant sectors (e.g. agriculture, forestry and waste) are involved in the implementation of integrated solutions.

61 See: https://www.un.org/sustainabledevelopment/energy/.



PART 4

THE ECE REGION AND THE NEXUS AREAS

4 NATURAL RESOURCE NEXUS AREAS AND THE ECE REGION: PATHWAYS TO INTEGRATIVE NATURAL RESOURCE MANAGEMENT

Part 2 of this study outlined some of the many interactions which make necessary a nexus approach to evidence-based policymaking, notably in the field of natural resources, defined for this study as water, food, energy, land and materials, with the cross-cutting dimensions of trade and transport (see page 7). If well implemented, nexus approaches have the potential to optimize efficiency in achieving goals and reduce negative externalities while promoting integrated planning, management and governance. Part 3 identified seven "nexus hotspots" in the area of natural resources, where a nexus approach is necessary and where the ECE is already making a significant contribution (see page 26). For each hotspot, it briefly described the interactions and challenges, as well as ECE's main activities for this hotspot. One additional premise for the natural resource hotspots has been to showcase different types of challenges facing any prospect for integrative natural resource use. For instance, the natural resource hotspots identified different intersectoral challenges, such as food loss and waste, transboundary natural resource use and life cycle assessments, to systemic challenges, such as the lack of integrative data and information, to financing concerns, such as land value capture, to integrative natural resource management, such as landscape restoration and integrative energy use. Together, these hotspots demonstrate a wider and cross-cutting set of factors affecting the natural resource nexus.

This part will offer suggestions for possible next steps by the ECE, based on the analysis of earlier parts and the experience within the ECE subprogrammes. It aims to describe an ambitious but realistic pathway for the ECE to incorporate the nexus approach wherever it is appropriate and thereby increase the effectiveness of design, revision and implementation of policy instruments to address complex natural resource issues. Expanding nexus frameworks that consider interactions between sectors, across scales, between regions, and linkages with the SDGs could help ensure sustainable natural resource management and use as well as integrated SDG implementation.

