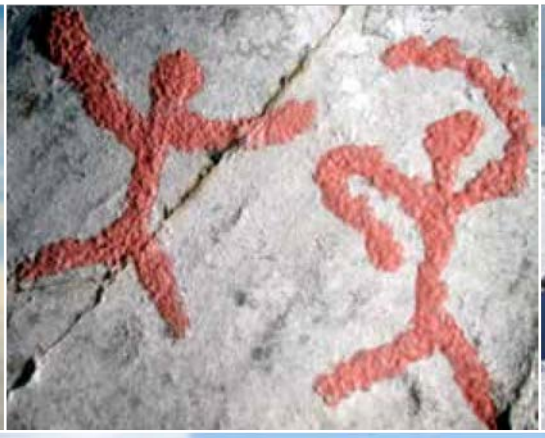
Klima- og
miljødepartementet

Priority research needs of the Ministry of Climate and Environment (2016-2021)


Priority research needs of the Ministry of Climate and Environment (2016-2021)

Contents

1 Introduction

Biodiversity and ecosystems provide the basis for all human existence. Nature and the cultural heritage together are of crucial importance for people's health, prosperity and security, and are the foundation for a good life for current and future generations. Climate change and a range of other environmental pressures, including pollution, are creating major challenges. Adaptation to climate change and the transition to a low-emission society will require extensive social transformation.

There is general agreement that dealing with climate and environmental problems is one of the most important tasks of our time. Norwegian policy is to take a long-term approach to safeguarding and managing biodiversity and the cultural heritage. Healthy ecosystems are needed to maintain the production of vital goods and services. Norway intends to become a low-emission society and achieve carbon neutrality by 2050. Another target is to eliminate releases of substances that are hazardous to health or the environment.

The Ministry of Climate and Environment has the overall responsibility for maintaining an overview of the state of the environment and identifying what action needs to be taken, and for coordinating climate and environmental policy. However, all sectors whose activities have an impact on the climate and environment must take a share of the responsibility for achieving national environmental targets.[1] It is therefore essential that climate and environmental issues are an integral part of research and other knowledge production that takes place with the help of funding from different sectors and industries.

Policy development and governance in the field of environment and climate change must be knowledge-based. This means that the environmental authorities must have information on the state of the environment, drivers of change, pressures and impacts, and appropriate tools and policy instruments. This document describes priority knowledge needs for the period 2016–2021. It is based on input from the Norwegian Environment Agency, the Directorate for Cultural Heritage, the Norwegian Polar Institute and the Norwegian Radiation Protection Authority.

2 Major environmental problems

The most serious environmental problems both globally and in Norway are climate change, loss of biodiversity and the spread of pollutants that bioaccumulate and are biomagnified along food chains. They must be addressed by means of an integrated approach and close international cooperation. Loss of cultural heritage is another problem that must be addressed. In a recent report, the European Environment Agency indicated that if Europe is to live within the planet's ecological limits, fundamental changes will be required in production and consumption systems, which are the main

[1] Meld. St. 18 (2012-2013) *Long-term perspectives – knowledge provides opportunity* (summary), white paper from the Ministry of Education and Research

drivers of the growing pressure on the environment.[2] This in turn will necessitate profound transformation of our societies.

Maintaining prosperity and a healthy environment will require innovation, greater resource efficiency and a green transformation within an environmentally sustainable framework. If economic growth is to be sustainable, it must be accompanied by low releases of greenhouse gases, hazardous substances and other pollutants, steps to safeguard the natural and cultural heritage, and less waste of resources.

According to the UN, the world population is likely to rise from seven to nine billion by 2050. The number of people in the middle class may rise from two to five billion – and overall, this is the group who use most resources and are responsible for the greatest share of environmental problems. The rising population will need more land and natural resources, and releases to air, water and soil may rise with the accompanying increase in production of goods and services. More and more chemical substances are being used in products. Some of these may be hazardous to health and the environment. Unless sustainable ways are found to address all these challenges, already existing environmental and social problems may be exacerbated.

Climate change is already affecting people and the environment across all the world's continents and oceans. In the years ahead, the impacts will gradually become more marked, with greater consequences for the natural and cultural heritage, society and individuals. Food production and access to clean water are likely to be poorer in parts of the world. Extreme weather events such as flooding and heat waves will affect larger numbers of people.

To achieve the two-degree target, greenhouse gas emissions from fossil energy use, for example for transport and heating, must be reduced rapidly. It will be necessary to find green alternatives to industrial use of emission-intensive raw materials and processes. This will require restructuring and innovation. The transformation process is already gaining speed in the EU and the Nordic region, in the US and in China. For the business sector, the challenge of climate change is partly about managing to be the first to market the best types of environmental technology: zero-emission and energy-efficient solutions. More knowledge is needed about good incentives for the development and deployment of environmental technology. In addition, radical changes will be needed in how the world's forests are managed. Unless we can stop deforestation globally, we will not be able to achieve the two-degree target. Carbon fixation must be increased by improving land-use and forest management in ways that also take biodiversity considerations and food security into account. Norway is playing a leading role in international efforts to reduce deforestation, and should therefore contribute to knowledge production in this field.

