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Climate change mitigation in agriculture and forestry and in the downstream sectors of food and timber use

Report of the Scientific Advisory Board on Agricultural Policy, Food and
Consumer Health Protection and Scientific Advisory Board on Forest Policy
at the Federal Ministry of Food and Agriculture

Climate change mitigation in agriculture and forestry and in the downstream sectors of food and timber use

Executive Summary

November 2016



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I Background and Motivation

Drastic reductions in global greenhouse gas (GHG) emissions are required to prevent global warming from reaching a level that will have unforeseeable negative consequences for ecosystems and society. At the UN Climate Change Conference in Paris in December 2015, the goal of keeping the increase in global average temperature well below 2°C as compared to pre-industrial levels was for the first time enshrined in an international agreement. The Parties even agreed to pursue efforts to limit the temperature increase to 1.5 °C. According to the Intergovernmental Panel on Climate Change, there will only be a likely chance of meeting the 2 °C limit, if greenhouse gas emissions can be reduced by 40-70 % by 2050 (as compared to 2010) and if emissions are near zero or if there is even a net carbon sequestration by the year 2100.

Germany and the EU are striving to reduce their GHG emissions by at least 80 to 95 % by 2050 as compared to 1990 (cf. Chapter 3.1). The Scientific Advisory Board on Agricultural Policy, Food and Consumer Health Protection (WBAE) and the Scientific Advisory Board on Forest Policy (WBW) support pursuing ambitious emission targets at global, EU and national levels, because they both contribute to international fairness and serve Germany's and the EU's own interests (cf. Chapter 3.3). Meeting such ambitious goals requires a transformation of the entire energy and economic system to a national economy with drastically reduced emissions. This transformation will gradually reduce the option to implement emission reductions only in those sectors of the economy where such reductions are particularly inexpensive. In the future, it will be essential to develop efficient emission reduction and carbon sequestration strategies for all sectors of the economy. It will also be important to create incentives early on for required structural adjustments and for technological innovations and to prevent investments that are undesirable from the perspective of climate policy. These efforts need to include all sectors of the economy, including the entire value chains from agriculture to food consumption and from forest production to timber use.

This long-term transformation is inevitably accompanied by uncertainties with regard to climate-friendly production and consumption, but also with regard to the design of an efficient climate policy. Intermediate climate change objectives and measures must therefore be subjected to regular critical examinations and they must be re-adjusted as required. One must also take into account that there are many synergies, but also trade-offs, between climate change mitigation measures and other societal goals such as the protection of nature and the environment, animal welfare, economic growth and healthy diets. These trade-offs need to be carefully considered and balanced against each other.

II Objective and structure of the report

To be able to meet ambitious climate change targets, agriculture, forestry, forest-based industries and food consumers must increase their contribution to achieving these targets. The

main objective of this report is to develop recommendations for political decision-makers regarding effective and efficient climate policies for the fields of agriculture and forestry, timber use and the food sector.

The recommendations in this report aim at contributing to the development of a comprehensive strategy for tackling climate change. Therefore, the recommendations include concrete policy measures. The efforts to fight climate change in the above-mentioned sectors should be compatible with European and national climate strategies and initiatives of society as a whole and with other societal goals and conditions. In addition, they should be embedded in adequate international climate agreements which are essential for effective climate protection.

The focus of this report is on climate protection based on a reduction of greenhouse gas (GHG) emissions. Adaptation to climate change is only mentioned insofar as it is of relevance to climate change mitigation. This applies even more to forestry than to agriculture, as the climate mitigation performance of the forestry sector is heavily dependent on the stability and productivity of the forests, which are managed on the basis of long production periods.

The report is structured as follows: Chapter 2 outlines the importance of agriculture and forestry, timber use and food consumption for the emission of greenhouse gases and carbon sequestration in Germany. It also addresses the effects of climate change and the possibilities of adapting to climate change in the forestry sector. Chapter 3 provides an overview of the climate policy objectives in Germany and the EU and the climate-related policy frameworks for the sectors considered here. Chapter 4 then discusses various climate policy instruments related to the agri-food industry, forestry, timber use and food consumption. Chapter 5 gives an overview of possible climate protection measures in the different sectors, assessed on the basis of specific criteria. Chapter 6 finally contains the overarching general recommendations and the sector-related recommendations for climate protection, which the Scientific Advisory Board on Agricultural Policy, Food and Consumer Health Protection (WBAE) and the Scientific Advisory Board on Forest Policy (WBW) have formulated.

III Situation analysis: Greenhouse gas emissions and carbon sequestration

The agricultural sector is a major emitter of GHG (cf. Chapter 2). According to the systematics of GHG reporting for 2014, 66 million tonnes of CO₂ equivalents of the overall emissions in Germany (903 million tonnes of CO₂ equivalents), came from source group 3 (Agriculture). Another 38 million tonnes of CO₂ equivalents were emissions from land use/land use change relating to arable land and grassland areas (source groups 4B and C) (cf. Figure KF.1). Overall, 11% of the overall GHG emissions in Germany can be attributed to agriculture and the use of arable land and grassland.

Considerable amounts of carbon are stored in above-ground and below-ground phytomass¹ and in soil organic matter. In the forests alone, 1,169 million tonnes of carbon are currently stored in living trees and deadwood. This corresponds to an average of approx. 385 tonnes of CO₂ equivalents per hectare of forest. Both agriculture and forestry can contribute to increasing as well as decreasing carbon stocks. Forestry in particular has a very large potential to sequester carbon in its products for a long period of time (product storage). Both sectors, but especially the forestry sector, can contribute to reducing GHG emissions and avoiding emissions from fossil energy sources through material and energy substitution effects. For Germany, the annual contribution of forestry and timber use to GHG reduction through storage and substitution effects alone is currently estimated to be 127 million tonnes of CO₂ equivalents. Without this contribution, the overall emissions in Germany would be 14% higher (in relation to the figure for 2014). In addition to moorland areas, forests are also among the most effective terrestrial carbon sinks due to their large surface area and high carbon density.