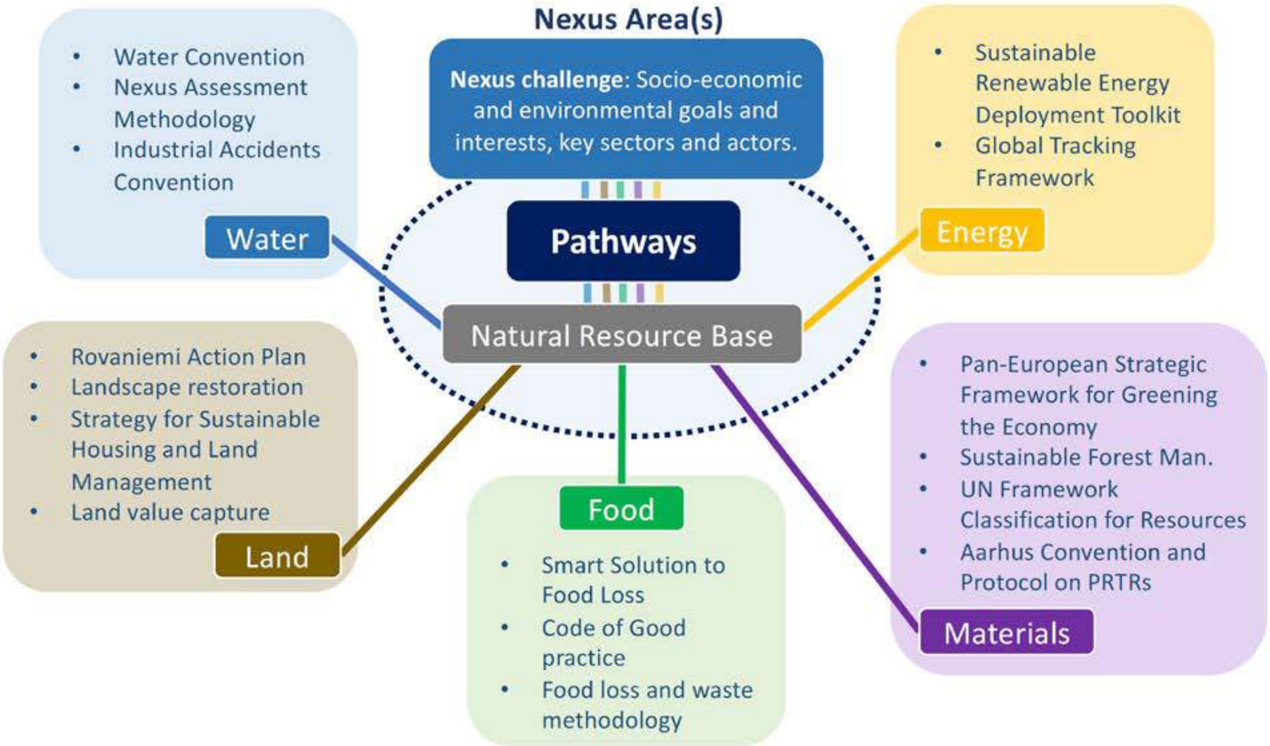
4.1 Existing ECE tools

Nexus approaches examine interactions between multiple sectors, uncovering synergies and exploring trade-offs between sectors. If well implemented, nexus approaches have the potential to reduce negative externalities while promoting integrated planning, management and governance. However, while the application and implementation of nexus approaches is still limited, the ECE has already tools in various sub-programmes which can be applied to address nexus issues. Some of these tools and approaches have been introduced in part 3 and are summarised in Figure 17.

There are several common features and challenges visible from the descriptions of these tools and instruments. They all:

- are based on in-depth analysis of the complex interactions, using the best available data.
- take a holistic and long-term approach, considering not only intersectoral impacts but also environmental, social and economic dimensions when seeking the optimal path forward.
- have a participatory element, with the consultation of stakeholders.
- contribute to achieving the SDGs and targets of Agenda 2030, and are in conformity with the principles of the United Nations.
- have emerged from a "bottom-up" process, wherein subprogrammes or technical expert or intergovernmental bodies have realised that a nexus approach is necessary to address the complex issues in their sector.

Figure 17: Pathways for a nexus approach on natural resource issues



Source: own figure.

The tools include conventions, a charter and a policy platform, standards and good practice guidance, strategies, an accounting system, data connected tools and dedicated projects and capacity-building activities. Their formal structure varies widely, as does the extent to which they are taken up by policymakers and stakeholders (see Box 9).

From the nexus hotspots, it would further appear that there is scope for ECE bodies and communities to learn from each other's experience in applying the nexus approach to natural resources, and for the ECE region itself to reinforce its leadership in these efforts, without imposing artificial homogeneity. Indeed, this has been one of the reasons for preparing the present study.

Box 9: ECE tools and approaches are relevant for the Natural Resource Nexus

	Type of Tool	Scale of application	Description	Bodies
Instruments	Conventions & Protocols	**Global**	Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention)	• Working Group on Monitoring and Assessment • Working Group on Integrated Water Resources Management
			Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention) and the Protocol on Pollutant Release and Transfer Registers (PRTRs)	• Task Force on Access to Justice • Task Force on Public Participation in Decision-making • Task Force on Access to Information
		ECE region	Convention on Long-range Transboundary Air Pollution	• Working Group on Effects • Working Group on Strategies and Review

Box 9: ECE tools and approaches are relevant for the Natural Resource Nexus (continued)

