NORWEGIAN MINISTRY
OF AGRICULTURE AND FOOD

Summary in English: Report No. 39 (2008–2009) to the Storting

Climate Challenges – Agriculture part of the Solution

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1 Summary

1.1 Climate challenges – agriculture can contribute positively to solutions

Climate challenges and food security

In a series of reports, the Intergovernmental Panel on Climate Change (IPCC) has presented documentary evidence of climate change, emission scenarios and consequences of global warming. The Fourth Assessment Report from the IPCC concludes that there are clear indications of global warming. In many regions, nature is already influenced by the increase in temperature. In the view of the IPCC, it is very probable that the increase in the global temperature is caused by anthropogenic greenhouse gas emissions. Climate challenges demand concerted efforts throughout the world.

At the same time, food security – access to adequate and secure supplies of food – is threatened in parts of the world. The global population is increasing rapidly, as is the need for food and energy. The United Nations Food and Agriculture Organisation (FAO) has estimated that almost a billion people, 14 per cent of the world's population, suffered from malnutrition in 2008. In 2050, there may be nine billion people on Earth. In order to avoid hunger and hardship, it will then be necessary to produce twice as much food.

Sustainable and climate-friendly production of sufficient food and energy for the world's population is a major challenge. This challenge is exacerbated by the climate problem. The world's food production is dependent on a nature in balance. Higher mean temperatures may at the same time enable the use of new land areas for agriculture. Estimates are uncertain owing to the lack of knowledge regarding local climate development but, in the case of North America, an increase of 20–50 per cent is estimated in the area suitable for agricultural production. In the case of Russia, a corresponding increase of approximately 40–70 per cent is estimated. On the other hand, cultivation of marshlands and loss of forest areas may result in increased greenhouse gas emissions from agriculture. Africa south of the Sahara may lose up to nine per cent of the land areas suitable for food production.

Agriculture is one of the sectors that will be most affected by climate change. The parts of the world that are currently vulnerable to drought may face further challenges associated with food production in the future. The production of and access to food is also unequally distributed. Assistance in the development of agriculture in poor countries is therefore crucial. While securing the provision of food, this will also provide an income to farmers and to the country as a whole if surplus production can be sold on the international market.

Ambitious Norwegian climate targets

As a leading nation in many environmental areas, Norway has taken an active part in international

political negotiations on climate challenges and ways of meeting them. Report No. 34 (2006–2007) to the Storting *(White Paper on Norwegian Climate Policy)* presents an ambitious Norwegian climate strategy (see also the Agreement on the Climate Settlement of January 2008 and Recommendation S. No. 145 (2007–2008) to the Storting).

Norway intends to be at the forefront of efforts to achieve a new and more ambitious international climate agreement based on the goal of limiting the average rise in global temperature to no more than 2° C above the pre-industrial level, to contribute to reduction of emissions in other countries and to cut global greenhouse gas emissions by 30 per cent of the level of Norway's emissions in 1990.

A realistic target is to reduce Norwegian emissions by 15–17 million tonnes CO_2 equivalents relative to the reference scenario presented in the National Budget for 2007, when CO_2 uptake by forests is included. In this case, approximately two-thirds of the cuts would be made in Norway.

The goal is that Norway will be carbon neutral, i.e. not contribute to net emissions of greenhouse gas, by 2030. The Government will give priority to measures that contribute both to mitigation of climate change and to conservation of biodiversity and other environmental assets.

In addition to strategies for international efforts and domestic climate targets, the White Paper on Norwegian Climate Policy discusses climate-related efforts in the various sectors in Norway, including agriculture. All sectors are expected to contribute to emission mitigation measures and other measures to ensure that Norway makes a positive contribution to reduction of the world's emissions of greenhouse gases.

All sectors must cut greenhouse gas emissions – agriculture will take its share of the responsibility

Domestic emissions are divided into four main sectors, which have been assigned their own targets for emission reductions by 2020. These sectors are petroleum and energy, transport, primary industries and waste management and manufacturing industries.

The Government's target for the primary industries and the waste management sector, cf. the White Paper on Norwegian Climate Policy, is that existing and new instruments in primary industries and waste management shall by 2020 reduce greenhouse gas emissions in these sectors by 1.0–1.5 million tonnes CO_2 equivalents relative to the Pollution Control Authority's mitigation analysis of 2007. The targets associated with the sectors are based on estimates, and will need to be reviewed in response to any changes in projections, costs, technological advances and other relevant factors. If emission trends indicate that Norway will not achieve its targets, the Government will consider further measures.