If we change our perspective from the supply side (producers) to the demand side (consumers), we can see that in 2006, food-related GHG emissions, based on the cradle-to grave approach,² amounted to about a quarter of total GHG emissions in Germany.^{3,4} Although a significant amount of these emissions arise from the primary production of food and are therefore included in the GHG emissions from agriculture, other stages along the value-added chain also generate a significant amount of emissions. The cumulative GHG emissions per unit of food (kg, kcal, etc.) differ therefore not only between different kinds of food but they also show significant differences for the same kind of food, depending on transport, processing, etc. Consumption patterns and eating habits therefore have a considerable influence on the GHG emissions along the entire agricultural value chain. It is thus important to take a closer look at consumption, which is not the case in classical GHG reporting.

EU agriculture and forestry are highly integrated in the global economy. National climate protection measures also have an impact on production and consumption in other countries. This impact can be positive or negative for the global GHG balance. Leakage effects, which can often only be roughly estimated, illustrate the significance of system limits for the quantification of GHG emissions. These effects can be significant for climate protection measures in agriculture and forestry, particularly due to direct and indirect land use changes. As far as possible, they were therefore taken into account in this report.

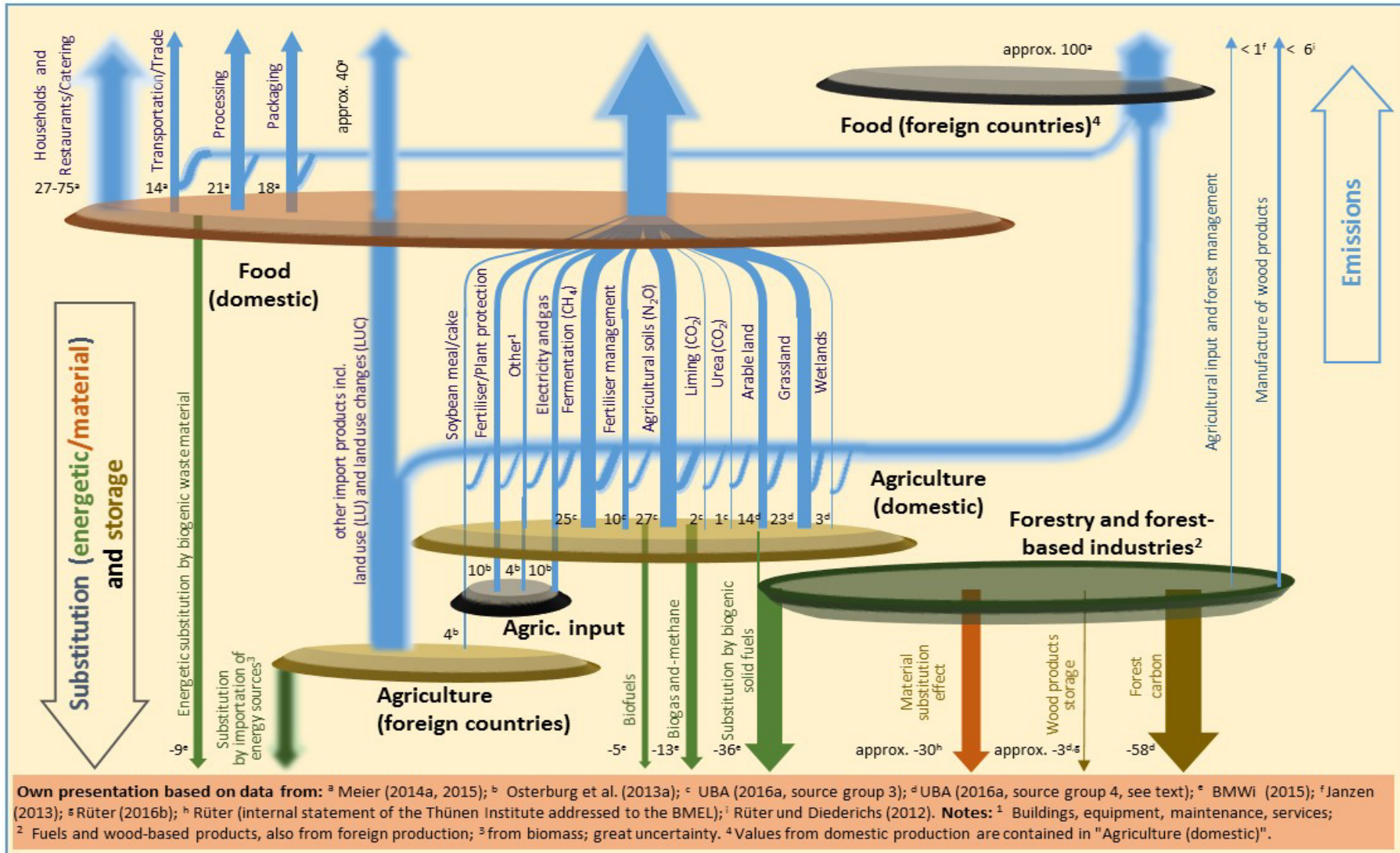
¹ Phytomass refers to both the biomass of living plants and the mass of dead plant material (necromass) of a defined area (Schaefer 2003).

² This includes all emissions arising from the production of agricultural raw material up to and including the use of food in private households and in the restaurant and catering sector (including disposal).

³ Comprehensive data from the National Food Consumption Survey II (Nationale Verzehrsstudie II; NVS II) are only available for 2006. More recent comprehensive data are not available.

⁴ A share of these emissions occurs outside Germany (imports, cf. Chapter 2.4).

Figure KF.1: GHG emissions, substitution and storage capacities relating to agriculture, food consumption, forestry and forest-based industries (in million tonnes of CO₂ equivalents/year, different years). The areas indicated by the oval shapes correspond to the absolute value of the difference between emissions on the one hand and substitution and storage capacities on the other hand of the sectors considered.



IV Overarching general recommendations for climate protection

Emission reduction and sequestration contribute to protecting the climate as a global public good. Individual countries can only benefit to a limited degree from their own greenhouse gas reduction or carbon sequestration efforts. For effective climate protection, they must rely on appropriate activities being taken by other countries. At the same time, there is a great temptation for countries to try and get a "free ride", i.e. not to make efforts to fight climate change themselves but benefit instead from the efforts made by other countries. International climate agreements at European and global levels are therefore particularly important for an effective climate policy.

Strengthen efforts for a global strategy for tackling climate change (addressed to the Federal Government and the EU)

The larger the number of countries that take serious efforts and actually implement climate protection measures, the easier it will be to achieve the necessary transformation to a so-called low-carbon economy. WBAE and WBW therefore strongly urge the Federal Government to invest substantially more resources in the development and implementation of a global strategy for tackling climate change and, at the same time, serve as an example by actively contributing to meeting ambitious national and European climate goals.