	Type of Tool	Scale of application	Description	Bodies
Instruments	Conventions & Protocols	ECE region	Convention on the Transboundary Effects of Industrial Accidents	• Joint Expert Group on Water and Industrial Accidents
			Espoo Convention and the SEA Protocol	• Working Group on EIA and SEA
	Agreements	Global	Agreement concerning the Adoption of Harmonized Technical United Nations Regulations for Wheeled Vehicles […] (the 1958 Agreement)	• Working party on pollution and energy • Working party on noise and tyres
			Agreement concerning the Establishing of Global Technical Regulations for Wheeled Vehicles […] (the 1998 Agreement)	
	Charter	ECE Region	Geneva UN Charter on Sustainable Housing	• Committee on Urban Development, Housing and Land Management
	Policy Platform	ECE region	Transport, Health and Environment Pan-European Programme (THE PEP)	• Bureau of THE PEP
	Standards	Global	Quality standards for the safe and transparent trade of food and agricultural produce	• Working Party on Agricultural Quality Standards
			Traceability standards and implementation support for the garment and footwear	• United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT)
			United Nations Framework Classification for Resources (UNFC) and the United Nations Resource Management System (UNRMS)	• Committee on Sustainable Energy
			UN Regulations (Nos. 49, 83, 96, 101 & 133)	• Inland Transport Committee
			UN Global Technical Regulations (GTRs Nos. 2, 11 &15)	• Inland Transport Committee
		ECE region	UN/FLUX fisheries data management standard	• United Nations Centre for Trade Facilitation and Electronic Business
	Good practice guidance	Global	Food loss and waste measuring methodology for fresh produce supply chains	• Working Party on Agricultural Quality Standards
			Code of Good Practice for Reducing food loss in handling fruit and vegetables	• Working Party on Agricultural Quality Standards
			Smart Food Loss Management System	• Working Party on Agricultural Quality Standards
			ECE Guidelines on Social Housing	• ECE Committee on Urban Development, Housing and Land Management

Box 9: ECE tools and approaches are relevant for the Natural Resource Nexus (continued)

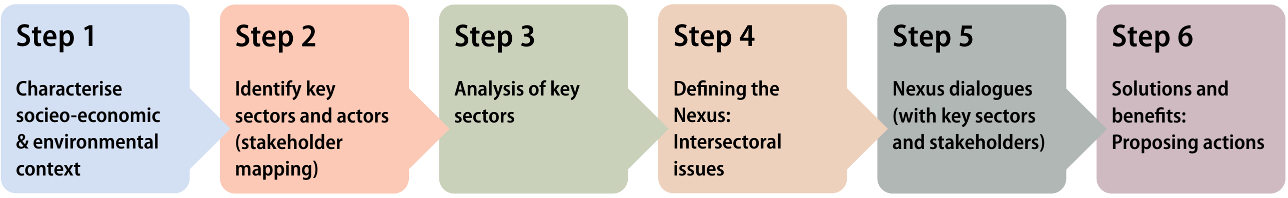
	Type of Tool	Scale of application	Description	Bodies
Instruments	Good practice guidance	Global	Maastricht Recommendations on Public Participation in Decision-making Lucca guidelines on access to information, public participation and access to justice with respect to genetically modified organisms Guidance on implementation of the Protocol on PRTRs	• Working Groups of the Parties to the Aarhus Convention and the Working Groups of the Parties to the Protocol on PRTRs
		Transboundary	Nexus Assessment Methodology - Assessing the water-food-energy-ecosystems nexus in transboundary basins	• ECE Task Force on the Water-Food-Energy-Ecosystems Nexus
			Sustainable Renewable Energy Deployment (accounting for water and environment) Toolkit for Policy Makers	• Group of Experts for Renewable Energy
			Guidelines on promoting the principles of access to information, public participation in decision-making and access to justice in international forums dealing with matters relating to the environment	• Working Groups of the Parties to the Aarhus Convention
	Strategies	ECE Region	Pan-European Strategic Framework for Greening the Economy	• Committee on Environmental Policy
			Strategy for Sustainable Housing and Land Management 2014-2020	• Committee on Urban Development, Housing and Land Management
Data production and use	Statistical Repositories	ECE region	Inland Transport Statistics for Europe and North America	• Inland Transport Committee
			ECE Statistical database	• Conference of European Statisticians
	Accounting	Global	System of Environmental-Economic Accounting	• Conference of European Statisticians
	Online tools	ECE region	Forest Information Billboard	• Committee on Forests and the Forest Industry and FAO European Forestry Commission
			Statistics for SDGs Public Wiki	• Conference of European Statisticians
	Data collection	ECE region	Joint Forest Sector Questionnaire Joint Pan-European Reporting on Forests and Sustainable Forest Management Joint Wood Energy Enquiry	• Committee on Forests and the Forest Industry and FAO European Forestry Commission