Research priorities should be considered in conjunction with broader industrial policy goals so that research activities stimulate industrial development in areas where Norway is well placed, for example shipping, aquaculture and process industries. Hydropower and Norway's role as an energy supplier to Europe are also important in this context.

[2] European Environment Agency: The European Environment – State and Outlook 2015.

Norway has special advantages because of its geographical situation and extensive, resource-rich seas and polar areas, and this has led to the development of some of the country's most outstanding research groups. They have a valuable role to play in developing knowledge about climate change and understanding its significance, finding low-emission solutions for the future and making Norwegian society more resilient. Norway also has an international responsibility for developing new knowledge in fields where the country has particular strengths.

The Paris Agreement from December 2015 is the first binding and truly global climate change agreement. Its overall aim is to keep the increase in the global average temperature to 'well below 2 °C'. In addition, countries are to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. There is an even greater need for climate research as a result of the higher level of ambition in the Paris Agreement.

Norway has a wide variety of ecosystems and landscapes, and a valuable natural and cultural heritage. Biodiversity loss and declining ecosystem services are global problems. Land-use change and habitat fragmentation are the main causes of biodiversity and cultural heritage losses.

Even though population density is low in Norway, there is considerable pressure on land resources in certain parts of the country. Climate change will add to existing problems***. It is a challenging task to provide a framework that will encourage social development and value creation that are kept to a greater degree within ecologically sustainable limits. Land conversion and land-use change, habitat fragmentation, depopulation of rural areas and urbanisation have impacts on landscapes, the natural environment and the cultural heritage, and result in substantial losses.

Interactions between the various factors that affect the environment are decisive for the cumulative environmental effects.

3 General guidelines

Norway's national environmental targets

Norway's national environmental targets (see Appendix 1) provide the framework for the work of the Ministry of Climate and Environment and other ministries, and are set out in the Ministry's annual budget proposal. In addition, the Government's political platform contains important guidelines for environmental research.

Long-term plan for research and higher education

Two of the six long-term priority areas in the Government's Long-term plan for research and higher education (2015-2024) are seas and oceans and climate, environment and clean energy. Within these areas, the environmental authorities will focus particularly on:

- the transition to a low-emission society
- improving understanding of climate change and good practices for adaptation
- sustainable social development
- improving management of marine ecosystems and natural resources
- clean seas and safe and healthy seafood

The international perspective

The nature of the major global climate and environmental problems means that they must be tackled through international cooperation. The whole research sector thus needs to become more international. Norwegian research groups and institutions should be encouraged to take part in international activities such as Horizon 2020, the EU's framework programme for research and innovation, and the joint programming initiatives (JPIs). This can maximise the benefits and dissemination of international research results at national level, and promote close links and synergies between Norwegian and international research activities. The Ministry considers it important for Norway to train researchers with sound interdisciplinary expertise on national and international environmental issues, so that they can play a part in international forums such as the UN Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and cooperation bodies under the multilateral environmental agreements. There is a special need for expertise in economics and other social sciences that can be used in interdisciplinary research.

Norway's environmental legislation and environmental policy instruments are largely EU-based, and EU legislation is incorporated into Norwegian law under the Agreement on the European Economic Area (EEA). It is therefore important to have an understanding of the EU system, how proposals and policy instruments are developed, the influence of different groups and institutions and how countries participate in these processes. Similarly, it is important to understand how trade agreements set a framework for policy development at international and national level.

Relevance of research to the public administration

There is an increasing need for research to be targeted to the needs of the public administration. Research is needed on issues that are important for developing and implementing Norwegian policy in order to achieve Norway's national environmental targets and meet its international commitments. Both the Research Council of Norway and research groups need to direct activities towards topics that are relevant to the public sector. Some cross-sectoral topics require knowledge production based on cooperation between sectors.

If Norway is to achieve its target of becoming a low-emission society by 2050, all sectors must contribute to the necessary transformation process. The Research Council has an important role to play in coordinating and setting priorities for research activities across sectors and industries so that they play the most effective part possible in achieving Norway's climate targets.

Dissemination

Research results must be disseminated effectively and clearly, and in ways that are suitable both for the general public and for the public administration. To ensure a good flow of information to different user groups, information must be communicated in ways that are adapted to different target groups. It is also important to maintain an active dialogue with the users of research results throughout the process.

Research and monitoring (long time series)

Environmental monitoring programmes are needed to gather information on trends in ecological status, environmental pressures and their impacts.

Monitoring data are an important basis for research, but research is also needed to develop sound methods of collecting monitoring data. Monitoring data enable scientists to analyse environmental trends, and it is vital to maintain and continue long time series. Sound monitoring of environmental change is an essential basis for research activities.

It is important to establish digital infrastructure for using and sharing environmental data across research institutes and administrative bodies. There must be public access to all data obtained using public funding.[3]

Norwegian involvement in the European Earth observation programme Copernicus opens up new opportunities for using remote sensing in monitoring, analysis and research.

4 Priority research needs

The rest of this document describes the priority research needs of the Ministry of Climate and Environment. For each thematic area, there is an introductory text followed by a list of bullet points describing more specific needs. For a complete picture of research needs, the introductory texts and bullet points should be considered together. The order of the bullet points in the lists is not an indication of their priority.