Use the pricing of GHG emissions as an incentive-based approach (addressed to the Federal Government and the EU)

The Advisory Boards recommend that the Federal Government continues its efforts within the EU to consistently use the pricing of GHG emissions as an incentive-based climate policy approach with a view to making GHG emissions more expensive. To this end, the Emissions Trading System (ETS) should be improved. However, due to high transaction costs, the Boards do not consider the inclusion of the agriculture and forestry sectors in the EU Emissions Trading System to be a feasible policy option (cf. Chapter 4.1). Moreover, the Federal Government should at EU and international level actively promote a GHG emissions-oriented taxation of fossil energy sources. It should also encourage the harmonisation of tax rates within the EU.⁵ These efforts should also include international transport (marine diesel, aviation gasoline).

Avoid the disaggregation of cross-sectoral GHG reduction goals into too many sub-goals (addressed to the Federal Government and the EU)

The Advisory Boards consider it appropriate to not only negotiate global goals but urge Germany and the EU to set cross-sectoral GHG reduction goals. However, they warn against disaggregating

⁵ A rise in prices of fossil energy sources would also promote the implementation of many climate protection measures in the fields of agriculture, food consumption, forestry and forest-based industries.

these cross-sectoral goals into too many sub-goals (such as sector-specific quantified reduction goals, e.g., for the agricultural sector) if these goals are not aligned with the respective abatement costs and the effects on other societal goals.

Make cross-sectoral climate policy more coherent (addressed to the Federal Government, EU, and the *Länder* (federal states))

The Boards consider it necessary to pay more attention to the coherence of the entire climate policy. With regard to climate protection measures outside of the ETS, it must for instance be taken into account how these measures actually work in combination with the ETS. In addition, more attention should be paid to the direct and indirect climate effects that a climate protection measure implemented in Germany will have in other countries.

Regard transformation to a low-carbon economy as a long-term process of learning and adjustment (addressed to the Federal Government, EU, *Länder*, and industry)

The transformation to a so-called low-carbon⁶ economy will take decades. This long-term transformation is associated with uncertainties – not only in the field of production and climate-friendly consumption, but also with regard to the development of an efficient climate policy. Therefore, research, information, advisory services and professional training need to play an important role. Intermediate climate change objectives and measures should be regularly subjected to critical examination and readjusted as required.

Improve the integration of the LULUCF source group in the national and EU climate policy post 2020 (addressed to the Federal Government and the EU)

The Advisory Boards recommend that the Federal Government continues its efforts within the EU to better integrate the source group land-use, land-use change and forestry (LULUCF) in the national and EU climate policy post 2020. This would create incentives for additional climate protection measures in the land use and forest sectors and avoid inappropriate incentives that currently arise from the different ways of taking emissions and carbon sequestration effects into account.

V Policy packages for "Moderate climate action" and "Ambitious climate action"

The Boards generally support ambitious global, but also EU and national, emission targets. Both synergies and trade-offs exist between climate protection and other societal goals, which are

⁶ When the term "low-carbon economy" is used in political discussions, "low-carbon" means "low in carbon from fossil energy sources".

discussed in this report (cf. Chapter 5). The development of a strategy for tackling climate change requires the balancing of conflicting objectives, which must be part of a societal negotiation process.

Against this background, the Advisory Boards developed two sets of measures (“policy packages”) that differ with regard to the envisaged levels of climate protection. They are the result of an in-depth analysis of (i) different “technical” emission reduction and sequestration measures (cf. Chapter 5) and (ii) potential climate policy instruments such as information and advisory services, economic incentives, rules and regulations (cf. Chapter 4). The packages differ less with regard to the types of climate protection measures than with regard to their scale and their degree of implementation. Only the most important measures in each package are mentioned here. Table KF.1. lists the emission reduction and carbon sequestration effects that the proposed measures of each package would result in.

Table KF.1: Potential for emission reduction or additional carbon sequestration in the policy packages “Moderate climate action” and “Ambitious climate action” (in CO₂ equivalents/year)

	Moderate climate action	Ambitious climate action
Agriculture	23-24 million t	40-44 million t
Food consumption	14 million t	34-35 million t
Forestry and timber use	28 million t	56 million t
Sum ¹⁾ of the measures recorded	65-66 million t	130-135 million t

Note: When interpreting the data, the methodological notes listed below must be taken into account.

¹⁾The quantities under Food consumption and Agriculture include in some cases double counting.

Source: Own presentation (cf. Chapter 6.2).

Attention should be paid to the following methodological aspects:

- a) The mitigation effects of the proposed measures do not in all cases qualify for national greenhouse gas reporting purposes. The climate protection targets envisaged by the policy packages can therefore not exactly be counted as a reduction in accordance with the systematics of official GHG reporting. This is also due to the fact that for GHG reporting purposes, emissions are attributed to the country in which they were emitted (applying the territorial principle). In case of measures that target food consumption, the possibilities to report the corresponding changes in emissions from food production depend on whether the respective food items were imported or produced in Germany.
- b) The reduction potential shown in the calculations is based on current framework conditions. An increasing “decarbonization” of the economy (i.e. a reduction of its reliance on fossil energy) will result in a lower potential for GHG emission reduction and increase in the abatement costs.

- c) The measures vary significantly, e.g., with regard to the time required for their implementation.
- d) The measures also vary with regard to the time period required until the envisaged climate change mitigation effects will become effective. Many measures will show immediate impact, but others (e.g., the re-wetting of moorland) might require time periods in the range of 20 years. In the case of forestry measures, such as changing tree species composition, the required time periods are even longer.
- e) There are positive and negative interactions among some of the measures which must be taken into account. For example, the goal "Consumption of animal products in accordance with the recommendations of the German Nutrition Society (DGE)" has implications for the goal "Maintaining permanent grassland".
- f) The potential to reduce GHG emissions by changing food consumption decreases if the associated product-specific emission factors are reduced. Among other factors, this could be the case due to the implementation of climate change mitigation measures in agriculture or due to technological progress.