4.2 Developing nexus-relevant tools

Given the bottom-up nature of the ECE's nexus-relevant tools, it is possible that there are some natural resource areas where a nexus approach would be appropriate, but which have not yet been developed. Where this is the case, to benefit from experience within the ECE, a process that can identify "nexus pathways" has been developed, based largely on experience with water and energy-related nexus activities that have been carried out by the ECE so far (ECE, 2018c, ECE, 2019f). The approach has been left intentionally broad as it is foreseen that it could be applied at many levels, ranging from the identification of new nexus-relevant activities for the ECE to helping decision-makers and project managers to consider intersectoral issues within the scope of their activities (see Figure 18).

This standardised approach would aim at identifying, assessing, and classifying synergies and trade-offs between the natural resource that is being examined and other sectors. This process should ideally identify gaps and barriers that exist both for the natural resource that is being analysed and the sectors involved. Following below is a proposed step-by-step process for how this could be achieved (see Figure 18), as adapted from the ECE nexus assessment of a transboundary basin methodology (ECE, 2018c) and a process proposed in the ECE sustainable renewable energy investment and deployment toolkit (ECE, 2019f).

Figure 18: Identifying a nexus pathway



Source: Adopted from ECE (2018c).

Any nexus approach needs to start by considering what **nexus challenges** characterise a given environment (e.g. main socio-economic and environmental goals and interests, key sectors and actors), irrespective of the level of analysis (e.g. local to global). This process should include the identification of **intersectoral linkages**, as part of defining the nexus, as well as allow for the identification of **transboundary linkages** within the nexus (Steps 1 to 4). These linkages can be classified as either positive or negative (e.g., water extraction having a negative impact on water flow downstream).

The assessment should further evaluate whether the identified interlinkages have been addressed in **existing or planned measures** (e.g., are synergies being promoted and trade-offs mitigated), at the national or global level. If not appropriately addressed, the assessment should entail reviewing whether these linkages are due to a **lack of measures** (gaps) or **conflicting measures** (barriers) that are generating **trade-offs**. If relevant, possible partner agencies should be invited to participate from the very beginning to avoid duplicating activities and ensuring successful cooperation and ownership in implementation.

The process has been left intentionally open to allow for modification and application to varied scales, contexts, and nexus challenges. However, the aim of the process could ultimately be to propose actions that can address interlinkages and **actions and measures** that can mitigate any negative impacts generated by these interlinkages. The analysis, as well as the development of possible actions, could ideally be anchored in a multi-stakeholder dialogue, both to collect data but also to ensure that proposed actions are accepted and taken up.

4.2.1 Building capacities for nexus implementation

The establishment of a nexus team on natural resource use in the ECE and the development of this report has demonstrated the potential added value in taking a nexus approach further within the UN development system in the ECE region. Both at the country level in United Nations Country Teams (UNCTs), and in government administrations. In practical terms, embedding nexus thinking and the establishment of nexus teams at the country level, whether within institutions or across sectors, to identify synergies and trade-offs and facilitate cross-sectoral coherence, can help to ensure sustainable natural resource management. The nexus approach provides some of the tools needed for countries to improve institutional and national capacities to tackle intersectoral challenges with regards to key societal challenges for natural resource management.

First, there are many ECE countries which do not yet have the capacity to implement activities which are often different from existing practice, especially when they call for breaking down traditional institutional boundaries, for instance among ministries. It is often these countries which have the most need for a nexus approach. For that reason, the development of nexus tools addressing natural resource use needs to be accompanied by capacity-building efforts. ECE has considerable experience in this type of activity, notably in the Caucasus and Central Asia, and is well placed to deliver this work.