4.1 The importance of the environment for people and society

Good ecological status in ecosystems, access to the natural environment and outdoor recreation areas, and the aesthetic and emotional benefits derived from landscapes, biodiversity and the cultural heritage are all important for people's health and well-being. They are also important assets for tourism and other forms of value creation.

The cultural heritage offers meeting places between the past, the present and the future. It provides tangible and authentic evidence of people's lives and activities throughout history, and is at the same time part of the dynamic contemporary environment that will be further developed by present and future generations.

Knowledge is needed about the importance to society of safeguarding the natural and cultural heritage, so that these considerations are taken properly into account in relevant processes in different sectors and at various administrative levels.

Key research needs:

- Understanding the cultural and social value and economic importance of the natural and cultural heritage.
- The cultural heritage as a resource for sustainable development

[3] Meld. St. 18 (2012-2013) *Long-term perspectives – knowledge provides opportunity*, white paper from the Ministry of Education and Research and Meld.St.14 (2015-2016) *Nature for life – Norway's national biodiversity action plan*, white paper from the Ministry of Climate and Environment.

- The importance and value of protected areas and the cultural heritage for value creation
- Long-term conservation of different categories of archaeological and architectural monuments and sites and cultural environments, including types for which Norway has a special responsibility.
- Effective measures for increasing participation in outdoor recreation activities.

4.2 Climate change and the transition to a low-emission society

According to the IPCC, the world needs a combination of deep, rapid cuts in greenhouse gas emissions and adaptation to climate change. Action to address the challenges arising from climate change must be considered in conjunction with other important objectives for societal development and environmental protection. Considerable research is needed on how Norway can achieve a transformation process that ensures adequate climate change mitigation and adaptation action and at the same time reduces other environmental pressures, including pollution, maintains biodiversity and safeguards the cultural heritage.

Norway is to adapt to the changing climate and become a low-emission society by 2050. This will be a demanding process, requiring changes in all sectors, especially transport, oil and gas production, manufacturing and agriculture. It will be important to identify how Norway can make use of new technology and solutions developed in other countries in its work at national level. Some of the technologies and instruments needed for the transformation process in these sectors already exist. However, there are major research needs relating to the effects of different policy instruments. Particularly important research topics are the interplay between different instruments and measures, and how to design and implement measures to ensure their acceptance and legitimacy and give sufficiently long-term signals to promote the transformation process. The research effort also needs to be organised in such a way that it supports work on the priority areas of Norwegian climate policy, see the white paper Meld. St. 13 (2014-2015) *New emission commitment for Norway for 2030 – towards joint fulfilment with the EU*.

There will be substantial costs associated with more frequent and more severe extreme weather events and a higher risk of flooding, landslides and avalanches in vulnerable areas, see the white paper Meld. St. 33 (2012-2013) *Climate change adaptation in Norway*. Effective preventive work requires knowledge of how exposure to climate-related risks will increase in different sectors and in local communities. More knowledge is needed about the costs that climate change may entail, and how adaptation needs can be taken more fully into account in planning processes. More knowledge is also needed about the impacts of climate change on the most vulnerable industries and sectors, and about which adaptation measures, including ecosystem-based adaptation, are most effective. Basic knowledge about the climate system still needs to be expanded, especially knowledge that is important for assessing the impacts of climate change and the need for new policy. Research-based development of climate services is needed. Information provided by these services will be an important part of the knowledge base, and should include information on how the climate will change in different parts of the country, tailored to different user groups.

Immediate emission cuts are needed to achieve the two-degree target, but at the same time low-emission technologies must be developed to make further emission reductions possible. In many manufacturing industries and much of the energy supply system it will be necessary to switch to different types of processes – for example, to switch from fossil to renewable factor inputs. There is a growing focus on the carbon footprint of food, and more knowledge is needed about food production techniques that result in low greenhouse gas emissions and make use of the carbon fixation capacity of soil. Norway is involved in a wide range of international climate-related processes, and further development of the international framework should be based on experience and research-based knowledge. The impacts of climate change and climate policy in other countries can influence Norwegian interests and are part of the wider picture

Norway is playing a leading role in efforts to reduce tropical deforestation. Since Norway's International Climate and Forest Initiative has a relatively long-term time frame, it is important to obtain broader research-based knowledge to improve the strategic priorities and targets of its activities. Better data for evaluating deforestation trends, more precise measurement techniques and better knowledge of the effects of different measures will improve the implementation and results of the Climate and Forest Initiative.

More knowledge is also needed about land-use conflicts, for example those related to population growth, food production and greater use of bioresources. Emissions should be analysed throughout the production chain (life cycle assessment), and studies of how the carbon cycle is affected by climate change are needed. Moreover, there is a need for more knowledge about conflicts between the use of areas for new and innovative production from bioresources and more traditional forms of food production.

It is important that technology-oriented research is followed up by knowledge development in the social sciences on the rapid deployment of new low-emission solutions. Social transformation in response to climate change, involving changes in technology, energy use and the energy supply system, will also create new environmental challenges that must be addressed using a wide range of environmental and sociological knowledge. More information is needed about how the results of energy research can be used in achieving national environmental targets, and their relevance to the priority areas of climate policy.