Table KF.2 provides an overview of the individual measures. The following measures have the largest reduction potential (in descending order):

- a) Changing tree species composition in forest production (increase in the proportion of coniferous trees) (effective in the long term⁷);
- b) protecting moorland under agricultural use (effective in the long term);
- c) reducing the consumption of animal products (effective in the medium term);
- d) promoting agricultural production of lignocellulose (e.g., from short-rotation plantations) (effective in the medium term);
- e) increasing the material use of wood in durable wood products (effective in the long term); and
- f) improving the N-efficiency of fertilisers (effective in the short term).

⁷ "In the long term" means effective > 20 years later; "in the medium term" means effective > 5 to 20 years later, and in "the short term" means effective up to 5 years later.

Table KF.2: Important measures in the sets of measures entitled "Moderate climate action" and "Ambitious climate action", broken down into different fields, and broken down within the fields according to time horizon for the GHG reduction

Measure (Chapter number)	Moderate climate action		"Ambitious climate action"		Abatement costs (€/t CO ₂ equivalent)	Time - horizon ¹⁾	Comments
	Area/ Product unit (scenarios as appropriate)	GHG reduction potential (million tonnes of CO ₂ equivalents /year)	Area/ Product unit (scenarios as appropriate)	GHG reduction potential (million tonnes of CO ₂ equivalents /year)			
Agriculture	23-24		40-44				
Maintaining permanent grassland (5.2.2.1)	34,100 ha/year (compared to ploughing in recent years)	2.5 - 3.1	34,100 ha/year (compared to ploughing in recent years)	2.5 - 3.1	15 – 60	Short-term	Synergies with water protection and nature conservation (extensive grassland)
Improving the N efficiency of fertilisers (5.2.4.1)	16.7 million ha of utilised agricultural area (UAA)	5.8	16.7 million ha of UAA	5.8	29 – 57	Short-term	Large synergies with other environmental objectives
Gas-tight covering of existing digestate storage facilities (5.2.6.1.1)	-	2.0	-	2.0	2 - 100	Short-term	Measure would become less important if the operation of biogas plants will not be continued after the 20 years of guaranteed support.
Increasing the use of livestock manure in biogas plants (existing installations) (5.2.6.1.2)	-	-	Not specified	1.0 – 4.8	Not specified	Short-term	Measure would become less important if the operation of biogas plants will not be continued after the 20 years of guaranteed support.
Lignocellulose from agricultural production (5.2.6.2)	425,000 ha (50 % of the assumed potential)	6.0	850,000 ha (100 % of the potential)	12	-25 - 70	Medium-term	Climate mitigation through energy substitution after only a few years in contrast to afforestation, cascade use would increase the reduction potential

Measure (Chapter number)	Moderate climate action		"Ambitious climate action"		Abatement costs (€/t CO ₂ equivalent)	Time - horizon ¹⁾	Comments
	Area/ Product unit (scenarios as appropriate)	GHG reduction potential (million tonnes of CO ₂ equivalents /year)	Area/ Product unit (scenarios as appropriate)	GHG reduction potential (million tonnes of CO ₂ equivalents /year)			
Reducing the use of peat as planting substrate (5.2.1.2)	-	-	Not specified	1.1-1.5	Not specified	Medium-term	Synergies with environmental objectives. Potential competition over use as an energy source, depending on the raw material for peat substitutes
Protecting moorland under agricultural use (5.2.1.1)	300,000 ha	7.0	900,000 ha	15.2	2 – 380	Long-term	Often large synergies with nature conservation, threat to the livelihood of farmers with a high percentage of moorland
Food consumption		14	34-35				
Implementing the DGE quality standards in mass catering facilities (5.3.5)	2.5 billion lunches/year in mass catering facilities	Already contained in the reduction potential under 5.3.2 and 5.3.3 (cf. 1 st column)	2.5 billion lunches/year in mass catering facilities	Already contained in the reduction potential under 5.3.2 and 5.3.3 (cf. 1 st column)	No information	Short-term	A balanced diet has synergies with health objectives
Reducing the consumption of bottled water (5.3.4)	25 % of 143.5 l per person and year	0.6	75 % of 143.5 l per person and year	1.8	< 0, cost reductions for consumers	Medium-term	Time savings for consumers
Abstinence from goods transported by air (5.3.7)	-	-	Reducing the emissions from goods carried by air by 80 %	0.7 – 1.7	< 0, cost reductions for consumers	Medium-term	Economic losses in export-oriented developing possible

Measure (Chapter number)	Moderate climate action		"Ambitious climate action"		Abatement costs (€/t CO ₂ equivalent)	Time - horizon ¹⁾	Comments
	Area/ Product unit (scenarios as appropriate)	GHG reduction potential (million tonnes of CO ₂ equivalents /year)	Area/ Product unit (scenarios as appropriate)	GHG reduction potential (million tonnes of CO ₂ equivalents /year)			
Consumption of animal products in accordance with the recommendations of the DGE (5.3.2)	81 million inhabitants: 50 % of the max. potential	11.0	81 million inhabitants: 100 % of the max. potential	22.0	Consumers: tendency towards cost reductions; agri-food industry: adaptation costs	Medium-term	Potential conflict with the conservation of grasslands. Conflict could be reduced by promoting more grassland-based cattle farming or alternative grassland use.
Reducing food waste (5.3.3)	25 % of the avoidable waste	3.0	75 % of the avoidable waste	9.0	No information	Medium-term	Synergies with environmental and nature conservation objectives through a reduced use of resources
Forestry, including timber use		28		56			
Changing tree species composition (5.4.4)	Coniferous trees are dominant (70 %), 50 % of the maximum potential	27.8	Coniferous trees are dominant (70 %), 100 % of the maximum potential	56.0	-145 (over the entire period), i.e. no costs, but benefits	Long-term	Conflict of aims with nature conservation, influence on the storage of carbon in the soil uncertain

Note: ¹⁾ Short term: up to 5 years, medium term: > 5 to 20 years, long term: > 20 years.

Source: Own presentation (cf. Chapters 6.2.2 and 6.2.3 of the long version of this report).

VI The most important recommendations for the agricultural sector

A large share of agricultural land is used for food production, i.e. for products that can only be substituted to a limited extent. The GHG emissions from agriculture must therefore also be assessed in relation to the agricultural production potential in different regions.⁸ In Germany, the climatic conditions for agricultural production are relatively favourable. At the global level, agricultural land will become scarcer in the foreseeable future. In view of these two facts, a nation-wide reduction in the intensity of agricultural production cannot be recommended. For the same reason, GHG emissions per unit of product are more relevant than GHG emissions per unit of land.