Second, capacity building and sustainable development education should be cornerstones of operationalising nexus approaches and methods that advance the sustainable management of natural resources. This can only be achieved by creating an enabling environment and building nexus competences and knowledge on how to apply nexus concepts and methods in practice. One key recommendation would thus be to develop a learning programme and strategy as part of any continued efforts to apply a nexus approach at the ECE, including the involvement of relevant UN Country Teams.

4.2.2 The nexus of a pandemic and the post-Covid-19 world

This report was started before the emergence of Covid-19 as a worldwide public health concern and the subsequent impact it had on the world under lockdown. The pandemic has served to remind us how vulnerable societies are to naturally occur infectious diseases. It has further demonstrated the inherent and complex relationships that exist between different sectors of economic activity, society, and natural environments, emphasising the relevance of the animal-human-environment interface. For instance, the "One Health"[62] approach, driven in part by the World Health Organisation, is an emerging concept that aims to bring together human, animal, and environmental health. These types of collaborative, multisectoral, and transdisciplinary approaches will be central to tackling future health challenges.

For the purposes of this report, Covid-19 highlights the impact an infectious disease can have on natural resource use. Since the onset of the pandemic, the world has seen a massive reduction in industrial activity and emissions, with both positive and negative socio-economic and environmental effects. For example, according to UNEP, deforestation, intensive farming and climate change are among the main drivers of the increased spillover of infectious diseases into human populations.[63] Safeguarding public health consequently requires to rethink the relationship we have with the environment and, more importantly, the drivers underlying the unsustainable use of natural resources. The nexus approach can be one instrument in this effort. On the positive side, reduced economic activity has cut pollution of all sorts and GHG emissions.

4.2.3 Nexus principles for the sustainable use of natural resources

The nexus approach offers a window of opportunity for understanding, and in some cases resolving, the trade-offs underlying unsustainable natural resource use as well as the interdependencies across sectors, stakeholders, and natural systems. The nexus hotspots in this report demonstrate that systemic thinking and integrated solutions need to guide the development and implementation of nexus approaches as they relate to natural resource use. Perhaps more importantly, there is a demand for solutions that are applicable across regions and their related nexuses.

One additional way forward in building capacities for nexus implementation would be to develop nexus principles that can be context-specific and applicable to any scale. For instance, every country may require different nexus approaches, including different methods for addressing variations within countries (e.g. related to consumption patterns and resource use intensities) that in turn, require specific nexus solutions. Although solutions may vary significantly depending on the context, taking a full life-cycle view and circularity, as some of the possible principles, could help in identifying approaches that ensure the sustainable use of natural resources.

62 See: https://www.who.int/news-room/q-a-detail/one-health.

63 See: https://www.unenvironment.org/news-and-stories/story/six-nature-facts-related-coronaviruses.

4.3 Recommendations

On the basis of the analysis of the study, and the experience of ECE channelled through the natural resource's nexus team, the following recommendations are proposed.

4.3.1 Addressed to member States: governance, participatory decision-making, and the rule of law

1. Promote integrated approaches to natural resources through mutual reinforcement and cross-referring at applicable levels of policy and decision making.
2. Recognise the added value in taking a nexus approach when considering key societal challenges regarding natural resource management as well as the need for improved institutional and national capacities to tackle these intersectoral challenges.
3. Encourage effective public access to information using Open Data, the interoperability of information systems and new and emerging digital technologies across different domains to identify nexus hotspots, inform decision-makers and raise public awareness.
4. Promote legal obligations and good practices for inclusive and effective public participation in decision-making and for multi-stakeholder dialogues to address the most sensitive areas of decision-making (e.g. energy, water, land, food, and materials).
5. Apply effective and systematic strategic environmental assessment and environmental impact assessment.
6. Encourage the development and use of eco-labelling, eco-auditing, and other means to support sustainable consumption and production.
7. Promote legal obligations and good practices for the protection of environmental defenders against penalisation, persecution, or harassment for exercising their rights in relation to the use of natural resources.