In 2006, agriculture accounted for more than 60 per cent of emissions in this sector, while waste management and fisheries accounted for 21 and 18 per cent respectively. Specific measures in the various areas will be assessed in relation to cost-effectiveness, implementation potential and capacity to achieve objectives.

In the Government's view, it is necessary to balance agricultural policy targets, climate targets, environmental targets and consumer considerations and quality of life in an integrated policy. The agricultural sector can make a positive contribution to resolving climate challenges.

As part of the follow-up of the White Paper on Norwegian Climate Policy and the Climate Settlement, the Government is therefore submitting a White Paper on agriculture and climate challenges. Agriculture is estimated to account for approximately nine per cent of Norway's emissions of greenhouse gases. This includes agricultural emissions of CO_2 from the use of fossil fuels. Emissions are particularly associated with animal husbandry, fertilisation and soil management. In order to ensure legitimacy and development, agriculture must take its share of the responsibility for reducing greenhouse gas emissions.

In the Government's view, a number of individual short-term measures may collectively contribute to a reduction of greenhouse gas emissions from agriculture. A main goal will be to reduce the climatory and environmental impact per unit of different goods produced, having regard to the varying nutritional value of different foods. Another objective is to increase the uptake of CO_2 in agriculture through targeted measures.

The White Paper presents measures and instruments sufficient to realise the technical emission reduction potential of 1.1 million tonnes CO_2 equivalents referred to in the Pollution Control Authority's mitigation analysis of 2007. The sector will thus fulfil at least its share of the sectoral target for primary industries and waste management of 1.0–1.5 million tonnes CO_2 equivalents.

New knowledge is necessary

Approximately three per cent of Norway's land area is cultivated soil, and approximately 37 per cent of the land area is forested. The Government

assumes that Norway will provide consumers with food on the basis of domestic production in accordance with the main lines drawn up in Report No. 19 (1999–2000) to the Storting *Norwegian Agriculture and Food Production.* We currently import approximately half of the food we eat. Domestic food production is a key element of our long-term supply strategy, and maintenance of Norway's long-term food production potential is of fundamental importance to our food security. Overall food production in Norway includes the fisheries sector, which is outside the scope of the present paper.

Agriculture has its basis in natural diversity and the productive capacity of nature. Climate change will affect both natural biodiversity and the diversity associated with food plants. This diversity is our insurance for the future, which must be safeguarded and used actively in efforts to limit the climate problem.

In biological production, all branches of agriculture are based, through photosynthesis and the carbon cycle, on nature's advanced interplay between uptake and emission of CO_2 and other greenhouse gases. Large areas of agriculture are dependent on and adapted to climatic conditions, and are thus more subject to the effects of climate change than other industries.

In recent years, net CO_2 uptake in Norwegian forests has been in the order of 25–32 million tonnes per year. This corresponds to approximately half of the total Norwegian greenhouse gas emissions. Net CO_2 uptake varies somewhat from year to year, partly as a result of natural variation in growth conditions, climate change, forest management and felling of timber.

The plants cultivated in agriculture are annual or perennial species with short circulation, which are either harvested or used for pasture. They take up large amounts of CO_2, which is passed on to food and animal feed. The gross uptake of CO_2 by agriculture is large, but the storage time for the carbon in the plants is short in a climate perspective. The «climate account» for agriculture shows a net balance of greenhouse gas emissions, but carbon storage in meadows and pasture on mineral soil is not calculated. Better data for carbon storage in meadows and pasture is needed in order to estimate the amount of this uptake with any certainty. According to a report issued by Bioforsk in 2008, large amounts of carbon are stored in agricultural soil – approximately 200 million tonnes. Measures that increase carbon storage in agricultural soil will be important in relation to climate.

There is consequently a serious need for more knowledge about carbon binding in soil, emissions of N_2O and emissions from livestock production. These are not solely Norwegian challenges. Agricultural production cannot take place without emissions of methane and N_2O. There is still little awareness of some of these emissions, particularly N_2O. Research has not so far resulted in measures for significant reduction of N_2O emissions without this resulting in considerable reduction in food production. Efforts are being made to obtain knowledge of the circumstances of emissions and their possible associations with food production.