Discussions about climate change mitigation measures in the agricultural sector often include recommendations for measures such as biofuel production, expansion of organic farming and substitution of imported soy feed by domestically produced grain legumes. Based on the currently available evidence, the Advisory Boards conclude that it is not possible to establish an unambiguously positive effect of these measures with regard to climate change mitigation.

VI.1 Improve the nitrogen efficiency of fertilisers

The use of nitrogen fertilisers is one of the main sources of agricultural greenhouse gas emissions. Improving the N efficiency of fertilisers and, as a consequence, reducing the nitrogen surplus in the agricultural sector contributes not only to climate change mitigation but also to attaining other environmental objectives.

VI.1.1 Tighten fertiliser legislation and strengthen its enforcement (addressed to the Federal Government and the *Länder*)

The amendment to the Fertiliser Application Ordinance has already been discussed for several years. In April 2016, the European Commission referred Germany to the European Court of Justice for non-compliance with the Nitrates Directive. In their joint opinion on the amendment to the Fertiliser Application Ordinance, the Scientific Advisory Board on Agricultural Policy (WBA), the Scientific Advisory Board on Fertiliser Issues (WBD) and the German Advisory Council on the Environment (SRU) made detailed recommendations (WBA, WBD and SRU 2013; SRU, WBAE and WBD 2016). WBAE and WBW recommend that the Federal Government and the Upper House (*Bundesrat*) quickly amend the fertiliser legislation and take account of the recommendations of

⁸ It must also be taken into account that agricultural production is mostly taking place in open systems and that the emissions of methane and laughing gas are caused by biological processes that cannot be fully controlled.

WBA, WBD and SRU. They recommend that the *Länder* ensure the effective enforcement of the fertiliser legislation and evaluate the effects of a tightening of the fertiliser legislation by 2020 on the basis of individual nutrient balances.⁹

VI.1.2 Introduce a nitrogen levy if nitrogen surpluses are not sufficiently reduced (addressed to the Federal Government)

If it turns out that the fertiliser legislation will not be tightened as called for or that N surpluses will not be reduced by 2020 by an amount sufficient to meet the climate and water protection goals, the Advisory Boards recommend that the Federal Government introduces a national levy on mineral nitrogen– if necessary in combination with a levy on organic nitrogen of animal origin and biogas digestate of plant origin. The proceeds of the levy should be redistributed to the farmers in an allocation-neutral way.

VI.1.3 Take further measures to improve nitrogen efficiency (addressed to the *Länder*, Federal Government, and industry)

Although the Advisory Boards consider the enforcement of tightened fertiliser legislation indispensable for improving the N efficiency of fertilisers, they recommend using a broader range of measures and instruments to this end. Such measures include investment aid for farmers, e.g., for low-emission slurry application methods or research and demonstration projects (low-emission mineral fertilisers, denitrification inhibitors, urease inhibitors, precision farming in nitrogen fertilisation – especially for the application of livestock manure –, N-reduced bread wheat production, etc.). To provide incentives for early investment, the level of investment aid for such measures should decrease over time.

VI.2 Protect agriculturally used moorland in a differentiated way (addressed to the Federal Government and *Länder*)

The Boards recommend that the Federal Government and the *Länder* (especially the *Länder* with extensive moorland areas) work together with other relevant actors to develop a strategy for the protection of moorland areas. This strategy should include binding time scales and implementation phases, as well as a long-term financing concept. As the strategy is long-term, its

⁹ To this end, farmers should not only document their nutrient balances on the farm but also enter them into an official online database.

implementation steps must be evaluated in regular intervals to ensure effective and efficient control.

First of all, the moorland strategy should make sure that all agricultural moorland areas worthy of protection receive a basic form of protection by ensuring good practices of agricultural land use. This protection should also include the conversion of arable land into grassland and setting upper limits for the use of fertilisers. Secondly, for moorland areas that require a higher level of protection, voluntary contractual agreement for climate protection should be used to promote location-specific extensive grassland use. Thirdly, areas with the highest degree of required protection should be taken out of agricultural production (i.e. set aside) by using tendering procedures. These moorlands should be restored through rewetting measures. There should be a clearly defined pathway that specifies for the coming 20 to 30 years how many hectares of agriculturally used moorland should be placed under basic protection, used extensively as grassland or be set aside and rewetted (e.g. 300,000 to 900,000 ha). Should it turn out that the desired land area cannot be acquired through tendering procedures, it might be necessary for certain areas to impose regulatory protection measures in combination with pre-defined compensatory payments. The protection measures should be implemented on a step-by-step basis, starting with the areas that have the lowest abatement costs.

VI.3 Develop and implement a strategy to phase out the use of peat (addressed to the *Länder* and the Federal Government)

The Advisory Boards recommend that the Federal Government and the affected *Länder*, together with environmental and industrial associations, develop and gradually implement a strategy to phase out the use of peat. As part of this long-term peat phase-out strategy, the Federal Government and the *Länder* should promote the development of peat substitutes that are as climate-, environment- and user-friendly as possible. The Boards recommend prohibiting the use of peat substrates by hobby gardeners within the next two years and, beginning in about five years, gradually phasing out their use in commercial horticulture. Public procurement provisions should be amended to make it possible to prescribe the use of peat substitutes in public horticulture and landscaping contracts.

VI.4 Protect permanent pastures according to the required level of protection (addressed to the *Länder* and the Federal Government)

With a view to preserving the climate- and biodiversity-relevant grasslands, the Advisory Boards recommend as a first step the mapping of the grassland areas of the *Länder* according to the

extent to which they merit protection. Species-rich and mesophilic grassland on organic soils with a high level of required protection would have to be protected by regulatory legislation in conjunction with some type of equity compensation.¹⁰ Requirements for grassland conservation should not prevent desired land use changes. For moorland with intermediate protection requirements, it is for example envisaged to (re-)wet grassland areas and convert them into other types of land use or vegetation. It should also be examined as to what extent an afforestation of grassland or the establishing of short-rotation forestry (SRF) should be allowed. The conversion of grassland that deserves less protection (e.g., intensively used grassland areas with few species on mineral soils) into arable land should be subject to mandatory official approval which would have to be granted if the farmer can prove that arable land is converted into grassland elsewhere (tradable permits to convert grassland).