Key research needs:

- Basic knowledge about the climate system and about greenhouse gases and other factors that influence the climate. There is a particular need for knowledge that is relevant to the development of climate change adaptation and mitigation policy.
- The impacts of climate change on biodiversity, ecosystem services and the cultural heritage, pollution, public health and the vulnerability of society, and interactions between climate change and other pressures.
- Ways of improving adaptation to climate change, including research on costs and on how society should respond to the rising risk of damage and lower value creation as a result of extreme weather events.

- How changes in the polar regions affect the global climate system, including the contribution of thawing permafrost to greenhouse gas emissions and how it may increase radon releases from the ground, and how snow and ice melting leads to changes in radiation locally and globally.
- Land-use change and land-use management in the context of climate change, including the effect of measures to reduce emissions and increase carbon uptake and albedo.[4]
- Zero-emission solutions in the transport sector (road, rail, sea and air) and effective energy and transport systems
- Low-emission industrial technology, including incentive structures for carbon capture and storage and criteria for the design of additional instruments targeting the sectors covered by the emissions trading system.
- Development of the international framework for addressing climate change. In particular, more knowledge is needed about how Norway`s international efforts in this field can be organised to be as effective as possible. This includes activities relating to EU climate policy.
- Development of international market mechanisms to encourage less developed countries to aim for larger emission cuts and at the same time promote the deployment of technological solutions.
- International and regional climate cooperation and research based on the results of global Norwegian initiatives such as the Climate and Forest Initiative.
- Global and pan-tropical greenhouse gas emissions from the forestry sector and the agricultural sector, and the knowledge base for improving land use.
- The effects of various measures to reduce emissions from deforestation and forest degradation, their economic implications and distributional effects, and their effects on biodiversity.

4.3 Ecosystem-based management

Ecosystem-based management is based on the principle that any decisions that may have an impact on the ecosystem must take into account the cumulative environmental effects on the ecosystem now or in the future. The objective is to ensure sustainable use of ecosystem services and maintain the structure, functioning and productivity of ecosystems. A lack of knowledge about ecosystems and ecosystem services or failure to identify their value properly results in losses of biodiversity and ecosystem services that may have serious social consequences. Sustainable management of ecosystem goods and services requires a knowledge of their value to society.

There is also a pressing need to learn more about which species occur in Norway and to map species distribution. More knowledge is needed about little-known species groups and their habitats, and about interactions between species and their habitats and between biotic and abiotic parameters. A great deal of new knowledge about species is being obtained through the Norwegian Taxonomy Initiative, which is headed by the

[4] The albedo effect influences the earth's climate because less sunlight is reflected from dark surfaces such as seawater than from light-coloured surfaces such as ice and snow. The albedo of a surface is a measure of its reflectivity, and is scored between 0 and 1.

Norwegian Biodiversity Information Centre and funded by the Ministry of Climate and Environment.

Climate change, the spread of alien species, pollution and land-use change make vulnerable ecosystems less resilient and contribute to biodiversity loss. More knowledge is needed about the resilience of ecosystems and their sensitivity to environmental and climate change. This includes knowledge about the functioning, structure and status of ecosystems, the impacts of various environmental pressures, and how management and use should be adapted to change. Knowledge about the drivers of local climate change and its impact on ecosystem structure and productivity is also needed. Moreover, there is a need for more knowledge about drivers of environmental change, environmental problems and their solutions.

Basic knowledge about marine ecosystems, natural fluctuations and the impacts of human activity is needed to develop an integrated ecosystem-based marine management regime. Future wealth creation based on the use of marine resources is also dependent on good ecological status and high biodiversity in the seas. More knowledge and a better understanding is needed of ecosystem function and of the impacts on ecosystems of climate change, ocean acidification, pollution and marine litter, particularly plastic and microplastics. Better methods of estimating cumulative environmental effects on marine ecosystems should be developed. In addition, social science and legal research related to ecosystem-based management of the marine environment is needed.

Key research needs:

- The impacts of climate change on critical ecosystem services such as safe food and clean water, including knowledge about preventive measures and instruments
- The links between biodiversity, ecosystem functioning and the capacity of ecosystems to provide ecosystem services
- How the integrity and resilience of ecosystems can be defined and measured to assess ecological status
- Measures and instruments for achieving objectives for good ecological status in all ecosystems, including what action is needed to ensure sustainable forest management and achieve objectives under the Water Management Regulations
- Impacts on biodiversity of measures to reduce greenhouse gas emissions or increase natural carbon stocks
- Impacts on forest biodiversity of the gradual replacement of natural forest with cultivated forest
- Measures to prevent the spread of alien species
- Ways of enhancing ecosystem services, for example in connection with energy and transport projects, through ecosystem restoration, ecological compensation, mitigation and the establishment of habitat (nature-based solutions)
- The environmental impacts of genetically modified organisms, experience of using analyses of sustainability and benefit to society and assessments of whether GMOs are used in an ethically justifiable and socially acceptable manner
- Basic ecological knowledge about microorganisms, and the impacts of alien microorganisms on naturally occurring biodiversity

- The spread and impacts of marine litter and microplastics, and possible measures to reduce inputs
- Methods of estimating cumulative environmental effects of various anthropogenic pressures on biodiversity and the cultural heritage, including the cumulative effects of industrial activities, ocean acidification and pollution on marine ecosystems.