In the Government's view, it is therefore necessary to strengthen research and knowledge development, including international research cooperation, in order to create a better foundation for emission mitigation measures. Norway should be among the leading countries for knowledge production in this field. At the same time, measures cannot be postponed pending new knowledge. In some cases, the implementation of measures and acquisition of new knowledge must be carried out simultaneously.

We throw away too much food – food waste gives rise to greenhouse gas emissions

Viewed in the light of the global food situation, the fact that Norwegian consumers and the food industry annually generate over one million tonnes of food waste is a problem affecting resources and the environment as well as a moral problem. Food waste gives rise to greenhouse gas emissions throughout the food value chain. Norwegian consumers throw away 50 per cent more food and remainders than they did 10 years ago. There is reason to assume that a large proportion of this is thoroughly satisfactory and wholesome food. According to Norway's greenhouse gas account, methane emissions from landfills for wet organic waste account for approximately 2.5 per cent of Norwegian greenhouse gas emissions. The Government will implement measures to encourage people to throw away less food, and also develop measures to increase the exploitation of food waste as a source of energy and fertiliser.

Agriculture must be adapted to new climate conditions

Adaptation to agricultural production that provides climate-related benefits must be given high priority. At the same time, measures for reducing greenhouse gas emissions and increasing uptake of CO_2 must be designed in such a way that they do not give rise to other social problems. A warmer cli-

mate will alter the conditions for agriculture, and both the pattern of emissions and the extent of binding of greenhouse gases may be changed. It is necessary that agriculture adapts to climate change by means of long-term strategies and specific measures that also involve assessing and exploiting new potential.

In connection with climate change, we will face new challenges and also find new potential in the area of plant and animal production. Climate change may affect growth conditions, erosion and run-off and greenhouse gas emissions, plant and animal health, animal welfare, technical solutions, trade, productivity and pattern of consumption. In order to ensure the greatest possible global production of food, agricultural products must be adapted to these changed conditions. The legislation must be revised in relation to new knowledge and changed conditions. Development of knowledge and expertise in the area of climate change and climate-related measures must be given high priority in management of agriculture and food. National and international cooperation are of fundamental importance in an increasingly globalised market for biological products and goods.

Increased risk of new plant and animal diseases – preparedness must be strengthened

Climate change may result in the establishment in Norway of new plants and animals and new plant and animal diseases. In addition to sound contingency preparedness, warning and combat routines, monitoring, surveys, international cooperation and research will play an important part in preserving the good plant and animal health situation in Norway. Good animal health is important for food safety and food security in general, and is also essential to good animal welfare. Increasing importance is also attached to the ethical aspect of animal husbandry. Consumers demand products that have been produced in a manner that pays regard to animal welfare and environmental considerations. Correct use of, and quality of, input factors such as seed, feed, pesticides and fertiliser is important both now and in the future for economic and health reasons as well as for reasons associated with climate and the environment.

1.2 Agriculture-related climate measures

Climate-related efforts in agriculture encompass many policy areas: agriculture, reindeer husbandry, food production, forestry, research, energy, biodiversity, land management, etc. The present White Paper provides a broad review of the status, potential and challenges of climate-related efforts associated with agriculture, on the basis of the climate policy platform laid by the White Paper, Report No. 34 (2006–2007) to the Storting *Norwegian Climate Policy.*

In the present White Paper, the Government considers emissions and uptake of greenhouse gases in the agricultural sector and the adaptation and instruments necessary for robust, climate-adapted agriculture in the future. The Government's proposal enlarges on and supplements Report No. 34 (2006–2007) to the Storting in relation to agriculture. The White Paper also forms part of the basis for the forthcoming reassessment of climate policy and the need for changes to instruments in 2010. The measures discussed in the White Paper include both measures designed to help in ensuring that Norway is able to comply with its obligations regarding emission reductions relative to the Kyoto Agreement and other agriculture-related measures that will positively affect the overall emission account.