VI.5 Limit the promotion of bioenergy to justifiable energy lines

The Boards do not regard the cultivation of agriculture-based biomass for the single purpose of energy as a useful climate change mitigation measure, with the exception of short-rotation forestry (SRF) and, to a certain degree, miscanthus grass. Therefore, the Boards are in favour of abolishing the current support measures for bioenergy. However, for already existing installations, legitimate expectations with regard to the current legislation need to be respected.

VI.5.1 Increase the climate mitigation performance of existing biogas plants and support new installations only if they ferment a high percentage of semi-liquid manure or residual material (addressed to the Federal Government and the *Länder*)

The climate mitigation performance of existing biogas plants should be increased by retrofitting the digestate storage facilities with gas-tight covers and by increasing the use of livestock manure and residual material instead of farmed biomass. The Advisory Boards recommend promoting necessary structural alterations, e.g., by way of investment subsidies under the 2nd pillar of the Common Agricultural Policy (CAP), but only in connection with “repowering” existing installations and expanding their lifespans. The tendering procedure planned under the draft EEG 2016 Renewable Energies Act should introduce minimum percentages for semi-liquid manure as a criterion for participation. New biogas plants should only be supported under the EEG if they use a minimum of 95 % mass fraction of semi-liquid manure or are mainly operated with residual material.

¹⁰ To a certain extent, this has already been practiced in Natura 2000 sites.

VI.5.2 Promote lignocellulose from agricultural production (addressed to the Federal government and the *Länder*)

The use of lignocellulose from agricultural production (e.g., short rotation forestry/SRF) has, in principle, a large reduction potential and relatively low abatement costs. In addition, the use of agricultural areas for SRF is from a climate point of view desirable for a number of reasons (cf. Chapter 6.3.2). The Boards welcome the fact that since 2010, SRF¹¹ is no longer defined as forest and that SRF, just like miscanthus grass, has become eligible for direct payments under the CAP. The Boards also welcome that SRF can be classified as ecological focus areas. The Advisory Boards recommend that the Federal Government and the *Länder* continue and expand the options for supporting SRF and miscanthus grass under the Joint Task for the Improvement of Agricultural Structures and Coastal Protection (GAK) and the rural development programmes. The Boards recommend promoting research and development activities aimed at a cascading use of biomass from SRF.

VI.6 Reduce GHG abatement costs through EU-wide calls for tenders (addressed to the Federal Government)

The Advisory Boards recommend considering the large differences in abatement costs between countries, regions and farms as an opportunity to develop a cost-efficient climate policy. This opportunity can be realized by introducing an EU-wide tendering procedure for GHG reductions. The Boards therefore suggest that the Federal Government solicits support at EU level for testing a tendering procedure in respect of a pilot project on moorland protection in the northern and north-eastern EU Member states. If the procedure is regarded favourably, the set of eligible climate change mitigation measures could be gradually expanded over time and the tendering procedure could be extended to include all Member States.

VII The most important recommendations with regard to food consumption

Effective climate protection also requires considerable GHG reductions in the area of food consumption. There is a potential for GHG reduction in this area in spite of the fact that food consumption represents an existential need. The focus of food-related climate protection measures is therefore not placed on reducing per-capita consumption but on shifting consumption to more climate-friendly food products. Contrary to what is often suggested, the Advisory Boards are – based on the current state of knowledge – not of the opinion that the

¹¹ With rotation periods of up to 20 years.

consumption of organic products or freshly prepared and regionally produced food makes an unambiguous or generally positive contribution to climate change mitigation (whereas forgoing food items transported by air clearly makes such a contribution).

VII.1 Establish consumption management as policy field

If climate protection measures lead to reduced agricultural production in Germany without a simultaneous change in domestic food consumption, there is a risk that GHG emissions are only shifted abroad as consumer demand would be increasingly met by imports. The Boards therefore recommend that the Federal Government and the *Länder* engage more actively in consumption management and go beyond information and general education campaigns. Consumption management requires multiple measures, including new instruments such as *nudging* (changing the decision-making architecture and behavioural options in a certain context). These options are not yet part of German food policy whereas daily consumption behaviour is already influenced in many different ways by marketing and media.

VII.1.1 Use learning-by-doing approaches: Implement multiple measures, generate empirical evidence, use and further develop new management options (addressed to the Federal Government)

GHG reduction measures that aim to change food consumption patterns are typically regarded as very complex or unpopular. There is limited knowledge at political level regarding the role that research in behavioural psychology and behavioural economics can contribute to the development of options for consumption management. Likewise, there is limited knowledge about new control options. What is required is the systematic creation of an evidence base with regard to the effectiveness of multiple measures to achieve behavioural changes. This evidence base needs to go beyond short-term laboratory studies. In addition, new measures should be developed, gradually implemented and systematically evaluated (e.g., in selected model regions). The Boards therefore suggest that the Federal Government designs a food policy that takes into account the climate-relevance of food consumption as part of a targeted learning-by-doing approach.

VII.1.2 Inform consumers in an understandable and motivational way about climate-friendly eating habits (addressed to the Federal Government and the *Länder*)

Consumers who wish to follow a climate-friendly diet need reliable and understandable information about how their eating habits can contribute to reducing GHG emissions. The Advisory Boards have doubts regarding the effectiveness of a one-sided concentration on explicit

informative appeals as the single strategy to change consumer behaviour. Nevertheless, they point out that informative appeals can, in principle, be very effective. Moreover, understanding the impact of one's food choices on climate change is a prerequisite for accepting other policy instruments. The Boards therefore recommend that the Federal Government and the *Länder* provide consumers with relevant information on climate-friendly food consumption, bundle the already existing proposals, and highlight the areas which offer for the individual consumer the largest GHG reduction potential in the area of food consumption.