4.4 Sustainable land use

In Norway's terrestrial ecosystems, land conversion and land-use change and the discontinuation of active use are having impacts on biodiversity, the cultural heritage and ecosystem services. Arctic ecosystems are an exception to this, since land use is less intensive and climate change is the greatest threat to biodiversity.[5]

Knowledge is needed on how to safeguard the natural and cultural heritage for future generations through sustainable land use and land-use management. This requires information on how the value of landscapes, biodiversity and the cultural heritage is being influenced by land conversion and land-use change, habitat fragmentation, and depopulation of rural areas and urbanisation, and on the consequences for society. Analyses are needed of which drivers of change are most important and how they interact. There is also a need for analyses of how land-use planning can become a better tool for achieving environmental targets.

Habitat fragmentation creates barriers in the landscape that hinder or prevent the migration and movement of animals and plants. Habitat fragmentation also tends to result in small isolated populations that have lower genetic diversity and are less adaptable and at greater risk of becoming extinct. Knowledge is needed on the impacts of habitat fragmentation on ecosystems and ecosystem function. A changing climate may result in a greater need for ecological corridors between areas of suitable habitat that allow migration and the spread of species. At the same time, mitigation and adaptation measures may create new barriers. Knowledge about such consequences is vital for the management of biodiversity and ecosystem services as the climate changes and larger areas are affected by human activity.

The environmental authorities must be able to quantify and document the cumulative effects of major development and construction projects.[6] There is a need for integrated studies of complex environmental effects and modelling tools that can identify the relative importance of anthropogenic pressures and natural factors.

The impacts of urbanisation are not limited to towns where the population is rising; depopulation of rural areas can also result in environmental problems. For example, open cultural landscapes may become overgrown, with negative impacts on landscapes and biodiversity, while buildings are left unused and gradually deteriorate. Along the coast, there is growing pressure on land as a result of business and industrial developments. A lack of knowledge, management tools and national strategies results in complex conflicts concerning land use and land-use management.

Key research needs:

[5] Conservation of Arctic Flora and Fauna (CAFF) 2013

[6] Nature Diversity Act section10

- Analyses of how policy instruments including legislation (the Planning and Building Act and sectoral legislation) are used to take environmental considerations into account generally, and particularly in areas that are under a great deal of pressure
- The impacts of growing pressure on land on the natural and cultural heritage
- The impacts of discontinuation of active farming and overgrowing of the landscape on the cultural landscape and species and habitats
- Methods of assessing the cumulative effects of various pressures on biodiversity and the cultural heritage
- The use of an ecosystem approach to land-use management in all ecosystems that are under pressure
- The impacts of habitat fragmentation on ecosystem function, and the importance of ecological networks and green corridors
- The survival and dynamics of small, fragmented populations, particularly in forests, and measures that can facilitate spread and movement to and between areas of suitable habitat
- Environmentally sustainable production of renewable energy that safeguards the natural and cultural heritage

4.5 Sustainable towns and urban areas

Urbanisation offers a great deal of potential for solutions that contribute both to economic growth and to reductions in greenhouse gas emissions and other pollution. However, an integrated approach to urban development is required for such solutions to be successful.

New interdisciplinary knowledge is also needed about how municipalities can achieve sustainable urban development that reduces greenhouse gas emissions, prevents losses of biodiversity, cultural heritage and areas of value for outdoor recreation and reduces releases of hazardous substances and other pollutants, while at the same time ensuring construction of the housing and roads needed by a growing population. Urbanisation and densification have direct local impacts on climate. Local warming can influence temperature trends and pollution levels, and thus have an impact on health and the local environment. Green areas in and around towns are important for recreation and in connection with adaptation to climate change, and the ecosystem services approach is a key element of their management.

There is a particular need for research on how the municipalities can use the Planning and Building Act when dealing with challenging tasks such as managing growth in the limited areas available, reducing greenhouse gas emissions and taking environmental considerations into account in planning, and how to minimise pressure on undeveloped areas. Furthermore, analyses are needed of how coordinated land-use and transport planning can be used to ensure a sound balance between residential and industrial/commercial areas, transport and other infrastructure and outdoor recreation areas

Climate change and accompanying changes, for example in precipitation patterns, will create problems that must be resolved. Research is needed on how to reduce or

prevent health problems arising from densification, for example those caused by noise annoyance and air pollution, and on ways of encouraging people to make use of opportunities for outdoor recreation near their homes.

Local air pollution is a health problem in a number of Norwegian towns, particularly in winter. Research is therefore needed on barriers to the introduction of effective measures to limit pollution from the most important sources, including road traffic and fuelwood use.

Norwegian business and industry is an important driver of urban development in Norway. Research is needed on how to provide a better framework so that this sector can function as a driver of sustainable urban development.