According to Statistics Norway, the total Norwegian greenhouse gas emissions rose sharply in 2007. Total emissions were then 55.1 million tonnes CO_2 equivalents. This was 1.6 million tonnes, or three per cent, more than in 2006. The rise was primarily caused by large emissions from the new natural gas plant at Melkøya, which resulted in an increase in emissions from petroleum and gas activities of 10.5 per cent. Continued growth in road traffic, shipping and other mobile sources also contributed to higher emissions. In addition, emissions from agriculture rose by 2.1 per cent from 2006 to 2007 owing to an increase in livestock and greater use of chemical fertiliser. However, this source was responsible for lower emissions than in 1990. From 2007 to 2008, emissions fell from 55.1 to 53.8 million tonnes CO_2 equivalents. This fall was due to reduced use of fossil fuels, particularly fuel for shipping. Investment in environmental technology in the production of mineral fertilisers also helped considerably in reducing emissions. However, greenhouse gas emissions are 7.4 per cent higher than the level Norway has committed itself to in the the Kyoto Protocol.

Pursuant to the Kyoto Protocol, Norway can release emissions of approximately 50 million tonnes CO_2 equivalents per year during the period from 2008 to 2012. The reduction of emissions from the current level to the level to which we have

committed ourselves must be achieved by means of emission mitigation measures, if necessary, supplemented by the flexible mechanism under the Kyoto Protocol. Norway has elected to adopt a target entailing voluntary strengthening of these commitments by 10 per cent. Norway will also strengthen its emission commitment by a further 1.5 million tonnes CO_2 equivalents by including forest uptake.

The Government regards as fundamental the inclusion of agriculture-related climate measures in an integrated agriculture and food policy, where one of the goals is to maintain or increase the level of food production.

In the present White Paper, the Government proposes climate-related measures in agriculture that will help reduce Norway's greenhouse gas emissions by more than 1.1 million tonnes CO_2 equivalents. These measures have significance for the agriculture sector in the greenhouse gas account, and help to meet Norway's obligations relative to the Kyoto Protocol as regards emission reductions during the period from 2008 to 2012.

The Government also proposes a number of agriculture-related measures that have significance for emission sectors other than primary industries and waste management. In the Government's view, the use of fossil energy for heating purposes in agriculture should be phased out by 2020. This measure would have significance for the energy and transport sectors in the greenhouse gas account and could potentially reduce emissions by approximately 50 000 tonnes CO_2 equivalents.

The Government also proposes a number of other positive climate-related measures for agriculture that will affect the uptake of CO_2 and carbon storage in the long term. These are measures for agriculture and forestry which have positive effects on climate, but which will not be credited in Norway's official greenhouse gas account in the short term, owing to the current formulation of the rules.

A statistical summary of appropriate measures for reduction of agriculture-related greenhouse gas emissions and increased uptake of CO_2 and carbon storage in agriculture and forestry is provided in chapter 1.3.

The Government further proposes a number of measures with a view to strengthened positive climate-related contributions by agriculture. The measures are summarised below.

International efforts

Climate challenges are global and must be resolved both through international cooperation and specific domestic measures. The Intergovernmental Panel on Climate Change has established that there is a pressing need to find good solutions quickly. At the same time, FAO studies show that the world's total food production must increase by 50 per cent by 2030 owing to the sharp rise in world population. These challenges are mutually reinforcing, and in the area of agriculture, climate issues must therefore be addressed while at the same time meeting the increasing need for food and energy of a steadily increasing population.

The Government will

- make efforts to bring about an ambitious, international climate agreement and short-term, effective emission reductions, among other ways, through measures to reduce deforestation and forest degradation in developing countries
- make efforts to ensure that food security is an integral part of the follow-up of the UN Climate Summit (COP 15) in Copenhagen
- make efforts to promote an international commitment to ensuring sustainable and climate-friendly agriculture throughout the world, among other ways, by increasing agricultural development assistance through multilateral and bilateral measures
- contribute to follow-up of international talks associated with the global food situation and climate challenges, cf. the high-level conference on world food security in Rome in 2008, and make active efforts to ensure that food security is addressed in international fora
- increase Norwegian assistance to the agricultural sector as part of the international focus on strengthening the sector
- promote international measures to limit the effect of climate-related increase in the prevalence of pests and diseases in plant and livestock production
- adopt a proactive and integrated approach to forestry issues in international forestry and environmental policy work, taking as a point of departure that a more central place must be given to forestry in future international legislation on climate-related measures
- actively strengthen efforts in the work on implementing the UN voluntary agreement on

sustainable management of the world's forest resources
- make efforts to bring about a regional agreement on sustainable management of forest resources in Europe

Agriculture's greenhouse gas account

Norway has international reporting obligations associated with the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The reports include information on greenhouse gas emissions associated with agricultural production as well as uptake of CO_2 by forest and in relation to land areas. In order to implement well-targeted and effective climate measures for agriculture, Norway must have the best possible greenhouse gas account. Data that is used in the greenhouse gas account and included in international reports is based on the best available methods and data. Norway's greenhouse gas account was revised and approved by a team from the Intergovernmental Panel on Climate Change in 2007. Improvement of methodology and basic data is nevertheless an ongoing task.