4.3.2 Addressed to ECE policy level bodies: strengthening ECE's contribution to the nexus approach for natural resources

1. Improve existing tools, possibly broadening their scope or how they complement and reinforce each other to form effective toolkits, raising their ambitions, or developing new partnerships inside or outside ECE region (see recommendation set 3).
2. Engage in an internal consultation process to further refine and agree on how the nexus approach could benefit the organisation and its sub-programmes, including efforts to get the units to communicate and cooperate more regularly on intersectoral issues (this consultation process is being implemented in parallel with the preparation of this study).
3. Develop new tools, with consideration of combining/incorporating existing ones, developed by sectors, where their usefulness is clear, after a review of ECE's activities to determine where new tools would be appropriate.
4. Build in-house capacity and knowledge for ECE staff to develop and implement a nexus approach in their respective areas of work, using tools supplied by ECE and/or partner organisation.
5. Engage relevant partners and countries in a dialogue to explore how the nexus approach could enhance regional cooperation and communication on nexus-relevant topics.

4.3.3 Addressed to ECE subprogrammes and expert bodies, and the appropriate expert communities in member States: developing and strengthening the activities described under the nexus hotspots

Food loss and waste

1. Work with more integrated approaches to food loss and waste with relevant intergovernmental bodies on water, land, and energy as well as through projects.
2. Identify needs gaps in the ECE inventory of guidelines and methodologies on food loss and waste and define inter-disciplinary approaches.
3. Identify new partnerships with all stakeholders to further interdisciplinary work on food loss and waste.
4. Extend assistance to the implementation of the standards and guidelines by all ECE countries considering inter-disciplinary approaches and linkages.
5. Raise awareness of food loss and waste all over the ECE region.
6. Build capacity, especially in the Caucasus and Central Asia, with the aim of improving quality, handling and transport of food and setting clear (numerical) targets for the reduction of food loss and waste.
7. Develop plug-ins into the ECE Smart Food loss management tool (FeedUP@UN) to integrate all available ECE tools, standards, and conventions.

Life cycle of vehicles

1. Invite participation of representatives of the transport sector in work on land use planning
2. Find synergies between ECE work on energy scenarios and transport infrastructure and technology
3. Use expertise from the Transport subprogramme to identify the contribution of the transport sector to pollution emissions in the ECE region, in the light of relevant ECE environment conventions, and consider how the situation could be improved and what ECE's role should be in this area.
4. Identify gaps in the ECE system of transport-related regulations regarding this nexus hotspot. For instance, is there a need for an official standard for Sustainable and Resilient Infrastructure?
5. Strengthen the work on the implementation of the standards and guidelines, including monitoring their use, and building capacity where necessary.

Land value capture

1. Arrange systematic comparisons of land-relevant instruments under ECE bodies, for instance, national forest programmes and integrated water resources management, with concepts of land-use planning and river basin management plans. The various strategies and approaches should be mutually reinforcing and cross-referring.
2. Monitor to what extent the concept of land value capture is being applied, and identify possible obstacles, and lessons learned.
3. Collect examples of good practice regarding land value capture, and prepare guidelines
4. Improve awareness of the potential of land value capture.
5. Implement capacity-building adapted to local circumstances in the Caucasus and Central Asia, where urbanisation is proceeding rapidly.

Natural resource use in transboundary basins

1. Develop cross-cutting activities building on current ones which can contribute to natural resource management in transboundary basins, in the following key areas: water-forestry, water-energy, water-energy-land use-ecosystems, climate adaptation and mitigation strategies, financing sustainable development in shared basins.
2. Promote ECE multi-lateral environmental agreements as nexus tools.
3. Promote the application of the ECE nexus assessment methodology for transboundary basins (ECE, 2018a, 2018b) and the ECE toolkit for sustainable renewable energy planning in transboundary contexts (ECE, 2020a, 2020b).
4. Invite extended participation from both inside and outside ECE to use the Task Force on the Water-Food-Energy-Ecosystems Nexus to identify nexus solutions and investments (synergic actions), sharing of experience and capacity building.
5. Organise joint sessions or back-to-back events between ECE bodies, e.g. between the Working Group on Integrated Water Resource Management and relevant sectoral committees.