Key research needs:

- How the framework for urban planning and development in Norway, including cooperation between authorities, business and industry, the general public and other interested parties, affects the prospects of combining population growth and industrial development with reductions in greenhouse gas emissions
- The framework for dealing with flooding, stormwater and other problems linked to more frequent and more severe extreme weather events and higher precipitation. Knowledge needs in this connection were set out in an Official Norwegian Report on stormwater in urban areas (NOU 2015:16)
- Measures and instruments that can be used to ensure that planning processes safeguard the natural and cultural heritage and areas of value for outdoor recreation
- The cultural heritage as a resource and as a basis for developing attractive towns and urban areas, for value creation in the broadest sense and for industrial development
- Ways of improving the environmental performance of historically important buildings, and the potential for climate-friendly and environmentally-sound development of the built environment
- Ways of planning and developing urban areas to reduce noise annoyance and health problems. This includes ways of encouraging outdoor recreation, for example by maintaining blue-green structures.

4.6 A clean environment

Hazardous substances and other pollutants in air, water and soils have adverse impacts on health and the environment and affect people's well-being. Hazardous substances are substances that are persistent, bioaccumulative and toxic. To assess how policy instruments can appropriately be used to protect people and the environment against exposure to hazardous substances, more knowledge is needed about sources of pollution, the spread of pollutants and their impacts on health and the environment.

Recent information gives cause for concern about new substances that are entering the environment, the quantities present in the environment and the impacts they may have on ecosystems and human health. More knowledge is needed about potentially harmful substances and groups of substances, and about the combined effects of different hazardous substances, climate change and other stressors. Knowledge is also needed about the spread of hazardous substances in the atmosphere and with ocean currents, and about releases from products and diffuse sources.

The international conventions and other cooperation on chemicals, both at global level and within the framework of the EEA Agreement (REACH, the EU chemicals legislation), are of crucial importance for halting releases and the spread of hazardous substances. To ensure further progress of international regulation of chemicals and their use, the properties that make substances hazardous to health and the environment must be documented.

Research is needed as a basis for developing new international agreements on reductions in long-range air pollution that are based on an effect-oriented approach. In this context, it is necessary to take into account the implications of climate change and knowledge about the interactions between short-lived climate forcers and air pollutants. The objective is to develop integrated strategies for reducing releases of both climate forcers and air pollutants.

Air pollution is too high in many Norwegian towns, particularly in winter, and poses a health risk to vulnerable population groups.

Key research needs:

- Methods of detecting and quantifying individual substances, the spread and impacts of new hazardous substances, including endocrine disruptors, nanomaterials and radioactive substances, and their combined short- and long-term effects
- The contribution of hazardous substances from different sources, including products and long-range transport, to impacts on people and the environment
- The impacts of climate change on inputs, transport and effects of hazardous substances
- Local and long-range air pollution, including sources, spread and critical levels for health and the environment
- Quantifying the effects of different measures to limit air pollution in towns
- More knowledge about the nitrogen cycle as a basis for selecting measures and instruments to avoid damage to health and the environment

4.7 Sustainable production and consumption – the green shift

Maintaining the capacity of ecosystems to provide ecosystem services that are vital to the economy and people's well-being is an essential basis for production and consumption. Healthy, well managed ecosystems provide opportunities to develop new and innovative industries, for example through nature-based solutions and by developing the bioeconomy. If Norway is to become a low-emission society, production and consumption systems must be made much more resource-efficient so that economic and social development can continue within the constraints of the Earth's limited resources and the need to keep human activity within safe ecological limits. Environmental pressures must be reduced, and a more integrated approach must be taken in various production and consumption systems to ensure their sustainability; examples are food, various consumer goods (e.g. medicines, toys), housing, energy and transport.

A shift to sustainable production and consumption within the Earth's ecological limits will require change in various areas. In many cases, fundamental transformation processes will be needed rather than gradual adjustment. This makes the task more

complex, because different systems, infrastructures and policy instruments are interconnected. Thus, knowledge will be needed that can promote the development of innovative, environmentally sound products and solutions that minimise resource use and environmental pressure and are based on a life-cycle approach.

Waste generation and consumption contribute to climate and environmental problems, but they can also become part of the solution. More knowledge is needed about resource efficiency. Waste volumes must be reduced, and a high proportion of waste must be recycled. At the same time, the use and production of hazardous substances must be reduced, and they must be removed from the recycling cycle. These approaches can reduce pollution by making better use of resources, reducing releases of pollutants and the managing the remaining releases more satisfactorily.

The social transformation process that will be necessary will require knowledge about effective use of policy instruments and about consumer behaviour and how consumers can learn about and be encouraged to make greener choices.

Phosphorus resources are limited, and research is needed on rates of fertiliser application, runoff and re-use of phosphorus.

Key research needs:

- How the concept of green competitiveness should be interpreted in a macroeconomic context and how this will influence the use of policy instruments
- The relationship between general policy instruments that shape the framework for the business sector and instruments with a narrower focus, for example those targeting technology development
- Methods of reducing waste volumes and increasing recycling, improving resource use, reducing releases of pollutants and managing releases more satisfactorily
- Waste separation and treatment methods that reduce releases and exposure to hazardous substances, and that increase recycling
- Life cycle analyses of different products, including their environmental impacts
- How green public procurement can promote the development of markets and technology for new products and services, and the environmental consequences of such changes.