The Government will

- improve agriculture's greenhouse gas account in order to improve the basis for implementing measures, including participation in developing better knowledge about and better models for calculation of carbon sinks in soil
- make provisions for maintenance of basic map data in order to acquire a better overall view of land use changes
- ensure continuity of existing statistical surveys of agricultural land in order to acquire a better basis for assessment of climate-related measures in agriculture
- strengthen the basis for Norway's international climate reports, and develop a climate centre function at the Norwegian Forest and Landscape Institute

Land-use policy

The topsoil is one of the most important carbon sinks on Earth. It is of fundamental importance that soil resources are managed in such a way that carbon sinks are not reduced. At the same time, there is a great potential for increasing the carbon storage of soil. Conservation of soil resources is crucial in the efforts to produce food for a steadily increasing population. Only three per cent of Norway is cultivated land. This is little compared with most countries. It is therefore essential to safeguard these land areas and, by means of effective legislation, to ensure sustainable management of them.

The Government will

- make active use of land-use policy as a tool in efforts to reduce greenhouse gas emissions, safeguard agriculture's potential for uptake of greenhouse gases, and ensure that cultivated and arable land – a basic limited resource – is safeguarded by municipalities' long-term planning and by transport policy and transport projects
- assess the need for more stringent soil conservation with a view to ensuring that regard is paid to climate considerations

Forest

Forest and forest soil are important carbon sinks. It is essential that these be preserved and further developed. Growing forest takes up CO_2, and active management of forest resources may play a part in increasing this uptake. In Norway, the forest annually takes up over half of the anthropogenic greenhouse gas emissions. In constructions, timber should increasingly replace less climate-friendly materials, and timber should replace coal, petroleum and gas as a source of energy. Greater use can be made of forest resources as a climate policy instrument. At the same time, this requires that regard is paid to environmental considerations associated with biodiversity, cultural values and enjoyment of the outdoor environment. Norway has acceded to United Nations Forest Forum (UNFF) guidelines concerning national forest programmes. The Government proceeds on the assumption that the total national focus on forest policy and Norway's international forest policy engagement collectively constitute an integrated national forest programme consistent with the UNFF guidelines.

The Government will

- adopt a proactive and integrated approach to forestry issues in international forestry and environmental policy work, taking as a point of departure that a more central place must be given to forestry in future international legislation on climate-related measures

- ensure that forest management and sustainable forestry are assigned a more prominent place in Norwegian international development policy
- actively strengthen efforts in the work on implementing the UN voluntary agreement on sustainable management of the world's forest resources
- collate the elements of the forest policy in accordance with the international guidelines for national forest programmes
- make efforts to bring about a regional agreement on sustainable management of forest resources in Europe
- make provisions for sustainable forest management in Norway, and assess measures conducive to increased climate-related benefits
- strengthen the use of forest policy instruments with a view to increased uptake of CO_2 by means of sustainable, active forestry, planting, plant breeding and other forestry measures
- make provisions for increased use of wood with a view to permanent binding of carbon and the environmental benefits of replacing more climate-unfriendly materials with wood
- give priority to measures that counteract climate change and have a positive or acceptable effect in relation to conservation of biodiversity and other important environmental assets
- strengthen environmental considerations in forestry by utilising the new instruments provided by the Nature Management Act and forestry instruments, e.g. environmental inventories, knowledge development and the Living Forests standard, so that biomass can be recovered from forest while maintaining biodiversity

Agriculture, food and consumer policy

The Government's target is that existing and new instruments in primary industries and the waste management sector shall reduce greenhouse gas emissions in these sectors by 1.0–1.5 million tonnes CO_2 equivalents relative to the reference scenario adopted by the Pollution Control Authority's mitigation analysis of 2007. The targets associated with the sectors are based on estimates, and will need to be reviewed in response to any changes in projections, costs, technological advances and other relevant factors. If emission trends indicate that Norway will not achieve its targets, the Government will consider further measures.