VII.1.3 Examine the feasibility of climate labels (addressed to the Federal Government, the *Länder* and the industry)

In the near future, the Boards do not regard the implementation of a CO₂ *footprint* label as a realistic policy option to influence consumer behaviour, because the transaction costs of introducing such a label are high and the required pre-conditions have not yet been met. However, the Federal Ministry should examine the possibilities for a CO₂ *footprint* label in research and demonstration projects. Information on the climate-relevance of specific products is important to consumers who are interested in climate-friendly consumption. As an alternative to a CO₂ *footprint* label for the food sector, it would be useful to consider a government-supported positive label for specific food groups that are particularly climate-friendly. There is already a positive label that is based on a comparable concept: the "Blue Angel" label. However, from an administrative point of view, it does currently not meet the needs of the complex food sector with its enormous variety of products. This is probably the reason why it has not been used for food products. A relaunch of the "Blue Angel" label as a strong climate label would have to be examined against this background.

VII.1.4 Provide contexts that favour climate-friendly diets (addressed to the *Länder*, municipalities and the industry)

Changes to the living environment through *nudging* (e.g., a changed choice of meals or a changed positioning of food products) and exposure to stimuli (*priming*) have proven to be effective in various studies. In the future, such approaches should be increasingly used to raise the attractiveness of products with lower GHG emissions. Mass catering facilities could, for instance, get advice with regard to changing the choice of meals in order to offer climate-friendly meals as the standard option, but also allow for an *opt-out* alternative. This could also provide retail and catering trade businesses with key incentives for socially responsible management.

VII.2 Reduce the consumption of animal products

The Boards recommend a reduced consumption of animal products for persons who consume more of these products than recommended by the German Nutrition Society (DGE). The Boards consider this recommendation as an important lever to reduce GHG emissions. Achieving this goal requires a comprehensive set of measures.

VII.2.1 Focus and further develop information campaigns (addressed to the Federal Government)

The Advisory Boards recommend the sharpening and further development of existing information campaigns with regard to healthy diets (such as IN FORM) with a stronger focus on climate protection through the reduced consumption of animal products. Reliable monitoring and evaluation systems should be established to assess the effectiveness of such information campaigns. The campaigns should make it clear that the goal is not to completely avoid meat or even all animal products. The goal is rather to reduce their consumption to a nutritionally balanced and climate-friendly level. However, the climate effects of meat consumption – and also of the consumption of milk products and cheese - have so far not been sufficiently communicated to the public.

VII.2.2 Assume a pioneering role in public mass catering facilities (addressed to the Federal Government, *Länder*, and municipalities)

Public mass catering facilities can assume a pioneering role with regard to offering meals that comply with the recommendations of the DGE. Both the *Länder* and the local governments, depending on their area of responsibility, are encouraged to make their contribution in this regard. To be able to implement the necessary significant improvements in catering, the municipalities (e.g., for schools) and the *Länder* (e.g., for universities and student welfare services) need support in terms of financial means and advisory services.

VII.2.3 Apply the regular instead of the reduced value-added tax rate for animal products and accompany this step by socio-political measures (addressed to the Federal Government)

At present, the market price of food products does not reflect the fact that the production of certain food products generates more GHG emissions per calorie or per gram of protein than the production of other food products. From a theoretical point of view, it would be logical to impose a climate tax on goods based on their respective product-specific GHG emissions. There is,

however, no empirical basis for establishing such a differentiated climate tax. Since the production of foods of animal origin causes on average higher product-specific GHG emissions per calorie or per gram of protein as the production of plant products, the Advisory Boards recommend that the Federal Government imposes the regular value-added tax rate (19 %) on animal products instead of the reduced rate (7 %). This step should be accompanied by socio-political measures in order to reduce socially undesired effects on low-income households. Such measures could, for example, include an adjustment of the food budget as part of social transfer payments or an adjustment of the taxation of lower income groups. Another option to be examined is the provision of free meals in nurseries and schools that comply with the recommendations of the DGE, also with a view to fostering sustainable eating habits.

VII.3 Reduce wastage of food (addressed to the Federal Government, *Länder*, and municipalities)

After reducing the consumption of animal products, reducing food waste has the second highest potential for reducing GHG in the entire field of "food consumption". The Advisory Boards therefore suggest that the Federal Government maintains and further develops the existing initiatives and programmes to reduce food waste. Consumers should be better informed about the fact that the "best-before" date is not an expiry date.¹² The Boards recommend that providers of public mass catering services also strive for a reduction of food waste in their facilities. In particular institutions for children and young people should make sure that food is presented in an appealing way and handled appropriately in order to strengthen the children's and young people's respect and appreciation of food. With regard to public tendering procedures for catering services, the Boards recommend that providers should be required to have a certified waste management system.

VII.4 Replace other foodstuffs with more climate-friendly products as well: Drink tap water instead of mineral water (addressed to the Federal Government, *Länder*, and municipalities)

This recommendation is presented as an example as it can be put into practice by consumers relatively easily. By drinking tap water, consumers can save costs, time and effort. The Boards recommend that the Federal Government conducts an appropriate information campaign to achieve behavioural changes in this regard. The information campaign should take up the above-mentioned synergy effects and develop an alternative to the sometimes very emotional

¹² The Boards do not consider it appropriate to abolish the best-before date as it is a valuable instrument to ensure food safety and food quality.

advertising for mineral water. The Boards also suggest the obligatory introduction of drinking fountains (water dispensers linked to water pipes) in mass catering facilities and public buildings.

VII.5 Assume a pioneering role in public mass catering facilities (addressed to municipalities, *Länder* and the Federal Government)

Promoting a greater choice of vegetarian meals and dairy products in mass catering facilities is considered a very promising measure to influence consumer behaviour. At the same time, food waste can be reduced by taking appropriate measures when preparing meals. The Advisory Boards suggest including the requirement to comply with DGE quality standards in the specifications and invitations to tender for public mass catering facilities. In addition, they recommend introducing the mandatory requirement to apply a waste management concept and to install drinking fountains (water dispensers linked to water pipes).

VIII The most important recommendations in the field of forestry and timber use

Unlike agriculture, forestry is not a major emitter of greenhouse gases. Without the storage of carbon in forests and wood products and their substitution effect, present GHG emissions in Germany would be more than 14% higher. However, the mitigation effect of forestry and timber use could be significantly reduced in the future due to a number of current developments in tree species composition and age structure, in the pest and pathogen regime, in the intensity of forest use and in the behaviour of forest owners.

The measures in the forestry and timber sector are interrelated and can affect one another both positively and negatively. The measures presented here are based on the consideration of the overall system of forest management and timber use. The suggested measures mainly focus on political instruments that provide incentives for forest owners to direct their forest management towards an improved climate mitigation performance.