4.8 The Arctic

Climate change, pollution, increasing accessibility and expanding economic activity are putting growing pressure on the environment in the polar regions. Alien species are also expected to become a substantial threat to the native biota. A number of polar species are dependent on the sea ice, and its declining extent may have major consequences for individual species and for ecosystems. Changes in the sea ice and its properties also have implications for ice dynamics and how forecasting models incorporate these parameters. The IPCC has emphasised that climate change drastically increases the risk of biodiversity loss, especially when it is combined with other pressures such as habitat change and pollution.

To deal with these issues, the public administration needs new research-based knowledge. High-priority topics include the impacts of climate change, short-lived climate forcers, ocean acidification, hazardous substances and growing human activity

on ecosystems and biodiversity in the polar regions. More knowledge is also needed on the role processes in the polar regions play in the global climate system, and on the global effects of climate change in the polar regions. Research data from the polar regions may also play a key role in the preparation of new multilateral environmental agreements and the further development of existing agreements. There is also a need for knowledge about the impacts of thawing permafrost and coastal erosion on the cultural heritage and about possible conservation strategies. Furthermore, knowledge is needed about the climate feedback loop created by the release of methane and carbon dioxide that has been locked in the permafrost. The research needs that have been identified apply to Svalbard, the sea areas around Svalbard and Jan Mayen, and the Antarctic.

Key research needs:

- The impacts of climate change, ocean acidification, pollution and commercial activities on habitats, ecosystems and key species (particularly ice-dependent species) in ecosystems
- Habitat selection throughout the year, important breeding sites, key biotopes, key localities and the importance of environmental pressures in wintering areas for migratory species
- Interactions in ecosystems – ecological relationships between predators and prey and how they vary through the year and between years
- The impacts of thawing permafrost and coastal erosion on the cultural heritage and possible management measures to respond to this situation

4.9 Governance and management

Several administrative levels are currently involved in spatial and land-use management and the management of natural resources and the cultural heritage in Norway. If there are bodies with conflicting goals or that use different knowledge systems or subscribe to different values, this can create difficulties as regards coordination, efficiency, legitimacy and management. The environmental authorities need knowledge about how organisation and management of administrative bodies can promote the achievement of national environmental targets.

The Government has initiated a reform of local and regional government, which involves the transfer of more and more authority from central government level to local and regional level. New and different stakeholders are gaining more influence as more local, network-based management models are taken into use. The environmental authorities need to know more about the extent to which this promotes sustainable management and helps to achieve national environmental targets.

Norway's marine management plans provide a framework involving all relevant sectors, with the goal of achieving integrated ecosystem-based management. Coastal zone management involves a number of sectors and sectoral legislation. This can result in a fragmented management system for the coastal zone and in regional differences, for example as regards land use.

The Planning and Building Act is intended to promote inclusive planning processes. However, little is known about how processes are initiated and followed up locally. This

is particularly true as regards zoning plans (land-use plans, which are a municipal responsibility).

Key research needs:

- How ecosystem-based management of the marine environment provides a basis for long-term sustainable use
- Social science research on conflicts between policy objectives and on planning processes, and on how such conflicts best can be solved at different administrative levels, for example in water resources management
- The effect of international agreements as instruments for achieving national targets relating to nature management

4.10 Cross-cutting instruments

Climate and environmental policy involves the use of policy instruments across sectors. Knowledge is needed about what role the measures and instruments used by the environmental authorities and other sectors and industries play in achieving national environmental targets and international commitments. This includes knowledge about effective application of policy instruments and about the coordination that is needed across sectors.

The 'effectiveness' of policy instruments is a concept that should be interpreted broadly, to include for example how to ensure that policy instruments are widely accepted by those who are involved or affected by them, so that the desired effects are achieved when the wider picture is considered. This kind of knowledge is needed for all national targets, particularly as regards ecosystem-based management of biodiversity and management and conservation of the cultural heritage.

A number of Norway's environmental targets can only be achieved through binding international cooperation. The environmental authorities need knowledge as a basis for initiating and continuing the development of multilateral environmental agreements. The UN Sustainable Development Goals apply worldwide and provide an important framework for research on sustainable development in Norway.

Key research needs:

- Effective use of policy instruments across sectors to ensure ecosystem-based, sustainable management
- Integrated models that can provide information on the consequences and costs of choosing different climate-related measures and policy instruments for achieving national climate and environmental targets
- Methods of economic analysis that can be used by administrative bodies responsible for climate, pollution and natural and cultural heritage management, including better methods of estimating the costs and impacts of environmental pressures and land use
- Development of methods of valuing ecosystem services and the cultural heritage, including ways of integrating climate change, environmental and cultural heritage considerations more fully into economic analyses, and methods of estimating and presenting the costs and impacts of poorer environmental quality.