The FAO proceeds on the assumption that, in 2030, food production must be 50 per cent higher than today, and must be doubled by 2050. In this connection, Norway too is clearly obliged to manage land areas well in order to produce food for its own population. Food production must be sustainable. The forecasts for Norwegian population development indicate that there will be one million more inhabitants in Norway in 2030. In Norway too, agriculture and food policy must be planned with a view to providing food for a steadily growing population.

Agricultural production is part of the carbon cycle. The plants that are cultivated bind large amounts of carbon, and are used directly as food or feed for livestock. The carbon is passed on to the food products. The food and food waste is then digested or degraded, so that the carbon is mainly returned to the atmosphere in the form of CO_2. This is treated as a zero sum game in relation to climate. However, emissions of methane and N_2O and consumption of fossil energy in connection with agricultural production must also be taken into account.

Greenhouse gas emissions from agriculture and food production must be mitigated while increasing food production. In order to achieve this, measures must be implemented in all parts of the food value chain. In this connection, it is important to increase carbon storage in soil, reduce greenhouse gas emissions from soil, optimise the use of nitrogen, reduce food waste and exploit food waste for energy purposes.

The Government will

- make efforts to ensure that food security is made an integral part of the follow-up of the UN Climate Summit (COP 15) in Copenhagen
- implement emission reductions in agriculture, involving potential reductions of 1.1 million tonnes CO_2 equivalents by 2020 – it is proposed that the measures be implemented in accordance with the agricultural policy targets adopted by the Storting
- by 2010, assess various ways of realising the technical reduction potential associated with biogas production among other things
- implement measures to increase carbon storage in agricultural soil
- make provisions to ensure that climate-related knowledge from conventional and ecological agriculture is exploited in effective adaptation and reduction of greenhouse gas emissions

- strengthen and systematise knowledge of the total environmental impact of the food value chain
- make further efforts to promote local food and seasonal goods in cooperation with producers and the grocery sector with a view to to reducing the total climate load of food
- participate in measures to promote a sustainable life cycle for foods including sustainable food consumption, reduced food waste and more efficient use of food waste

Renewable energy

The consumption of non-renewable energy – coal, petroleum and gas – has risen enormously since pre-industrial times. The total global energy consumption will continue to rise sharply. It is crucial that more energy consumption is channelled into renewable energy sources. Norwegian agriculture has great potential for delivering renewable energy based on biomass – timber and agricultural waste, etc. In Norwegian forestry, only approximately 50 per cent of the annual volume increment of forest is currently felled, and there is thus considerable technical potential for increased production of bioenergy although the economic conditions for this are currently limited. In agriculture too, there are considerable unexploited resources suitable for production of bioenergy.

The Government will

- ensure targeted and coordinated policy instruments for increased expansion of bioenergy by up to 14 TWh by 2020
- promote increased sustainable production of bioenergy based on agricultural resources, particularly by means of increased recovery of raw materials from forestry and improved exploitation of biproducts and waste from agriculture
- put together an integrated policy instrument package for development of biogas, including sound overall solutions for handling organic waste and animal manure in an organised cooperation between agriculture, manufacturing industries and the municipal sector
- promote increased use of bioenergy for heating purposes in the agricultural sector and strengthen agriculture's position as a supplier of biomass heating
- contribute to technological developments and knowledge production concerning second-generation biofuel from sources such as waste and timber
- make provisions for increased sustainable development of renewable and climate-friendly electricity from small-scale power plants

Adapting to climate change

Global warming will result in climate change, and this applies to Norway too. Large parts of agriculture are dependent on and adapted to climatic conditions, and are more subject to the effects of climate change than other industries. These effects may be positive, in that, in many places, climate will not to the same extent limit biological production. At the same time, climate change will result in negative consequences through changes in precipitation patterns, extreme weather situations, erosion, increased run-off of nutrients, etc. There will also be a risk of increased greenhouse gas emissions and an increased risk of new pests and new plant and animal diseases. Preparedness for pests and plant and animal diseases and measures for adapting to climate change are therefore major priority areas.