VIII.1 Ensure that forests are productive and used in a sustainable manner

Apart from the storage of carbon (C) in phytomass and soils, the climate change mitigation effects of the forestry sector are mainly based on productive forests that generate timber which can be converted into durable wood products with high substitution effects. In view of the risks of climate change, it is a key challenge to sustainably maintain a high productivity and use of the forests.

VIII.1.1 Promote the cultivation of adapted and productive tree species (addressed to the Federal Government, *Länder* and certification systems)

In the long term, the tree species composition of forests must be adapted to changing site conditions. This adaptation requires further research activities to be able to assess the effects of climate change more accurately depending on tree species and origins. Moreover, the respective contribution to climate change mitigation should be taken into account when it comes to choosing appropriate tree species and mixtures of tree species. This choice should also consider the wood products derived from these tree species and the time span that they remain in the economic cycle. In this context, the carbon balances of productive coniferous tree species are clearly the best. The Advisory Boards therefore recommend using forestry support programmes in order to both promote an adaptation of the forests to climate change and increase their mitigation performance through the cultivation of coniferous tree species that are less susceptible to drought stress (e.g. Douglas fir, grand fir, black pine and, on certain sites, also silver fir) mixed with deciduous tree species. The increased cultivation of these tree species also requires changes to those certification standards (e.g. FSC) that have so far mainly focused on the tree species composition of natural forest communities. Instead, the guiding principles for tree species composition in the future should ensure that all forest functions are comprehensively fulfilled. The climate change mitigation function should explicitly be included.

VIII.1.2 Take account of the climate change mitigation effects of forest reserves (addressed to the Federal Government, *Länder*, and municipalities)

The storage of carbon in unused forest ecosystems lags well behind the climate mitigation performance of sustainably used forests. Climate change mitigation and adaptation aspects should therefore receive more attention when it comes to the designation of forest reserves. Forest stands that are on the one hand very different from natural forests and that have on the other hand a high climate mitigation potential (e.g., secondary coniferous forests) should be excluded from protected area regimes. With a view to the necessary consolidation of protected areas, public authorities should increasingly purchase or swap areas of high nature conservation value that are currently located in private and communal forests. A differentiated balancing of climate change mitigation and biodiversity protection goals can thus contribute to improved resource efficiency.

VIII.2 Ensure the protection of forest soils (addressed to the Federal Government, *Länder* and certification systems)

The forest soils in Germany continuously accumulate organic matter and therefore make an important contribution to climate change mitigation. The carbon stocks of our forest soils (up to a depth of 30 cm) are currently increasing by approx. 0.4 t of carbon/ha/year. If we include the deeper layers of the mineral soil (> 30 cm in depth), this value is even much higher. However, as a result of inappropriate use, forest soils can lose their carbon sink function and even turn into carbon sources. It should therefore be avoided to disturb forest soils, e.g., by machine traffic off the extraction tracks or by letting forest land lie exposed for prolonged periods as a result of clear-cutting. Avoiding such disturbances is particularly important in forest sites with soils that have a carbon storage capacity which is very sensitive to silvicultural activities and other forestry interventions. Silviculture and forest technology must be aligned with ecological requirements. With a view to the various effects of forest management activities (forest traffic, nutrient depletion, compensatory liming), locally differentiated methods and concepts have to be applied in order to maintain the function of forest soils and conserve their structure, storage capacity and fertility.

VIII.3 Improve advice and support for small- and medium-sized private and communal forest enterprises to meet climate protection goals (addressed to the EU, Federal Government, and *Länder*)

A forest management approach that appropriately addresses climate change mitigation and adaptation requirements needs to be implemented by local forest owners and forest managers. This requires an improved basis and better models for forestry planning as well as comprehensive advice and support for local decision-makers, which needs to be well coordinated.

So far, there is often still a lack of geographically explicit information on sites, growth rates and risks, which is adjusted to the expected climate development. Such information would be required for medium-term forestry planning (forest management planning). It is an important public task to generate the necessary data bases and models, which need to come from research and development projects. These data bases and models should in particular be made available to the managers of private and communal forests for planning purposes. The implementation of such an approach requires comprehensive site maps, which are still missing for most private forests.

In addition, new extension instruments must be developed to reach out to the owners of small and very small private forests as the share of forest owners who respond to financial assistance and traditional regulatory measures is declining.

VIII.4 Increase public awareness about the positive climate change mitigation effects of forestry and timber use

The positive effects of forestry and timber use on the climate described in this report should be communicated more clearly to the public in order to strengthen people's awareness that sustainable forest management and the use of timber in the form of durable wood products make the best contribution to climate change mitigation in this sector. Meeting this goal requires the joint effort of all actors in the forestry and timber sector.

VIII.5 Increase the "longevity" of wood products and promote their multiple and cascading use (addressed to the Federal Government and the *Länder*)

The storage of carbon and the substitution efficiency of wood are heavily dependent on the longevity of wood products. This longevity can especially be increased by the use of timber in the construction sector. However, there are many obstacles to an increased use of timber for construction purposes. The Federal Government and the *Länder* should therefore quickly adjust their building codes to the latest scientific findings and technological standards (e.g., fire safety, noise protection, and health effects) in order to expand the use of timber in the construction sector. In parallel, consumers, planning experts and architects should be provided with comprehensive information.

A more efficient use of material would increase the output of finished products per unit of raw material. The multiple and cascading use of wood offers great potential in this respect. Along the entire use chain, wood should be used as efficiently as possible and its material use should always take precedence over the generation of energy. Initiatives aimed at the implementation of multiple and cascading uses should be supported through structural measures and incentives.

IX Strengthen climate protection efforts and tap the potential of agriculture, food consumption, forestry and forest-based industries

The Advisory Boards conclude by emphasising that ambitious climate change objectives are necessary. To meet these objectives, agriculture, forestry and forest-based industries (including timber use), as well as food consumers, must further increase their contribution to climate change mitigation. This report shows that there is great potential in this regard. The necessary transformation to a so-called low-carbon economy will take decades and should therefore be regarded as a long-term process of learning and adjustment. Some of the climate protection measures with the greatest mitigation potentials require a long period of time to become fully effective. Therefore, it is imperative to begin with their implementation as quickly as possible.