4.11 Monitoring, mapping and analysis

Research and development are needed to advance both monitoring and mapping. New technology and new methods can make it possible for publicly-funded programmes to measure new parameters, measure more parameters at the same time, include larger areas and achieve higher resolution temporal and spatial resolution (e.g. continuous measurement). At the same time, monitoring and mapping programmes can be made more cost effective. There has been rapid development of e-infrastructure in recent years, both in Norway and elsewhere. There is considerable potential for improving access to monitoring data and using the data more widely, which can be realised by further developing a common digital infrastructure for environmental monitoring in Norway and internationally.

More knowledge is also needed about how new methods such as remote sensing from aircraft, drones or satellites can be used to monitor and map larger areas where access may otherwise by difficult. Data assimilation techniques that use the data in forecasting models can improve our knowledge of environmental status and trends.

Molecular methods and DNA technology have been revolutionised in recent years. Such techniques are now widely and actively used for example to study the genetic effects of escaped farmed salmon on wild salmon, and to estimate population sizes and familial relationships in large carnivores. However, these methods need to be further developed before they can be used in monitoring.

Key research needs:

- Cost-effective methods of mapping and monitoring climate change and the natural and cultural heritage, including the use of remote sensing
- Development of a common digital infrastructure for climate and environmental monitoring to improve access to data and encourage its use by researchers and the public administration
- Further development of statistical methods and modelling techniques for monitoring climate variables that can be linked to data on the cultural heritage and biodiversity
- Cost-effective methods of climate and environmental monitoring, including monitoring of marine and coastal areas. One application is for mapping and monitoring microplastics and hazardous substances
- Methods and technology for early detection and warning and for modelling the spread of invasive alien organisms.

Appendix 1.
Norway's environmental targets in 2016[7]

Biodiversity

- Norwegian ecosystems will achieve good status and deliver ecosystem services.
- No species or habitat types will become extinct or be lost, and the status of threatened and near-threatened species and habitat types will be improved.
- A representative selection of Norwegian nature will be maintained for future generations.

Cultural heritage

- Losses of cultural monuments and sites will be minimised.
- By 2020, a standard of repair requiring only normal maintenance will be achieved for a selection of archaeological monuments and sites.
- By 2020, a representative selection of cultural monuments, sites and environments will be protected by individual protection orders.
- By 2020, a standard of repair requiring only normal maintenance will be achieved for protected buildings, other structures and vessels.

Outdoor recreation

- Everyone will have the opportunity to take part in outdoor recreation as a healthy and environmentally sound leisure activity that provides a sense of well-being both in their local communities and further afield in the countryside.
- Areas of value for outdoor recreation will be safeguarded and managed in a way that maintains the natural environment.
- Access rights to uncultivated land will be maintained.

Pollution

- Pollution will not cause injury to health or environmental damage.
- Releases of substances that are hazardous to health or the environment will be eliminated.
- The growth in the quantity of waste generated will be considerably lower than the rate of economic growth, and the resources in waste will be used as fully as possible through recycling and energy recovery.
- The 24-hour mean concentration of particulate matter (PM_{10}) will not exceed 50 µg/m^3 on more than 7 days per year.
- The hourly mean concentration of nitrogen dioxide (NO_2) will not exceed 150 µg/m^3 for more than 8 hours per year.

[7] These environmental targets were published in the budget proposal for 2016 from Ministry of Climate and Environment. They may be revised. The current environmental targets are always those published in the most recent budget proposal from the Ministry.

- By 2020, noise annoyance will be reduced by 10 % from the 1999 level. By the same year, the number of people exposed to indoor noise levels exceeding 38 dB will be reduced by 30 % from the 2005 level.

Climate change

- Norway will become a low-emission society by 2050.
- Norway will achieve carbon neutrality in 2050.
- Norway will conditionally undertake to reduce global greenhouse gas emissions by at least 40 % by 2030 compared with the 1990 level.
- As part of an ambitious global climate agreement in which other developed countries also take on extensive obligations, Norway will have a binding target for carbon neutrality by 2030 at the latest. This means that Norway will have to reduce emissions by the equivalent of 100 % of its own emissions by 2030.
- Norway will reduce global greenhouse gas emissions by the equivalent of 30 % of its own 1990 emissions by 2020.
- Greenhouse gas emissions from deforestation and forest degradation in developing countries will be reduced in ways that contribute to sustainable development
- Norwegian society will prepare for and adapt to climate change.

The polar regions

- The current extent of wilderness-like areas in Svalbard will be retained and biological and landscape diversity will be maintained virtually untouched by local human activity
- The 100 most important elements of Svalbard's cultural heritage will be safeguarded by means of a predictable, long-term management system.
- Environmental pressure from human activity and the risk of such pressure in the polar regions will be reduced.

Published by: Ministry of Climate and Environment

Rock carving: Alta museum. Photo: Viggo Lindahl
Smoke rising from a chimney: Photo: Svein Magne Fredriksen
Seal on ice: Photo: Harald Rensvik, Ministry of Climate and Environment
Houses in Bergen: Photo: Svein Magne Fredriksen, Ministry of Climate and Environment
Vikran, Ingøy in Finnmark. Photo: Viggo Lindahl

Publication code: T-1552 E