The Government will

- strengthen and continue monitoring and report routines in order to keep abreast of developments and monitor the potential effects of climate trends as a basis for assessment of measures
- make provisions for plant breeding and development of plant varieties with a view to adapting to climate change and increased climate-related benefits
- strengthen monitoring and preparedness for plant and animal diseases and zoonoses (infectious disease in animals that can be transmitted to people), and assist in developing and implementing new technology and monitoring methodology
- ensure that legislation and supervision help prevent the spread of plant and animal diseases and zoonoses
- make provisions for targeted research in order to obtain knowledge about effective and environmentally friendly measures for combating plant pests.
- make provisions for sustainable management of the cultural landscapes, also paying regard to values associated with biodiversity and cultural heritage

Research, development and expertise

Climate challenges require vigorous long-term investment in research directed towards society, public administration and industry. There is a need for more knowledge concerning both trends in climate change and the consequences of and adaptation to climate change, concerning climate policy, measures and emission mitigation. Increased focus on research, on development and on raising the level of expertise are also basic preconditions for strengthened focus on climate change in the agricultural sector. Understanding of the carbon and nitrogen cycles and of carbon as a storage resource is key to being able to implement cost-effective measures in agriculture. New knowledge must also contribute to high self-production of food and realisation of potential for innovation in a changed climate.

The Government will

- strengthen investments in research and technology and new technical solutions, etc. in order to reduce emissions of methane, N_2O and CO_2 from agriculture
- make efforts to make Norway one of the leading countries in the work on knowledge production for a climate-adapted agriculture
- make provisions for stronger international research cooperation, particularly with the other Nordic countries, the remainder of Europe, the USA and Canada
- make provisions for research directed at obtaining a more complete picture of the effects of climate change on plants and animals in Norwegian agriculture
- give priority to research associated with carbon and nitrogen cycles and storage resources
- make provisions for a dynamic and targeted system for knowledge production, competence development and dissemination of knowledge based on concerted action by industry, research institutions and public administration
- strengthen knowledge production associated with effects of climate-related measures in agriculture on biodiversity and other environmental values

1.3 Measures

The following tables summarise agriculture-related climate measures that may be appropriate in the efforts to reduce greenhouse gas emissions from agriculture and to increase the uptake of CO_2. The point of departure for the emission mitigation measures is the Pollution Control Authority's mitigation analysis of 2007. The assessment of effects on climate and costs has been made in accordance with the guidelines followed by the Pollution Control Authority in its work. The tables show instruments that may help to realise the measures and the time scale within which each measure may affect climate change.

Table 1.1 lists appropriate climate-related measures in agriculture capable of contributing to fulfilment of Norway's obligations regarding reduction of greenhouse gas emissions by 2020. The appropriate measures are associated with agriculture. Biogas is the measure with the greatest potential. Other measures are associated with methane emissions from animal husbandry and measures for reduced emissions of N_2O in connection with nitrogen fertilisation.

Table 1.2 summarises appropriate climate-related measures associated with forestry and agriculture, that will result in increased uptake of CO_2 in the long term. Active measures for renewing forest and establishing new forest may significantly increase the forest's positive contribution to climate-change mitigation. However, the measures have no effect as regards fulfilling Norway's obligations regarding reduction of emission levels. This is because the measures have no effect on Norway's greenhouse gas account owing to the current formulation of the international rules.

Table 1.3 shows the potential positive effects of certain climate-related measures where use of raw materials from agriculture is important. The figures for bioenergy are based on the Government's target of increased development of bioenergy, cf. the White Paper on Norwegian Climate Policy and the Government's bioenergy strategy. It is assumed that a large part of the raw materials for increased production of bioenergy consists of forest raw materials. The instruments for realising increased production of bioenergy in accordance with the target will include Enova funding. An assessment has also been made of the effects of increased use of wood for construction purposes and various wood products.

Tabell 1.1 Potential for climate-related measures in agriculture conducive to fulfilling Norway's obligations regarding reduction of greenhouse gas emissions by 2020, cf. the sectoral target for primary industries and waste management in Report No. 34 (2006–2007) to the Storting (see also Annex A of the Kyoto Protocol).