Measuring the use of natural resources with the System of Environmental-Economic Accounting (SEEA)

1. Support the implementation of SEEA and production of underlying data (with specialist agencies, notably in ECE). Further, develop methodologies for SEEA-based indicators, and carry out capacity building activities, together with national and international partners in the region.
2. Develop a proposal to use big data and environmental monitoring data in real-time and pollutant release and transfer registers, to provide information on the flows (e.g. energy, waste and air pollution), and thus help to manage natural resources more efficiently.
3. Systematically review the data situation for all nexus hotspots, possibly helping to gather or mobilise data, and/or integrating data used/generated in the nexus work into the Conference of European Statisticians (CES) data structure.

Forest landscape restoration

1. Improve methodology, monitoring and knowledge on landscape degradation in the ECE region.
2. Develop methodology and good practice guidance in forest landscape restoration tailored to the ECE region.
3. Support the cooperation of the Joint ECE/FAO Forestry and Timber Section, with other ECE units (water, energy, land) as well other partners (e.g. IUCN and the World Bank) in promoting forest landscape restoration.
4. Assist countries of the region, notably of the Caucasus and Central Asia, and Eastern and South-East Europe in implementing their commitments with regard to forest landscape restoration (e.g. under the ECCA30/Bonn Challenge), including in their work on mobilisation of resources for that purpose.
5. Support development of National Forest Programmes and financing strategies as an inclusive tool to promote the involvement of other sectors in sustainable forest management, including forest landscape restoration.
6. Review and update the Rovaniemi Action Plan for the Forest Sector in a Green Economy (2013), which is based on a nexus approach, and as part of the ECE move towards a circular and bio-based economy.

7. Continue to monitor the sustainability of forest management in the region, and support member States in achieving sustainable forest management.

Integrated management of energy and mineral resources

1. Promote the implementation and use of the UN Framework Classification of Natural Resources (UNFC), including capacity building, and consulting other relevant ECE bodies (e.g. forest, water, statistics).
2. Strengthen the integrated and holistic management of energy and mineral resources through the application of the United Nations Resource Management System (UNRMS).
3. Adopt circular economy principles, and natural resources use based on closed-loop systems to ensure resources are conserved within given product life cycles.
4. Provide a focus on the critical materials required for sustainable energy.
5. Apply UNFC and UNRMS in sustainable resource management: this could be useful for Micro, Small, and Medium Enterprises (MSMEs) to build innovative business models and to gain from the new avenues that are being opened in a post-COVID-19 world.
6. Take action to increase women entrepreneurship in sustainable resource management value networks.
7. Review the status and possible availability of renewable energies, including links to agriculture, forestry, and water.
8. Include energy aspects in Environmental Performance Reviews (EPRs).
9. Ensure "Social License to Operate" in sustainable resource management through responsive, inclusive, participatory, and representative decision-making at all levels.
10. Support the adoption of UNFC and UNRMS through the creation of International Centres of Excellence in Sustainable Resource Management.

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Natural Resource Nexuses in the ECE region

The 2030 Agenda and its Sustainable Development Goals (SDGs) provide an ambitious and comprehensive framework that opens new perspectives for policymaking and international cooperation. Its integrated character highlights the linkages and complementarities that exist between different goals and targets.

UNECE is supporting countries to address these key sustainable development challenges through an integrated, multisectoral approach leveraging UNECE norms, standards and conventions, and by building capacities and providing policy assistance. At the crossroads of all UNECE programmes and expertise, four high-impact "nexus" areas have been identified where multiple SDGs converge:

- Sustainable use of natural resources
- Sustainable and smart cities for all ages
- Sustainable mobility and smart connectivity
- Measuring and monitoring progress towards the SDGs.

This publication discusses the complex interactions and feedback loops between human and natural systems affecting the natural resource base involving seven hotspots and provides several recommendations.

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