Measure	Instrument	Approx. cost in NOK per tonne CO_2	Feasibility/time scale for effect, etc.	Climate-related benefit – binding/ reduced emissions (million tonnes CO_2 equiv. per year)	
				Uptake or storage	Emission reduction
Methane					
Biogas – use of animal manure and food waste	Economic instruments, R&D, information	Socially profitable	2020		0.50
Increased efficiency in milk production and bovine meat production		Commercially profitable			0.25
Increased efficiency in sheep farming	Guidance	Commercially profitable	2020		0.04
Reduced reindeer stocks	Requirement regarding maximum reindeer stocks	Not assessed	2020		0.01
N_2O					
10 per cent reduction of N fertilisation of grain crops	Legal requirements and information		2020		0.03
10 per cent reduction of N fertilisation of grass and pasture	Legal requirements, information and assessment of grant	Not assessed	2020		0.14
CO_2/N_2O					
Energy and reduced N_2O from crop remainders (straw, etc.) in agriculture	General energy price and investment support		2020		0.14
Total agricultural measures related to sectoral target for primary industry and waste management					1.11

Tabell 1.2 Potential for climate-related measures in agriculture with positive effects for Norway's total emission account (UNFCCC). The measures are associated with forest, land and land-use changes (LULUCF).

Measure	Instrument	Approx. cost in NOK per tonne CO_2	Feasibility/ time scale for effect	Climate-related benefit – binding/reduced emissions (million tonnes CO_2 equiv. per year)	
				Uptake or storage	Emission reduction
Forestry					
Increase forest production in current land areas. Increase from 50 to 70 million plants (subject to increase in felling to 15 million m^3)	Grant for commercial and environmental measures in forestry and forestry fund scheme	142	10 years	0	
			50 years	1.0	
			100 years	1.5	
Planting of new land areas. 5 000 ha per year to 100 000 ha in 20 years.	Grant for commercial and environmental measures in forestry and forestry fund scheme	100–150	10 years	0	
			50 years	2.2	
			100 years	2.0	
Plant breeding 10 per cent breeding progress	Ordinary schemes for financial support for plant breeding (Norwegian Forest and Landscape Institute and Norwegian Forest Seed Centre)	24	10 years	0	
			50 years	1.3	
			100 years	1.3	
Fertilisation of a percentage of available land in bilberry fields (Development class IV, Site class 11–17) 12 600 ha per year.	Any financial support can be channelled through the scheme for grants for commercial and environmental measures in forestry	0–120	After 10 years	0.4	
Reduced net binding as a result of increased felling from approx. 10 million m^3 to 15 million m^3*			10 years	-7.0	
			50 years	–6.7	
			100 years	–2.5	
Agricultural soil					
Reduce cultivation of marshland**	Regulations on cultivation of new land	Not quantified	2020		0.335
Reduced soil management in the autumn	Production grant regulations Grant for changed soil management	175	2020		0.096
Catch crop in 10 per cent of area of grain crop	Grant for catch crop (regional environmental programme)	2 500	2020		0.090

* Pursuant to current legislation, Norway's obligation as regards emissions will not change even if we choose to reduce carbon sinks in Norwegian forest. This applies as long as the net uptake by forest is not reduced to less than 1.5 million tonnes CO_2 (corresponding to three per cent of total Norwegian emissions in 1990).

** The figure expresses the sector's reduced emissions in 2020. Estimated on the basis of current cultivation of new land, the effect of changes in the Regulations on cultivation of new land only amounts to a small proportion of this.

Tabell 1.3 Potential for other climate-related measures on the basis of raw materials from agriculture.

Measure	Instrument	Approx. cost in NOK per tonne CO_2	Feasibility/ time scale for effect, etc.	Climate-related benefit – binding/reduced emissions (million tonnes CO_2 equiv. per year)	
				Uptake or storage	Emission reduction
Bioenergy* 14 TWh substitutes fuel oil	Enova, Ministry of Agriculture and Food's bioenergy programme, and other general instruments	< 100	Calculated in relation to oil-fired boilers (with emission of 340 g CO_2 per KWh)		4.8
Increased use of wood**	Grants for wood-based innovation programme and R&D	25–50		0.8	1

* Energy from exploitation of crop remainders in agriculture is included in raw material potential

** Pursuant to current legislation, permanent binding of carbon in wood products is not included in the greenhouse gas account. The effect of substituting wood for other materials is included in other sectors' accounts if the alternative is produced in Norway, but it is not reflected in agriculture's account.

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